Transportation Research Interdisciplinary Perspectives 11 (2021) 100437

Contents lists available at ScienceDirect

Transportation Research Interdisciplinary Perspectives

journal homepage: www.sciencedirect.com/journal/transportation-research-interdisciplinary-perspectives

Perception of autonomous vehicles – A Ghanaian perspective

Williams Ackaah [a,*], Van Laar David Leslie [b], Kwame Kwakwa Osei [c]

[a] CSIR – Building and Road Research Institute, U. P. O. Box 40, Kumasi, Ghana
[b] Regional Transport Research and Education Centre Kumasi, Civil Engineering Department, KNUST, Kumasi, Ghana
[c] Kumasi Technical University, Civil Engineering Department, Kumasi, Ghana

ARTICLE INFO

Keywords:
Autonomous vehicles
Perception
Sustainable transport
Safety
Ghana

ABSTRACT

This paper examines the general perceptions of the public on Autonomous Vehicles (AVs). A survey was conducted that sampled 417 respondents. The survey was carried out using the convenience sampling method and was administered partly online and partly through face-to-face interviews. Descriptive analysis using SPSS was carried out for the variables using the chi-square tests to assess statistical significance. Most (66.4%) respondents were familiar with AVs. Majority (55.4%) had a positive opinion on AVs and most (78.2%) were interested in experiencing AVs. However, respondents still preferred to have some control (i.e., level-3 automation and below) should they experience using AVs. Respondents also expressed concern about AV use, with safety as the most important consideration. Respondents would utilize the free time available in use of AVs to be productive and work. Participants were optimistic, believing AVs will be available in the next ten years. To ensure public acceptance of AVs, government can: set out policies that make Ghana an attractive market for car manufacturers; put in place the necessary infrastructure to accommodate AVs into the existing transportation system; educate the public on the usefulness of AVs; highlight the positive impact AVs would have on the transportation system; introduce policies that would allow for AVs to be set at reasonable prices and for individuals to have subsidies and tax benefits associated with AV use. Further research should be carried out to include a larger proportion of respondents from several other cities in Ghana.

Introduction

Cities, nowadays, are constantly faced with rapidly rising populations which have led to changing patterns of movements for shopping, leisure, and work. With the continuous growth of the economy and a rise in both the urban population and vehicle ownership, there has been an increase in traffic demand, leading to delays, an increase in travel time, pollution, and fuel consumption. Errampalli et al., (2015) showed that vehicles that operate in congestion consume more fuel than those operating in steady-state traffic conditions for the same average speed. Also, according to Errampalli et al., (2015), congestion leads to an increase in travel time and road user cost. These problems are more prominent in the growing economies of the developing world.

Speaking of developing countries, according to Igliński and Babiak (2017), they are the countries most affected by the rise in greenhouse gases (GHG) emissions due to their rapid growth in transport demand. Even though the effects of GHG emissions are more pronounced in developing countries, the continuous increase in GHG emissions affects all nations globally because the transport sector is one of the largest emitters of GHG. In the Emissions Gap Report of 2019 produced by the United Nations Environment Programme (UNEP), it was estimated that GHG emissions rose by 1.5% per year for the last ten years with 2018 recording the highest GHG emissions total yet. To put that into context, the Emissions Gap Report of 2019 estimates that GHG emissions would need to be 55% lower by 2030 than in 2018 alone to limit global warming by 1.5–2 degrees Celsius. In an ironic but unfortunate twist, it has taken the deadly COVID-19 pandemic in 2020 to slow down GHG emissions in the world. This was seen in the Global Energy Review 2020 published by the International Energy Agency (IEA) where due to the pandemic, global energy demand decreased by 3.8% in the first quarter of 2020 resulting in an estimated decrease of GHG emissions by 8% for the year. However, the pandemic is a rare occurrence and once its effects are no longer felt, GHG emissions will rise to previous levels. Also highlighted in the report is that there is no sign yet of when GHG will peak indicating a likelihood that GHG emissions will continue to rise.

One other huge consequence of the increase in vehicle use and ownership due to rapid economic and population growth is traffic safety and the unfortunate rise in fatalities from road traffic crashes. Traffic

* Corresponding author.
E-mail address: ackaahwillie@yahoo.com (W. Ackaah).

https://doi.org/10.1016/j.trip.2021.100437
Received 1 March 2021; Received in revised form 21 July 2021; Accepted 2 August 2021
Available online 14 August 2021

fatalities and injuries, not only affect the livelihoods of those affected but also damage the economy of countries with high rates of traffic crashes. The global status report on road safety 2018 published by the World Health Organisation (WHO) revealed that more than 90% of the world's fatalities due to traffic crashes emanate from low- and middle-income nations. Also, the continent with the highest road traffic death rates is Africa (WHO, 2018). Ghana recorded 2,284 deaths due to traffic crashes in 2019 according to the Motor Traffic and Transport Department (MTTD) – the highest for the past decade (Graphic Online, 2020). Maddox (2012) states that over 90% of traffic collisions can be attributed to human error.

All the above side effects or consequences such as noise and air pollution, congestion, safety, fuel use, and transportation costs due to economic growth, population growth, increase in vehicle ownership, and traffic demand put a blemish on the transport sector. This has led many different nations and institutions such as the automobile industry and technology industry to try and find innovative ways of making the transport sector safer, less polluted, less congested, more fuel-efficient, and cheaper. The result is the creation and use of Autonomous Vehicles (AVs).

Most developed nations have now been able to test autonomous vehicles on their roads. However, in developing countries and especially countries in Africa, no plans and/or policies have been formulated involving autonomous technology.

The Mobility 2030: ICE in Africa report published by Klynveld Peat Marwick Goerdeler International Limited KPMG, 2020 shows a thriving and growing market for the auto industry. In their report, they stated that the African auto aftermarket was worth $10 billion in 2019 and that the demand for automobile parts is projected to be $15 billion by 2022.

This shows that there is an increasing demand for vehicles in Africa and governments should take advantage of this opportunity to encourage automobile manufacturers to test their autonomous vehicles in their countries. The earlier African countries formulate plans and policies regarding autonomous vehicles, the better prepared they will be for the inevitable trickle-down of the technology from the developed nations.

Therefore, the objective of this paper is to determine the perception Ghanaians have of autonomous vehicles. This information will help guide the government to be more proactive and better prepared in making decisions and policies in the best interest of citizens before the technology inevitably trickles down into the country.

Literature review

What are autonomous vehicles (AVs)?

Autonomous Vehicles (AVs) are vehicles that can operate without physical control or monitoring by a human operator (Department of Motor Vehicles, California (DMV), 2020). This is the ideal vision of autonomous vehicles. However, due to its relative infancy, the Department for Transport, United Kingdom (UK) in its report titled "The pathway to driverless cars" makes a point to stress that successfully achieving the ideal vision of autonomous vehicles requires more testing and time.

Over the years, there has been a steady evolution of technology implanted and used in vehicles. These technologies have slowly bridged the gap from standard vehicles driven manually to autonomous vehicles. For Anderson et al., 2016, the technologies that have been innovated have made it easier and more comfortable for drivers by making some decisions on their own and reducing the element of driver errors with assists such as crash warning systems, adaptive cruise control (ACC), lane-keeping systems, and self-parking technology. There are varying levels to which these assist and support systems are incorporated into vehicles - known as levels of automation. Different organisations have slightly different interpretations of the levels of automation. There are three main interpretations of levels of automation widely used:

- National Highway Traffic Safety Administration (NHTSA) levels of automation;
- Society of Automotive Engineers (SAE) levels of automation; and
- German Association of the Automotive Industry (VDA) levels of automation.

In the case of the NHTSA levels of automation, it categorized automation levels into five, starting from level-0 and ending at level-4 which is a fully self-driving vehicle. NHTSA was the first to try to identify and describe the varying automation levels, however, its descriptions of the automation levels were not specific and clear enough (Godsmark, 2017). This led to the formulation of the SAE levels of automation which was built on the principles already laid out in the NHTSA levels of automation (Godsmark, 2017).

The SAE levels of automation are categorized into six levels ranging from the least form of automation which is level-0 to the highest form of automation which is level-5 as shown in Table 1. The levels are categorized based on the vehicles' abilities and intelligence to know its surroundings and position within it (Frisoni et al., 2016).

The SAE and NHTSA levels of automation are almost the same from level-0 to level-3 but where the specificity and clarity of the SAE build on and differentiates itself from the NHTSA is in its separation of NHTSA's level-4 (fully self-drivable level) into two levels, namely level-4 (highly automated) and level-5 (fully automated) (Frisoni et al., 2016; Godsmark, 2017). This is observed clearly in Fig. 1.

Similar to the SAE levels of automation, VDA also describes six levels ranging from level-0 to level-5 with level-4 and level-5 indicating highly automated and fully automated, respectively. The VDA automation levels describe the duties of the system and driver at each level as seen in Table 2.

Stakeholder and public opinion of AVs

To get an idea of stakeholder and public opinions on AVs, several researchers and studies have conducted surveys. Freemark et al. (2019) conducted a large survey on transport and planning government officials representing 120 cities in the United States for their thoughts on AVs. Freemark et al's. (2019) revealed in a survey that most officials are positive about AVs with 58% saying that AVs will increase safety and 62.6% saying they expect AVs to increase the quality of life. Officials,

Table 1
SAE Automation Levels (SAE International as cited in Frisoni et al., 2016*).*

SAE Level	Name	Description
0	No Automation	The human driver performs all aspects of the dynamic driving task, even when enhanced by warning or intervention systems.
1	Driver Assistance	A driver assistance system of either steering or acceleration/deceleration but not both is provided in some driving modes with the human driver performing all other aspects of the dynamic driving task.
2	Partial Automation	Driver assistance system(s) of both steering and acceleration/deceleration is provided in some driving modes with the human driver performing all other aspects of the dynamic driving task.
3	Conditional Automation	For some driving modes, the automated driving system performs all aspects of the dynamic driving task with the human driver expected to respond to a request to intervene.
4	High Automation	For some driving modes, the automated driving system performs all aspects of the dynamic driving task even if the human driver does not respond to a request to intervene.
5	Full Automation	For all driving modes, the automated driving system performs all aspects of the dynamic driving task full-time under all road and environmental conditions.

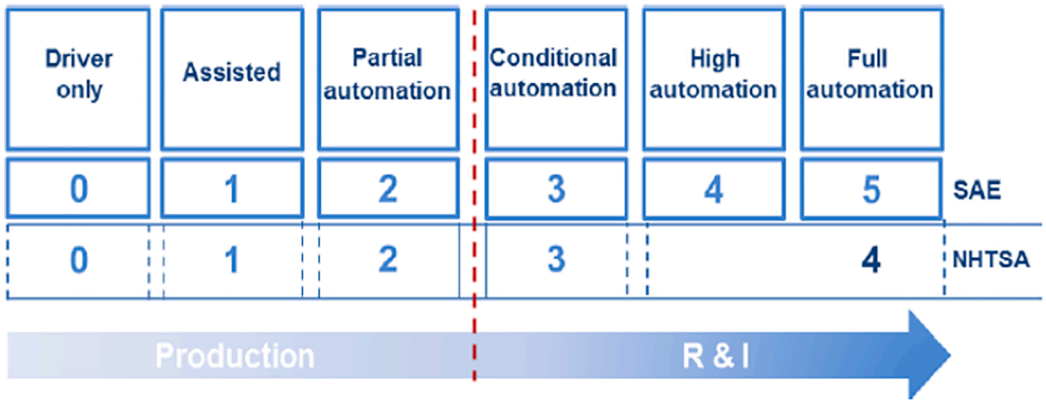

Fig. 1. *Comparison of SAE and NHTSA automation levels* (EPoSS, 2015 as cited in Frisoni et al., 2016).

Table 2
VDA levels of Automation (VDA-magazine, 2015).

VDA Level	Name	Description
0	Driver Only	Human driver performs the longitudinal and lateral dynamic driving task with no system active.
1	Assisted	Human driver performs either the longitudinal or lateral dynamic driving task with the system performing the other dynamic driving task.
2	Partial Automation	Human driver must monitor the system at all times whilst the system performs longitudinal and lateral dynamic tasks in a defined use case/driving mode.
3	Conditional Automation	Human driver does not need to monitor the system at all times whilst the system performs longitudinal and lateral dynamic tasks in a defined use case/driving mode. However, the human driver must be able to resume performing the dynamic driving task when requested by the system.
4	High Automation	Human driver is not required to perform any dynamic driving task during a defined use case/driving mode whilst the system performs longitudinal and lateral dynamic driving tasks in all situations in a defined use case/driving mode.
5	Full Automation	Human driver is not required during a full journey whilst the system performs all dynamic driving tasks in all road and environmental conditions.

also, mostly expected AVs to reduce congestion (38.6%), emissions (51.3%), and costs (50.3%). However, the survey also revealed some reservations officials had that included increased vehicle miles travelled (42.1%), increased number of vehicles (32.3%), increased urban sprawl (36.6%), and reduced government revenues (23.6%) and employment (36.6%).

In terms of public opinions, surveys conducted have produced varying results with some surveys indicating the public's unwillingness to use or adopt AVs whilst other surveys indicate a willingness to use or adopt AVs. For example, in their survey of 500 drivers, Schoettle and Sivak (2015) discovered that most of them were not comfortable riding in a fully automated vehicle. Only 18% of the British public surveyed in 2014 felt that fully autonomous vehicles should be an issue that the automotive manufacturers concentrate on (Ipsos MORI, 2014).

Generally, the major public opinions and/or perceptions can be grouped into four main domains: benefits, safety, technology and social costs. The perceptions concerning the aforementioned domains have been found in the literature to have some significant associations with factors including demographics, geographical location, economy and vulnerability.

Benefits

Apart from increased convenience levels, safety improvement on the roadways is one of the most important benefits expected by prospective users to be significantly associated with autonomous vehicles (Howard and Dai, 2014). It is anticipated that there will be reduction in road crash related fatalities due to predicted fewer number of crashes. AVs are expected to contribute to smooth flow of vehicular traffic and consequently improves the environment by reducing noise pollution and emissions levels. The intention to purchase an AV has been linked to their environmental benefits. Wu et al. (2019), for example, asserted that about 60% of the population would be willing to purchase an AV provided they are to be environmentally beneficial. Also, there are economic prospects of AVs as a result of the predicted savings in energy consumption associated with them (Bansal et al., 2016; Mezei and Lázanyi, 2018). In spite of the numerous potential benefits reported by several studies, it is interesting to mention that other researchers have reported counter-expectations. A research by the Taiebat et al. (2019) suggests that the perceived benefits from AVs could induce vehicular owners, especially in higher income groups, to travel extra miles, which to some extent could offset the potential energy-saving benefits that are expected from automation. The authors further forecast a 2–47% increase in travel demand for an average household as connected and autonomous vehicle usage increases. These do not only increase energy use but also traffic congestion and emissions.

Safety

Globally, there is a growing concern about the current rise in fatalities from road crashes (WHO, 2018). As such, the advent of AVs is seen by many researchers to be a major step towards achieving significant safety improvement on roadways. The findings from studies such as Hulse et al. (2018) revealed that autonomous vehicles were perceived as a "somewhat low risk" form of transport. However, the risky behaviours of both vulnerable road users (i.e., pedestrians, bicyclists and motorcyclists) and drivers have been found by researches to be a major contributing factor of road crashes (King et al., 2009). The question therefore is that, given the risky behaviours of pedestrian and motorcyclists, would pedestrian and cyclist crashes on roadways be reduced, even if autonomous vehicles were to behave more safely around pedestrians and other human operated modes? Compared to human operated vehicles, the risks involving AVs are perceived differently depending on the type of road user. In a study by Hulse et al. (2018), it was reported to be more risky to be a passenger in an AV than in a human-operated vehicle. The authors further found that pedestrians, in an area of AVs, were perceived to be at a lower risk than those in human operated vehicles. Jardim et al. (2013) reported that 59.5% of respondents of their study in the US indicated that safety of AVs had a positive influence on their purchase intentions of the new automobile technology and 82% of respondents puts safety ahead of cost as the most influential driver for adopting AVs. It is worth mentioning that an individual's level of awareness of AVs is associated with their perceived safety of AVs (Pyrialakou et al., 2020).

Social cost

In spite of the expected benefits associated with autonomous vehicles, there are several concerns over their social costs. According to Taiebat et al. (2019), the benefits of autonomous vehicles such as low energy consumption, and increase travel speed could induce travel among users. This increase vehicle kilometre travelled and consequently increase congestion, air pollution, and urban sprawl (Bahamonde-Birke et al., 2018). Moreover, social equity is predicted to reduce with limited accessibility options resulting from a decline of public mass transportation (Bahamonde-Birke et al., 2018; Krueger et al., 2016). Another concern about social equity is related to affordability. Comparatively, high income earners are expected to enjoy the new generation of vehicles more than low income earners. Fagnant and Kockelman (2015) raises the concern of the uncertainty over who is liable if an accident were to occur.

Technology

Autonomous vehicles are new technological advancement in the automobile industry. The main factors that influence prospective consumers' intention for adopting newly-emerging and high technology based products include but not limited to trust, familiarity with technology, perceived ease of use and usefulness of the technology. Studies into automation have posited that trust is a major contributing factor of the adoption of any such automation (Kim et al., 2019; Lee and See, 2004; Häuslschmid et al., 2017). Autonomous vehicles are equipped with the technology which takes away the active personal-driving role of drivers and entrusts maximum control to the vehicles. Consequently, there may be reduced levels of trust since such automation turns drivers into passive supervisors (Pettersson and Karlsson, 2015; Sun et al., 2020). According to Gkartzonikas and Gkritza (2019), individuals are more willing to travel with newly-emerging modes when they are more familiar with the technology. Further, an individual's attitudes and opinion about an emerging technology will be more favourable when evaluated to be more positive. Moreover, the more consumers find it easy to use an emerging technology, the more they are likely to adopt the technology because their perceived sense of efficacy and control are enhanced (Davis et al., 1989; Nastjuk et al., 2020).

Demographics trends in public opinions with AVs

There are significant trends and variations by socio-demographics in the perceptions and/or opinions of the public concerning AVs. From the body of literature, the socio-demographic characteristics of people including age, gender, nationality/geographic location and vulnerability determine how they accept new automobile technologies (Abraham et al., 2017; Bansal et al., 2016). It is important to mention that diverse opinions of AVs have been identified in the literature.

Gender

The gender of the individual plays a key role in determining AV acceptance. In a study by Schoettle and Sivak, 2014, women were found to be less likely to show interest in AVs than men. Compared to females, males are more likely to perceive autonomous vehicles as less risky and therefore have a positive attitudes towards them (Hulse, et al. 2018). But some studies (e.g., Haboucha et al., 2017) have reported significant differences in the effect of gender on AV opinions when compared among respondents from different countries.

Age

Similar to gender, the impact of age on perceptions about AVs have been found to vary in diverse ways. According to Payre et al. (2014), older people are more likely to accept AVs but less likely to pay for this technology. On the other hand, Hulse, et al. (2018) posits that older people, relative to younger ones, are more likely not to ride in an autonomous vehicle. The elderly are less enthusiastic about the prospect of using AVs than their younger counterparts (Kyriakidis et al., 2015; Ipsos MORI, 2014; Bansal et al., 2016; Portouli et al., 2017). Risk levels by autonomous passengers have also been reported by Hulse et al. (2018) to be not significantly associated with age. Contrary to the findings of Hulse et al. (2018), Moody et al (2020) reported that young males have higher positive perceptions about the safety of AVs. Young males are more likely to undertake risky driving behavior, hence their positivity towards AV safety.

Nationality/geographical location

Hilgarter and Granig (2020) mentions that the opinions of individuals about transport mobility depend on whether they are urban or rural dwellers. Public acceptance of AVs and its influencing socio-demographics have been found to vary by nationality and/or geographical location. This could be attributed to cultural differences. KPMG (2013), for example, reported significant variations in the acceptance of AVs when they conducted a number of focus-group meetings with people from Chicago, Los Angeles, and Iselin. Also, Moody et al. (2020) explored the differences in perception in AV safety across multiple countries. The authors reported that urban, fully employed individuals with higher incomes and education levels perceive fewer years until AVs are safe to use. Also, individuals from developing countries that face greater road safety challenges predict fewer years until AVs will be safe enough for them to use. On the other hand, individuals in developed countries with greater motorization rates and lower road fatality rates are more pessimistic about the present and future safety of AVs (Moody et al., 2020). While gender was reported by Haboucha et al. (2017) to have significant impact in determining interest in AVs in Israel, the authors found no significant gender difference in the North America. Contrary to the findings in India, North American men, compared to the women, were reported to have higher willingness to ride in AVs (Anania et al., 2018).

Vulnerable road users

One area that is gradually gaining the attention of researchers is the navigation and mobility issues of persons with disabilities in the era of AVs. According to CAAT (2019), the AVs are expected to be more noiseless than the traditional gas-powered vehicles. This noiseless feature of AVs poses as a major safety challenge to the visually impaired pedestrian who rely on the sound they hear on the roads to safely interact with the approaching vehicle and navigate to their destination. Azizi Soldouz et al. (2020) conducted a study with visually impaired people from Canada and abroad. The authors found that majority of the visually impaired people prefer to get feedback and alerts from connected and autonomous vehicles (CAVs). Comparatively, blind people who rely on conventional navigation tools such as white cane and guide dogs are less likely to trust CAVs than those who rely on mobile applications and technology-based devices for navigation purposes (Azizi Soldouz et al., 2020). Moreover, the positive attitudes of people with disabilities towards AVs may be influenced by their mobility issues with current public transit services and neighbourhood built environments (Hwang et al., 2020). However, a direct experience interacting with AVs will make individuals develop positive attitudes towards AVs. As reported by Penmetsa et al. (2019), significantly higher expectations of the safety benefits of AVs are associated with vulnerable road users who have the experience of interacting directly with AVs than those with no AV interaction experience. Similarly, Das et al., 2020 mentions that "participants with real AV interactions have higher expectations and interest in AVs than the participants with no experience."

Methods

Sampling and data collection

The survey for the study was conducted from July to August 2020 among the Ghanaian general public. No persons were excluded from the study except those who were under 18 years of age. Therefore, the

survey included both drivers and non-drivers as AV use is not subject to just the drivers' viewpoint. To gather data from as many people across the entire country, part of the survey was administered online through Google Forms and shared on various social media platforms such as Twitter, Facebook, and WhatsApp and also via contact and email lists. The rest were administered in person in Kumasi through face-to-face interviews at various locations such as taxi and bus (trotro) stations, offices, shops, restaurants, and the Kwame Nkrumah University of Science and Technology, Kumasi (KNUST) campus. The sampling method used in conducting the survey was the convenience sampling method. The convenience sampling method was adopted since it is simple, easy to use, aids in hypothesis generation, fast and cheap (Dudovskiy, 2016). As mentioned above, part of the survey was administered online. Three hundred (300) respondents completed and submitted the online form. One hundred and fifty (150) questionnaires were distributed in person in Kumasi. Of the 150 questionnaires distributed in person, 140 questionnaires were returned generating a response rate of 93.3%. In addition to the 10 questionnaires that were not returned, a further 23 questionnaires were discarded because they were incomplete leaving 117 complete questionnaires from the distribution to analyse. Therefore, there were a total of 417 responses analysed in the study after combining the online and the face-to-face surveys. Before answering the questionnaire, respondents were provided with a background on AVs and the different levels of automation that exist to encourage respondents to form their own opinions on AVs. The survey took approximately 20 minutes to complete.

Measures

To determine the perceptions of the Ghanaian public on AVs, data on the public needed to first be collected as stated above before any analysis. Therefore, a questionnaire was formulated that focused on gathering data based on the demographics (age, gender, income and education level) of respondents and their general opinions on AVs. Also, all questionnaire answer options were represented with discrete variables in the Statistical Package for Social Sciences (SPSS). Questions that were asked included:

- What is your gender?
- What age range do you belong to?
- What is your highest level of education?
- What is your monthly income?
- Do you own a vehicle?
- What is your driving experience?
- Have you heard of AVs before?
- What is your opinion on AVs?
- Would you be interested in using AV should they be available?
- Which level of automation would you prefer using?
- Would you have concerns about using AVs?
- Which of the following factors would you consider to be the most important before using AVs?
- What would you do with the free time available from not driving if you were to use AVs?
- When do you think AVs will be available and roaming around on roads in Ghana?

A descriptive statistic and inferential statistics in the form of chi-square test of independence were adopted to analyse the responses in SPSS. Descriptive statistic is mainly a quantitative method and to a lesser degree a qualitative method that summarizes the data gathered from a study and presents the data in a way that can easily be interpreted and understood by everyone (Trochim, 2020; Woodrow, 2014). Data for descriptive statistics is mainly gathered through surveys but others such as case studies and correlational methods may be used (Baha, 2016). The use of descriptive statistics makes it easier for data to be understood and provides clarity. But, using descriptive statistics alone only summarizes the data obtained and doesn't provide more detail such as the underlying factors that affect the data and the different influences on the variables (Baha, 2016).

Chi-square test of independence was employed to determine whether there is an association between the socio-demographic characteristics of the respondents and their opinions about AVs. For the purpose of this study, test with p value < 0.05 were considered to have significant associations at 95% confidence level.

Results

Demographics

The results show that respondents to the survey were almost evenly split between men and women – 49.9% for men and 50.1% for women. A majority (62.6%) of respondents were between the ages of 18 to 29 years. Those over 60 years represented only 2.9% of respondents. The sample appears to be biased towards the younger population. However, this trend is in line with that of the Ghanaian population which is reported by the Ghana Statistical Service to have a younger population (Ghana Statistical Service, 2013). A majority (92.6%) having achieved a high school education or higher. More than half (58.0%) of respondents earn a monthly income of less than GH₵ 1000 (where US$1.00 ≈ GHS 5.50 at the time of data collection). The highest-earning respondents (greater than GH₵ 5000) made up 7.2% of the total. Over two-thirds (69.3%) of respondents do not own a vehicle, however, a majority of them (63.1%) have driving experience. Respondents were mostly from the two major cities of Accra (34.3%) and Kumasi (50.6%). All the details on the demographics of the study have been presented in Table 3.

Familiarity with and general opinions on AVs

A little over two-thirds of respondents indicated that they had already heard of AVs before the survey as seen in Table 4.

There was a marked difference ($\chi^2(1) = 16.917$; $p < 0.050$) between males (75.96%) and females (56.94%) on their familiarity with AVs in the survey. The relationship between age and those who have heard of AVs before was also significant ($\chi^2(5) = 19.768$; $p < 0.050$). Those with prior knowledge of AVs tended to be younger with 72.29% of those aged 18–24 and 75.27% of those aged 25–29 being aware of AVs. Education level and familiarity with AVs also had a significant relationship ($\chi^2(3) = 36.889$ and $p < 0.050$) with postgraduates (79.37%) and those with a bachelor's degree (72.03%) having heard of AVs before whilst only 29.03% of respondents with only basic education knew of AVs beforehand. There was a significant relationship between monthly income and those who have heard of AVs ($\chi^2(6) = 22.085$ and $p < 0.050$). Respondents earning less than GH₵ 500 were less likely (67.24%) to have heard of AVs before than those who earned greater than GH₵ 5000 (73.33%). Owning a vehicle does not indicate that a person has heard of AVs before as their relationship was not significant ($\chi^2(1) = 3.214$ and $p = 0.073$). There was a significant link between driving experience and familiarity with AVs ($\chi^2(4) = 23.633$ and $p < 0.050$).

A majority (55.4%) of respondents hold either a positive or somewhat positive opinion on AVs. On the other hand, only 13.0% of respondents hold a negative view (i.e., respondents have a low opinion of AVs; are less willing to use and/or accept AVs; and generally, believe that the perceived disadvantages of AVs outweigh the benefits) of AVs (Table 5).

Majority of males (59.14%) and females (51.67%) either have a positive or somewhat positive opinion (i.e., respondents have a high opinion of AVs; are more willing to use and/or accept AVs; and have belief in the perceived benefits AVs may provide) on AVs. However, the number of respondents who had an opinion on AVs did not differ by gender ($\chi^2(4) = 7.989$ and $p = 0.092$). Age, on the other hand, had a significant association with the opinion of respondents on AVs ($\chi^2(20) = 106.150$ and $p < 0.050$). A higher proportion (16.67%) of those aged

Table 3
Demographics of the study.

Demographic Group	Frequency	Percent (%)
Gender of Respondents		
Male	208	49.9
Female	209	50.1
Total	417	100.0
Age of Respondents		
18–24	166	39.8
25–29	93	22.3
30–39	56	13.4
40–49	56	13.4
50–59	34	8.2
60+	12	2.9
Total	417	100.0
Education Level of Respondents		
Basic Education (Primary/JHS)	31	7.4
Senior High School	62	14.9
Bachelor degree	261	62.6
Post Graduate	63	15.1
Total	417	100.0
Monthly Income of Respondents		
Below GH₵ 500	116	27.8
GH₵ 500–1000	126	30.2
GH₵ 1000–2000	74	17.7
GH₵ 2000–3000	41	9.8
GH₵ 3000 – 4000	16	3.8
GH₵ 4000 – 5000	14	3.4
Greater than GH₵ 5000	30	7.2
Total	417	100.0
Location of Respondents		
Kumasi	211	50.6
Accra	143	34.3
Tema	18	4.3
Cape Coast	7	1.7
Sunyani	6	1.4
Tamale	4	1.0
Other	28	6.7
Total	417	100.0
Vehicle Ownership of Respondents		
Yes	128	30.7
No	289	69.3
Total	417	100.0
Driving Experience of Respondents		
None	154	36.9
Less than a year	77	18.5
1 to 5 years	83	19.9
5 to 10 years	59	14.1
Greater than 10 years	44	10.6
Total	417	100.0

Table 4
Respondents who have heard of AVs before.

Question -Have you heard of AVs before?		
Response	Frequency	Percent (%)
Yes	277	66.40
No	140	33.60
Total	417	100.00

Table 5
Respondents' opinion on AVs.

Question -What is your opinion on AVs?		
Response	Frequency	Percent (%)
Positive	114	27.3
Somewhat positive	117	28.1
Neutral	132	31.7
Somewhat negative	22	5.3
Negative	32	7.7
Total	417	100.0

above 60 expressed negative opinions on AVs compared to the 25 to 29 year-olds (2.15%) and the 18 to 24 year-olds (4.82%). A significant link was found between the education level of respondents and their opinions on AVs ($\chi^2(12) = 51.004$ and $p < 0.050$) as respondents with the lowest level of education in the survey were more negatively opinioned on AVs (45.16%) than their higher-educated colleagues. The relationship between monthly income and respondents' opinion on AVs was significant ($\chi^2(24) = 57.751$ and $p < 0.050$). All earners had mostly positive opinions on AVs with only 21.43% and 14.29% of those earning between GH₵ 500-1000 and GH₵ 4000-5000 respectively having a negative opinion. Vehicle owners held a more positive opinion on AVs (60.93%) than non-owners (52.94%) but the difference between vehicle owners and non-owners was not significant ($\chi^2(4) = 6.257$ and $p = 0.181$). Driving experience was significantly related to the respondents' opinion on AVs ($\chi^2(16) = 67.200$ and $p < 0.050$). Those with no driving experience were more positive on AVs (54.55%) than negative (10.40%). Only respondents with 5 to 10 years of driving experience had any significant negative opinion on AVs (37.29%).

Interest in using AVs

A large portion of respondents (78.20%) said that they would be interested in using AVs as seen in Table 6.

Gender was not significantly associated with interest in using AVs ($\chi^2(1) = 0.009$ and $p = 0.926$). Also, the study found that males (78.37%) and females (77.99%) were practically identical in their interest in using AVs. The younger age groups are more interested in using AVs than the older age groups as the relationship between age and interest in using AVs was found to be significant ($\chi^2(5) = 38.313$ and $p < 0.050$). This is highlighted by the fact that only 11.45% of 18 to 24-year-olds and 16.13% of 25 to 29-year-olds show no interest in AV use. On the other hand, 30.36%, 46.43%, and 35.29% of 30 to 39-year-olds, 40 to 49-year-olds, and 50 to 59-year-olds, respectively show no interest in AV usage. The only mild surprise is that just 16.67% of over 60-year-olds showed no interest. Education level and respondents' interest in using AVs had a significant relationship ($\chi^2(3) = 17.877$ and $p < 0.050$). Respondents with only basic education showed a high (48.39%) non-interest in AVs.

Levels of automation

The level of automation respondents preferred the most was level-3 with 29.00%. About 17.00% of respondents prefer the full automation of level-5. There are also 13.90% of respondents who want to still be fully in control with no form of assistance whatsoever and prefer level-0 (Table 7).

Results showed that the number of respondents who preferred a certain level of automation did differ by gender ($\chi^2(5) = 12.867$ and $p < 0.050$). Both genders, male (31.73%) and female (26.32%) prefer level-3 automation. Also, whereas men are more likely to use level-5 automation (21.15%) than women (12.92%), women are more likely to use level-0 (17.70%) than men (10.10%). Most age groups prefer level-3 automation. Age was found not to have a significant relationship with the level of automation preference of respondents ($\chi^2(25) = 35.810$ and $p = 0.075$). Unlike age, education level has a significant link with respondents' preferred level of automation ($\chi^2(15) = 34.036$ and $p < 0.050$). The respondents with the highest level of education, that is,

Table 6
Interest of respondents in using AVs.

Question -Would you be interested in using AV should they be available?		
Response	Frequency	Percent (%)
Yes	326	78.20
No	91	21.80
Total	417	100.00

Table 7
Level of automation respondents prefer.

Question -Which level of automation would you prefer using?		
Response	Frequency	Percent (%)
Level-0	58	13.9
Level-1	44	10.6
Level-2	83	19.9
Level-3	121	29.0
Level-4	40	9.6
Level-5	71	17.0
Total	417	100.0

postgraduates and bachelor degrees, prefer level-3 with 42.86% and 27.97%, respectively. The highest income earners (greater than GH₵ 5000) are more likely to use level-3 automation (46.67%) but this is not as notable because monthly income and the level of automation preferred by respondents did not have a significant relationship ($\chi^2(30) = 29.473$ and $p = 0.493$). Both vehicle owners (29.69%) and non-owners (28.72%) prefer level-3 automation. However, vehicle ownership did not have a significant association with the preferred level of automation ($\chi^2(5) = 4.462$ and $p = 0.485$). There was a significant relationship between driving experience and respondents' preferred level of automation ($\chi^2(20) = 51.770$ and $p < 0.050$). A plurality of the highly experienced drivers (greater than 10 years) would prefer level-3 automation (38.64%) whilst 20.13% of respondents with zero driving experience are more likely than others to prefer level-0 automation. Also, 42.37% of respondents with driving experience between 5 and 10 years prefer level-2 automation.

Concern about AVs

Most of the respondents (73.9%) would have concerns (i.e., respondents have reservations on issues related to AV use such as its safety and security; and its cost) about using AVs as shown in Table 8.

AV use concern by respondents was not based on the difference in gender ($\chi^2(1) = 0.020$ and $p = 0.888$). The majority of men (73.56%) and women (74.16%) equally expressed concerns with using AVs. A majority (91.67%) of respondents over 60 years old would be concerned about using AVs. However, there was no significant difference in the ages of respondents regarding their concerns about AV use ($\chi^2(5) = 4.299$ and $p = 0.507$). The relationship between education level and AV use concern was significant ($\chi^2(3) = 7.854$ and $p < 0.050$) with 93.55% of respondents with only basic education being concerned about AV use. Half (50.00%) of those earning between GH₵ 4000-5000 say they would not be concerned about using AVs. However, monthly income did not have a significant relation with AV use concern ($\chi^2(6) = 9.176$ and $p = 0.164$). There was no significant difference ($\chi^2(1) = 0.139$ and $p = 0.709$) between owners (72.66%) and non-owners (74.39%) on sharing the same concern about using AVs. Driving experience and AV use concern were significantly related ($\chi^2(4) = 9.498$ and $p = 0.050$). Respondents with driving experience between 5 and 10 years would be more concerned about using AVs (89.83%) than others with differing driving experiences.

Factors to consider before using AVs

The majority (73.90%) of respondents claim safety is the most important factor they would consider before using AVs. The next most important factors for respondents are reliability with 11.30% and cost with 8.60%. Just 2.60% of respondents would factor vehicle emissions into their decision to use AVs (Table 9).

Women (77.03%) are more likely than men (70.67%) to consider the safety of AVs before using them. Men (11.06%) are more likely to worry about the cost of AVs than women (6.22%). These results based on gender, however, were not significant ($\chi^2(4) = 5.021$ and $p = 0.285$). Age and the most important AV use factor considered by respondents were significantly linked ($\chi^2(20) = 43.681$ and $p < 0.050$). The youngest, that is, 80.12% of 18 to 24-year-olds and 88.17% of 25 to 29-year-olds and the oldest respondents, that is, 75.00% of over 60-year-olds both consider safety to be more important than middle-aged respondents. Also, the most important AV use factor considered by respondents differed significantly based on the respondents' education level ($\chi^2(12) = 23.251$ and $p < 0.050$). Approximately 78.16% of bachelor degree holders and 76.19% of postgraduates consider safety as the most important factor compared to just 62.90% of those who stopped at the senior high school level and 54.84% of those with basic education. Moreover, monthly income was significantly associated with the most important AV use factor considered by respondents ($\chi^2(24) = 47.423$ and $p < 0.050$). No respondents (0.00%) earning anything higher than GH₵ 2000 even considered cost. More non-vehicle owners (76.47%) than owners (67.97%) consider safety as the most important factor, however, the most important AV use factor considered by respondents did not differ by vehicle ownership ($\chi^2(4) = 5.950$ and $p = 0.203$). The most important AV use factor considered by respondents did differ by driving experience ($\chi^2(16) = 19.313$ and $p < 0.050$) as 22.73% of the most experienced drivers (greater than 10 years) consider reliability as the most important factor which is higher than any other group.

Use of free time in AVs

Respondents tended to lean more towards work (34.80%) than reading (28.50%) in free time AV use as shown in Table 10. Others would rather prefer not to do anything (12.50%) whilst 13.90% of respondents would play with their phones and chat with friends/family.

There was a significant relationship between gender and respondents' use of free time in AVs ($\chi^2(5) = 11.487$ and $p < 0.050$). Both men (35.58%) and women (33.97%) are equally likely to work when riding in an AV whilst women (13.40%) are more likely than men (4.33%) to watch movies/TV shows. Age was not significantly associated with respondents' use of free time in AVs ($\chi^2(25) = 31.015$ and $p = 0.189$). Respondents over 60 years old are the least likely to work (25.00%) and the most likely to do nothing (25.00%) when riding in an AV. Education level and respondents' use of free time in AVs had a significant relationship ($\chi^2(15) = 41.635$ and $p < 0.050$). Only 19.35% of respondents with basic education prefer to spend their free time in an AV working whilst 38.71% of them prefer to do nothing. A majority (64.29%) of respondents earning GH₵ 4000-5000 and about half (46.67%) of respondents earning greater than GH₵ 5000 monthly would prefer working. However, monthly income did not have a significant relationship with respondents' use of free time in AVs ($\chi^2(30) = 41.614$

Table 8
Respondents concern about AV use.

Question -Would you have concerns about using AVs?		
Response	Frequency	Percent (%)
Yes	308	73.9
No	109	26.1
Total	417	100.0

Table 9
Most important AV use factor for respondents.

Question - Which of the following factors would you consider to be the most important before using AVs?		
Response	Frequency	Percent (%)
Safety	308	73.90
Cost	36	8.60
Vehicle emissions	11	2.60
Comfort	15	3.60
Reliability	47	11.30
Total	417	100.00

Table 10
Respondents' use of free time in AVs.

Question - What would you do with the free time available from not driving if you were to use AVs?		
Response	Frequency	Percent (%)
Work	145	34.80
Read	119	28.50
Chat with friends/family	58	13.90
Watch movies/TV shows	37	8.90
Play games	6	1.40
Nothing	52	12.50
Total	417	100.00

and p = 0.077). Respondents' use of free time in AVs did not differ by vehicle ownership ($\chi^2(5) = 8.335$ and p = 0.139). Individuals with more than 10 years of driving experience are more likely to do nothing (18.18%) or chat with friends/family (27.27%) than any other group. Also, 49.15% of those with 5 to 10 years of driving experience prefer to work with the given free time in an AV. However, respondents' use of free time in AVs did not differ by driving experience ($\chi^2(20) = 30.587$ and p = 0.061).

AVs availability in Ghana

A plurality of respondents (37.6%) think AVs will be available and in use in Ghana in the next 10 years whilst 31.2% of respondents think AVs will be available in the next 10–20 years. Also, 16.3% believe AVs will be available after 30 years (Table 11).

The relationship between gender and when respondents think AVs will be available in Ghana was significant ($\chi^2(3) = 8.018$ and $p < 0.050$). More Women (40.67%) than men (34.62%) believe AVs will be available in Ghana in the next ten years. A majority (66.67%) of respondents over 60 years old expecting AVs to be available in the country in the next ten years contrasted with only 36.75% of those belonging to age group 18–24. Also, the 25 to 29-year-olds are the most pessimistic group as the result shows 23.66% of them expect AVs to be available after 30 years. These results, however, were not significant ($\chi^2(15) = 20.815$ and p = 0.143) implying that the timeframe for when respondents think AVs will be available in Ghana does not depend on or differ by the age of respondents. The timeframe for when respondents think AVs will be available in Ghana does depend on and differs by education level ($\chi^2(9) = 22.418$ and $p < 0.050$). The majority (58.06%) of those with basic education expect AVs in the next 10 years whilst 19.35% of them expect AVs after 30 years. Also, 42.86% of postgraduates anticipate AVs being available and in use in Ghana in 10 to 20 years. Monthly income was found to have a significant association with when respondents think AVs will be available in Ghana ($\chi^2(18) = 28.966$ and $p < 0.050$). Of respondents earning the highest monthly income, 46.67% expect AVs in 10 to 20 years. Non-vehicle owners (18.69%) are more likely to expect AVs to be available after 30 years than vehicle owners (10.94%), however, there was no significant relationship between vehicle ownership and when respondents think AVs will be available in Ghana ($\chi^2(3) = 4.185$ and p = 0.242). The timeframe for when respondents think AVs will be available in Ghana did differ by driving experience ($\chi^2(12) = 29.853$ and $p < 0.050$). Drivers with more than 10 years of driving experience (56.82%) are more likely to expect AVs in the next 10 years than those with no driving experience (42.21%).

Table 11
Respondents' opinion on the timeframe of AV availability.

Question - When do you think AVs will be available and roaming around on roads in Ghana?		
Response	Frequency	Percent (%)
In the next 10 years	157	37.6
In 10–20 years	130	31.2
In 20–30 years	62	14.9
After 30 years	68	16.3
Total	417	100.0

Discussion

The proportion of male and female respondents of the survey closely matches the 2010 Ghana population census which showed Ghana has a population structure that is 48.80% male and 51.20% female (Ghana Statistical Service, 2013). The age of respondents was mostly youthful, but a highly educated group. However, the monthly income of respondents leaned towards the lesser earners in society.

The more experienced drivers were more likely to have heard of AVs than the less experienced drivers. The opinion of respondents on AVs is mostly positive but similar to the findings of other studies (e.g., Kyriakidis et al., 2015; Bansal et al., 2016; and Portouli et al., 2017), the elderly were more negative on AVs than their younger counterparts. This could be attributed to the fact that the elderly may not be as familiar with technology as the younger ones – a demotivating factor to travel with AVs (Gkartzonikas and Gkritza, 2019). Majority of all the respondents across gender, age, education level, monthly income, vehicle ownership, and driving experience have a strong appetite to use AVs should they be available in Ghana. Men and women are equally likely to be interested in using AVs which is consistent with Haboucha et al. (2017) who found in the US no significant gender differences in AV use. It however contradicts studies by Kyriakidis et al. (2015), Jardim et al. (2013), Schoettle and Sivak (2014), and Bansal et al. (2016) that suggest that women are less likely to be interested in using AVs than males. The younger respondents are more interested in using AVs and is confirmed by similar studies (Kyriakidis et al., 2015; Ipsos MORI, 2014; Bansal et al., 2016; Portouli et al., 2017).

Respondents prefer level-3 automation which suggests that whilst they are open to using AVs, they still want a certain degree of control over their driving. Also, women are more cautious than men and prefer to be more in control of their driving. One curious result though is the fact that respondents over 60 years of age are simultaneously the most likely age group to prefer level-0 and level-5. These are two completely contrasting levels of automation and may be a consequence of some older respondents wanting complete control whilst others would welcome the stress reduction of level-5 that comes with no longer driving.

Most respondents expressed concern about AV use with men and women being equally concerned. Those with a lower education level are more likely than highly educated individuals to have concerns about using AVs. Relatively, individuals with lower education levels are mostly not adequately informed and therefore lack better understanding of the technology involved in AVs. This consequently builds lack of trust and negative attitudes towards AVs which could also hinder development and slow down deployment when the technology matures (BOSCH, 2021; World Economic Forum, 2021). Almost all income earners have the same high level of concern whilst vehicle owners and non-owners are equally concerned about AV use.

Consistent with the findings of Jardim et al. (2013), respondents of this current study regard safety as the main factor before considering AV use. This result is not surprising for respondents from a developing country with greater road fatality rates. They must have major safety concerns for a newly-emerging automobile technology, especially when they have not had a direct experience with it. They might as well be interested in automobile technology that minimises human errors – a major contributing factor of crashes in Ghana and the world as a whole (Maddox, 2012). The more educated the respondents are, the more likely they are to view safety as the most important AV use factor. The environment was the factor least considered by respondents. This could be attributed to the lack of awareness of the extent of air pollution in the form of emissions contributed by the conventional vehicles and how much AVs can help reduce pollution. One would assume the lower-income earners to consider cost more highly than their higher-earning

counterparts and that assumption proved to be true. Interestingly, the more experienced drivers are less concerned about safety than their lesser experienced colleagues. The reason could be their perception of having enough experience over the years to control their vehicles in a safe manner

More respondents would prefer to spend their free time in AVs working. This falls in line with a study by Anderson et al. (2016) that stated spending more time in AVs actually increases the productivity of riders by allowing them to work in the AV and thus reducing office working hours. Most respondents are highly optimistic, believing that AVs would be available in Ghana in the next ten years.Women are more optimistic than men in that regard. The older respondents are more optimistic than the younger respondents about when AVs will arrive in Ghana.

Conclusions and recommendations

Conclusions

Autonomous vehicles are a relatively new mobility option currently penetrating the market in some developed countries. This innovation will have a big impact on the sustainability of our transport systems and will also positively affect the transport infrastructure and its environment. It will also have an impact on travellers' mode choice in the future and as a consequence, it will alter the transportation system and the way we travel. However, for AVs to be in use and penetrate the market in Ghana, it must first be generally accepted by the public. It is therefore imperative and in our best interest to understand the publics' perception of AVs.

The findings from the study are as follows; almost two-thirds (66.40%) of the public was familiar with AVs. Majority (55.40%) of the public had a positive opinion on AVs and a high proportion (78.20%) of the public were interested in using AVs. Most (29.00%) preferred level-3 automation should they experience using AVs. Regardless of the positive view on AVs, the public still had major reservations with majority (73.90%) expressing concern about AV use with safety as the most important consideration. A large proportion (63.30%) of the public would use the free time available in AVs productively and work or read. In terms of when the public expects AVs to be available in Ghana, most believe it will be in the next ten years. Most of the socio-demographic characteristics of the respondents were found to influence interest in AV usage, level of automation, concern about AVs, factors to consider before using AVs among others.

Recommendations

Based on the findings above, the following are recommended; firstly, since most respondents are highly optimistic that AVs would be available in Ghana in the next ten years, the government must set out policies that make Ghana an attractive and friendly proposition for car manufacturers to invest in and conduct tests of AVs on the roadways of Ghana. In a large market like Africa, Ghana can take the initiative and capitalize on the appetite for car manufacturers to penetrate the African market by allowing the conditions for its competition in the market. Such car manufactures should take into consideration the most preferred level of automation (i.e., level 3 for the case of this study) in order to meet the needs and expectation of prospective users. Of course, the government must put in place the necessary infrastructure to accommodate and smoothly incorporate AVs into the existing transportation system. The government must educate the public on the usefulness of AVs and their benefits including roadway safety enhancement, reliability and productivity increment as they spend their free time in AVs working. The government can encourage a positive attitude towards AVs through enthusiasm and positive advocacy campaigns tailored to provide adequate understanding of the newly-emerging automobile technology among the public. Ghanaian culture is one that lays a great deal of importance on the opinions of family and friends. Therefore, the government can increase awareness by conducting widespread education on the positive impacts of AVs and through advertisement in both online and offline media. With the government increasing awareness, word of mouth begins to spread around friends and family of the public inevitably leading to a greater appetite to use AVs. Policies that would allow for AVs to be set at reasonable prices and for individuals to have subsidies and tax benefits associated with AV use could be introduced to attract the public. The government can also encourage the older generation to use AVs by enlightening them about the benefits an AV would provide to their lifestyle and alleviating their concerns about the risks of AVs. Since the sustainability of the environment was found not to be a major factor considered by respondents to use AVs, there is the need to sensitise the public to cultivate a character that seeks to promote environmental sustainability; the consequence of this will be the adoption of AVs when they are available.

Limitations and future research

This study can be improved upon as some limitations require further research which are as follows; most of the responses were from two cities- Accra and Kumasi. Additional research may be done to include a larger proportion of responses from several other cities in Ghana. Another limitation is that since part of the survey was online, any clarification on the survey that was needed by the respondent or misunderstanding about the survey that the respondent had could not be explained or corrected unlike in the face-to-face interviews. Again, the study leaned too much towards the 18 to 24 year-old age group. Future research can contemplate sample weighting methods to fix the age issue. Lastly, respondents have not had an AV experience before, therefore most of their responses were based on how they think they will feel if they experienced riding in an AV rather than what they have already experienced. Analysis was based mainly on the socio-demographic characteristics of respondents. Respondents' travel patterns and purposes, and neighbourhood characteristics are important factors that may influence their decisions. We therefore recommend future studies to consider these factors to gain more insight into the issue. Further, this study adopted mainly descriptive statistics and inferential statistics in the form of chi-square test to gain understanding of the perceptions of the Ghanaian public about AVs. Such approaches do not reveal the joint impact of socio-demographic characteristics on AVs interests and concerns. Chi-square test, for example, cannot provide any inferences about causation. Analysis methods such as structural equation modelling that explains the complex interactions of influencing factors are recommended for future studies.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abraham, H., Lee, C., Brady, S., Fitzgerald, C., Mehler, B., Reimer, B., Coughlin, J.F., 2017. Autonomous vehicles and alternatives to driving: trust, preferences, and effects of age. In Proceedings of the transportation research board 96th annual meeting (TRB'17).

Anania, E.C., Rice, S., Walters, N.W., Pierce, M., Winter, S.R., Milner, M.N., 2018. The effects of positive and negative information on consumers' willingness to ride in a driverless vehicle. Transp. Policy 72, 218–224.

Anderson, James M., NidhiKalra, Karlyn D. Stanley, Paul Sorensen, Constantine Samaras, and Tobi A. Oluwatola. (2016). Autonomous Vehicle Technology: A Guide for Policymakers, Santa Monica, Calif.: RAND Corporation, RR-443-2-RC. Available at: https://www.rand.org/pubs/research_reports/RR443-2.html.

Azizi Soldouz, S., Hasnine, M.S., Sukhai, M., Nurul Habib, K., 2020. Looking through the perceptions of blinds: potential impacts of connected autonomous vehicles on pedestrians with visual impairment. Transp. Res. Rec. 2674 (5), 183–195.

Baha, H., 2016. An Introduction of Descriptive Analysis, its advantages and disadvantages. Master of Public Policy and Good Governance Research Methods in Comparative Politics.
Bahamonde-Birke, F.J., Kickhöfer, B., Heinrichs, D., Kuhnimhof, T., 2018. A systemic view on autonomous vehicles: Policy aspects for a sustainable transportation planning. disP-The Plann. Rev. 54 (3), 12–25.
Bansal, P., Kockelman, K.M., Singh, A., 2016. Assessing public opinions of and interest in new vehicle technologies: An Austin perspective. Transportat. Res. Part C: Emerg. Technol. 67, 1–14.
BOSCH, 2021. Lack of understanding about automated driving is keeping Brits in the slow lane. Accessed 20/05/2021. https://www.bosch.co.uk/news-and-stories/stories/lack-of-understanding-about-automated-driving-is-keeping-brits-in-the-slow-lane/.
CAAT. Connected and Automated Vehicles. http://autocaat.org/Technologies/Automated_and_Connected_Vehicles/. Accessed 20/05/2021.
Das, S., Dutta, A., Fitzpatrick, K., 2020. Technological perception on autonomous vehicles: perspectives of the non-motorists. Technol. Anal. Strat. Manage. 32 (11), 1335–1352.
Davis, F.D., Bagozzi, R.P., Warshaw, P.R., 1989. User acceptance of computer technology: a comparison of two theoretical models. Manag. Sci. 35 (8), 982–1003. https://doi.org/10.1287/mnsc.35.8.982.
Department of Motor Vehicles, California. "Autonomous Vehicles". Retrieved from https://www.dmv.ca.gov/portal/vehicle-industry-services/autonomous-vehicles/autonomous-vehicle-definitions/[Accessed 19th June 2020].
Dudovskiy, J., 2016. The Ultimate Guide to Writing a Dissertation in Business Studies. A Step-by-Step Assistance.
Errampalli, Madhu, Senathipathi, Velmurugan, Thamban, Deepa, 2015. Effect of Congestion on Fuel Cost and Travel Time Cost on Multi-Lane Highways in India. Int. J. Traffic Transp. Eng. 5 (4), 458–472. https://doi.org/10.7708/2217-544X10.7708/ijtte.2015.5(4).10.
Fagnant, D.J., Kockelman, K., 2015. Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. Transport. Res. Part A: Policy Pract. 77, 167–181.
Freemark, Y., Hudson, A., Zhao, J. (2019). Are cities prepared for autonomous vehicles? Planning for technological change by US local governments. J. Am. Plann. Assoc.
Frisoni, R., Dall'Oglio, A., Nelson, C., Long, J., Vollath, C., Ranghetti, D. &McMinimy, S. (2016) Self-Piloted Cars: the future of road transport? Steer Davies Gleave&European Parliament, Committee on Transport and Tourism. Available at: http://www.europarl.europa.eu/RegData/etudes/STUD/2016/573434/IPOL_STU(2016)57343 4_EN.pdf.
Ghana Statistical Service. (2013). 2010 Population & Housing Census Report: Children, Adolescents & Young People in Ghana.
Gkartzonikas, Christos, Gkritza, Konstantina, 2019. What have we learned? A review of stated preference and choice studies on autonomous vehicles. Transport. Res. Part C: Emerg. Technol. 98, 323–337.
Global Energy Review. (2020). IEA, Paris https://www.iea.org/reports/global-energy-review-2020.
Global status report on road safety. (2018). Geneva: World Health Organization; 2018. Licence: CC BYNC-SA 3.0 IGO.
Godsmark, P. The Definitive Guide to the Levels of Automation in Driverless Cars. (2017). Available online: https://driverless.wonderhowto.com/news/definitive-guide-levels-automation-for-driverless-cars-0176009/.
Graphic Online. "Road crashes: 2,284 fatalities recorded in 2019 – MTTD". (January 17, 2020). Retrieved from https://www.graphic.com.gh/news/general-news/road-crashes-2-284-fatalities-recorded-in-2019-mttd.html.
Haboucha, Chana J., Ishaq, Robert, Shiftan, Yoram, 2017. User preferences regarding autonomous vehicles. Transport. Res. Part C: Emerg. Technol. 78, 37–49.
Häuslschmid, R., von Buelow, M., Pfleging, B., Butz, A., 2017. March). Supporting Trust in autonomous driving. In: In *Proceedings of the 22nd international conference on intelligent user interfaces*, pp. 319–329.
Hilgarter, Kathrin, Granig, Peter, 2020. Public perception of autonomous vehicles: a qualitative study based on interviews after riding an autonomous shuttle. Transport. Res. Part F: Traffic Psychol. Behav. 72, 226–243.
Howard, D., & Dai, D. (2014). Public perceptions of self-driving cars: The case of Berkeley, California. In Transportation research board 93rd annual meeting (Vol. 14, No. 4502, pp. 1-16).
Hulse, Lynn M., Xie, Hui, Galea, Edwin R., 2018. Perceptions of autonomous vehicles: Relationships with road users, risk, gender and age. Saf. Sci. 102, 1–13.
Hwang, J., Li, W., Stough, L.M., Lee, C., Turnbull, K., 2020. People with disabilities' perceptions of autonomous vehicles as a viable transportation option to improve mobility: An exploratory study using mixed methods. Int. J. Sustain. Transport. 1–19.
Igliński, H., Babiak, M., 2017. Analysis of the potential of autonomous vehicles in reducing the emissions of greenhouse gases in road transport. Procedia Eng. 192, 353–358. https://doi.org/10.1016/j.proeng.2017.06.061.
Ipsos MORI. (2014) Only 18 per cent of Britons believe driverless cars to be an important development for the car industry to focus on. Ipsos MORI Loyalty Automotive Survey. Ipsos MORI. Available at: https://www.ipsos.com/ipsos-mori/en-uk/only-18-cent-britons-believe-driverless-cars-be-important-development-car-industry-focus.
Jardim, A. S., Quartulli, A. M., & Casley, S. V. (2013). A Study of Public Acceptance of Autonomous Cars. Worcester Polytechnic Institute: Worcester, MA, USA.
Kim, Moon-Koo, Park, Jong-Hyun, Oh, Jeesun, Lee, Won-Seop, Chung, Dongjae, 2019. Identifying and prioritizing the benefits and concerns of connected and autonomous vehicles: A comparison of individual and expert perceptions. Res. Transport. Busin. Manage. 32, 100438. https://doi.org/10.1016/j.rtbm.2020.100438.
King, Mark J., Soole, David, Ghafourian, Ameneh, 2009. Illegal pedestrian crossing at signalised intersections: incidence and relative risk. Accid. Anal. Prev. 41 (3), 485–490.
KPMG (2013). Self-Driving Cars: Are We Ready https://assets.kpmg/content/dam/kpmg/pdf/2013/10/self-driving-cars-are-weready.pdf.
KPMG (2020). Mobility 2030 ICE in Africa. 3–5. Retrieved from https://assets.kpmg/content/dam/kpmg/za/pdf/pdf2020/mobility-2030-ice-in%20africa.pdf.
Krueger, Rico, Rashidi, Taha H., Rose, John M., 2016. Preferences for shared autonomous vehicles. Transport. Res. Part C: Emerg. Technol. 69, 343–355.
Kyriakidis, M., Happee, R., de Winter, J.C.F., 2015. Public opinion on automated driving: Results of an international questionnaire among 5000 respondents. Transport. Res. Part F: Traff. Psychol. Behav. 32, 127–140.
Lee, J.D., See, K.A., 2004. Trust in automation: Designing for appropriate reliance. Hum. Factors 46 (1), 50–80.
Maddox, John. (2012). Improving Driving Safety Through Automation, presentation at the Congressional Robotics Caucus, National Highway Traffic Safety Administration, July 25.
Mezei, János Imre, Lázanyi, Kornélia, 2018. Are we ready for smart transport? Analysis of attitude towards public transport in Budapest. Interdisciplinary Description of Complex Systems: INDECS 16 (3), 369–375.
Moody, Joanna, Bailey, Nathaniel, Zhao, Jinhua, 2020. Public perceptions of autonomous vehicle safety: An international comparison. Saf. Sci. 121, 634–650.
Nastjuk, Ilja, Herrenkind, Bernd, Marrone, Mauricio, Brendel, Alfred Benedikt, Kolbe, Lutz M., 2020. What drives the acceptance of autonomous driving? An investigation of acceptance factors from an end-user's perspective. Technol. Forecast. Soc. Chang. 161, 120319. https://doi.org/10.1016/j.techfore.2020.120319.
Payre, William, Cestac, Julien, Delhomme, Patricia, 2014. Intention to use a fully automated car: Attitudes and a priori acceptability. Transport. Res. Part F: Traffic Psychol. Behav. 27, 252–263.
Penmetsa, Praveena, Adanu, Emmanuel Kofi, Wood, Dustin, Wang, Teng, Jones, Steven L., 2019. Perceptions and expectations of autonomous vehicles–A snapshot of vulnerable road user opinion. Technol. Forecast. Soc. Chang. 143, 9–13.
Pettersson, I., Karlsson, I.C.M.A., 2015. Setting the stage for autonomous cars: a pilot study of future autonomous driving experiences. IET Intel. Transport Syst. 9 (7), 694–701.
E. Portouli, G. Karaseitanidis, P. Lytrivis, A. Amditis, O. Raptis and C. Karaberi. (2017). "Public attitudes towards autonomous mini buses operating in real conditions in a Hellenic city," 2017 IEEE Intelligent Vehicles Symposium (IV), Los Angeles, CA, pp. 571-576, doi: 10.1109/IVS.2017.7995779.
Pyrialakou, V.D., Gkartzonikas, C., Gatlin, J.D., Gkritza, K., 2020. Perceptions of safety on a shared road: Driving, cycling, or walking near an autonomous vehicle. J. Saf. Res. 72, 249–258.
Schoettle, B.; Sivak, M. (2014). A Survey of Public Opinion about Autonomous and Self-Driving Vehicles in the US, the UK, and Australia. Available at: https://deepblue.lib.umich.edu/bitstream/handle/2027.42/108384/103024.pdf?sequence=1&isAllowed=y.
Schoettle, B. & Sivak, M. (2015). Motorists' Preferences for Different Levels of Vehicle Automation. University of Michigan, Transportation Research Institute. Available at: https://deepblue.lib.umich.edu/bitstream/handle/2027.42/114386/103217.pdf?sequence=1&is Allowed=y.
Sun, Xu, Li, Jingpeng, Tang, Pinyan, Zhou, Siyuan, Peng, Xiangjun, Li, Hao Nan, Wang, Qingfeng, 2020. Exploring personalised autonomous vehicles to influence user trust. Cogn. Comput. 12 (6), 1170–1186.
Taiebat, Morteza, Stolper, Samuel, Xu, Ming, 2019. Forecasting the impact of connected and automated vehicles on energy use: a microeconomic study of induced travel and energy rebound. Appl. Energy 247, 297–308.
Trochim, W.M.K. Research Methods Knowledge Base. (2020). Retrieved from: https://conjointly.com/kb/descriptive-statistics/.
United Nations Environment Programme. (2019). Emissions Gap Report 2019. UNEP, Nairobi.
VDA-Magazine (2015), "From Driver Assistance Systems to Automated Driving". VDA magazine – Automation.
Woodrow, L., 2014. Presenting Descriptive. Statistics. 5 (1), 49–60.
World Economic Forum (2021). Look no hands: self-driving vehicles' public trust problem. https://www.weforum.org/agenda/2019/08/self-driving-vehicles-public-trust/ Accessed 20/05/2021.
World Health Organization (2018). Global status report on road safety 2018: summary (No. WHO/NMH/NVI/18.20). World Health Organization.
Wu, Jingwen, Liao, Hua, Wang, Jin-Wei, Chen, Tianqi, 2019. The role of environmental concern in the public acceptance of autonomous electric vehicles: A survey from China. Transport. Res. Part F: Traffic Psychol. Behav. 60, 37–46.