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Autonomous Vehicles Down Under: An Empirical Investigation of Consumer Sentiment

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Abstract

Of the many issues surrounding the potential introduction of Autonomous Vehicles (AVs), consumer response remains unclear. The current paper presents an empirical investigation of consumer sentiment towards AVs based on an online survey of 455 Australian adults. Market segmentation procedures are used to cluster participants according to their attitudes and concerns towards AVs with clusters then profiled according to demographics, personality traits and contextual/situational factors. Results suggest unsurprisingly that attitudes and concerns are a useful predictor of the likelihood of purchasing an AV. More favourable attitudes towards AVs are associated with younger, male respondents, those who drive less currently and those more open to sharing their car. More negative attitudes prevail with older, female respondents, those who drive more, and those less open to sharing their car. Results have important implications for policy-makers and researchers alike.

1. Introduction

The first significant on-road autonomous vehicle (AV)[1] testing in Australia began in Sydney in March, 2018 following various pilot tests and trials around the country[2]. This event was significant both in terms of the timing (just after the first pedestrian/AV fatality in Arizona) and the fact that Australia has been a relative laggard in the AV space with a generally-held view that consumers are sceptical and not yet ready to embrace this technology (KPMG 2018). However, recent evidence from Sydney (large city) and Perth (small city) suggests this scepticism may not be homogeneous, with around one-third of consumers indicating they would be somewhat or very likely to purchase a fully driverless vehicle if available in 2025 (forthcoming in Smith *et al.* 2018). This raises questions about who is likely to embrace or reject AVs, as well as the extent to which personal, situational/contextual characteristics and existing travel patterns and constraints might influence consumer attitudes and stated intentions towards purchasing AVs.

Within this context, the current paper presents an empirical investigation of consumer sentiment towards AVs in Australia. The paper begins with a literature review covering

[1] Australia, through the Australian National Transport Commission (NTC 2016) adopts Society of Automotive Engineers International Standard J3016 (SAE 2018) that defines six levels of automated driving (levels 0–5). Most people's understanding of the term autonomous vehicle would probably refer to the highest level in both definitions, which means vehicles can make end-to-end trips independently. Nevertheless, there are also partial AVs, which can perform autonomous driving under certain circumstances.

[2] https://www.itnews.com.au/news/autonomous-cars-to-be-trialled-across-sydneys-busiest-roads-487392

consumer sentiment towards AVs and some of the main personal and contextual factors underlying this sentiment. We then present an overview of the data used and the analytical approach. Using an online sample of 455 adults drawn from Sydney and Perth, we use market segmentation procedures to categorise/cluster participants according to their attitudes and concerns towards AVs. We then profile these clusters on key dimensions including their willingness to purchase an AV, demographics and contextual factors (city size, existing travel patterns and constraints). Results and discussion follow, before drawing conclusions as to the wider significance of the findings.

2. Literature Review

The focus of this literature review is on: i) evidence-to-date on general consumer sentiments towards AVs, drawing both from Australian and overseas evidence; and ii) demographic, situational and contextual factors, which have been reported to influence these sentiments.

2.1 Consumer Sentiments Around AVs

As of 2016 we are starting to see various trials of driverless technology including ride-share services in Singapore (Grab) and the U.S. (Uber) and shuttle buses operating under restricted conditions in France, Switzerland, Germany and the Netherlands (Nordhoff *et al*. 2018). However, consumer sentiment remains mixed given the uncertainties surrounding the technology (Daziano *et al*. 2017) although we might anticipate views to converge more as respondents have more physical experiences with the technology (Nordhoff *et al.* 2018). A recent study of 5,000 participants from 109 nations, found that one-third of participants do not believe that fully-automated vehicles will reach 50% market share before 2050 (Kyriakidis *et al*. 2015). Evidence also suggests significant differences across countries. For instance, in a comparison of Australia, the UK, and the US, (Schoettle & Sivak 2014a) found that Americans were generally less positive (57%) than their Australian (64%) and UK (67%) counterparts. A study by the same authors reports those from China and India appear more positive towards AVs, with a higher willingness to pay (WTP) for the addition of AV technology to their personal vehicle while those from Japan were not as enthusiastic, with a lower WTP (Schoettle & Sivak 2014b). Location within countries may also have an effect on AV acceptance, with urban areas tending to show greater acceptance than rural areas (Deb *et al*. 2017; König & Neumayr 2017).

The wide variability in public opinion is also reflected in the WTP, with studies showing that some are prepared to pay more than US$30,000 for the addition of driverless capability (Kyriakidis *et al.* 2015), while many are unwilling to pay anything, even after expressing interest in driverless capabilities (König & Neumayr 2017; Kyriakidis *et al*. 2015; Schoettle & Sivak 2014a). The disconnect between interest and WTP can be seen in one study that saw a drop in interest from 37% to 20% upon learning that the technology would cost US$3,000 (JD Power and Associates 2012). WTP differs depending on the level of automation being considered, with WTP for Level 4 driving capability found to be more than double WTP for Level 3 capability (Bansal *et al.* 2016). This suggests that greater levels of automation are more desirable, however, studies also show that many people are concerned about the reliability of fully autonomous driving, with a strong desire for drivers to have the ability to take control of the vehicle when wanted (König & Neumayr 2017; Schoettle & Sivak 2014a).

Much has been documented around perceptions of the main benefits and concerns associated with AVs (Sun *et al.* 2017). In their cross-national study that included Australia, Schoettle & Sivak (2014a) cite a number of benefits including: reduced crashes and reduced severity of

crashes (85% of Australian's believe somewhat or very likely); less traffic congestion (71%); shorter travel times (68%); lower vehicle emissions (70%); better fuel economy (74%); and lower insurance rates (66%). In terms of concerns, overreliance on the technology was the major concern (74% of Australians were moderately or very concerned) with other prominent issues around safety (71%); liability (68%) system security (66%); privacy (66%) and increased distractions for drivers (66%).

Concerns have also been raised around the loss of personal autonomy and deskilling of the driver as AVs may consign the driver to "being moved" rather than "moving" (König & Neumayr 2017). Without regular driving practice, passengers will lose the knowledge and skills to navigate (McBride 2016), resulting in a population unable to take control of a vehicle, even in an emergency situation (Douma & Palodichuk 2012). This leads to issues around trust, as the task of driving is ceded to an automaton (König & Neumayr 2017). People using vehicles tend to feel safer with human drivers than AVs (Hulse *et al*. 2018), with most preferring their children to travel in traditional buses over AV buses (Anania *et al.* 2018). Even among those who are happy to ride in a Level 4 AV, more than two in five would spend their time "watching the road", indicating a somewhat provisional level of trust in the system (Schoettle & Sivak 2014a). Despite the potential for vehicles to prioritise occupant safety over non-occupant safety, it seems that pedestrians currently 'trust' AVs more than human-driven vehicles, while passengers see AVs as riskier (Hulse *et al*. 2018). While a healthy level of scepticism can be beneficial if it ensures that a passenger in an AV pays attention and can take control of the vehicle when necessary, a lack of trust may also lead to poor market adoption of AVs and a failure to realise the many potential benefits of AVs (König & Neumayr 2017). Public trust may be fragile, with even minimal (and perhaps unavoidable) failures potentially fostering mistrust (König & Neumayr 2017). Given the likely safety and other benefits of AVs, any delay in the adoption of AVs may be costly in terms of human lives (Kalra & Groves 2017).

2.2 Demographic and Situational Factors

Evidence suggests younger people have a greater intention to use AVs (Hohenberger *et al.* 2016; Hulse *et al.* 2018; König & Neumayr 2017; Payre *et al*. 2014; Schoettle & Sivak 2014a). In terms of gender, males seem generally more positive regarding AV technology (König & Neumayr 2017; Payre *et al.* 2014; Schoettle & Sivak 2014a). It has been suggested that this difference is related to a greater perception of risk felt by females to AV use (Hulse *et al*. 2018; Schoettle & Sivak 2014a) and a greater response to that risk (Anania *et al*. 2018). Interestingly, this gender difference was reversed in India, with females quite positive about AV technology to the extent where they preferred their children to be driven by an AV bus rather than a human-driven bus (Anania *et al.* 2018). Some suggest that technology acceptance may play a role in observed gender differences, with males more positive about AVs on a number of measures compared to females (Deb *et al*. 2017). It has also been suggested that males anticipate a greater level of pleasure rather than anxiety about the use of AVs (Hohenberger *et al*. 2016).

Technology acceptance seems to play a role independently of gender, with people who currently use other automated driving features such as Adaptive Cruise Control more willing to use and pay for automated vehicles (König & Neumayr 2017; Kyriakidis *et al.* 2015). At the other end of the spectrum, those without a car at all have been found to have a positive attitude towards AVs and a greater willingness to pay than most (König & Neumayr 2017). However, this is likely due to the clear utility benefits offered by AVs for those without a car or licence, rather than an indication of technology acceptance.

Varying results have been found for regular car users, with some results suggesting they are less open to AVs (König & Neumayr 2017) and others suggesting that WTP was directly correlated with mileage and driving frequency (Kyriakidis *et al.* 2015). This contradiction may be explained by looking more closely at the type of driving done by regular drivers.

Interestingly, current attitudes towards AVs have not been found to be affected by status and social recognition (Hulse *et al.* 2018; König & Neumayr 2017). However, Madigan *et al.* (2016) identified a significant positive association between social influence (norms) and behavioural intention to use AVs, comparing two trials, La Rochelle (France) and Lausanne (Switzerland). Some have also proposed that AVs pose a threat to existing identities and power structures, particularly in societies where cars signal wealth, role in society and reputation (McBride 2016). While those currently without access to a motor vehicle will gain a greater sense of independence and ability through AVs (McBride 2016), for those who see their car as an extension of their persona, conversion to the use of an AV may result in a *"fracturing of the person's identity which leaves them suspended in fear and uncertainty"* (McBride 2016: 183).

The pace of technological change and the potential disruption that the introduction of AVs could bring to future mobility necessitates deep understanding of consumer sentiment. Few empirical investigations have been conducted on this topic within Australia which, while a highly advanced society, has been slow to embrace technological innovation, particularly within the automotive fleet.

3. Data and Methods

A sample of 455 participants from Sydney and Perth, drawn from a larger study of consumer behaviour known as the 'Values Project' (over 7,500 participants), were recruited for this analysis in mid-2017[3]. The Values Project involves a series of short online surveys that capture age, gender, and people's guiding principles to life, which are metricised into various universal components (e.g., benevolence, hedonism, stimulation, achievement and power). We were able to recruit a sub-sample of these people to participate in our survey focused on car-sharing and driverless vehicles. This survey included three sections: a) information about participants' current vehicles, their typical commute, and any after-work constraints; b) perceived benefits and deterrents towards car-sharing; c) general attitudes and concerns towards AVs and their likelihood of purchasing an AV (if available in 2025). Participants were told to assume these were fully driverless cars which, other than indicating the destination, they would have no control over at any time during the trip (equivalent to Level 5 SAE in standard AV parlance). Participants also completed eight stated choice experiments focused around car-sharing and driverless vehicles, the results of which are reported elsewhere (Smith *et al*. 2018).

Exploratory factor analysis (alpha factoring extraction) was applied to ascertain to what extent the items reflect two distinct attitudes towards the benefits and limitations/concerns around AVs. Participants were then clustered based on their attitudes and concerns towards AVs (SPSS). Ten Likert-type variables were included in a two-stage clustering technique, using Euclidean distance on standardised data. The hierarchical, exploratory stage (using an agglomerative method and comparing various algorithms – single linkage, centroid, Ward) provided a comprehensive portrayal of the potential solutions and led to the decision on three clusters as most appropriate. The seeds obtained in the hierarchical stage were used as centroids

[3] See http://www.thevaluesproject.com/about/ for details of the Values project.

in k-means clustering (Hair *et al.*, 2014). MANOVA was used to identify those attributes of most significance in explaining the variation in key features across the groups.

4. Results

4.1 Sample Statistics

The sample included 55.3% males with an average age around 45 (sd=11.87, median=40), close to the median adult age (participants were 18+) at the last census (47 years as per ABS 2016, http://www.abs.gov.au/ausstats/abs@.nsf/mf/3235.0). One in five respondents (or 21.5%) reported constraints in their activities after work, and similarly one in five (20.1%) pay for parking at work. Almost half (44.7%) had a tertiary education level, 66% commuted by car with an average commute duration of 28 minutes. Only 15% declared they did not know about AVs and 39.2% were positive about AVs, with 34% expressing their willingness to purchase an AV if available by 2025.

4.2 Attitudes Towards AVs

Figure 1 provides a summary of the expectation of benefits of AVs. Approximately 40% of respondents indicated a level of uncertainty that the benefits usually attributed to AVs would be realised. The highest level of uncertainty was around whether AVs would lead to lower vehicle ownership (43% unsure). While there was general consistency in frequencies for each item, respondents were less optimistic about AVs contributing to lower congestion and faster travel, each having about 30% respondents indicating some level of disagreement. Overall, 40% of respondents reflected a positive outlook on the benefits of AVs and 20% were somewhat reserved on the benefits.

Figure 1: Respondents' expectation on the benefits of (attitudes towards) AVs

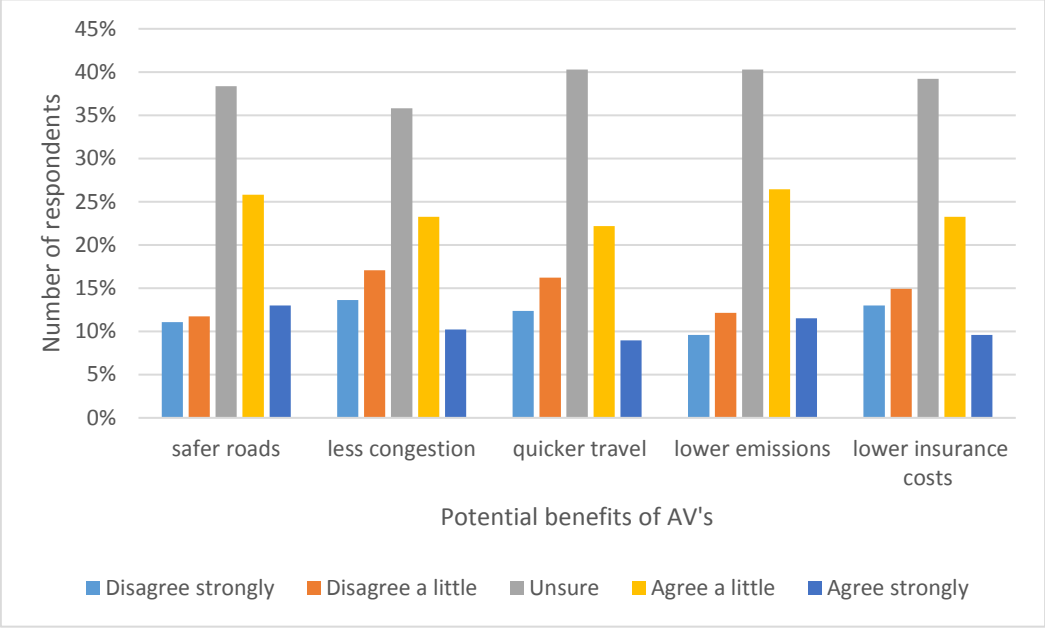
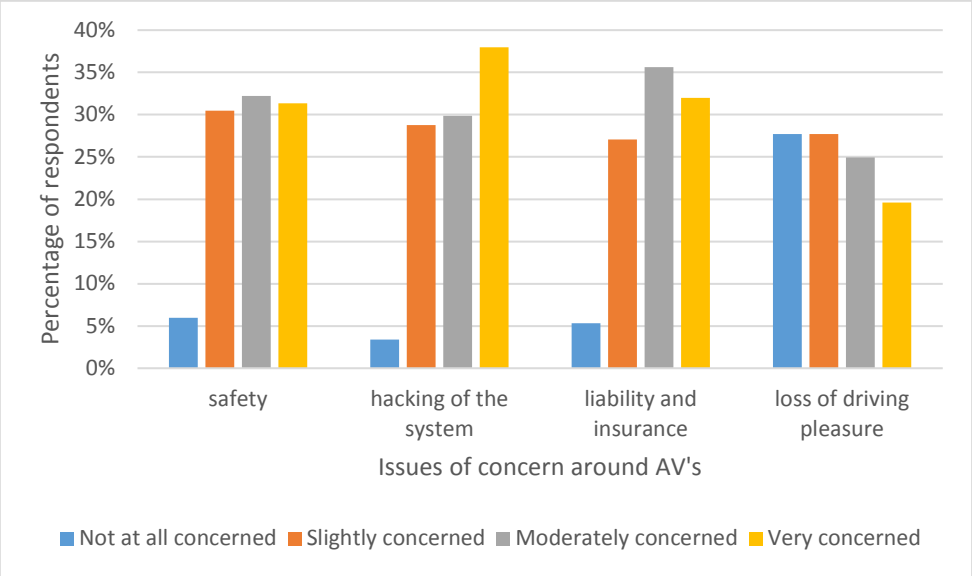


Figure 2 summarises levels of concern over the potential negative effects of AVs. Hacking the system is at the top of their list, with around two in five respondents indicating that they were very concerned. On balance, respondents are worried about insurance and liability (64% being

at least moderately concerned) and road safety (68%). Loss of pleasure from driving was of no concern at all to around 30% of participants, but at the same time of high concern to 20% of participants.

Figure 2: Respondents' concerns on the potential negative effects of AVs



4.3 Factor Analysis Results

The results of the exploratory factor analysis showed two uni-dimensional factors: 'Attitudes towards benefits of AVs' (explaining 67.2% of the variance in the six items and with Cronbach alpha of 0.902) and 'Concerns about AVs' (explaining 62.2% of the variance in the four items and displaying a Cronbach's alpha of 0.780). With one exception (loss of pleasure from driving), all indicators had loadings over 0.6 (Table 1), with the strongest items related to relieving congestion and lowering insurance costs. The goodness-of-fit measures suggest valid constructs (face, convergent, discriminant – correlation between constructs = - 0.37), significantly correlated to the stated willingness to purchase an AV if available in 2025 (0.58 and - 0.38, respectively, as shown in Section 4.4). Factor scores were computed for further analysis (comparison across clusters).

Table 1: Attitudes towards AVs (Factor Loadings)

Benefits			Concerns	
less congestion	0.851		liability and insurance	0.849
quicker travel	0.832		hacking of the system	0.740
lower insurance costs	0.820		safety	0.738
safer roads	0.777		loss of pleasure from driving	0.478
lower emissions	0.762			
lower vehicle ownership	0.621			

4.4 Clustering Results

Participants were clustered into three groups, which we termed 'AV Optimists' (32%), 'AV Fence-sitters' (41%), and 'AV Sceptics' (27%). All multivariate tests (Pillai's trace, Wilks'

lambda, Hotelling's trace, and Roy's largest root) indicated significant differences across the groups ($p < 0.001$). Table 2 presents a summary of the MANOVA analysis profiling the clusters based on their overall attitudes towards AV (both individual items and their summarised factor scores), their demographic characteristics, current car use and stated intention to participate in a car-sharing scheme. AV Optimists are more likely to be male, willing to allow their vehicle to be used by others and drive to work less than the other groups. The AV sceptics are more likely to be female and older and commute by car more regularly. The AV Fence-sitters constitute the largest cluster and are dominated by female representation although they are of a similar age to the AV Optimists.

Table 2: Opinions on Fully Autonomous Vehicles and a Profile of Three Clusters of Australian Citizens

Cluster Details	AV Optimists	AV Fence-sitters	AV Sceptics	p-value
Cluster Size	148	187	123	
General opinion AVs (5 = Very positive, 1 = Very negative)	**4.08**	3.20	2.06	<0.001
Attitudes towards benefits of AVs (factor score)	**3.85**	3.16	2.06	<0.001
• safer roads	**4.03**	3.24	2.04	<0.001
• less congestion	**3.75**	3.05	1.98	<0.001
• quicker travel	**3.72**	3.06	1.99	<0.001
• lower emissions	**3.79**	3.30	2.27	<0.001
• lower insurance costs	**3.81**	3.06	1.98	<0.001
• lower vehicle ownership	**3.69**	3.15	2.42	<0.001
Concerns about AVs (factor score)	3.02	3.13	**4.36**	<0.001
• safety	3.17	3.32	**4.57**	<0.001
• hacking of the system	3.64	3.44	**4.46**	<0.001
• liability and insurance	3.35	3.35	**4.59**	<0.001
• loss of pleasure from driving	2.46	2.89	**3.65**	<0.001
Likelihood of Purchasing an AV in 2025	**4.22**	2.71	1.57	<0.001
Profile				
Gender (% male)	58%	35%	42%	<0.001
Age	44.22	42.74	**49.16**	<0.001
Car Use				
Allow vehicle to be part of peer-to-peer sharing	**2.72**	2.36	1.83	<0.001
No. of days drive to work	2.7	2.8	**3.3**	0.025
Used an App-based ride share service in the past 12 months	**58%**	49%	33%	0.008
Commuting time (min)	**34.07**	25.25	26.63	0.001

Note: In boldface font we present the highest values.

5. Discussion

The gender and age characteristics of the three identified groups confirm previous studies in Australia (and similar Western democracies), with favourable attitudes towards AVs associated with younger, male respondents and negative attitudes towards AVs associated with older, female respondents (König & Neumayr 2017). Evidently, those with less day-to-day car-dependence, proxied by the number of days they drive to work and willingness to share their vehicle, are more likely to embrace automation. The intention to purchase an AV is associated primarily with the respondent's attitudes towards the benefits of AVs. However, those more likely to purchase an AV in 2025 (i.e. AV Optimists, 4.22) held a similar level of concern about AVs (3.02) as those expressing a little more caution (i.e. AV Fence-Sitters, 3.13), but the level of concern held by the AV Sceptics is significantly higher (4.36). AV Sceptics were highly concerned with safety (4.57), interference by hackers of the system (4.46) and liability and insurance (4.59). There is an association between willingness to share the current vehicle and the level of AV optimism (p-value <0.01). In addition, AV Optimists were more likely to have used an App-based rideshare service in the past 12 months (p-value <0.01). This relationship could be associated with age, in that younger people are more likely to be open to the idea of sharing (Sun *et al*. 2017). From a travel behaviour perspective, the AV Sceptics were more likely to use their car for commuting, but the AV Optimists had longer commutes.

These results have various implications for policy-makers seeking to promote a shift to AV use. First, there is evidently significant heterogeneity in the views and concerns around AVs across the population and this will likely be influenced further by exactly how the technology manifests itself over the coming decades. This in turn could be further complicated by fundamental questions around whether AVs will be associated with a large-scale shift in current vehicle ownership and sharing models. Currently, the Australian consumer has views shaped largely by the popular media reporting on overseas experiences and a few low-profile trials in Australia and it is fair to say the majority are unsure or sceptical, something that is borne out by the results of our survey. Second, the strong relationship between attitudes towards the benefits of AVs and likelihood to purchase (despite higher levels of concern), suggests that it is critical to highlight both the benefits of AVs, as well as focus on alleviating concerns, which has come under particular scrutiny after the Arizona fatality in March 2018.

6. Conclusions

Of the many issues surrounding the potential introduction of Autonomous Vehicles, consumer response remains unclear. Presented here is an empirical investigation of consumer sentiment towards AVs based on an online survey of 455 Australian adults. Results suggest that attitudes and concerns may be a useful predictor of the likelihood to purchase an AV. More favourable attitudes towards AVs are associated with younger, male respondents, those who drive less currently and those more open to sharing their car. More negative attitudes prevail with older, female respondents, those who drive more, and those less open to sharing their car.

As with any participant-based survey relying on self-report to a hypothetical situation, there are cautions over the strength of inference that should be drawn. We acknowledge the potential limitations of the source of participants here (the Values Project), which, while providing a convenient and low-cost means of sampling, could lead to inadvertent unrepresentativeness. However, we point to the fact that such online samples are being routinely used for travel-behaviour studies around the world and the results presented here do not seem out of line with expectation raised in the literature review. We also acknowledge the challenges of framing

hypothetical situations people have little/no experience with. It will be intriguing as people become more familiar with autonomous and driverless vehicles, if/how these attitudes and preferences adapt.

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