Attitudes and Perceived Usefulness of Autonomous Shuttles: an On Board Survey

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Abstract

The forthcoming integration of autonomy into social and economic systems is a priority area of research. While non-trial research exercises such as public confidence surveys, traffic simulations or policy reviews remain important, they fail to include the 'on the ground' learning. This paper presents user experience data collected from passengers whilst they were travelling on-board an AV shuttle travelling at low speeds on the UWA campus. The user responses indicated that approximately half the users thought the shuttle to novel but not a practical form of transport, leaving half that did indicate a willingness to adopt the service as part of their day to day travel.

1   Introduction

AV technology providers are investing in trials with the aim to demonstrate AV transport system benefits. Learnings are key for project development stakeholders, who must navigate a complex mix of common and local factors. Trial participant experience creates a common body of knowledge regarding institutional barriers, public perceptions and possible solutions. This paper sets out one such trial and reports on the user attitudes and stated choice responses collected from respondents during their travel experience.

Despite their relevance, non-trial research such as public confidence surveys, traffic simulations, or policy reviews fail to include the 'on the ground' aspects inherent in AV trials. Over the past seven years there has been an emergenet literature reporting perceptions and levels of awareness AV's as well as the potential to adopt new technologies (Gkartzonikasa and Gkritzab, 2019). Respondents and transport experts alike are asked about what impact will have on vehicle ownership (e.g., Choi and Ji, 2015), personal travel (e.g., Brown et al., 2014) or to make an assessment on the whole of system impact (e.g., Underwood et al., 2014). Substantial reviews by Becker and Axhausan (2017) and Gkartzonikasa and Gkritzab (2019) report a general willingness to accept technology and a willingness to pay a premium for improved safety. However, respondent samples were concerned about data privacy (Silberg et al. 2013), legal issues (Begg, 2014) insurance (Schoettle and Sivak, 2014) and cyber security (Greaves et al 2018). An overall unease about research based on non-trial questionnaires is that little work is directed at behavioural responses (i.e., attitudes towards the technology and barriers of adoption are the primary aim of the research)

or that models are based on hypothetical, futuristic and unexperienced contexts (e.g., Zmud et al., 2016).

A recent paper by Wicki, Guidon, Bekcker et al (2019) reports a stated mode choice study that is based on an actual AV shuttle trial in Neuhausen am Rheinfall, Switzerland. Whilst, the models is based on 761 respondents who were aware of the trial, the paper is not clear if any of these respondents had experienced the AV. The data-set collected at UWA is unique because the respondents were presented with tasks just before boarding the bus and complete a second set of taks whilst riding or alighting the service.

2 Autonomous shuttle trials in Australia and corresponding research output

Sun, Olaru, Smith *et al.* (2017) noted that AV trials were typically held within a state of healthy contest between states and territories governments and institutions located in their boundaries. At the time the Australian and New Zealand Driverless Vehicle Initiative (ADVI) was the peak body group that advocated and facilitated cooperation between government and industry. Whilst little has changed in terms of cross boarder competition, the commencement of the IMOVE CRC (a ten year collaborative research centre, 2017 -2027) has seen some shift in the coordinating body as both government and industry dollars have looked to leverage Australian Government grant dollars.

The trials broadly fall into one of two categories.

Some trials are initiated with the aim to develop and refine a piece of technology:

- In NSW the C-ITS trial fitted connected vehicle technology to alert drivers to potential hazards[1]. The Coffs Harbour trial vehicle initially operated as a scheduled service open to the public and is presently (July 2019) under trial at a retirement village where on demand services are operating (Bellingen Shire Courier Mail, 2018). At this stage there are no available reports on public perception or satisfaction.
- The CANDrive trial aimed to provide information about drivers ability to reengage a semi-automated vehicle when needed (https://www.business.act.gov.au/resources_and_networks/candrive-automated-vehicle-trial).

Other trials are based on fully developed technologies using commercially available vehicles. With the exception of the proposed RAC intellicar trail (rac.com.au/intellicar), these trials have used slow moving shuttles available from Local Motors, Navya or Easymile

- NSW Regional Shuttlebus Trial(s) will use two highly automated Easy Mile EZ10 with capacity to carry up to 12 passengers. https://www.transport.nsw.gov.au/projects/programs/smart-innovation-centre/regional-automated-vehicle-trials
- Shuttlebus and interactive transportable bus stop trial (South Australia) Local Motors has partnered with SAGE Automation to conduct a last mile driverless

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[1] Further details available at
https://roadsafety.transport.nsw.gov.au/research/roadsafetytechnology/cits/citi/index.html

shuttle and interactive transportable bus stop trial at Holdfast Bay near Glenelg. https://dpti.sa.gov.au/news?a=422018

In addition the Greenwich Gateway airport, UK, reports survey of perceptions revealed that, after interacting with the trial (on-board or observing the shuttle), people had a lowered sense of risk and a higher positive attitude towards the driverless shuttle (Hulse, Xie and Galea, 2018)

The UWA autonomous shuttle trial is performed using a fully developed commercially available vehicle from Easy Mile.

3 The autonomous vehicle trial on campus

In August 2018 the University of Western Australia (UWA) sponsored an autonomous bus trial on its Crawley Campus. Partnering with Easymile, France, the project trialled a 12 passenger EZ10 shuttle on the UWA public Open Day and subsequent week. Whilst the EZ10 driverless shuttle is able to follow multiple (pre-programmed) routes and operate in an on-demand environment (e.g., the Coffs Harbour trial) the UWA service operated under a scheduled service at slow speeds along a pedestrian route. The novelty for users was that the shuttle could navigate turns and respond to unexpected obstacles by coming to a stop.

The preparation of the trial (three weeks) was labour-intensive and required completion of diverse activities: site assessment and route evaluation, licensing application, operator training, routes mapping and testing, survey design, ethics approval and marketing.

Three routes were initially proposed, with one deemed infeasible during testing, given the traffic conditions, road geometry and dense vegetation (Pedestrian slow, in yellow) - 1.2km length and with the max commercial speed of 5km/h as demanded by the university campus. Remaining routes were used for small sample testing only.

4 Stated choice and hypothetical bias

Stated choice (SC) methods are used to investigate consumers' preferences by the way of a carefully-designed survey asking respondents to choose in several different situations with several factors (Louviere et al., 2000). They are regarded especially useful to assess people's opinion when a new product/service is launched or substantially modified (Petrik et al., 2016). Whilst the method may seem highly appropriate to understanding new technologies, respondents may display a high degree of 'hypothetical bias' based on tendencies to over- or underestimate their reactions to future events based on their perceptions or expectations (Kahneman and Thaler, 2006). A hypothetical bias represent the difference between a decision maker's stated intention and their actions in the market.

Figure1: 'Pedestrian Slow' and 'Ring Road 2' Routes for the AV Trial (Map data: Google, DigitalGlobe)
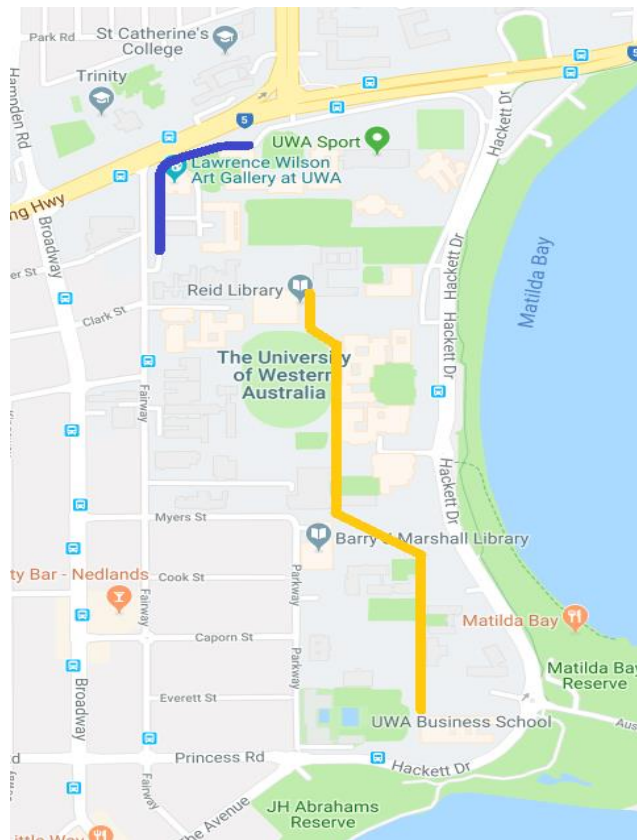
Estimating models of travel behaviour in a potentially new transport paradigm will remain problematic until real market alternatives become available. In the meantime collecting choice data from people who do have a chance to participate in trials and comparing results to choice studies delivered by pencil and paper or set in driving simulators is important. This paper adds to (or possibly starts) a small evidence base on how people think they may adapt to an autonomous future after experiencing the technology. It is expected that this evidence base will become broader over the next five to ten years.

4.1 Experimental design for on board choice tasks

The binary choice tasks considered two options (AV or walking along a campus route of up to 1.8km, Figure 2) and included three transport related attributes: a) waiting time; b) travel time; and c) cost. The attributes were presented in the context of a short trip (800m), a mid-way stop (1,200m), or an across campus journey (1,800m), with variant information regarding weather conditions ('heavy rain', 'patchy rain', 'hot', being above 35C and 'fine'). A 16-task D-efficient design using N-Gene software (Rose et al., 2014) was applied. The choice data analysed in this paper is limited to the 114 respondents who completed tasks just prior to boarding as well as completing tasks on board as well as the respondents who only completed tasks on board. Respondents who completed all eight tasks before boarding (i.e. did not follow instructions) were

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removed for the purposes of this study. The choice tasks for before and after samples are drawn from the same design (i.e. attribute levels and task descriptions are not altered).

Figure 2: Example Choice Task

The purpose of the design was to collect choice responses to on campus transport options whilst respondents were on board (or just after alighting) the driverless shuttle. As the attributes of the shuttle were being experienced it was deemed appropriate to limit the experimental attributes to travel cost and times under varying weather settings.

4.2 User experience data collection

Over 700 visitors expressed interest in riding the AV shuttle and 300 people participated, of which 243 completed a user survey. Attitudes and concerns were taken from the scales developed in Greaves et al. (2018). In the survey they were framed to respondents' opinions to autonomous vehicles in general rather than to driverless shuttles like the one operating at UWA. Also, an extended online survey elicited responses to a stated choice experiment, in which the 114 respondents (staff and students) responded to eight scenarios that they completed whilst riding the shuttle or with the option of four before boarding and four after alighting.

5 Results

The sample was dominated by females (56.4%) and students (67%), with 56.6% aged between 18 and 24 years and 23.5% were over 40 years of age. Over half of the respondents had a very positive ('thrilled') attitude towards AVs, with only 2.4% expressing a negative attitude.

The main perceived benefits referred to safer traffic and accessibility (Figure 3), with the subjects being less convinced that AVs will bring substantial travel time savings or reducing car ownership. 'Concerns' were also collected, with 'system tampering'

attracting significantly higher value compared to the other four potential issues (Figure 4).

A confirmatory factor analysis (Greaves et al., 2018) was undertaken and the factors 'attitudes' and 'concerns' achieved good reliability (Cronbach's $\alpha_{attitude}$=0.80 and $\alpha_{concern}$=0.81).

Although expected that the AV ride may shift attitudes and preferences, no significant differences were detected. The overall attitudes improved marginally (p=0.062) from an average of 3.51 (before) to 3.78 (after), but not the concerns. Data was pooled for analysis and factor scores entered the choice models as covariates.

Figure 3: Degree of agreement with statements regarding AV
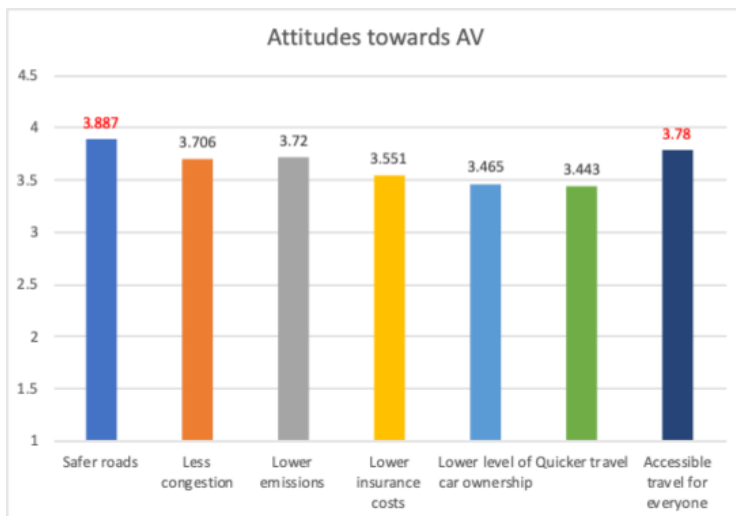
The main respondent concern expressed was about system tampering, with a significantly higher value compared to the other four potential issues.

Figure 4: Issues/concerns with the AV
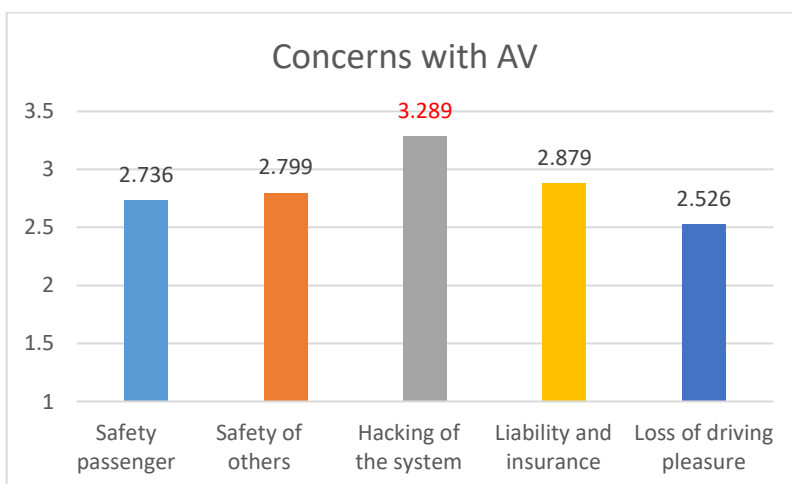
5.1 Choice Model Results

A number of different models were examined. The model presented (Table 1) is a 2-class latent class model (LCM). A dominant class was observed (38%-62% split), the main difference being that the smaller Class-1 viewed the AV shuttle as a way of saving time for getting across campus. Class 2 were less interested in riding the bus and only showed some interest when the weather was poor or the ride was free.

Table 1: LCM model results

Attribute	Class-1: "Time savers"		Class-2: "Comfort and low cost seekers"	
	Coefficient	P-Value	Coefficient	P-Value
Weather (Hot, Patchy rain) X ASC Bus	2.549	3.66	1.105	3.67
Weather (Heavy rain) X ASC Bus	4.304	2.97	1.943	4.95
'Concerns' X ASC Bus	-0.222	1.28	-0.069	0.90
AV shuttle fare $ (including free ride) Before *After*	-0.731 *-1.666*	1.21 *2.45*	-1.339 *-1.008*	3.66 *4.92*
Travel time (min) Before *After*	-0.365 *-0.379*	2.51 *3.58*	-0.025 *-0.020*	0.51 *0.51*
Class Probability Model				
Constant (Class-1)	4.863	2.26	-	
Likely to use an AV shuttle bus if available (5 point scale)	1.859	2.44	-	
Gender (Male)	1.558	1.81	-	
Class membership probability	*0.376*		*0.624*	
Model Fit Statistics				
LL-ASC Ct. only	402.64			
LL- Model	327.10			
McFadden's psuedo-r2	0.188			
AIC/N	1.112			

If we assume that the shuttle was permitted to travel at 7.5km/hour (25% higher than permitted on the trial) a cross-campus journey of 1.4km allows for approximately 5 minutes in travel time savings when compared to walking. This will the basis for fare calculations using the willingness to pay values estimated in by the choice model.

The major difference in the before and after willingness to pay is associated with the "time savers" who were relatively cost insensitive before riding the bus. The *before* willingness to pay is $25 per hour or a willingness to pay a $2.10 fare to save five minutes on a cross campus journey, but after WTP was $12 per hour ($1.00 fare). However, it should be noted that the dominate class showed a low willingness to pay to save time (time parameters for class two are not significantly different from zero) and tended to use the bus during unfavourable weather conditions and for free travel. But the reader is cautioned that these are latent classes estimated using panel data and therefore each individual's *posterior* willingness to pay is a probability estimate based on their sequences of choices (Train 2003). To this end the willingness to pay estimated on observations made by 40 of 114 individuals who completed the before and after data is at first $9.64 per hour (willing to pay 80c per trip) versus $6.57 per

hour (willing to pay a 50c fare) after completing the ride. We believe that the low speed restrictions (5km/hr) experienced by respondents contributed to the lower (after) WTP values.

6 Discussion and Conclusion

Scores for 'attitudes and 'concerns' showed enthusiasm for AVs within the sample and no substantial barriers, other than system hacking and cost. Attitudes did not change significantly after the ride, perhaps because the trial conditions limited the experience of their potential.

Several LCM models estimated (not shown) also revealed no association between 'attitudes', 'concerns' or age within classes. Self-selection bias could explain this, the survey capturing mainly participants who have positive views and a desire to experience AVs; with few elderly participants, a segment deemed most likely to embrace them. However, of those who chose to ride the shuttle there appeared to be a significant segmentation between those who found the shuttle to be novel and exciting but not practical for day to day travel and a second class who viewed the on an campus transport solution (as opposed to walking) to be viable.

Results raise three relevant questions: 1) what is the role of 'on the ground' experience/trial to promote the AV features; 2) how can we minimise sample bias (and gauge the views of those indifferent or opposing AVs and persuade them to trial them); and 3) are the parameters of the current trials (low-speed 'fun rides') sufficient to offer insights into future AV traffic conditions? Would the experience impact the design of stated choice scenarios including AV as a viable car option, given the gap between the reality of the AV trials and their potential?

7 References

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Appendix
Survey format for attitudes and concerns

The survey format and wording for data collection on attitudes (Figure A1) and concerns (Figure A2) are displayed below.

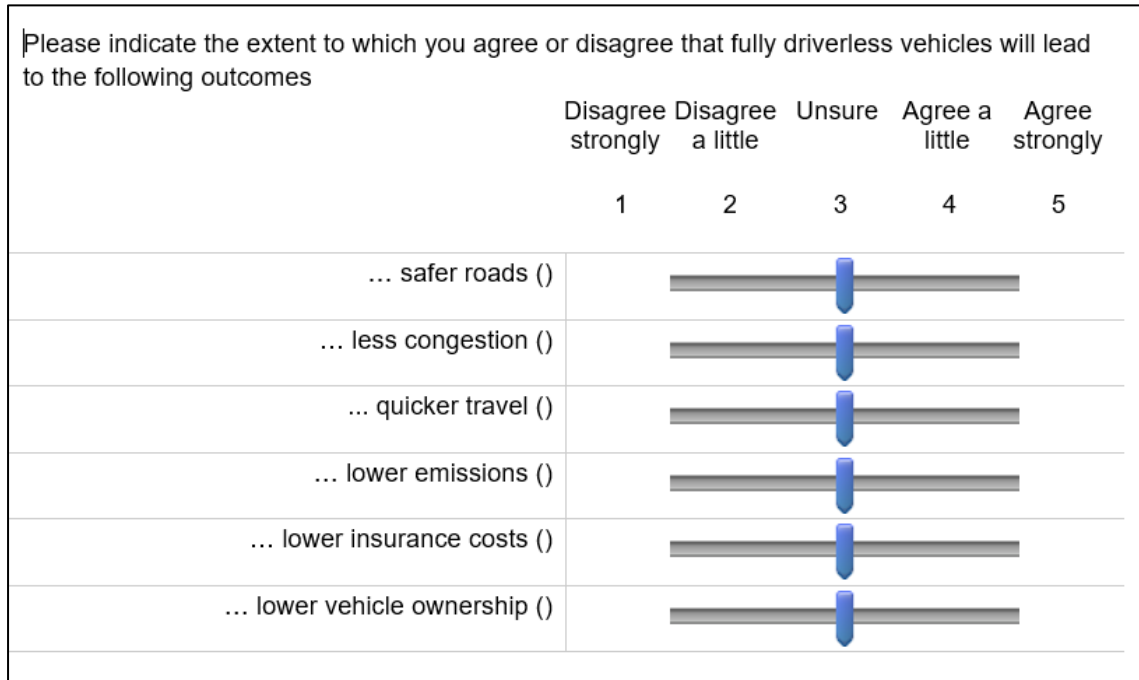**Figure A1: Survey question on attitudes towards driverless vehicles**

Figure A2: Survey question on driverless vehicles concerns