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Autonomous Vehicles and Ride-pooling: Insights from a qualitative study

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Abstract

Autonomous vehicles (AVs) promise to revolutionise our travel patterns in the near future. Novel AV models might emerge, such as AVs with ride-pooling services. Identifying the determinants for AVs' adoption among travellers is critical for multiple stakeholders such as car manufacturing companies and transport policymakers. However, relevant research on how travellers perceive AVs and the motives and barriers to AV adoption in Australia is still in its infancy. This study examines the beforementioned questions by conducting an exploratory online survey with open-ended questions and demographic characteristics. We analysed the responses from 275 undergraduates from the University of Western Australia (UWA). NVivo was used for the qualitative data and SPSS for the quantitative data. The results show positive attitudes towards both ride-pooling services and AVs. We further identified three primary motivations and five barriers to AV adoption. "Service quality" was found as the most important motivation and "safety" the largest barrier. In the end, this study discusses the findings and provides suggestions for relevant parties.

Key words: Autonomous vehicles, ride-pooling, qualitative study

1 Introduction

Car manufacturers and technology companies are developing autonomous vehicles (AVs). AVs have been proposed to reduce traffic accidents by avoiding human drivers' errors such as drunk driving and driving fatigue (Post, Veldstra and Ünal, 2021). AVs may also increase mobility for groups including seniors, children, and people with disability (Golbabaei *et al.*, 2020). In addition, AVs enable travellers, especially current drivers, to multitask while commuting (Litman, 2013). With the advent of AVs, it is crucial to identify people's motivations for and barriers to use, thus, facilitating the process of their launch on the market.

Quantitative studies have dominated the research into perceptions and acceptance of AVs, including technology acceptance models and stated choice surveys (Gkartzonikas & Gkritza, 2019; Golbabaei et al., 2020; Jing et al., 2020). The growing body of quantitative studies examined the public's attitudes towards AVs by focusing on predictors such as psychometric attributes and demographic characteristics. In order to assess consumers' behaviour more comprehensively, previous quantitative studies call for more qualitative techniques to identify the factors that might not have been explored yet (Milakis, Arem and Wee, 2017; Nordhoff, Kyriakidis, *et al.*, 2019). Some researchers conducted qualitative studies on AVs' acceptance in several forms, including interviews (Buckley, Kaye and Pradhan, 2018; Molnar *et al.*, 2018; Merfeld, Wilhelms and Henkel, 2019), small focus groups (Brinkley *et al.*, 2017; Robertson *et al.*, 2017; Dichabeng, Merat and Markkula, 2021; Etminani-Ghasrodashti *et al.*, 2021; Post, Veldstra and Ünal, 2021) and surveys (Pettigrew, Talati and Norman, 2018; Pettigrew *et al.*, 2019).

Merfeld et al. (2019) conducted in-depth interviews with 25 driver's license holders in German. Their results showed three motivational structures for using AVs: *self-fulfilment, security, and responsibility*. This study relates *self-fulfilment* to respondents' hedonic values, including career success, social connections, and life quality. *Security* includes personal integrity and safety; *responsibility* consists of social responsibility and accountability. Some studies had participants experience advanced driving simulators prior to conducting structured interviews (Buckley, Kaye and Pradhan, 2018; Molnar *et al.*, 2018). Buckley et al. (2018b) had 68 respondents spend 20 minutes in a driving simulator programmed to imitate a level-3 AV driving environment. The follow-up interviews revealed ability, helpfulness and integrity, among others, as determinants of AV acceptance.

Dichabeng et al. (2021) conducted an online focus group among 21 British drivers to discuss their perceptions of level-4 and level-5 AVs, including private and shared AVs. Their study identified *trust, service quality,* and *price value* as the three main factors affecting AVs acceptance. *Trust is* primarily generated from perceived risks (mentioned by all 21 respondents), trusting in co-passengers, privacy security, preference for supervision, and several other sub-factors. The *service quality* mainly reflects reliability, comfort, and convenience. The reliability was also mentioned by all respondents, including punctuality, emergency actions, travel and waiting time. Lastly, *price value,* consists of cost and the perceived benefits, such as environmental friendliness and in-vehicle productivity.

Some previous researchers found used surveys – mostly online – convenient because the survey construction for researchers and the survey completion for participants are separated. Online surveys' administrative settings are also less onerous than interviews and focus groups, such as the appointment making and the scheduling for different participants. Moreover, online surveys are more convenient and less time-consuming to collect both qualitative and quantitative data.

In this study, a sample of undergraduate university students in Australia is chosen to examine the determinants for AV adoption among the young generation. Previous studies show that young people might be the earliest AV adopters (Haboucha, Ishaq and Shiftan, 2017; Berrada, Mouhoubi and Christoforou, 2020; Winter *et al.*, 2020). The exploratory nature of this study aims to discover young people's initial thoughts of ride-pooling services and AVs, as well as their motivations and barriers to using AVs. The structure of this chapter is as follows. Section 2 presents the methods, including the survey description, participants recruitment, and the data analysis procedure. Section 3 shows respondents' stated willingness to ride in AVs regarding

the demographic profile. Section 4 provides insights from the qualitative inquiry, including respondents' general opinions on ride-pooling services and AVs and their motivations and barriers to AV adoption. Section 5 discusses and concludes the primary findings.

2 Methods

2.1 Survey description

This survey consists of open-ended questions about ridesharing and AVs, and demographic questions, as shown in **Table 1**. The survey started with the familiarity question for ridesharing services, followed by the introduction of different ridesharing services, including ride-hailing and ride-pooling. Then, the first open question was to capture respondents' initial thoughts on ride-pooling services by asking, "*What are your thoughts on ride-pooling services?*".

The following several questions focus on AVs. Similarly, a familiarity question was asked to assess whether respondents had heard of AVs. However, respondents were given no prompt illustration about AVs afterwards to avoid restricting their instinctive first thoughts on AVs. Then three open questions about AVs were displayed to respondents to capture their initial thoughts about AVs, their motivations to use AVs, and their reasons for not using AVs. These three open-ended questions about AVs are followed by a closed-end question to capture the overall attitude towards AVs by asking, "*If driverless cars were available now, would you be willing to ride in them?*". This question's options use a five-point Likert scale ranging from "*No. There is no way I would ride in an autonomous vehicle*" to "*Yes. Without any doubts*".

Table 1 Qualitative questionnaire open-ended questions

Category	Questions	Question type	Objectives
Ride-pooling	*Have you heard of ridesharing service before? (e.g. Uber, UberPool, Grab, Ola)*	Multiple choice	Familiarity with ridesharing services
	Introduction of different ridesharing services	Text description	Initial thoughts on ridesharing
	What are your thoughts on ride-pooling services?	Open-ended question	
AVs	*Have you heard of driverless vehicles (driverless cars, automated cars, autonomous vehicles) before?*	Multiple choice	Familiarity with ridesharing services
	What is the first thing that comes to mind when you hear the terms 'autonomous vehicle' or 'driverless car'?	Open-ended question	Initial thoughts on AVs
	If driverless cars were available now, what would be your motivations to use them?	Open-ended question	Motivations for AVs
	If driverless cars were available now, what would be your reasons NOT to use them?	Open-ended question	Barriers for AVs
	If driverless cars were available now, would you be willing to ride in them?	Multiple choice	The overall attitude of AVs

2.2 Survey distribution and participants

After a small-group pilot study within the office and some revisions, the survey was distributed in September 2021 through an online survey platform, Qualtrics[1]. Participants for this survey were undergraduates from the UWA Business School. After one-month distribution, 279 students signed up for this study. After deleting the unfinished survey, 275 valid records were used for data processing, reaching a valid response rate of 98.6% – all the valid records contained at least one reasonable word for each open-ended question.

2.3 Data analysis procedure

The quantitative data (other than responses to open questions) were imported into SPSS to test the significant differences between demographic groups using t-tests and ANOVAs. Respondents' scripts to four open questions were automatically generated and downloaded from Qualtrics. Any identifying information was replaced with pseudonyms. For example, the first female from the survey was coded as F1. Later, all the open-ended answers were imported into NVivo 20 – a qualitative data management software (QSR International) – for coding and analysis. The first author undertook the entire coding based on a hierarchical progressive process using nodes in NVivo to match relevant concepts. This study is exploratory and borrowed no pre-existing conceptualisations. Therefore, data were coded by line unit to capture all relevant concepts. A new node would be created as a new concept emerged. The advantage of this approach is allowing concepts to arise on their own and not due to any expectancy bias of the researchers. At last, similar nodes were merged into main nodes for summaries and interpretations.

3 Stated willingness to ride in AVs

Almost all respondents have heard about ridesharing services (98.5%) and AVs (96.7%) before, indicating a high familiarity. The overall average score of willingness to ride in AVs for all students is 3.50 out of five, indicating a generally positive attitude towards AVs. The five-point score was further regrouped into three levels to better identify students' attitudes. Scores of one and two were regrouped into "negative", score three into "neutral", and scores of four and five into "positive". After regrouping, we had 17% negative, 15% neutral, and 68% positive attitudes. These group percentages echo the relative high willingness to ride score.

Table 2 shows the demographic distribution of the sample and the results relating to the potential willingness to ride in AVs. Because participants are all undergraduate students in their 20s, age was removed from the demographic information. This dataset consists of more female students, domestic and working students. About two-thirds of students own a car, and over 90% hold a driver's license. Around one-third of students have experienced at least one traffic accident before. Students' average commuting distance is 14.4 kilometres per trip, time is half an hour, and the cost is AUD 6.7. Besides, positive correlations are found between commuting distance, time, and cost.

[1] www.qualtrics.com/au/

By comparing the demographic distribution based on the general attitudes towards AVs, students who currently have a job or own a car have a relatively more positive attitude. This result resonates with previous findings that full-time workers with higher income tend to use AVs (Narayanan, Chaniotakis and Antoniou, 2020). Besides, no difference was found by gender, student type, income, driver's license and accident experience. Since all respondents for this study are students, income might not be a key factor. Moreover, no correlation was found between the attitude towards AVs and travellers' commuting distance, time, and cost.

Table 2: Demographic distribution regarding general attitudes towards AVs

	N	%	Mean of attitude	SD	% Negative[a]	% Neutral	% Positive[b]
Total	275	100%	3.50	0.96	17%	15%	68%
Gender							
Male	102	37%	3.63	0.94	14%	12%	75%
Female and other[c]	173	63%	3.43	0.96	20%	16%	64%
Student type							
Domestic	195	71%	3.63	0.92	15%	10%	75%
International	80	29%	3.20	0.99	23%	26%	51%
Work							
Not working	91	33%	3.29**	1.03	21%	24%	55%
Working	184	67%	3.61	0.91	16%	10%	74%
Income							
No income	42	15%	3.43	1.02	19%	17%	64%
Have income	182	76%	3.53	0.95	18%	11%	71%
Prefer not to say	51	19%	3.45	0.97	16%	23%	61%
Car owner							
No	92	34%	3.29*	1.04	22%	23%	55%
Yes	183	66%	3.61	0.90	15%	10%	74%
Driver license							
No	23	8%	3.48	0.73	13%	26%	61%
Yes	252	92%	3.50	0.98	18%	13%	69%
Accident before							
No	178	65%	3.44	1.01	20%	15%	65%
Yes	97	35%	3.61	0.85	12%	13%	64%
Commute info	**Mean**	**SD.**					
Distance (km)	14.4	9.9					
Time (minutes)	29.7	18.4					
Cost (AUD)	6.7	6.9					
Correlation	Distance	Time	Cost	Attitude			
Distance	1						
Time	0.83*	1					
Cost	0.42*	0.33*	1				
Attitude	-0.03	-0.03	-0.05	1			

a: Negative – score = 1 or 2 on a five-point scale

b: Positive – score = 4 or 5 on a five-point scale

c: Gender – other stands for 11 respondents prefer not to specify their gender

T-tests: *** p<0.001, ** p<0.05, * p<0.01.

4 Insights from Qualitative Inquiry

This section provided insights from the coded references from the open-ended answers. Codes from each open-ended question were combined into several main nodes to have an instinctive understanding of students' overall attitudes. The next two subsections identified respondents'

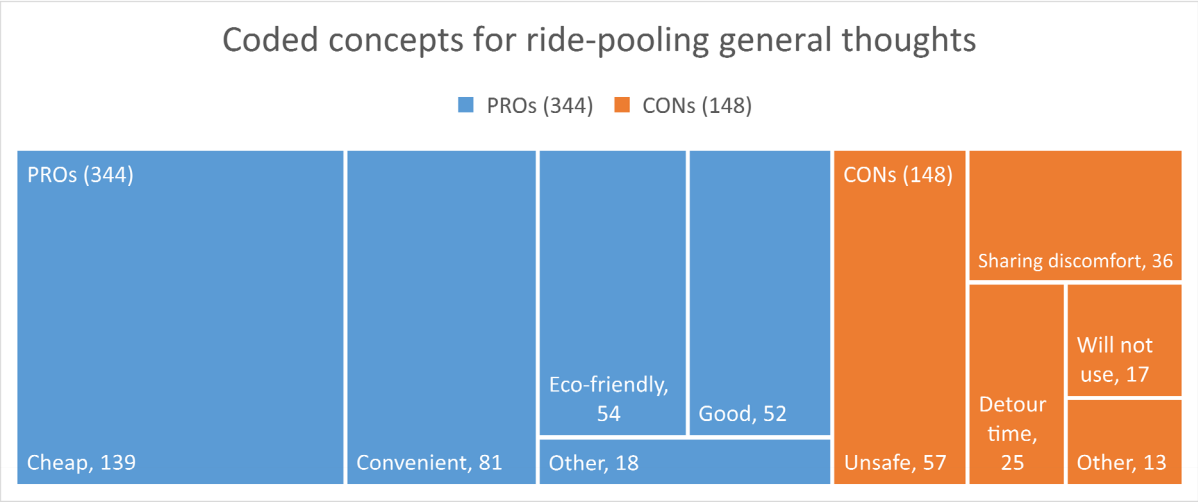
initial thoughts, motivations and barriers from the coded references. The analysis and the positioning of the results from open-ended questions will be discussed in section 5.

4.1 Thoughts on ride-pooling services and AVs

4.1.1 Ride-pooling services

Figure 1 summarise the number of coded references per main node and sub-codes for the general thoughts of ride-pooling. All sub-codes are categorised into two main codes: **PRO** and **CON**. Overall, respondents presented an apparent positive attitude towards ride-pooling services. **PRO concepts** were mentioned 344 times, while **CON concepts** were mentioned 148 times. **PRO concepts** contain "*cheap*", "*convenient*", "*eco-friendly*", and "*good*". In contrast, **CON concepts** include "*unsafe*", "*sharing discomfort*", and "*detour time*". In addition, 17 participants stated they would not use ride-pooling services mostly because they would stick to their current travel modes (driving or public transport).

Figure 1: Coded concepts per main and sub-concept – general thoughts on ride-pooling



[a]: Other PROs for ride-pooling are: "*meet new people*" (7); "*safe*" (4); "*provide jobs for drivers*" (4).

[b]: Other CONs for ride-pooling are: "*expensive*" (5); "*poor market regulations*" (4); "*should have better pooling algorithms*" (2); "*difficult to use*" (1); "*drivers' low job benefits*" (1).

Respondents frequently raised "*cheap*" (n=139, same below) when commenting on ride pooling services. Whilst some (25) acknowledged that the low cost came with longer travel times, students with low budgets were attracted by the discount on offer through sharing costs. Words conveying the idea of "*Convenient*" were mentioned 81 times. Respondents found ride-pooling services convenient in occasional situations such as after-party and for people who currently do not own a car. For example, students mentioned, "*They are convenient and very useful on a night out*" [M39]. About 20% of students thought ride-pooling services were "*eco-friendly*" because of pooling rides and fewer vehicles were needed [F18]. Respondents' generally positive attitudes were captured by words such as "good", "great", and "cool". Although not listed on the figure, several students mentioned that they would use ride-pooling services if they were not in a rush [F44, M45, F97, M75].

The most frequently raised **CON concept** was "*unsafe*", to which over 20% of students (57) referred. According to the answers, "*unsafe*" comes from "*the uncertainty of sharing passengers*" [F11, F90, F118] and "*drivers' quality*" [F28, M24]. Some people are also concerned that other passengers might know their home locations [M41]. Six female students

stated they would avoid ride-pooling when they were alone or travelling at night. The other two disadvantages are "*sharing discomfort*" and "*detour time*", which were mentioned 36 and 25 times, respectively.

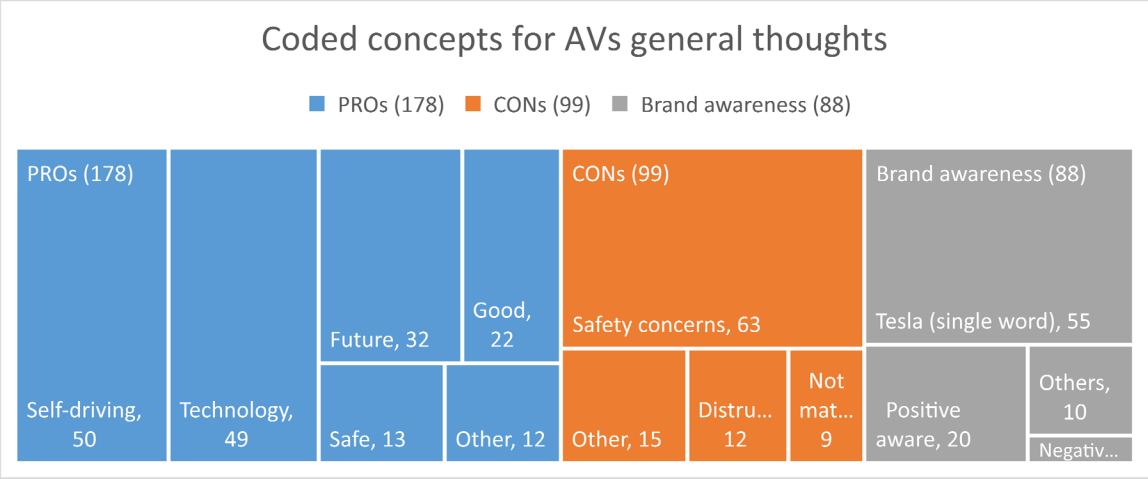
An interesting note from the ride-pooling is the gender difference. Ride-pooling is regarded as convenient for occasional situations, such as for a late night out, which was mentioned mostly by males [M4, M9, M39, M70]. On the other hand, female students tend to perceive ride-pooling as unsafe and stated they "*would never use at night*" [F147]. Despite the perceived danger, female students still acknowledge the advantages of ride-pooling. Quotes from two female students stated that *"Not necessarily time-efficient if the routes are out of one's way and potentially dangerous, especially for women in ride-pooling circumstances. Although it is more cost-efficient and better for the environment if it saves multiple trips by car"* [F18]; *"Very convenient, much more accessible and affordable than taxis. Could potentially be unsafe without right oversee."* [F135]

4.1.2 AVs

Figure 2 summarise the number of coded references per main node and sub-codes for the general thoughts of AVs. All sub-codes are categorised into three main nodes: **PRO**, **CON**, and **Brand awareness**.

Respondents expressed a relatively positive attitude towards AVs, with **PRO concepts** mentioned 178 times, compared to 99 mentions of **CON concepts**. **PRO concepts** are diverse, including "*self-driving*", "*technology*", "*future*", "*good*", and "*safe*". The most mentioned **CON concepts** contained "*safety concerns*", "*distrust*", and "*not matured*". Besides, **Brand awareness** was mentioned 88 times, including "*Tesla*", "*positive awareness*", "*other brands*", and "*negative awareness*".

Figure 2: Coded concepts per main and sub-concept – general thoughts on AVs



[a]: Other PROs for AVs are: "*eco-friendly*" (5); "*multitasking*" (4); "*electric vehicles*" (2); "affordable" (1).

[b]: Other CONs for AVs are: "*expensive*" (5); "*I enjoy driving*" (3); "*people would get lazy*" (3); "*uncertain liability*" (3); "*drivers' unemployment*" (1).

About 20% of students (50) associated AVs with"*self-driving*" and described how AVs work based on their imaginations. For example, a student mentioned, "*I think of vehicles or cars without a human driver that can navigate the environment using AI and sensors*" [M28]. Some

students related AVs to "*technology*". Words used for "*technology*" include "high-tech", "robot", and "AI/artificial intelligence". Students also thought AVs were "*futuristic*" and would popularise fast in the next decades. "Good" was also mentioned by about 10% of students (22) by using "great" or "cool". Moreover, several students perceived AVs were safer than human-driven vehicles because of fewer errors.

Over 22% of students had "*safety concerns*" about AVs. Words used to express their "*safety concerns*" include "dangerous", "risky", and "scary". Several students were afraid of the "malfunctions" and "more accidents" because of equipment failures. Moreover, students "*distrust*" AVs and think the driverless-related technologies are "*not matured*" yet.

Brand awareness refers to respondents' awareness of AV manufacturers and other AV trials. Particularly, the word "tesla" was mentioned 78 times by almost one-third of students. It is worth noting that 55 students only gave the single word "*Tesla*" as their answer to this open question. Twenty students associated the word "tesla" with high technology or ease of driving, showing a "*positive awareness*". Example quotes are "*tesla. No need to hold onto the wheel of the car*" [F18] and "*Similar to Teslas, obtaining a drivers license may become easier.*" [F83]. Ten students also mentioned other AV bus trials, such as the RAC bus trial in South Perth, which was coded as "*other brands*". For example, a student expressed, "*RAC offered a free driverless ride to their customers to show this technology, so they're the first thing to come to mind when I think of them. Otherwise, it'd be Tesla.*" [F52]. Only three students mentioned Tesla or other brands negatively, indicating a "*negative awareness*". For example, one student mentioned, "*Tesla's lack of safety precautions or easily overridden precautions*" [F142].

Overall, students currently hold a generally positive attitude towards AVs and think AVs are promising and futuristic. The general public's attitudes towards AVs can be easily affected by the publicity of AVs, not only the promotions of AV-related stakeholders but also the news from the media. Another quote about the publicity is "*the RAC buses in south Perth, as well as the Tokyo Olympics use of them to transport athletes. Also Tesla's lack of safety precautions or easily overridden precautions.*" [F134]. On the other hand, all the three con-concepts – "*safety concerns*", "*distrust*", and "*not matured*" – reflect respondents' concerns about their safety in AVs because of current unmatured technologies and reported AVs accidents. Besides engineers' efforts to advance AV technology to a more mature and secure level, how and why people trust AVs are also crucial for AVs' popularisation.

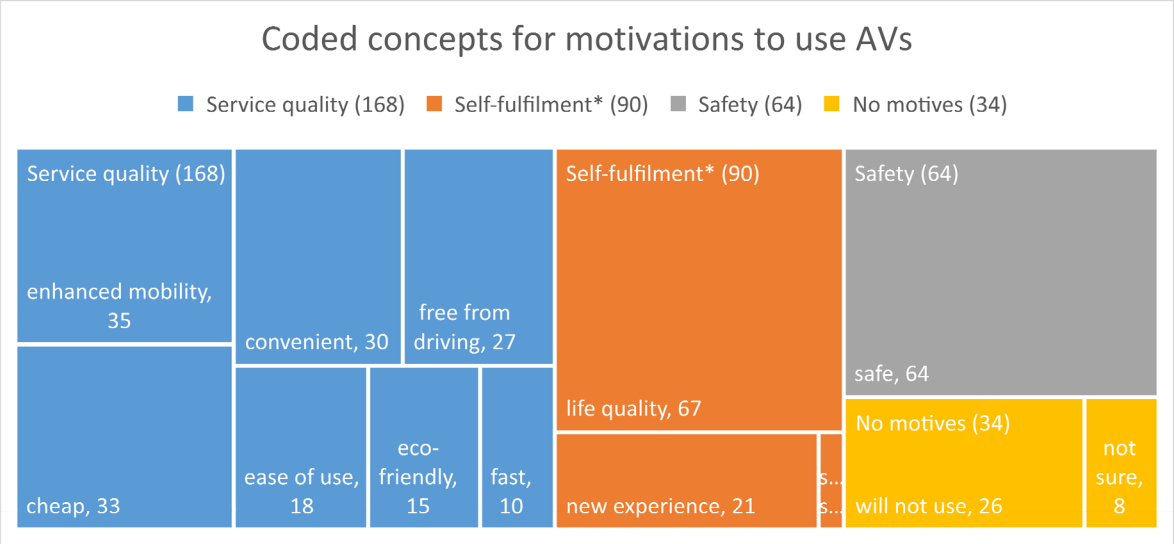
4.2 Motivations and barriers to AVs adoption

4.2.1 Motivations

Similar to the previous section, answers for the motives for AVs were coded in the form of a single sub-concept and then categorised into main concepts.

Figure 3 presents the coded concepts for motives per main and sub-concept. All responses for the motivations to use AVs were coded into 356 references, which were later coded into sub-nodes. Then all sub-nodes were categorised into main codes/concepts based on their similarity, resulting in three main emergent concepts: "***service quality***", "***self-fulfilment***", and "***safety***".

Figure 3: Coded concepts per main and sub-concept – motivations for AVs adoption



*: "***Self-fulfilment***" includes two references as "*social status*" (2), which does not clearly show on the chart due to the relatively small amount.

Over half of respondents regard "***service quality***" as their biggest motive, including "*enhanced mobility*", "*cheap*", "*convenient*", "*free from driving*", "*ease of use*", "*eco-friendly*", and "*fast*". The mobility would be enhanced for both drivers and non-drivers. With the self-driving ability, students assumed that they could use AVs in certain situations when they could not drive, such as after drugs [F77], fatigue [F83, F170], and on long-distance road trips [M26, M35, F86, M96, F169]. AVs also provide instant mobility for non-driving students who claimed they did not possess a driver's license [F81, F99, F101]. About 12% of students mentioned "*cheap*" (33) and "*convenient*" (30). People who do not drive are happy to use AVs and believe AVs are "*convenient*" because they no longer need to acquire a driver's license [M49].

"*Free from driving*" is a motive for about 10% of students (27), including drivers and non-drivers. Those who drive stated that AVs could reduce their driving anxiety [M70, F158], especially in traffic jams. Moreover, they could use the in-vehicle time to multitask. As one respondent said, "*Less anxiety on the roads, I get really worried while driving to destinations. Would also allow me to do other things will driving, catch up on work or watch a movie.*" [F158]. Eighteen students thought AVs would be easier to use than human-driven cars. Fifteen students mentioned "*eco-friendly*", as some assumed AVs would run on clean energies such as electricity [F60] and reduce emissions [F33, F139]. Ten students perceived AVs to be "*faster*" because of less traffic congestion [F33, F44].

"***Self-fulfilment***" refers to the hedonic values and desire to use the time that respondents gained by autonomous driving to enrich their lives (Merfeld, Wilhelms and Henkel, 2019). Referred by 42% of students, "***self-fulfilment***" consists of "*life quality*", "*new experience*", and "*social status*". Referring to the psychological consequences of meaningfully using in-vehicle time, "*life quality*" had the highest reference frequency of 25%. Students imagined a list of hypothetical in-vehicle activities, such as resting, studying, and looking outside. One student mentioned, "*I would be motivated to use a driverless car, so I could slow down and enjoy life. Stop and look out the window and truly appreciate the beauty in the world. From my knowledge of driverless cars currently, I believe it would be a safer option if all cars were driverless. I trust the technology.*" [M85]. In addition, several innovative students expressed their

excitement to use AVs because of the "*new experience*", and they would try the latest technology. Two students thought AVs would enhance their "*social status*".

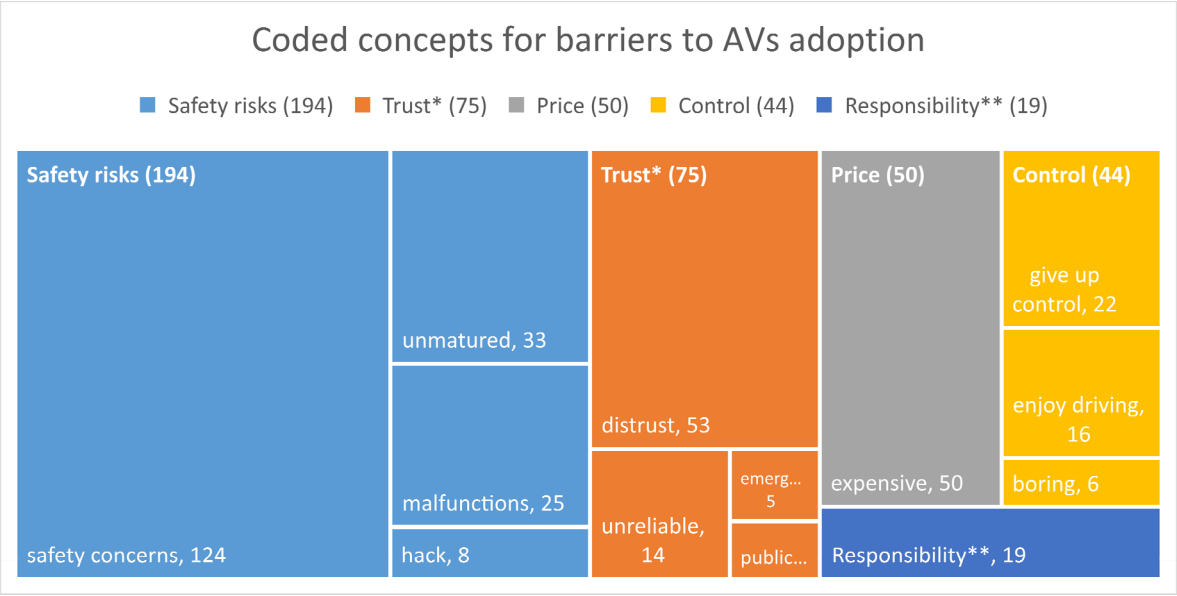
The third motive is "***safety***". Most students with this motive believed AVs would be safer than human-driven vehicles because AVs could reduce accidents caused by human errors. In contrast, several students held a relatively hesitative attitude and would use AVs only if they had been tested correctly to be safe. As one mentioned, "*High level of safe driving, mature developed system in the market, promotions by governments or something like that*" [F48].

Of all 275 respondents, 34 expressed uncertainty about their motivation or no motivation to use AVs, echoing the previous 17% negative attitude. Eight respondents were "*not sure*" about their motivations for using AVs. Moreover, 26 gave "*no*" to answer this AV motivation question. We analysed the reason for no motive and found that three students expressed their enjoyment of driving and would not give up driving control to robots. Two students mentioned they had no motivation as they saw AVs as normal commuting vehicles. Several students expressed their worries about the safety and reliability of AVs; thus, they would not use AVs. For example, one student mentioned, "*I probably won't use them yet. Maybe I will wait until more driverless cars are available later and see how they are before considering buying one myself.*" [F156]

4.2.2 Barriers

Figure 4 display the coded concepts for barriers per main and sub-concept. Responses for the barriers to AVs adoptions were coded into 382 references. Similar to the last section, sub-codes were combined into five main concepts: "***safety***", "***trust***", "***price***", "***control***", and "***responsibility***".

Figure 4: Coded concepts per main and sub-concept – barriers for AVs adoption



*: "***Trust***" also includes "*publicity*" (4) that are not properly displayed on the chart.

: "*Responsibility"*** includes: "*ethical problems*" (7), "*unemployment*" (6), "*infrastructure*" (5), and "*eco-friendly*" (1).

Over 70% of students identified "***safety***" as their biggest concern to use AVs. The majority of students expressed personal "*safety concerns*". Others are concerned about the specific safety risks of AVs. For example, thirty-three students worried about the "*unmatured*" technology and stated they "*would be hesitant to use one unless it had advanced enough to be safe on the roads*." [M61]. Some students also thought AVs might "*malfunction*" or be "*hacked*" easily, resulting in severe crashes.

"***Trust***" issue is another large obstacle to AVs adoption. Around 20% of students (75) "*distrust*" AVs because they doubt the sophistication and accuracy of the self-driving systems. For example, as one student expressed, "*Heavy rain, lots of snow or atmospheric smog can blur road signs and lane markings, increasing the risk of accidents. Autonomous vehicles struggle to make good decisions in these situations, as rain, fog and dust make it difficult for radar sensors to scatter or block laser beams and interfere with the camera's ability to detect images.*" [F57]. Besides, several mentioned that AVs would be "*unreliable*" or uncertain. Five students questioned AVs' "*emergency control*" ability and four mentioned previous news about AVs' crashes ("*publicity*"). One student pointed out, "… *Tesla had some accidents related to its self-driving system.*" [M97]

The third barrier is the perceived high "***price***" of using AVs. No more than 20% of students assumed AVs to be expensive as other new technologies, especially at an early stage when limited brands and models are available. Some students thought "*AVs would not be financially unrealistic for the average person*" [F69], and some assumed probably high service costs.

"***Control***" was mentioned by 16% of students (44) and included "*giving up control*", "*enjoy driving*", and "*boring*". Some students were reluctant to hand over the vehicle control to robots, and others believed humans were more reliable than self-driving systems. Sixteen students expressed enjoyment of driving, and another six described AVs as "*boring*" cars, almost the same as current human-driven cars.

"***Responsibility***" refers to the respondents' desire for social responsibility. Although mentioned by less than 10% of students, "***responsibility***" includes "*ethical problems*", "*unemployment*", "*infrastructure*", and "*eco-friendly*". Seven students wondered how AVs would prioritise the safety of onboard passengers and pedestrians if there were emergencies. Six worried about the "*unemployment"* of current taxi and bus drivers. Five were concerned about the accessibility of AV-related "*infrastructure*".

5 Discussion and conclusion

Respondents for this study generally had a positive attitude towards ride-pooling services and AVs. Respondents' overall score of the willingness to ride in AVs is 3.50 out of five. Moreover, after regrouping, I found 68% positive attitudes, 15% neutral attitudes, and 17% negative attitudes towards AVs. Because participants are undergraduates from UWA, this study confirmed previous findings that the young generation, students and highly-educated people were more willing to use AVs (Haboucha, Ishaq and Shiftan, 2017; Shabanpour *et al.*, 2017). Besides, students with a job tend to have a more positive attitude. Previous studies suggest that full-time working and higher-income people are inclined to use or purchase AVs (Narayanan, Chaniotakis and Antoniou, 2020). Although no difference was observed between groups with and without income, this study still echoes previous findings. Car owners tend to hold a more positive attitude, which contrasts with previous studies (Liljamo, Liimatainen and Pöllänen, 2018; Liu *et al.*, 2019; Yoo *et al.*, 2021). One potential explanation is that respondents in our

study are young, new drivers who might get inexperienced and bored with driving. Therefore, these new drivers hope to use AVs to free their hands and multitask in the vehicle, as mentioned in the previous section.

5.1 Ride-pooling services

Based on the coded references, over 70% of first thoughts on ride-pooling services are positive. Respondents thought ride-pooling services as "*cheap*", "*convenient*", and "*eco-friendly*" but might be "*unsafe*", "*discomfort to share*", and generate "*detour time*". Normally passengers receive a discount if they choose to pool the ride, which is also the most critical incentive for travellers to pool rides. Pooling rides will reduce the number of cars on the road and be more friendly to the environment by fewer car emissions.

Besides, over a quarter of respondents perceive ride-pooling services as "*convenient*", especially for people who do not drive and in occasional situations, such as after-party and a late night out. An interesting observation of this concept is that males tend to think ride-pooling "*convenient*" more than females. Females also acknowledge the convenience of ride-pooling but believe it could also be unsafe. They expressed the reluctance to ride-pooling at night or travelling alone as it might be risky. Previous studies have confirmed that females tend to be more sensitive to risks and have less risk tolerance (Liu, 2021). Some transportation companies, such as Didi, Uber, and Ola, formulated many policies to alleviate the perceived and actual possible risks, such as enabling female passengers to choose the gender of the driver and pooling passengers (The Economic Times, 2020; McCowen, 2021).

The "*unsafe*" of the ride-pooling service generates two aspects: the quality of drivers and the uncertainty of other passengers. The quality of drivers could be affected by the market regulation of ridesharing services. Unlike the taxi industry, which is highly regulated (Jin *et al.*, 2018), ridesharing, especially ride-pooling services, is a rather novel notion and thus might lack regulations. Besides, the drivers' quality might be reflected in ride-pooling service quality. Under-regulation in the ridesharing industry could lead to the passengers' distrust. Therefore, adequate government regulation is required to protect consumers. People also feel unsafe about pooling passengers because they worry about their location being revealed to others. A possible solution might be setting pick-up and drop-off points that can locate in public places. Passengers could choose their favoured location as the trip origin and destination.

Since the ride-pooling service is not yet available in Perth, most respondents have not used it and would perceive the discomfort of sharing rides. Previous studies found the "*discomfort of sharing*", especially when the travellers are assigned to a middle seat (Etzioni *et al.*, 2021). However, some respondents expressing a positive sentiment mentioned they use ride-pooling services weekly [M6, M62, F131]. With ride-pooling services' increased popularity and market share, more people might perceive them the same as public transport.

5.2 AVs adoption

The results indicate a positive slant on how respondents think about AVs. "***Service quality***" is the most prominent determinant of the acceptance of AVs. "***Service quality***" attributes to "*enhanced mobility*", "*cheap*", "*convenient*", "*free from driving*", "*ease of use*", "*eco-friendly*", and "*fast*", as discussed before. Service quality is important for transport systems (Dichabeng, Merat and Markkula, 2021). These findings are consistent with previous studies that people are more willing to use AVs for increased mobility, convenience, and environmental friendliness

(Daziano, Sarrias and Leard, 2017; Pettigrew *et al.*, 2019; Dichabeng, Merat and Markkula, 2021). "*Ease of use*" is similar to the construct "perceived ease of use" in the Technology Acceptance Model. Many studies have confirmed that the perceived ease of use positively affects people's acceptance of AVs (Zhang *et al.*, 2020; Jing *et al.*, 2021).

"***Self-fulfilment***" is the ability of AVs to enhance one's life quality. As the most frequently mentioned motive, "*life quality*" enables in-vehicle productivity of AVs travellers, resulting in more meaningful use of time and more peace of mind, especially for current drivers. "*New experience*" relates to respondents' personal innovativeness. Previous studies found that tech-savvy people interested in new technologies are more likely to be early AV adopters (Haboucha, Ishaq and Shiftan, 2017; Sener, Zmud and Williams, 2019).

"***Safety***" is both a motivation and the largest barrier to AVs adoption. A quarter of respondents regarded AVs as safer than human-driven vehicles. In contrast, over 70% of respondents associated safety risks with AVs. This ambivalence of how respondents perceive safety finds quantitative support in previous studies (Zmud, Sener and Wagner, 2016; Haboucha, Ishaq and Shiftan, 2017). Moreover, some studies found that people with a higher perceived safety of AVs had a higher intention to use AVs (Bansal, Kockelman and Singh, 2016; Nordhoff, de Winter, *et al.*, 2019; Manfreda, Ljubi and Groznik, 2021). This study confirms the importance of safety for AVs adoption as both motive and barrier. In other words, increasing safety levels will help facilitate AVs adoption by reducing the concerns and barriers while promoting safety motives.

The lack of "***trust***" in AVs is another critical barrier to AVs adoption. Many studies have proved that trust is a strong indicator of the behavioural intention to use AVs (Panagiotopoulos and Dimitrakopoulos, 2018; Hegner, Beldad and Brunswick, 2019; Liu, Yang and Xu, 2019; Zhang *et al.*, 2020). Moreover, trust is associated with other factors, such as perceived safety risks. The lack of trust results in a higher perceived safety risk, thus a lower general acceptance of AVs (Liu, Yang and Xu, 2019). On the other hand, the perceived safety risks will reduce the initial trust and generate a more negative attitude towards AVs (Zhang *et al.*, 2019).

This study found that some distrust of AVs originated from the doubt about the AVs' ability to handle emergencies. Besides, as several respondents thought AVs are currently unmatured yet, the under-developing technologies do not guarantee safety. This interpretation is also a type of distrust in AVs because respondents distrust either the sophistication or the operating accuracy of the self-driving system. Some hold a sceptical attitude towards AVs' ability to handle emergencies and complicated situations such as foggy weather. Others are concerned about equipment failure.

Most respondents' familiarity with AVs comes from the mass media about current AV trials, such as the Tesla and RAC AV bus trials in Perth. One problem arises that respondents would be inclined to be exposed to the negative news about AVs, such as the crashes of a Tesla trial car in the US. However, according to Tesla's safety report[2], the actual crash rate of AVs is much lower than that of human-driven automobiles. For example, Tesla recorded one crash for every 4.41 million miles driven with autopilot engaged in the last quarter of 2021, compared to every 484,000 miles for the human-driven automobile. The accumulation of exposure to

[2] Tesla Vehicle Safety Report | Tesla https://www.tesla.com/VehicleSafetyReport

only negative news on AVs causes confirmation bias so that respondents tend to project a distrust in the reliability and matureness of AVs-related technologies.

Besides, about one-third of the respondents mentioned "Tesla" as their first thought for AVs, proving that their knowledge of AVs might relate to the news about Tesla's products and strong brand awareness. This awareness was found mostly positive because more participants related Tesla to the words "advanced technology" and "interesting" than accidents or crashes. However, even though Tesla came to their minds as a relative positive word, three respondents still mentioned Tesla's recent AV crashes and were concerned about the reliability of AVs. This phenomenon further confirmed that exposure to negative news might affect people's judgment more. One way to reduce people's distrust and concerns might be more positive news showing to the public.

Other barriers to AVs adoption are "***price***", "***control***", and "***responsibility***". Cost is a significant variable in using AVs (Haboucha, Ishaq and Shiftan, 2017; Zmud and Sener, 2017). Zmud and Sener's (2017) findings show that the cost is the third determinant of using AVs, after trust and safety. New technologies might be expensive, but the price would decrease with the increase in the market share. Besides, the respondents are all undergraduates without a stable income, so they might concern about the price of owning an AV. Some respondents are unwilling to give up control to AVs, and many drivers expressed their driving enjoyment. This finding is in line with Asgari and Jin's (2019) results that those who enjoy driving are less likely to adopt an AV and were the hardest to be persuaded to pay for AV features. Responsibility is not the main barrier, but some respondents care about the ethical problems, the unemployment of bus and taxi drivers, and the AV-related road infrastructure.

5.3 Practical implications

This study offers certain practical implications. First, its results provide insights for assessing people's instinctive thoughts about ride-pooling services. The government could enhance the regulation of ridesharing companies. Moreover, ridesharing companies could strengthen the standards and conduct regular safety training for drivers. More advanced algorithms could also be developed to match the pooling passengers and reduce detour time.

This study confirmed that young people in Australia have a relatively positive attitude towards AVs. Thus, AV promotion in Australia could target these people. We also identified the critical obstacles to AVs adoption – "***safety risks***" and "***trust***" – and explored the underlying reasons for people's lack of trust in AVs. Policymakers and automakers could address the benefits of AVs and keep the public up with the latest technology development through different mass media such as the internet and TV, which would balance the negative news from the crashes. Another possible way is to conduct the AV trails in the neighbourhood and encourage people to take rides and provide feedback. Further trials could be improved based on the feedback. Previous studies found that people have more trust in AVs after experiencing AV simulators or real AVs (Molnar *et al.*, 2018; Paddeu, Parkhurst and Shergold, 2020). As many level-3 AV buses are under trial, the public could be involved as the passengers feel AVs' designed high reliability and usability.

5.4 Limitations and future research

Overall, this study contributes to identifying the motives and barriers to AVs adoptions from the perspective of potential AV users in Australia – the highly-educated young generation. Our

study captured both qualitative and quantitative data using an online survey with open-ended questions and a demographic section. The results reveal the demographic profile of AVs potential users and the motives and barriers to AVs adoption. Our study has limitations. First, the participants in this study were only undergraduates. A larger sample from a more diverse community might capture different attitudes. Second, this study is online without participants experiencing real AVs; thus, each participant fills their knowledge gap with their imagination. Hypothetical bias might arise because they have not been exposed to the current developments of AVs. Future studies could apply descriptions and videos of the current development of AVs or maybe adopt a real AV trial.

This study presented an exploratory qualitative study. Future work could use field experiments and analytical methods to collect quantitative data on people's choices. For example, we could use stated choice methods to explore the first-order implications of AVs on travel time, the value of time, and vehicle use. Besides, we could use technology acceptance models to measure the behavioural aspects of the second and third-order implications, including energy consumption, safety, and public health. Afterwards, the choice and behavioural results could be incorporated into agent-based or activity-based models to simulate and predict possible changes in travel demand, vehicle ownership, and environment. Further long-term research could investigate land use and road infrastructure.

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