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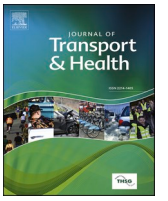

Older drivers in Australia and advanced vehicle technologies: What are their opinions? A qualitative study

Helen Nguyen [a,*], Kristy Coxon [b], Julie Brown [c], Nick Neville [b], Gian Luca Di Tanna [c,d], Yun-Wen Hsieh [a], Lisa Keay [a,c]

[a] School of Optometry and Vision Science, Faculty of Science, The University of New South Wales, NSW, Australia
[b] School of Health Sciences, and the Translational Health Research Institute, Western Sydney University, NSW, Australia
[c] The George Institute for Global Health, Faculty of Medicine, University of New South Wales, NSW, Australia
[d] Department of Business Economics, Health and Social Care, University of Applied Sciences and Arts of Southern Switzerland, Switzerland

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ABSTRACT

Background: There is limited research on older drivers' perspectives on advanced vehicle technologies (AVTs). This study investigates what older drivers know and understand about AVTs in the current vehicle market, and identifies what motivates older drivers to use or not use AVTs.
Method: Older drivers (≥65 years) living in New South Wales, Australia completed semi-structured telephone interviews guided by the Car Technology Acceptance Model. All interviews were audio-recorded and transcribed verbatim. Content analysis and deductive-inductive thematic analysis were completed on each transcript independently by two researchers, with all themes presented to the investigative team, discussed until consensus was reached. Participant recruitment were ceased after thematic saturation.
Results: 24 participants (mean age: 74.5 years; 13 males, 11 females) were interviewed. Eleven different AVTs were mentioned by participants. Attitudes towards these AVTs impacted how much participants understood how these technologies worked. These attitudes and motivation of technology usage could be explained by four major themes; (1) AVTs help with safety but overall responsibility remains with the driver, (2) Lack of clear information and instructions make AVTs look confusing, (3) AVTs need to be more user-friendly for older adults, and (4) Expensive out-of-pocket costs stop AVT usage.
Conclusions: Despite understanding the safety benefits of simple, standard AVTs, older drivers perceive barriers that hinder their use of more complicated technologies. Increased consultations to make AVTs more acceptable to older adults are needed. In conjunction, more resources and options aimed at helping older adults better understand and access AVTs need to be developed.

1. Introduction

Driving allows individuals to maintain their independence and connect with their community, particularly as they age. However, it is a complicated task relying upon a combination of visual, cognitive and physical skills which may decline with age, making older drivers one of the most vulnerable road users (Anstey et al., 2005). In line with the United Nation's Safe System Approach's "safe

* Corresponding author. School of Optometry and Vision Science, The University of New South Wales, Sydney, UNSW, NSW, 2052, Australia.
E-mail address: helen.nguyen1@unsw.edu.au (H. Nguyen).

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vehicles" pillar, in-vehicle advanced vehicle technologies (AVTs) have been developed to assist with safe driving and may support older drivers to continue driving safely for as long as possible (Eby et al., 2016).

Select AVTs have been shown to be beneficial for road-related injuries and crash avoidance. Both lane departure and forward collision warning technologies can reduce the likelihood of crashes by 27–39% and 17–33%, respectively (Wang et al., 2020). Autonomous braking systems have been shown to reduce real-world rear-end crashes by 38% (Fildes et al., 2015) with a meta-analysis reporting fatal pedestrian and serious injury pedestrian crashes to reduce by 15.3% and 38.2% each year, respectively, if all vehicles in France were fitted with this feature (Chauvel et al., 2013). Speed warning systems in a US study was shown to potentially reduce curve-navigating speeds by 8–10%, thus reducing the risk of curve crashes (Davis et al., 2018). Electronic stability control has been found to reduce single-vehicle and loss-of-control crashes in both US and Canadian studies (Chouinard and Lécuyer, 2011; Sivinski, 2011).

It should be noted, however, that none of the evidence mentioned above showing select AVTs to improve road safety was primarily focused on older drivers. The studies either did not report participant demographics (Chauvel et al., 2013; Chouinard and Lécuyer, 2011; Fildes et al., 2015; Sivinski, 2011; Wang et al., 2020), or were skewed towards young drivers (Davis et al., 2018). Further, studies examining the attitudes to AVTs have also mostly focused on younger drivers. A scoping review looking at both the safety benefits of AVT usage, and the perceptions and opinions held by different age groups towards these technologies revealed only 10 studies out of the 324 identified to focus on older drivers (Furlan et al., 2020). The studies on younger and middle-aged drivers were focused on a large range of AVTs (13 types), most of which were found to help increase safe driving in both age groups. These drivers also held positive attitudes towards the usefulness and trustworthiness of AVTs. Studies on older drivers looked at a more limited range of AVTs (seven types) however most technologies, such as lane departure and blind spot warnings, were seen to help with safety. However, the attitudes older drivers have towards AVTs were mostly unreported (Furlan et al., 2020). This is an issue as older adults interact with and learn how to use technology differently and therefore may not hold the same opinions on the technologies' usefulness and their personal abilities to use the technology easily and correctly. Previous research has shown that despite being aware of select AVTs and their benefits, usage is low amongst older drivers who are cautious to adopt select new AVTs (Eby et al., 2018; Oxley et al., 2019a). However, most studies looking at the relationship between AVTs and older drivers use questionnaires and surveys which do not allow for richer discussions into the behavioural reasons underpinning why older drivers perceive these technologies the way that they do (Eby et al., 2016, 2018). These study designs also limit the ability to explore the usage patterns of older drivers and why some AVTs are used more than others. This study therefore aims to add further evidence to this area through semi-structured interviews by 1) investigating what older drivers know and understand about AVTs in the current vehicle market in Australia, and 2) identifying what motivates older drivers to use or not use AVTs.

2. Methods

Semi-structured interviews were designed and conducted to answer this study's research questions. This is because semi-structured interviews are focused yet flexible enough to allow for new and or complicated themes to be developed and thoroughly examined (Britten, 1995; Liamputtong, 2019). For this study, this interviewing method is appropriate as it allows older Australian drivers to freely speak about their experiences with AVTs whilst allowing the researchers to guide conversations towards the research questions if needed.

2.1. Participants and recruitment

Potential participants were purposively recruited from three areas in New South Wales (NSW), Australia: (1) the Central Coast, (2) Port Macquarie, and (3) metropolitan Sydney. The first two are located in regional coastal areas and were chosen as they have a higher proportion of older adults and people who choose driving as their main mode of transport compared to the state's average. Metropolitan Sydney was included to reflect potential differences between regional drivers and metropolitan city drivers. All participants were living independently in the community, aged 65 years and older with a current, valid driver's licence, indicated that they were still driving at the time of interview, and could converse in English. Recruitment of participants was expected to continue until no more themes could be developed from the transcripts. For the sample size, a target of at least twenty participants were planned to be recruited based on recommendations for qualitative research (Hennink and Kaiser, 2022) and preliminary searches of the literature on qualitative studies focusing on driving and driver attitudes on safety technologies (Gish et al., 2017; Vrkljan and Polgar, 2007). Ethics approval for this study was granted by The University of New South Wales Human Research Ethics Committee, with all work was carried out in accordance to the relevant laws and guidelines outlined by this committee.

Recruitment was completed by two research team members (author initials HN and EN) and occurred either face-to-face following presentations to senior groups at senior community centres about the study or through advertisements pinned onto the centres' community boards or in community newsletters. Potential participants could indicate their interest to participant in one of two ways. If the individual agreed to participate at the time of face-to-face approach, they were given a copy of the study's information statement and asked to sign a written consent form with the research personnel as witness. If the individual contacted the research team after coming across the study advertisement, the participant information statement was explained over the phone by a research personnel and verbal informed consent was recorded. As more males than female expressed interest in the study when recruitment first started, senior women's groups were then purposively targeted to reduce potential sex biases in the final data.

2.2. Semi-structured interviews and data analysis

All semi-structured qualitative interviews were conducted over the phone, lasting approximately 30 min, by three female researchers trained in qualitative research. All interviews were audio-recorded, transcribed verbatim and quality checked by the same three researchers. There were no prior relationships between the three interviewers and the participants. The interview guide (Table 1) was created based upon the "Car Technology Acceptance Research Model" (CTAM); a car-technology specific framework consisting of a range of determinants used to explain the behavioural intentions and usage patterns of drivers towards in-vehicle technologies (Osswald et al., 2012). By adding in the determinants related to "perceived safety" and "anxiety", this model is an extension of the "Unified Theory of Acceptance and Use of Technology" (UTAUT) framework which was constructed to combine all developments and iterations of the Technology Acceptance Model (TAM); a well-accepted, widely-used framework created to investigate consumer adaption and use of new information technologies. As Table 1 illustrates, CTAM determinants such as "attitudes towards using technology", "social influences" and "perceived safety" were incorporated into the semi-structured interview guide.

Content analysis of the transcripts was completed independently by two researchers to determine which AVTs were mentioned by the participants during the interviews and how often. AVTs were then categorised according to how respondents felt about them as either 'positive' (liked by all participants), 'negative' (disliked by all participants), or 'mixed'. Inductive-deductive thematic analysis of the transcripts was then used to see whether the final themes and conclusions could be validated with the constructs of the CTAM framework. This analysis was completed independently by two researchers using the QSR International NVivo V.12 qualitative data analysis software. All transcripts were first coded inductively without using the CTAM as reference and preliminary themes were created. All transcripts were then re-coded with additional themes made using the determinants of the CTAM. All themes from both coding steps were then combined and reviewed by all authors before finalisation. Coding and thematic analysis of the interviews were done as interviews were completed which therefore allowed the authors to empirically determine when data saturation occurred (Hennink et al., 2017). Recruitment was stopped after no new codes or themes could be created in five consecutive interviews. No transcripts were returned to participants for further discussion. Findings were only provided to the participants after finalisation of the thematic analysis. This study is reported in accordance with the *Consolidated criteria for reporting qualitative research* guidelines (Tong et al., 2007).

Table 1
Semi-structured interview guide with incorporated CTAM components.

Rapport question: How long have you been driving for and what car are you driving right now?		
CTAM Component	Question	Additional Prompts
Perceived Safety	What do you think makes someone a good or safe driver? What factors do you see on the roads at the moment do you think makes driving a bit more difficult/unsafe? What features do you believe make a car safe?	Mention road conditions, driving habits, other drivers, laws etc. N/A
Attributes	When buying a car, what features do you normally look for? **(For those who mention that they have AVTs OR that they have looked at AVTs when looking for a car):** What safety features do you like? What safety features do you NOT like?	N/A
Social Influence + Anxiety	How did you come to know about AVTs? Is there anyone around you who uses AVTs when they drive?	Mention family, friends, and other health professionals if not brought up by interviewee. Interviewer may have to explain what AVTs are and give some examples if the participant is not sure/has not heard of them before.
Effort Expectancy and Facilitating Conditions	**(For those who have used AVTs before)** How did you learn how to use AVTs? **(For those who have not used AVTS before)** How do you normally like to learn how to use new technologies? If given the opportunity, what do you find is the best way for you to learn how to use AVTs?	Mention self-directed, family, friends, dealership, magazines, online sources, front-seat passenger assistance, help menus, instruction manuals etc. methods.
Self-Efficacy and Performance Expectancy	**(For those who have used AVTs before)** Have you seen any changes to your driving since using AVTs? **(For those who have not used AVTS before)** Do you see yourself using AVTs to drive in the future? Why/why not?	N/A
Attitudes Towards Using Technologies + Anxiety	Do you think using AVTs make you a safer driver? Why/why not? **Bonus question (if you feel that the participant is very pro-AVT)**: In your opinion, why do you think some people do not like in-built car safety technologies?	N/A

3. Results

A total of 24 participants (mean age: 74.5 years; 13 males, 11 females) living in either the Central Coast, Port Macquarie or metropolitan Sydney were interviewed. On average, the whole cohort had 55.3 years of driving experience. When split by region, participants living in Port Macquarie were slightly older and had thus spent more years driving (mean age: 77.2 years; years driving: 57.2 years) compared to those living on the Central Coast (mean age: 74.9 years; years driving: 56.7 years) and metropolitan Sydney (72 years; years driving: 52 years). Most of the male participants were recruited from the Central Coast and Port Macquarie whilst participants from metropolitan Sydney were predominately female (Table 2).

3.1. Content analysis on attitudes towards advanced vehicle technologies

The number of times different types of AVTs were mentioned by the participants, as well as quotes supporting their attitudes towards these technologies, are presented in Table 3. A total of 11 different AVTs, mostly those included as standard features, were brought up during discussion by participants. In general, AVTs were viewed positively if they were deemed easy-to-use with little need for driver intervention. These technologies were also regarded as useful for completing certain driving manoeuvres, for example blind-spot warnings helping with shoulder checking, and were accepted as beneficial towards safety. Positively-viewed technologies were well understood and participants could describe in detail when, why and how they used these features. AVTs which could temporarily take control of the vehicle away from the driver were viewed negatively and deemed uncomfortable and/or unsafe to use. There were no noticeable differences in the attitudes held by male and female respondents. However, when looking at attitude differences split by region, lane departure warning systems and cruise control were generally positively received by those living on the Central Coast and Port Macquarie, compared to the more mixed perceptions held by metropolitan Sydney drivers. It should also be noted that most of the participants (16/24) did not know the technical names of the AVTs they had in their cars even when they could explain how a particular feature worked. Only reversing cameras, cruise control, Bluetooth and GPS (Global Positioning System) were mentioned without prompts from the interviewer.

3.2. Themes and their corresponding CTAM determinants

There were four major themes identified that emerged from the thematic analysis (Table 4). All themes were supported by the CTAM framework.

1. AVTs help with safety but overall responsibility remains with the driver

This theme aligned with the CTAM determinants of "performance expectancy" and "attitudes towards using technology". Participants understood that AVTs have been created to improve and assist with safe driving. They found features such as reversing cameras and sensors used in lane departure warning, blind-spot warning and forward collision systems made them feel more confident and comfortable behind the wheel. However, all respondents, regardless of gender and region, emphasised that AVTs should not be relied upon to ensure driving safety. This is because an individual's skills to safely operate a vehicle were consistently regarded as better than the technologies' abilities, thus keeping the onus of safety with the driver. For example, participants pointed out, AVTs should only be the *"second line after the driver"* [M, 74] and people "*should be very careful not to feel that we can drive unsafely because we've got safety features"* [M, 87]. This may also be why some do not want to use AVTs as they do not trust the technologies' abilities to keep them safe as highlighted by the following quote: *"I'm not very keen on all these new gadgets because there's more to go wrong."* [F, 78].

2. Lack of clear information and instructions make AVTs look confusing

The CTAM determinants of "effort expectance", "facilitating conditions", "self-efficacy", "social influence" and "anxiety" were used to support the creation of the theme related to how older drivers learnt to use AVTs. Self-directed learning was the most common method voiced by all respondents from the regional sites and metropolitan Sydney. This included finding out how the features worked by *"sheer accident"* [F, 82] by searching the internet, and using their social networks. However, female respondents were more likely to mention getting help from family members or friends compared to the male respondents. Self-learning was so prevalent as respondents felt that there was little to no advice offered to them from experts. They believed experts, such as car salespersons, could help them learn more about technologies they deemed as more complicated to use, such as adaptive cruise control. Respondents lamented that when they bought their vehicles, *"nobody explained a thing to me"* [F, 68] and that it would have been more helpful if *"the salespeople*

Table 2
Characteristics of participants from Central Coast, Port Macquarie and Metropolitan Sydney.

No. of Participants at Location	% Female	Mean Age (Years)	Mean Years spent Driving
Central Coast (n = 10)	40	74.9	56.7
Port Macquarie (n = 6)	16	77.2	57.2
Metropolitan Sydney (n = 8)	75	72	52
Total (n = 24)	45	74.5	55.3

[will] actually talk to you about it in the first instance." [M, 82]. This is because respondents felt that the vast amount of information on AVTs in car manuals made things more confusing and discouraged their interest in learning more about the technologies. They also complained about the time needed to go through the manuals to completely understand what AVTs are available in their car, as one respondent claimed: *"I'm still finding out minor things about this car after 3 years … because there's hundreds of pages."* [M, 87].

3. AVTs need to be more user-friendly for older adults

As respondents reported a tendency to learn about using AVTs on their own, technologies which were deemed too complicated to learn appeared to often be ignored and regarded as unnecessary to use. This sentiment was expressed by both males and females irrespective of where they lived. The third theme therefore stems from the CTAM determinants of "attitudes towards using technology" and "perceived safety." Whether or not the AVT was seen as useful seemed to depend upon its user-friendliness. Technologies which were more difficult to use were more likely ignored and perceived as not useful as one respondent mentioned "*It's [the AVTs] overwhelming and the fact that I don't need most of them …"* [F, 72]. AVTs which are more autonomous in nature and are capable of temporarily taking over control of the vehicle from the driver were generally disliked and viewed as potentially unsafe. This relates to the sentiments expressed in the first theme which saw respondents regarding their skills as better than the technologies' abilities. As one respondent summarised [M, 77], AVTs which can take over control are *"hand-outs"* which makes them *"uncomfortable"*. Another

Table 3
Advanced vehicle technologies mentioned by participant and the overall attitudes towards the technology.

Advanced Vehicle Technology (AVT)	Number of Participants who mentioned the AVT n (%)	Attitude towards Technology (overall)	Attitude towards Technology split by Sex and Region		Quotes
Reversing camera with rear sensors	21 (88)		Central Coast (6 males, 4 female)		"The reversing camera and the reversing beeping and also the bit at the front, because I haven't been the greatest parallel parker, but it makes me better now because I can tell where the car is actually on the road." [F, 69] "…the distance between you and the car behind you when you're backing so that the camera showing behind… the idea of that… I like that technology." [M, 76]
			Port Macquarie (5 males, 1 female)		
			Metropolitan Sydney (5 females)		
Lane departure warning system	12 (50)		Central Coast (3 males, 1 female)		"Oh, mine's got some of it…it's got a thing that you can set on it that sorts of give you a warning if you go over your lanes which is good." [F, 69] "It beeps when you're driving on the freeway and [when] you go out of your lane. I turn that off, I don't find that very useful at all. In fact, I find it very irritating." [F, 67]
			Port Macquarie (2 males)		
			Metropolitan Sydney (2 males, 4 females)		
Adaptive Cruise Control	11 (46)		Central Coast (2 males, 1 female)		"Cruise control is good…we use it a lot!" [M,80] "I have used cruise control before but not to any great length, and I didn't really like that experience because it's just another thing that if you don't do 100% right you just get a lot of beeping, just like the fridge door opening or microwave, there's always something telling you what to do and it drives me crazy." [F, 70]
			Port Macquarie (4 males)		
			Metropolitan Sydney (1 male, 3 females)		
Bluetooth connectivity	10 (42)		Central Coast (3 males, 2 females)		"The Bluetooth… now that's really good." [F, 74] "They can have Bluetooth allowing you to use your phone in the car. Now to me – that is wrong." [F, 82]
			Port Macquarie (N/A)		
			Metropolitan Sydney (5 females)		
Navigation system/Global positioning system (GPS)	9 (38)		Central Coast (2 males, 2 females)		"We find that the GPS is very useful because, you know, the woman or the man will tell you what you got to do. Unfamiliar circumstances, that's very useful." [M, 71] "I think they are brilliant because I have a very poor sense of direction and it has really been…I love my GPS in my car." [F, 67]
			Port Macquarie (1 male)		
			Metropolitan Sydney (4 females)		

Forward collision warning	8 (33)		Central Coast (3 males)		"I've been impressed with the Mazda having its forward radar warning…" [M, 74]
			Port Macquarie (3 males)		"I have the sensors that go off when I [am] close to someone else in the rear and the front of the car which I find very good." [M, 74]
			Metropolitan Sydney (2 females)		
Automatic high beams	8 (33)		Central Coast (4 males)		"And I don't find that works very well, I would've preferred to turn the high beam off myself because it doesn't always…it turns off at times when I don't want it to turn off." [F, 67]
			Port Macquarie (3 males)		"I think things like automatic lights, I'm not happy with those because the first time I read a Mercedes handbook, it said that sometimes it doesn't work, so just check that it's happened. That makes it worse than not having it." [M, 87]
			Metropolitan Sydney (1 female)		
Automatic emergency braking	8 (33)		Central Coast (2 males)		"Yes, well down to about probably 10 k's an hour and just about stop and suddenly I felt the brakes go on
			Port Macquarie (2 males)		much stronger. It stopped earlier than I would have stopped. It decided to stop. I was very impressed." [M, 74]
			Metropolitan Sydney (2 males, 2 females)		"Not too sure about the self-braking that always worries me a bit." [M, 77]
Lane keeping assist	6 (25)		Central Coast (3 males)		"And that's very disconcerting having the steering taking over moving you around the lane because you're might be doing it for a particular purpose. There might be some reason why I would want to move to the left or right in the lane. So I find that to be a bit intrusive so I turned it off." [M, 74]
			Port Macquarie (3 males)		
			Metropolitan Sydney (N/A)		"I don't have the… frankly I don't see the point, if you're paying attention you know you're in the right lane and don't need the car to push you back." [M, 69]
Blind-spot warning system	6 (25)		Central Coast (1 male, 1 female)		"The Honda that we have has an excellent little camera that's in the left hand side mirror which when you put your left hand blinker on, it shows up the blind spot on the left side...you can also press a button

			Port Macquarie (2 males)		and show it up. I think that's a really good safety feature." [M, 71] "I really love the feature that tells you what's coming up on your blind spots and your mirrors. You know…when you're…a light beeps and there's a light that comes on and it beeps on the mirror when a car is either passing you on the right or the left. I find that incredibly helpful because it's always been a problem." [F, 67]
			Metropolitan Sydney (2 females)		
			Central Coast (N/A)		"The reason I've got the car I have now is that I tend to have a heavy foot, and the car I have has a heads up in it. So, when I look ahead on my windscreen, I see the speed limit I should be doing, and the speed I am doing. That's makes a hell of a difference." [F, 82]
			Port Macquarie (1 female)		
			Metropolitan Sydney (N/A)		
Heads-up display	1 (4)				

green = positive attitude (all participants who mentioned the technology liked it)
yellow = mixed attitude (only some participants who mentioned the technology liked it)
red = negative attitude (all participants who mentioned the technology did not like it)

respondent [M, 74} described having the vehicle take-over as *"disconcerting"* and *"intrusive"*, especially when the intervention is not needed therefore making the AVT come across as a hindrance towards driving safety.

4. Expensive out-of-pocket costs stop AVT usage

Additional costs associated with purchasing a vehicle with AVTs disincentivised their use and made respondents less likely to value such vehicles, despite their awareness of the technologies' safety and importance. All respondents appeared to prioritise other vehicle factors such as affordability and price and indicated they would only invest in a vehicle with AVTs if their budget allowed. AVTs were only included in the vehicle-purchasing decisions if the respondent felt that they were necessary *"If I can afford them and think they are necessary, I would get them."* [M, 74].

4. Discussion

This study contributes further information on why older drivers perceive certain AVTs the way that they do, and why they are more inclined to use select technologies over others. It can be seen from the semi-structured interviews that there is hesitancy around how select AVTs help with safety. This is particularly for AVTs which are considered more difficult to learn about which therefore inhibits their use. Where the individual lives also determine which technology they use. As mentioned above, lane departure warnings and cruise control were well liked by drivers from more regional areas compared to metropolitan Sydney. This might be because lane departure warnings have been shown to not work accurately in urban traffic conditions where lane marking are harder to distinguish (Leng and Chen, 2010). Meanwhile, variable speed limits in more urban areas limit cruise control from being used. This study also provides more discussion towards the importance of user-friendly designs to ensure the appropriate support is available for older drivers to become more competent at using AVTs. It would be worthwhile for future policies surrounding technology design to consider the needs and skills of older adults. The results from this study also highlight the importance of marketing strategies for AVTs which should be positioned as supportive features to promote safety. This would decrease negative attitudes older drivers have of select technologies and increase their likelihood to learn more about and use AVTs.

The awareness and attitudes towards AVTs voiced by respondents in this study is in agreement with finding from research in this area. Similar to this study's findings, previous Australian surveys have shown AVT awareness to be low amongst drivers aged 65 years and older even after interviewer prompting, with overall understanding of AVTs limited to simple, familiar features available as standard inclusions (Oxley et al., 2019a, 2019b). This might be because older drivers tend to drive older cars which lack many of safety technologies (Cox and Cicchino, 2022; Cox et al., 2022). The LongRoad study which is set in the USA further argued the lack of AVT awareness and usage to be attributed to the lack of trust and negative connotations surrounding the technologies' perceived usefulness, functional limitations, and system costs (Eby et al., 2018); sentiments also voiced in this study. Older drivers are less enthusiastic about AVTs compared to younger drivers and are more likely to rate them as a distraction (Owens et al., 2015; Zhan et al., 2013). Overwhelming distractions, specifically from false alarms, were one of the main reasons why participants in this study held negative attitudes towards select AVTs and wanted to turn them off. Another study also noted false alarms to be the reason for poor perceptions and usage of AVTs (Eby et al., 2016). Increased automation also decreases technology enthusiasm which is why, just like this study, AVTs such as lane-keeping assist have been rated negatively by older drivers (Lajunen and Sullman, 2021; Liang et al., 2020). It has been proposed that this might be because older drivers tend to self-rate their skills highly based upon self-perceived efficacy rather

Table 4
Major themes identified from the semi-structured interviews with older drivers, and their corresponding CTAM determinants.

CTAM Determinants	Theme	Description	Quotes
Performance expectancy and attitudes towards using technology	AVTs help with safety but overall responsibility remains with the driver	AVTs can make driving safer. However, they cannot be relied upon to ensure driving safety. The onus of safety still lies with the driver whose skills are viewed as being better than the technologies' abilities.	"They are second line after the driver. The driver is responsible first but having them looking over your shoulder, it's a good thing." [M, 74] "So I guess what I'm saying is I'm a bit ambivalent about the modern motor vehicles, I think the more features … yeah … but somehow the responsibility of the driver could be lessened, and they're in a bit of a false sense of security." [M, 71] "But I think we should be very careful not to feel that we can drive unsafely because we've got safety features." [M, 87] "The features that keep you in the white lines or not they probably help but if you are a good driver I don't think you really need them." [M, 80] "… so I'm not very keen on all these new gadgets because there's more to go wrong." [F, 78]
Effort expectancy, facilitating conditions, self-efficacy, social influence, and anxiety	Lack of clear information and instructions make AVTs look confusing	With the lack of clear advice from experts, such as car salespersons, self-directed learning of AVTs is common. However, the lack of guidance can make older drivers feel confused about the vast information on AVTs and disengaged with learning more about these technologies.	"I think I have an affinity for technology. Nobody taught me, in fact some of the things I found out, I found out by sheer accident." [F, 82] "Just myself … I read a lot on the internet, I talk to my friends about vehicles and what's been offered and also talk with my family." [M, 74] "These days I'm still finding out minor things about this car after 3 years … because there's 100s of pages." [M, 87] "I open the book and instructions don't make any sense to me." [F, 79] "I think it's also really important, particularly someone whose 60 and over, if they haven't had a car with bells and whistles that the things are explained to them properly because nobody explained a thing to me." [F, 68] "… so the fact that they would be prepared to talk to you even after they have sold the vehicle, is a critical point I think with anybody who purchases a car. To make sure the salespeople will actually talk to you about it in the first instance, but refresh your memory again a month or 2 later if you need it." [M, 82]
Attitude towards using technology and perceived safety	AVTs need to be more user-friendly for older adults	AVTs which are deemed too complicated to use or are capable of temporarily taking over control of the vehicle are not well-received by older drivers.	"Yep its autonomy, we like to be in control and we don't like hand-outs … and that's where the automatic braking is sort of an issue …" [M, 77] "I suppose it's a bit like me not being not comfortable with the thought of cruise control … is that people perhaps want to be more in control of what they do rather than relying on technology." [F, 74] "… but it does have lane keeping assist which means that if you move towards the edge of a lane, the steering tries to steer you back into the centre. And that's very disconcerting having the steering taking over moving you around the lane because you're might be doing it for a particular purpose. There might be some reason why I would want to move to the left or right in the lane. So I find that to be a bit intrusive so I turned it off." [M, 74] "And they said to me they don't use it because they can't actually see it …" [M, 71] "I was told that it was automatic and could do all these wonderful things but I think it's very

(*continued on next page*)

Table 4 (*continued*)

CTAM Determinants	Theme	Description	Quotes
			complicated in that it's got a whole lot of buttons on the steering wheel. But it's also got all other things on the dashboard that do the same thing I think there's just too many things to press. It's overwhelming and the fact that I think I don't need most of them …" [F, 72]
Facilitating conditions	Expensive out-of-pocket costs stop AVTs usage	Even though AVTs are understood to assist with safety, their high added-on costs disincentives older drivers from including them when purchasing a new vehicle.	"If I can afford them and I think they are necessary, I would get them." [M, 74] "… but no it's mainly comfort and affordable as you say, basically." [M, 75] "Yeah, so having got the camera came with the car, so I'm quite happy that it's there and I certainly use it but you know I probably wouldn't have gotten it if I had to pay for." [M, 76] "Of course the price. We'd have to see how much extra everything is because we can't sometimes get all those gadgets." [F, 79]

than functional ability (Ackerman et al., 2010), therefore viewing technologies as a hindrance rather than an assistance to their driving ability (Freund et al., 2005); opinions also held by this study's respondents. These unfavourable attitudes may be why many older drivers prefer other vehicle features over AVTs when looking for a new car (Koppel et al., 2013; Oxley et al., 2019a; Zhan et al., 2013). This would explain why many respondents in this study valued vehicle cost and other attributes, such as comfort, over AVTs even if they were aware of the technologies' safety benefits. Future studies could explore ways of addressing the negative perceptions to increase support and uptake of AVTs amongst older drivers.

Negative attitudes and flawed assertions about certain AVTs may stem from the lack of clear instructions and guidance available for older adults to learn more about AVTs (Gish et al., 2017). The majority of respondents in this study learnt how to use the technologies themselves, mainly through a trial and error method using the vehicle's manual. This is reflective of other studies in the literature. Self-directed learning and other external resources, such as the internet, and information from family and friends are the most common ways many older adults gain understanding of AVTs (Koppel et al., 2013; Zhan et al., 2013). Further, paper-free manuals, currently used by companies such as Apple, may make accessing information about AVTs easier compared to the content-heavy vehicle manuals which some respondents in this study found too cumbersome to navigate. Other studies have investigated the point of sale as an opportunity for conveying information about AVTs. Dealership personnel are only approached if the individual feels comfortable and has had positive experiences with the car salesperson (Liang et al., 2020; Zhan et al., 2013). Men are also less likely to ask others for help with AVTs compared to women (Eby et al., 2018), which was also reflected in this study. It has been well proposed that men tend to not ask for help as much as women due to a combination of both personally endorsed masculine stereotypes and societal gender stereotyped attitudes (Juvrud and Rennels, 2017). Further, the stereotypes and attitudes men hold towards masculinity tend to not change in comparison to women and their views on femininity (Lopez-Zafra et al., 2012). Technology use has also traditionally been characterised as a masculine activity which may prevent men from seeking out help due to stereotypes on men inherently having high technical ability and proficiency (Cooper, 2006).

Older adults have been reported to prefer more comprehensive sources, such as a hands-on program guided by experts, regardless of gender (Greenwood and Baldwin, 2022). Training and education programs, particularly ones encompassing both an in-class and hands-on on-road components, aimed at increasing AVT awareness and knowledge for older drivers may help older drivers make full use of AVTs. Such programs have been shown to increase the positive attitudes older drivers have on AVTs by allowing to them to better understand how to use these technologies correctly to keep themselves and their passengers safe (Dennis Thomas et al., 2020; Liang et al., 2020). Information retention is also longer amongst older drivers who go through both the in-class and on-road components compared to those who only complete one or the other (Castellucci et al., 2020). In Australia, new guidelines to help driver trainers and assessors respond to the increasing number of advanced driver assistance technologies were introduced in 2022 with a consumer guide expected to be released in 2023 (Rajan and Other-Gee, 2022). On-road training on how to use AVTs could be delivered by driving instructors and/or driver trained occupational therapists. Further, these professionals could offer AVT training courses to older adults who have either recently bought a vehicle or are intending to purchase a vehicle with AVTs. The older drivers in this study expressed an interest in help on AVTs but did not articulate the format this could take, noting that driver training for AVTs is not currently widely offered in this setting. Training courses held during license renewals may also be feasible, but care must be taken to ensure that this extra step does not introduce additional burden to older adults, particularly those who are already negotiating age-based licensing requirements. For example, the participants in this study all live in the state of NSW, Australia, which currently has an age-based licensing scheme for those aged 65 years and older. An alternative to the on-road AVT training programs are simulations and or videos set-up which may be sustainable ways to show drivers how to use the technologies. A previous study has found perceptions of safety, trust, and perceived usefulness of AVTs to increase in older drivers after they were exposed to the technology via simulation (Classen et al., 2020). However, there needs to be more work done to decide the best mode of delivery.

As mentioned by this study's participants, how a technology is designed and its ease-of-use are important factors to whether or not

the feature is liked and used by older adults. Even though the majority of older drivers do own older cars, there is an increasing trend of older drivers looking for and purchasing new higher-end vehicles containing many of the new AVTs (Young et al., 2017). As most older drivers learn about AVTs themselves, their designs therefore need to be both easy to learn and navigate and practical enough to meet the diverse needs and abilities of older drivers (Vrkljan and Miller-Polgar, 2005). For example, many AVTs are designed using the automatic Human Machine Interface guidelines which aim to minimise driver workload and distraction when using the technology (Green, 2008). However, these guidelines do not address specific design concerns for older driver (Young et al., 2017). Only two guidelines, the Transport Research Laboratory and the Battelle Crash Warning System guidelines, have been found to advise on designs for older drivers. However, their suggestions are broad which therefore make their application difficult to monitor (Young et al., 2017). The only regulations which specifically mention older drivers are two SAE Technical Standards, J2119 and J2217, which detail designs rules that would accommodate for the visual, cognitive and physical changes related to ageing (Young et al., 2017). It could be argued that the lack of consideration for older drivers in the guidelines may be due to ageism which would become a barrier to technology usage (Mannheim et al., 2019). Some studies suggest taking a holistic approach to designing technologies for older adults which combines their capabilities and limitations, needs, preferences and desires for technology use by involving them in the design process (Eby and Molnar, 2012; Rogers and Fisk, 2010). It would therefore be worthwhile for future policies surrounding designs of AVTs to better integrate the needs and opinions of older drivers.

Strengths of this paper include the use of semi-structured interviews and the CTAM framework to guide the creation of the questions. The CTAM framework ensured that questions and discussions were centred around car technology and safety only, and not other technologies where opinions, knowledge and motivation of use may be different. Combining both content and thematic analyses allowed for richer discussion the authors could quantitatively see which AVTs were more popular and well-known while also using the qualitative data to understand why these differences exist. There was also a similar split between male and female participants interviewed therefore reducing the potential of sex biases in the results. Findings could also be generalised to the greater population as similar numbers of participants were recruited from different socio-economic areas. However, there are study limitations that must be noted. The first is that the sample size is relatively small at only 24 participants, however the authors did conclude data saturation has been reached. Self-selection bias may pose potential issues towards the generalisability of the results as only those who already had an interest in vehicle technology would be interested in participating. Eligibility criteria used in the study could have been stricter to allow for richer discussions of more different types of AVTs. This could have been done by only recruiting people who had recently bought a relatively new car with AVTs included. There were also no participants recruited from remote areas. This would impact the generalisability of the findings to drivers in these communities who have been shown to have different driving challenges and preferences than drivers in urban settings (Payyanadan et al., 2018).

5. Conclusion

In conclusion, this study shows that older drivers are aware of a range of standard AVTs on the market. Their motivations of use is dependent on their attitudes towards the technology with more complicated and autonomous features seen as a barrier for adopting these features. More appropriate resources and options for older adults to learn how to use AVTs need to be developed. There also needs to be more discussion surrounding the design of AVTs to make them more user-friendly for older drivers. Such discussions can guide the creation of future policies and resources aimed at AVT adoption in older adults. Studies investigating how AVTs influence vehicle purchase may also give more insight into why some technologies are preferred over others.

Author statement

Helen Nguyen: writing – original draft, conceptualisation, methodology, formal analysis; Kristy Coxon: writing – review and editing, conceptualisation, methodology; Julie Brown: writing – review and editing, conceptualisation, methodology; Nick Neville: writing – review and editing, conceptualisation; Gian Luca di Tanna: writing – review and editing, conceptualisation; Yun-Wen Hsieh: writing – review and editing, formal analysis; Lisa Keay: writing – review and editing; conceptualisation, methodology.

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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.

Data availability

Data will be made available on request.

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