Age and Safety Perceptions in Autonomous Vehicles

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Executive Summary

Autonomous vehicles are the future of the transport industry. How accepting is society, and are we ready for this advanced technology? We investigated how age and safety perceptions differed with autonomous vehicles before and after trialling one with the research questions:

- Do safety perceptions of autonomous vehicles vary in different age groups?
- Do these perceptions change with trialling the vehicle?

We hypothesised that the younger age groups would be more accepting with less safety concerns towards the technology and the older age groups would be more critical. A survey was distributed via multiple platforms utilising the snowball and convenience sampling methods which gathered 448 responses. With the assistance of HMI Technologies we were able to conduct trials with an autonomous vehicle over three days on a private stretch of road by Christchurch International Airport. 88 participants attended focus groups following the trials to discuss whether their safety perceptions had changed.

Our research found that post-trial 98% of people felt safe in the vehicle but wanted to change or add other safety measures for extra comfort and assurance. While the general trend was a greater concern on physical safety, younger age groups were also aware and concerned about cyber security.

Introduction

HMI Technologies, in association with Christchurch International Airport, are currently trialling autonomous vehicles (AVs) to explore their potential use as a transport service, including travel from airport terminals to off-site parking facilities. HMI Technologies, while looking at all the facets that need addressing to deploy these vehicles in NZ and Australia has recently launched New Zealand's first AV, Ohmio. To help HMI develop a line of AVs that would be accepted by the public, we have conducted research around age and safety perceptions of AVs to find how they can be made more appealing for public usage. Our research questions are: "do safety perceptions of autonomous vehicles vary in different age groups?" and "do these perceptions change with trialling the vehicle?". AVs are the future of the transport industry and provide significant benefits for the environment and human safety. AVs have the ability to reduce traffic congestion which will save passengers time and money (Fagnant & Kockelman)(Payre, Cestac, & Delhomme, 2014). Benefits for the environment include less fuel consumption and reduced greenhouse gas emissions contributing to a more sustainable and energy secure future (Fagnant & Kockelman, 2015)(Payre, Cestac, & Delhomme, 2014). Since this technology is still new and in development stages, there is little existing research available around it, including research regarding age and safety perceptions of the public. Research is needed with physical trials in order to gain the public's true safety perceptions as opposed to just speculating on their imagination (Payre, Cestac, & Delhomme, 2014). This report aims to fill this gap of missing research and assist HMI with future developments of AVs for a smoother integration into society. We hypothesise that the younger age group will be more accepting towards AVs with less safety concerns than the older age groups.

Literature Review

AVs have the potential to benefit the future of our safety and the environment extensively. Research has outlined the ability for AVs to improve road safety by eliminating human error (Pendleton et al., 2017)(Payre, Cestac, & Delhomme, 2014). AVs cannot drink and drive, and will not fall prey to other factors that play a role in human error like speeding, aggression, fatigue, inexperience, and slow reaction times. Fagnant and Kockelman (2015) believe that AVs have the ability to reduce fatal crash rates by at least 40% by removing human error assuming malfunctions are minimal. With the success of AVs, road accidents could become a thing of the past (Casley, Jardim, & Quartulli, 2013).

There is a considerable amount of public mistrust regarding AVs. People find the lack of control unsettling and tend to mistrust that a computer can operate safely on roads (Casley, Jardim, & Quartulli, 2013). Another general idea found is that experienced drivers tend to trust their own abilities more than a computer (Bansal & Kockelman, 2016). LIDAR sensors create 3-dimensional models of everything surrounding the vehicle, giving it a constant view of what is around. This means that the computer already knows more about its surroundings than a human driver could (Casley, Jardim, & Quartulli, 2013). This highlights that AVs are actually safe and efficient regardless of what safety perceptions the public may have. Locus of control is a personality trait that echoes the extent of what a person believes they can control in events that affect them (Payre, Cestac, & Delhomme, 2014). This can be a reflection of why people have a lack of faith in AVs and highlights why our research in

particular is needed as physical trials of an AV has the ability to alter one's opinion with experience.

Bansal and Kockelman (2016) conducted a survey in Texas, USA, around the topic of safety perceptions and acceptance of AVs. The survey results showed that 61.4% of respondents were very worried about equipment failure, 52.9% were very worried about legal liability, and 55.1% were very worried about the vehicle being hacked. Another survey by Kyriakidis, Happee, and de Winter (2015) also found similar results from their survey as their respondents were most concerned with software hacking and misuse in AVs.

Little to no correlations have been found in existing research with age being a key variable in terms of safety perceptions and acceptance (Kyriakidis, Happee, & de Winter, 2015)(Payre, Cestac, & Delhomme, 2014). Scholars have hypothesised that the younger age groups would be more accepting towards the technology than older age groups who might struggle to connect with it (Bansal, Kockelman, & Singh, 2016). AVs have significant potential for helping the elderly have more independence where they previously would not have been able to transport themselves, therefore looking at their perceptions is essential as they need to be able to connect with the technology and feel safe in doing so (Casley, Jardim, & Quartulli, 2013). The fact that no research has found any correlation of age or focussed solely on age being a key variable in public perceptions regarding safety concerns relates back to why this study is needed to fill in the gap of missing research.

Methods

Survey

The method used to gather our primary data is known as sequential data collection which consists of different collection procedures (Creswell & Plano Clark, 2007). The data was collected in three stages: first being the survey, second being the vehicle trial, and third being focus groups. The qualitative and quantitative data can then be related together to answer our two research questions (Creswell & Plano Clark, 2007).

Surveys were the first method chosen to answer our first research question because they are a time efficient way to gather primary data from a large sample size (Casley, Jardim, & Quartulli, 2013). Surveys are useful for gathering relevant information about people in terms of their opinions, beliefs and experiences which gives us raw data on how the public truly feel about AVs (McGuirk & O'Neill, 2010).

An 11-question survey was constructed on http://canterbury.qualtrics.com that ranged from asking respondents about their general opinion regarding AVs and progressed into more specific questions about any safety concerns that they may have. When constructing the surveys, reading other research reports with similar survey topics helped find specific questions to get the best responses. For example, Schoettle and Sivak (2014) asked their respondents about their general opinion regarding AVs, this question is something we thought would be beneficial to us and therefore added it into our survey. The term "driver-less vehicle" was used in the surveys instead of "autonomous vehicle" to avoid any confusion as a simplified term is better understood by the general public.

Before finalising our survey, 15 pilot surveys were distributed to identify whether any of the questions or terminology could be misleading or misinterpreted (Flowerdue & Martin, 2015). Snowball sampling methods were used for the initial distribution of the surveys. The survey was posted in a range of different social media sites like Facebook, LinkedIn, and HMI's twitter page to reach a large audience. New Zealand Geographical Society, Aotearoa New Zealand and Mobilities Network also emailed the survey to people signed up to their mailing list. In order to gain survey responses from all age groups, retirement villages were contacted to gain permission for paper copies to be distributed to their residents. Convenience sampling was used for this aspect of distribution as paper copies were taken to Russley Retirement Village as they were close to the location of physical trials and we believed we would get more people attending them for this reason.

Physical Trial

Of the three methods used in our research, the physical trial of the AV required a vast amount of time and organisation. It was important to include a physical trial as this allowed for observations to be made regarding if people's perceptions had changed.

From Wednesday 20th to Friday the 22nd of September, 2017, HMI Technologies provided the equipment necessary to conduct trials with the AV. This consisted of a strip of sealed road that was approximately 1km long, privately owned by HMI and Christchurch International Airport. The AV that was used in the trial was a French manufactured NAVYA ARMA which has a capacity of 15 passengers. During the trial, the AV did not exceed 20km/h to simulate the speed it will be used under commercial operations at Christchurch International Airport. The trial had groups of 1-10 participants trialling the vehicle at a time, allowing for a sufficient variety of individuals to partake. Each trial allowed for group dynamics to be closely observed.

Unfortunately, the vehicle was not operating fully autonomously during the physical trial. This was due to the relocation of the GPS base station from which the vehicle maps routes. As a result of this, the GPS location was not recalibrated to the new location. The case for the relocation was to comply with Aviation Security at the Christchurch Airport. Due to this occurrence, the vehicle was manually driven using a controller conducted by an employee from HMI Technologies. All sensors were still fully functioning during the trial meaning that the vehicle would still stop if any obstacles were detected.

Focus Group

On completion of the physical trials of the AV, participants were given the opportunity to partake in a focus group. HMI Technologies also provided facilities at the test strip in which we could conduct the focus groups. The facilities consisted of a prefabricated shipping container with a table and chairs. When the focus groups commenced, each participant signed a consent form acknowledging their contribution to our research and that all information provided will remain confidential.

Focus groups provide qualitative responses that are not limited to a certain number of answers as in the initial survey. Cameron (2010) highlights the benefits of in-depth focus groups as a method to obtain more information as a group of participants interact and respond to each other. This approach exposes individuals to new ideas and different point

of views that they may not have previously considered which also has the ability to change their perceptions.

The focus groups were semi-structured in terms of having five main questions but the discussions allowed more questions to be introduced to enhance the flow and direction participants were taking on the topic. Two methods of recording the focus groups were used; note-taking and audio recording. One group member led the focus group discussion while another would be taking notes to record the main themes discussed by each group (Cameron, 2010; Gomez & Jones, 2010). Audio recordings were also used to provide the exact details required to transcribe the conversation and portray the tone of voice used, which is not recorded by the note-taker (Flowerdew, 2005). This enabled the focus group leader to engage with participants and the note-taker was able to take general notes without either member needing to remember exact details. The transcriptions from focus groups were then categorised into main themes for data analysis.

Results

Survey

As outlined in the methods, a range of data was collected from the survey. The key questions that are relevant to our research have been analysed to identify any relationships between age and safety in the data.
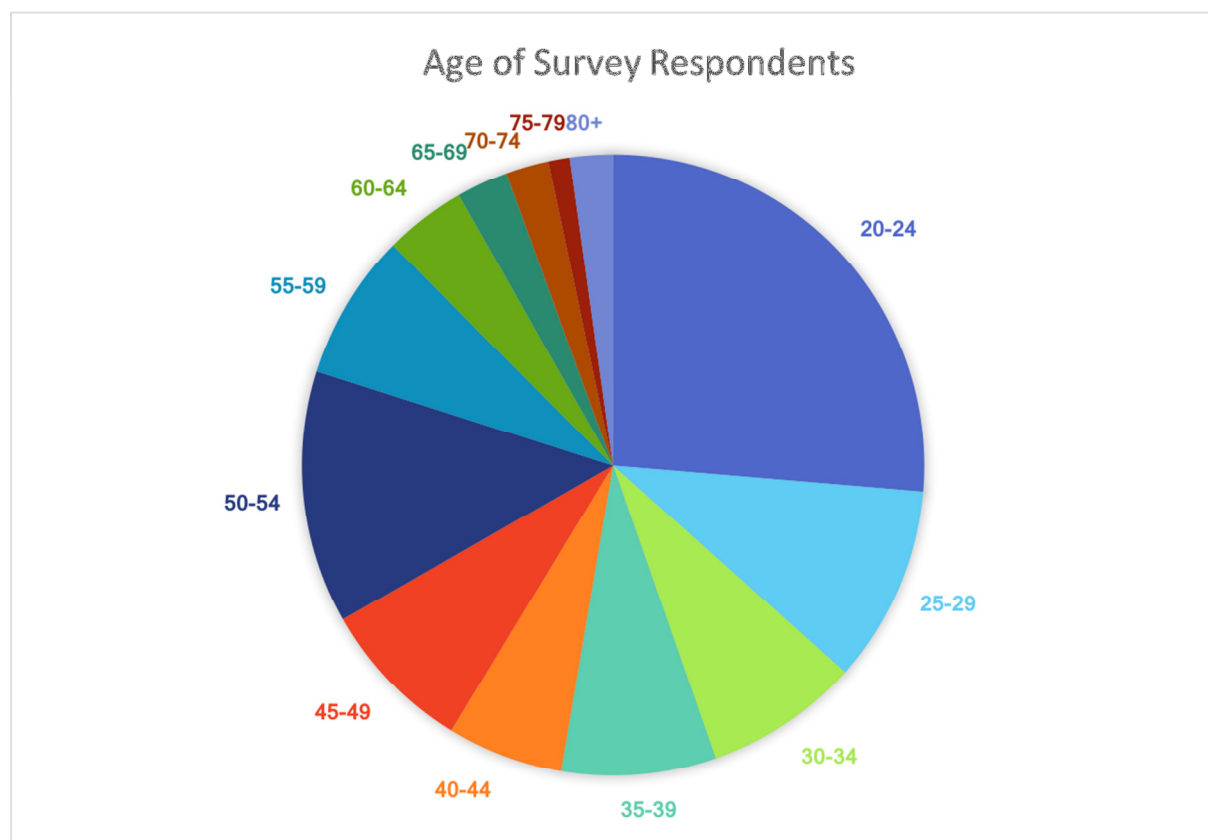

Figure 1. Ages of the survey respondents

The age of the survey respondents is one of two key aspects in our research. There are two significantly larger age groups in figure 1, 20-24 and 50-54. This is a result of the snowball and convenience sampling methods used to gather data. By group members and their families sharing the survey on Facebook, it skewed the responses towards friends of a similar age and older family members from these two age groups.
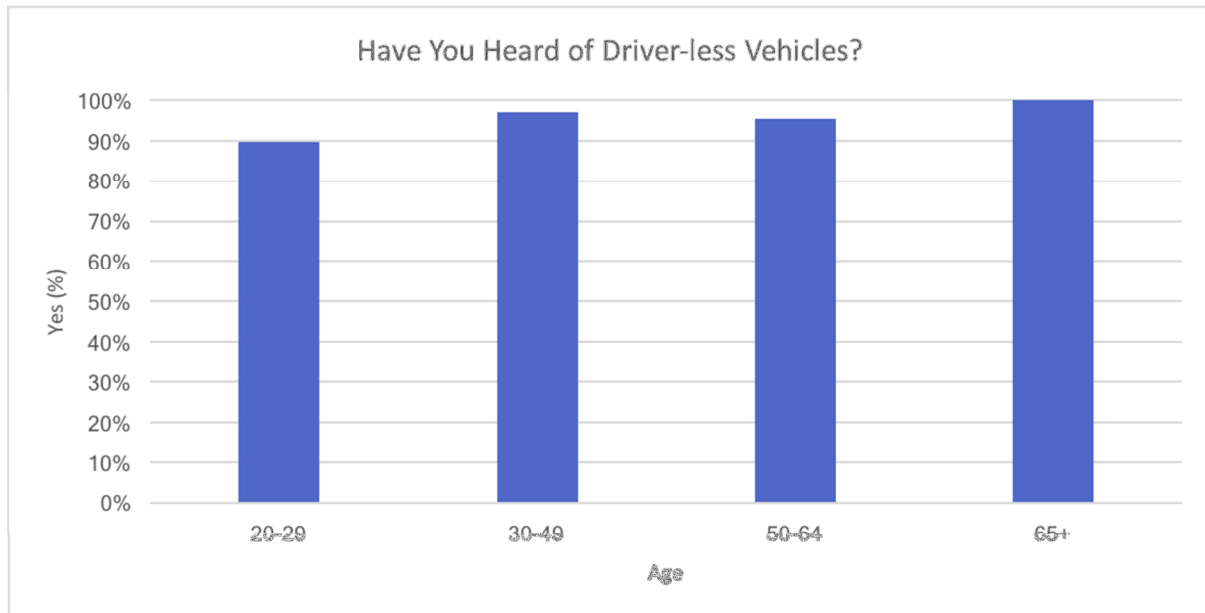

Figure 2. Survey results from the question, "Have you heard of driver-less vehicles?"

The first survey question we asked in relation to AVs was if the respondent had previously heard of AVs before answering the online survey. In order to display the general trend of the results, the 13 age groups were condensed into 4, as shown in figure 2. Figure 2 shows that the majority of respondents were aware of AVs. The graph shows the youngest age group, 20-29, was the least aware, however, 89% affirmative responses is still a strong positive result.
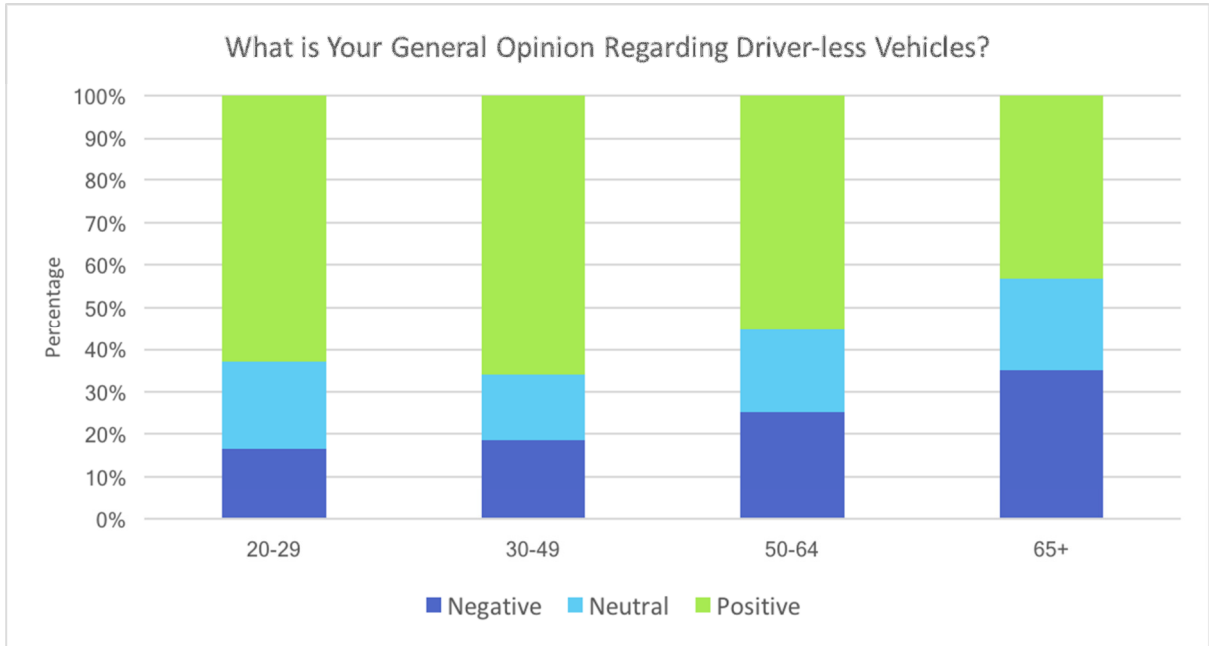
Figure 3. Survey population's general opinion regarding driver-less vehicles

Respondents were asked about their general opinion regarding AVs. Figure 3 shows that the neutral responses towards AVs remained similar regardless of age. However, the younger age groups have a more positive opinion towards AVs. Over 60% of the age group 20-29 having a positive opinion, meanwhile in the 65+ age group, only slightly over 40% of opinions are positive. Figure 3 also shows a trend that negative opinions increase with age, as 17% in the 20-29 group have a negative opinion and increases to 35% in the 65+ category.
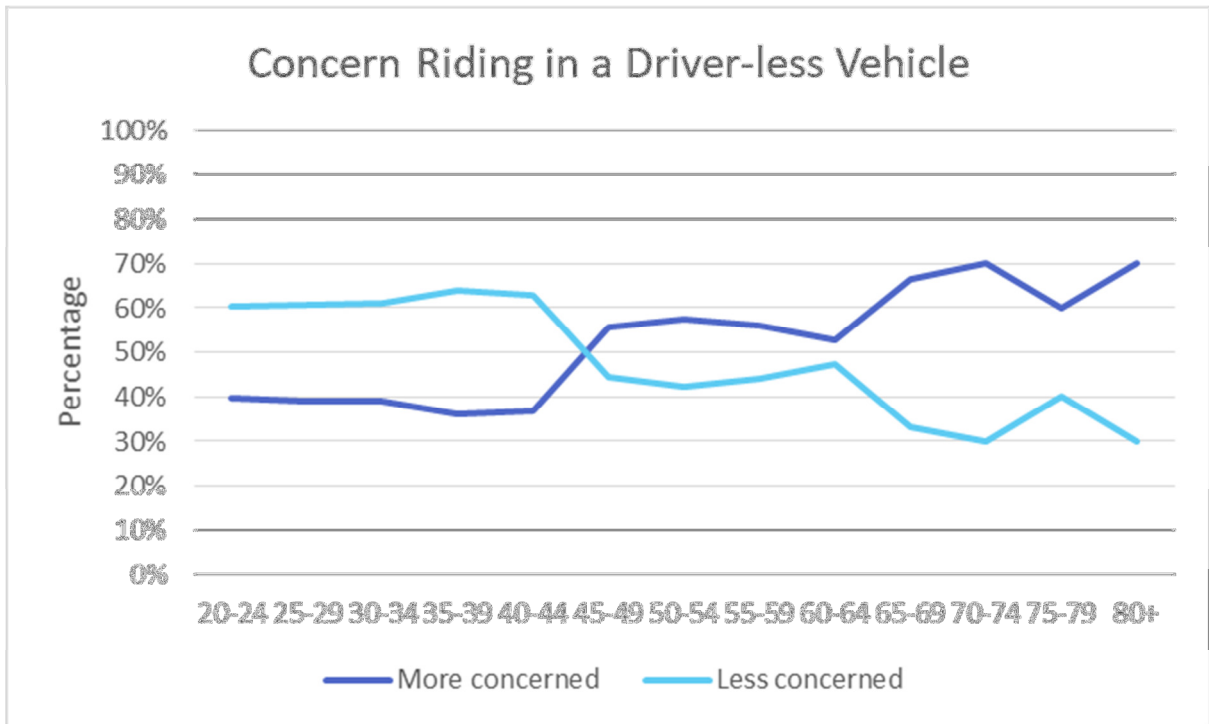

Figure 4. Respondents level of concern of riding in a driver-less vehicle by age.

Another question asked how concerned they would be riding in an AV. There were four possible answers to choose from; very concerned, moderately concerned, slightly concerned and not at all concerned. From this data, the results were condensed into two main categories; more and less concerned. Figure 4 shows that approximately 60% of respondents aged below 45 were less concerned about riding in an AV. The percentage of people less concerned about riding in an AV then gradually declines to 30% as age increases to 65+. Figure 4 shows that from 45 years onwards, those more concerned about riding in an AV increases from 50% to 70%.
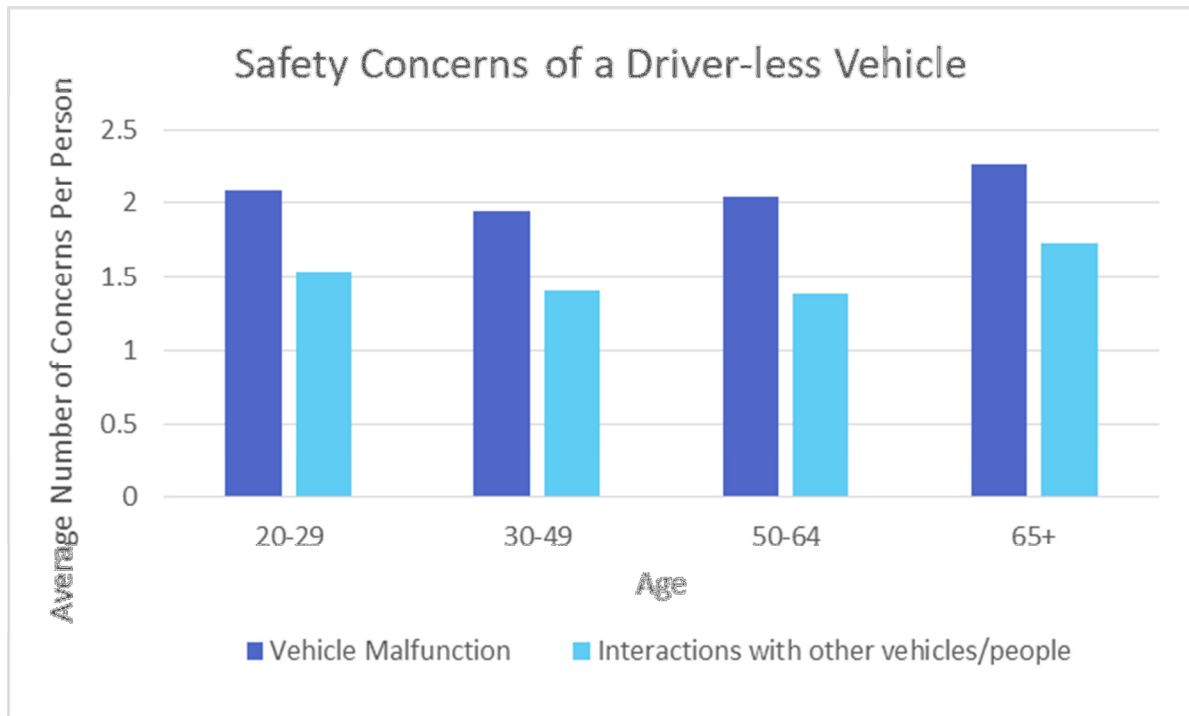

Figure 5. Average safety concerns per person with driver-less vehicles by age

In the next question, respondents were asked what safety concerns they had with AVs. Respondents could select as many possible answers as applicable, and these were condensed into two main categories. The two new categories are; vehicle malfunction and interactions with other vehicles & people. Figure 5, shows clearly that there is a greater concern for the vehicle itself malfunctioning, rather than the vehicle interacting with other vehicles, road users and people in an open environment. These findings are consistent across all age groups.
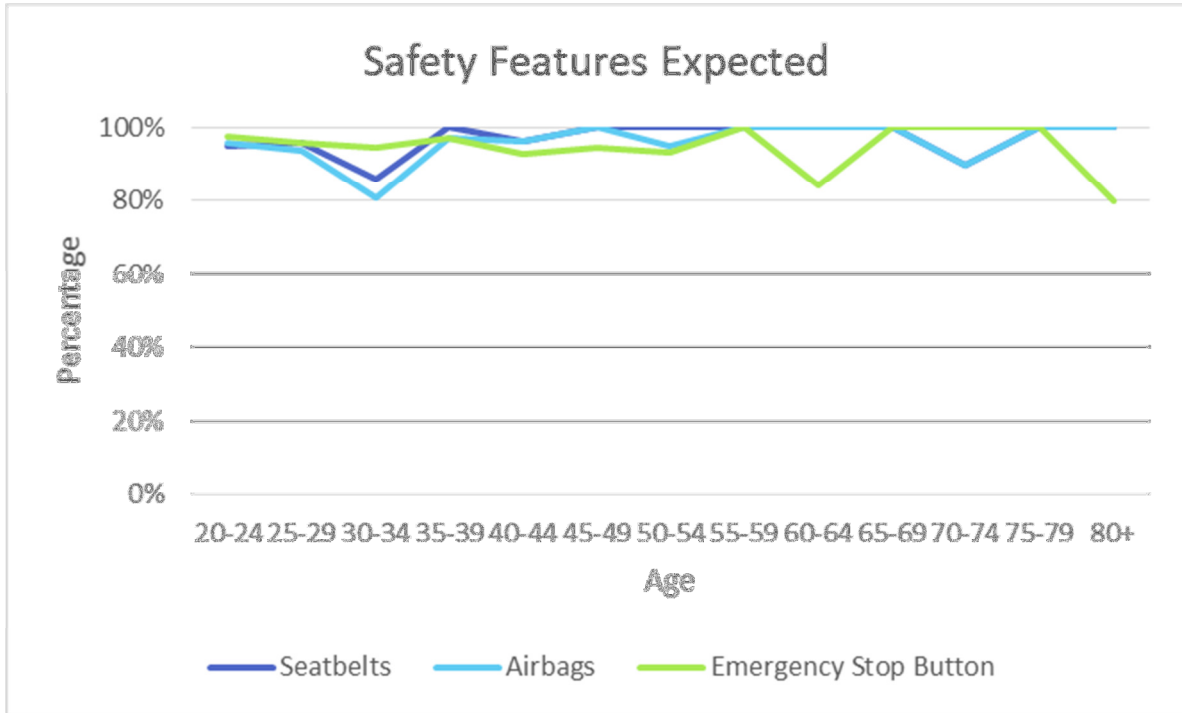
Figure 6. Percentage of people that expected safety features of seatbelts, airbags and an emergency stop button across age.
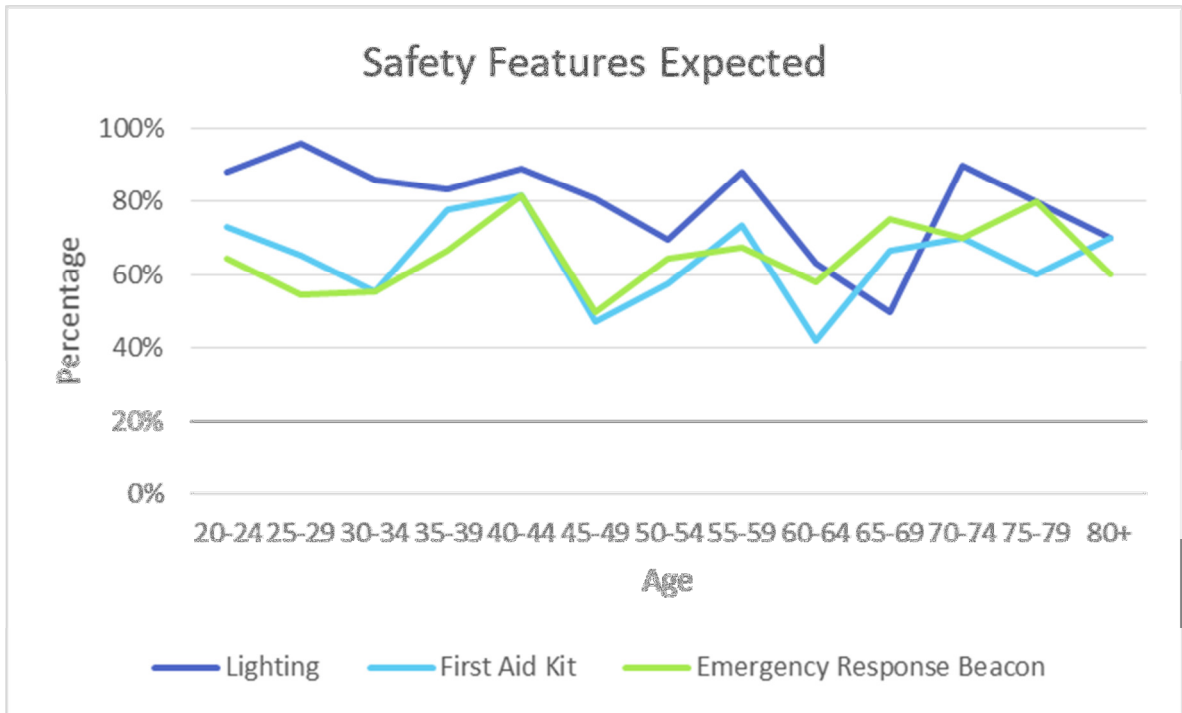

Figure 7. Percentage of people that expected safety features of lighting, first aid kit and emergency response beacon across age

The survey also asked what safety features respondents expected to be present in an AV. Once again, there were a number of options available to be selected in the survey. Figure 6 shows the 3 most frequent responses; seatbelts, airbags and an emergency stop button. All of these safety features were expected by close to 100% of all age groups. Figure 7 shows the other safety features that were also frequently chosen by survey respondents in the same survey question. These included; lighting, a first aid kit and an emergency response

beacon. These were less expected by the respondents across all age categories than the three shown in figure 7 above. However, these all still remained above 50% for the majority of age groups. From figure 6 and 7, we can identify a strong expectation of a range of safety features being available in AVs.

Focus Group

From those who participated in the vehicle trial, 88 attended the focus groups afterwards. The second key aspect in our research was to see if, and how, participant's perceptions of AVs changed after interacting with the vehicle. The information gathered from the focus groups, in collaboration with the survey data, was collated into a format that allowed our results to display qualitative and quantitative evidence.
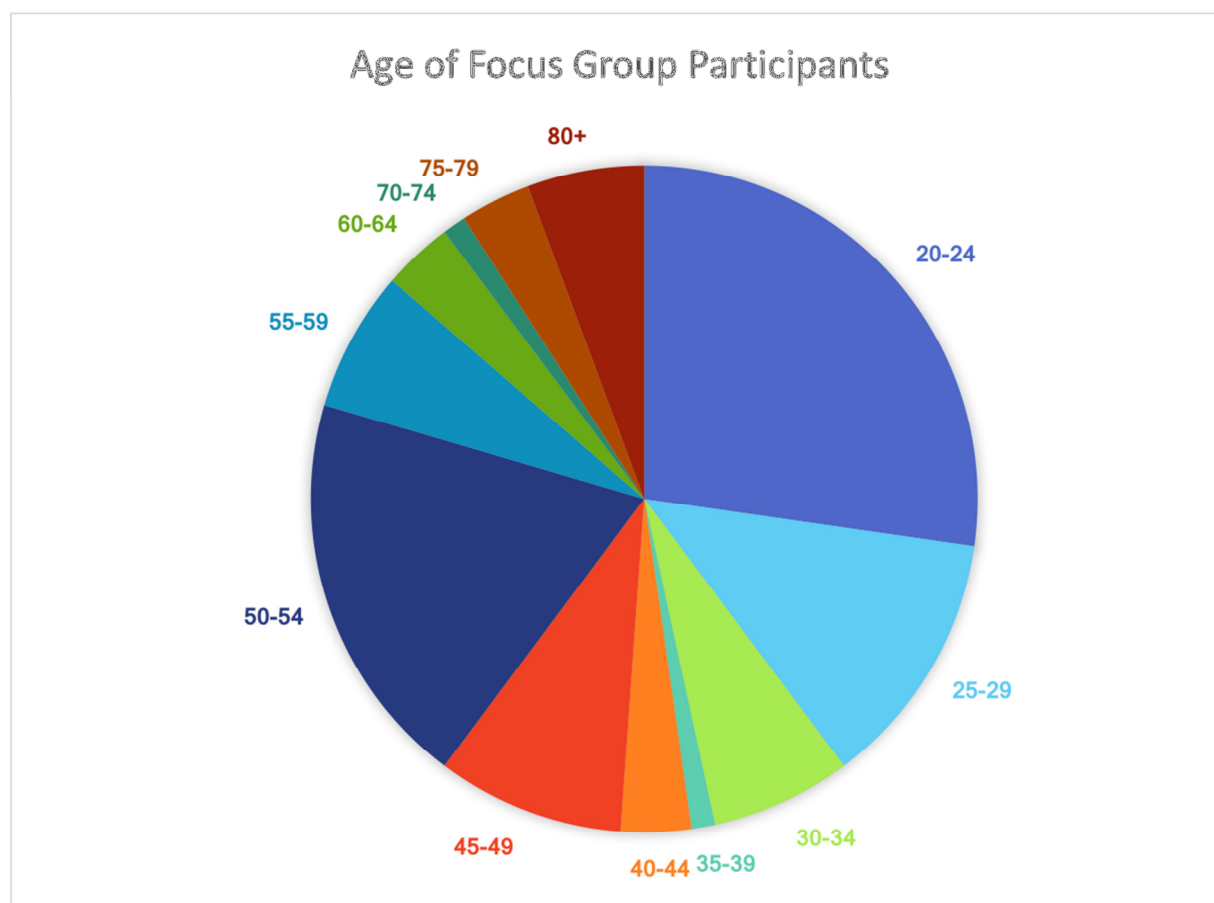

Figure 8. Ages of the focus group participants.

The age demographics for the focus group participants are displayed in figure 8. From observing the graph, we can see a clear distribution of participants in all age categories.
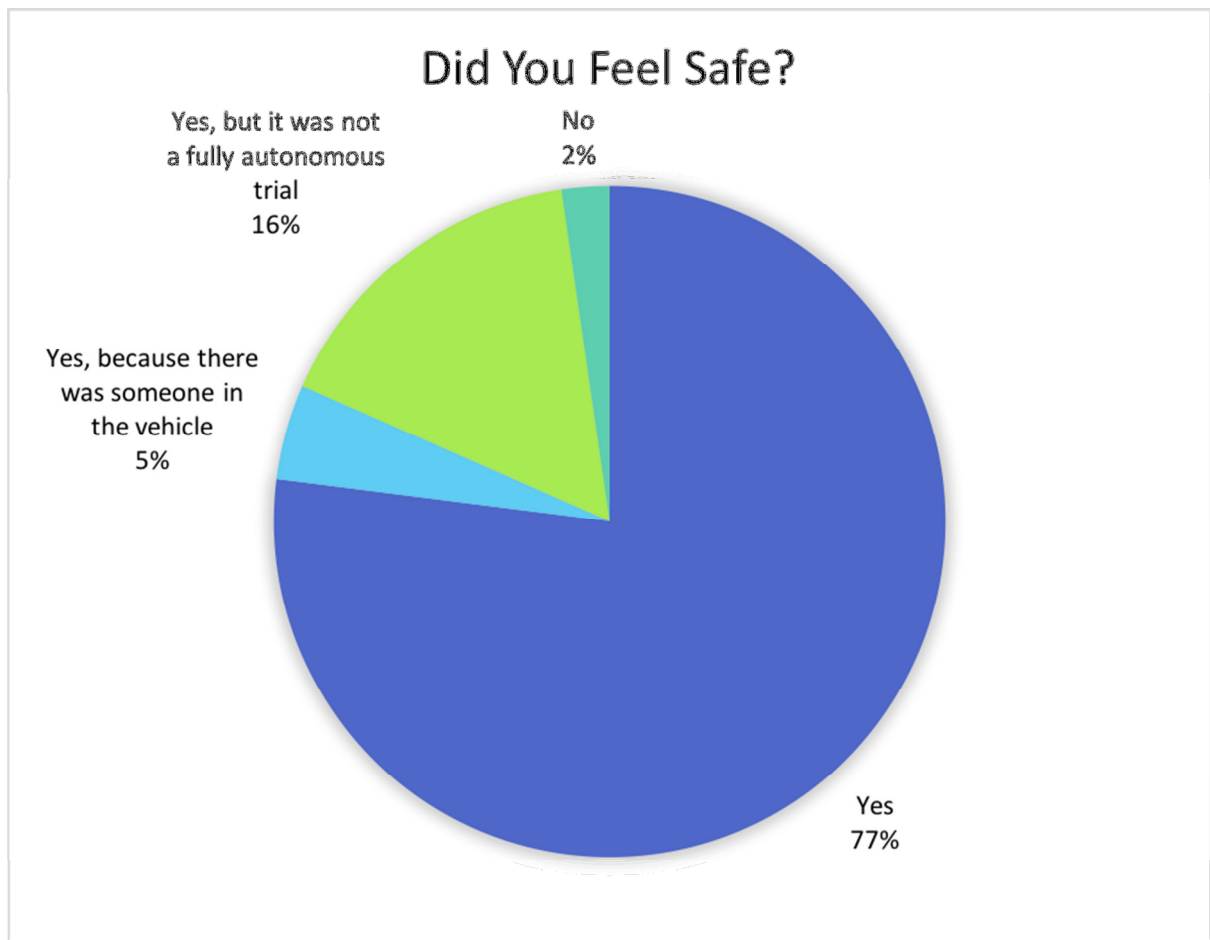
Figure 9. Responses to question, "Did you feel safe?"

Participants were asked if they felt safe while trialling the vehicle. 77% of participants stated that they felt safe in the vehicle and an additional 5% responded that they felt safe due to a HMI employee being present in the vehicle. The following 16% stated that they felt safe but identified that it was not a truly autonomous trial. Only 2% of participants responded that they did not feel safe while trialling the vehicle.
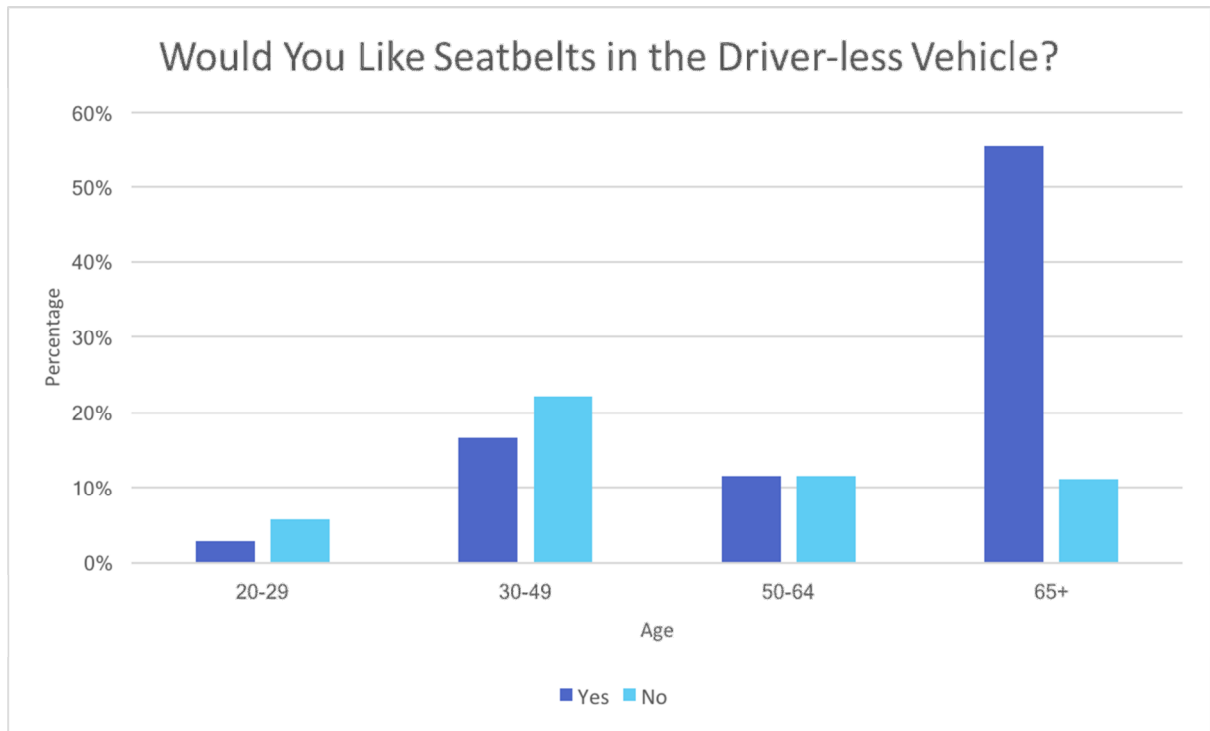
Figure 10. Responses to question, "Would you like seatbelts in the driver-less vehicle?"

During the focus groups all perspectives and opinions of the vehicle were observed to gain a well-rounded idea of participant's expectations. The largest criticism regarding the safety of the vehicle was the absence of seatbelts. Due to the AVs intended purpose, participants believed that seat belts should be in the vehicle. The need was specifically emphasised for elderly and young children who have slower reaction times and may be more prone to injury if the vehicle were to suddenly stop.

The amount of participants that wanted seatbelts varied between age groups. Figure 10 displays that as age increases so does the number of participants requesting seatbelts. The highest percentage of those wanting seatbelts across all age groups was in the 65+ age category, with 55% specifically requesting seatbelts, while less than 5% of those aged 20-29 requested seatbelts.

Discussion

It is important to find out if the ages of the 448 survey respondents are representative of the New Zealand population age demographics. The age brackets in the initial survey need to be aligned with the census age brackets in order for a comparison to our findings. This dictates whether we can infer our findings to the wider population and can be achieved by comparing our data with the New Zealand census data.
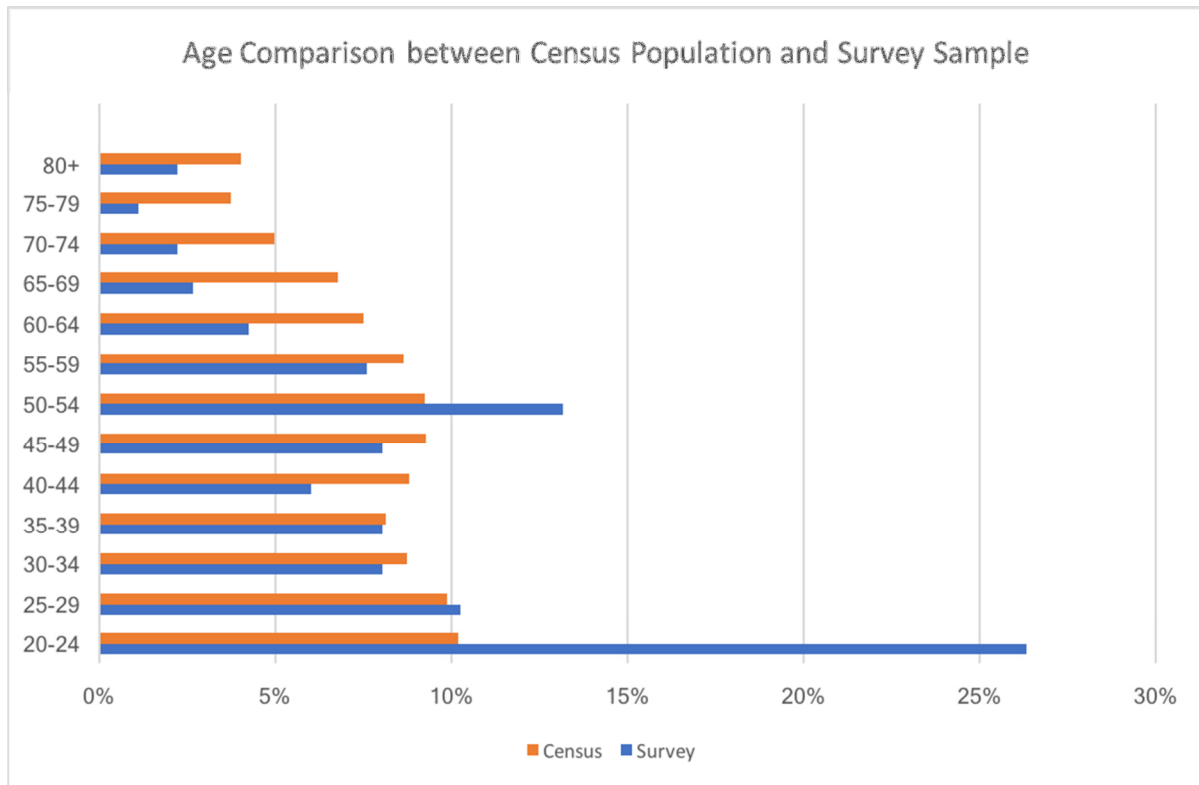
Figure 11. Comparison of age demographics of the New Zealand population (Statistics NZ, 2017) and the survey respondents.

Figure 11 shows that our survey sample is a relatively accurate representation of the ages of the New Zealand population, despite the survey over-representing the 20-24 and 50-54 year age groups for reasons previously explained. A significant proportion of survey respondents are also in each of the age groups over 60 years of age. With this comparison, we are able to identify the age bias of our survey results and take this into consideration when concluding our findings.

As identified in the trial methods, a limitation to our research was not having the vehicle operating fully autonomously during the trials. This was out of our control and we believe participants felt distrustful towards the vehicle because of this. To minimise this confusion, it should have been more clearly explained to participants that this was not due to a software or vehicle fault. For this reason, we cannot imply that the results from the trials we conducted would replicated in a fully autonomous trial.

Our initial survey found that the majority of respondents were already aware of AVs. Across all age groups, the average awareness was 94.2%. A similar question researched by Bansal and Kockelman (2016) found that 59% of respondents had heard of the Google self-driving car. Our results show a greater awareness of this technology and takes age as a variable into consideration with the younger age groups being more accepting of them and the older age groups being more critical. It was clear that across all age groups the most prevalent safety expectations were seatbelts, airbags and an emergency stop button. Other safety concerns such as vehicle malfunction and the vehicle's interaction with other road users were also expressed to a lesser extent by respondents.

Although time consuming to analyse, the focus group data contained new ideas that we had not previously considered, as well as contradicting results in comparison to the survey data (Cameron, 2010). The general feedback after trialling the vehicle was that all age groups felt safe but there was a wider variation in participants wanting seatbelts between the age groups. The younger age groups expressed less desire for seatbelts than older age groups. All other safety aspects were of less concern to the older groups.

It must also be noted that many participants from each age group believed seatbelts to be unnecessary in this case, for reasons such as its slow speed and seatbelts not being present on other modes of public transport. In the 20-29 and 30-49 age groups, there were more participants that opposed having seatbelts than those wanting them.

Despite scholars, Bansal, Kockelman and Singh (2016), hypothesising that younger age groups would be more accepting of AVs, our focus groups showed that all ages were generally accepting of AVs. Younger age groups raised more concern about hacking, lack of instructions, security cameras, emergency stops and music inside the vehicle. Overall, the older age groups were more welcoming of AV technology and had less concerns about security and technical aspects of the vehicle. They would be excited to use AVs as a method of transport because it allows them to remain independent and they enjoyed experiencing this technology in their life-time.

The focus group participants expressed an interest in trialling the vehicle from the survey. As a result, we did not receive participants with a neutral or negative view on AVs and therefore, our focus group data has a positive bias. However, the survey contained a question where respondents could express why they opposed AV technology or were not interested in trialling the vehicle. Some responses to this question included ethical concerns, being pregnant and concerns around the loss of jobs in the transport sector. In future research, a focus group could be conducted with participants opposed to AVs in order to provide a fair representation of the population or expand the survey with questions to understand the reasoning behind a person's possible negative opinions.

Conclusion

Our findings throughout our research have identified that there is a relationship between age and safety perceptions. Having initially agreed with what the scholars hypothesised, our survey data supported the claim that younger age groups would be more accepting towards the technology than older age groups who might struggle to connect with it (Bansal, Kockelman, & Singh, 2016). However, our focus group data contradicted this claim as the older age groups were more excited and accepting towards this technology.

There are many possibilities for future research. We believe that if another trial is to be conducted it should commence under the conditions where the vehicle is functioning fully autonomously. For future research it would be beneficial if the trials include obstacles like pedestrian crossings and other cars to simulate a more realistic environment.

Addressing the first research question, we found that the younger age groups had a more positive opinion regarding AVs and less safety concerns than the older age groups. We can

also conclude that there is evidence in our research to support different age groups emphasising the importance of different aspects of safety.

To answer our second question, interactions with AVs can change people's perceptions. In summarising our report, it is challenging to determine if the focus group results are reliable as the AV was not working fully autonomously. This report is beneficial and provides guidance to HMI and the development surrounding future research of AVs.

Acknowledgements

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