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Designing autonomous vehicles for People with Disabilities: Surveying user needs and preferences

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1. Introduction

The cumulative disadvantage faced by People with Disabilities (PwDs) has a detrimental effect on their physical, financial, and emotional well-being. Furthermore, it has been shown that lack of mobility and social inclusion are important indicators associated with this disadvantage (Bricout et al., 2021; Sterkenburg, 2020; Tabattanon et al., 2019). This is significant as an inability to access transport violates a person's human rights and affects their dignity. Furthermore, the automotive industry and culture have been found to sacrifice user needs for other considerations, with universal design approaches rarely applied (Bayless and Davidson, 2019). As we move towards an autonomous future, a lack of accessible automated vehicles (AV) may further compound these issues and present one of the biggest barriers to transport access for PwDs. A large body of evidence suggests that the best approach to future Accessible AV design is to engage in collaborative user-centered design approaches, so that vehicle development and prototyping are informed, tested and guided by direct input from PwDs to ensure equal access (Asha et al., 2021; Carvalho et al., 2020; D'Souza, 2013). As part of the effort to address this issue the research team sought out PwDs across Australia to gather insights into the needs and perspectives around current transport use and future AV technologies, through the deployment of an accessible online survey. The findings from this study provided insights into the diverse range of user needs and perspectives including user preferences of existing and concept AVs, the level of assistance required in boarding and disembarking, and preference for vehicle features.

2. Methodology

This section of the report will provide further details of the survey conducted, including the format, recruitment strategy, data collection and analysis methods used results and limitations. The study used a mixed-methods survey; this was distributed online through Transport and Main Roads' existing network and by QUT researchers. The participants included PwDs based around Australia who are potential end-users of future accessible Autonomous Vehicles. The survey was used to gather data, including: Participant demographics, the needs and perspectives of this population for current public transport availability, access, and limitations, and perspectives on future accessible Autonomous Vehicles and their design. The survey collected qualitative and quantitative data through a series of multichoice questions and several short response questions. The survey was designed with a focus on accessibility and included appropriate alternative text (alt-text) for all images.

Participant Recruitment

The surveys were distributed in two formats: online and paper forms. The online distribution used the Qualtrics software platform and was distributed by Transport and Main Roads (TMR) accessibility department. TMR have an existing contact network of PwDs and advocacy groups who have previously advised that they are willing to participate in surveys distributed by TMR. The QUT research team were responsible for distributing surveys using existing networks of collaborators, industry partners and disability organisation directors and community group leaders operating within Australia.

Methods

As part of the research Study One of the aims was to gain insight into the needs and perspectives of PwDs in Australia around current transport use and future AV technologies. A survey was chosen for this approach as it was seen to be the most suitable method to gather a breadth of insights from the target population. The survey employed a mixed-method approach, but the focus was on quantitative data to ensure the information obtained was statistically significant (Creswell and Creswell, 2018).

Data Collection

Data collection for Study One was in the form of a mixed-method survey which utilised a series of multichoice questions supplemented by short response questions that participants could use to provide further clarity for their responses. The survey was distributed online through the Qualtrics software and as paper forms. The Queensland Disability Network team assessed the survey to ensure it was accessible to people with low vision and blindness.

Data Analysis

Data analysis was conducted using Microsoft Excel, employing a range of descriptive tools to effectively visualize and summarize the dataset. For participant responses related to Disability Types and Transportation Services, bar graphs were used to depict the frequency of different categories. It should be noted that respondents could select multiple disabilities that reflect their situation or experience. Therefore, the basic units of the bar plot depict overall counts of disability types, as a single respondent could contribute to more than one data point in the plot. For variables such as Seating Preference, Assistance Needed, and Vehicle Feature Preference, stacked bar graphs were utilized. These stacked bar graphs account for the possibility of multiple selections within categories, especially in relation to disability types. In sections like “Assistance Needed,” frequency analyses were conducted where respondents were grouped based on their selected disability types, and these grouped responses were then visualized using percentage-based stacked bar graphs.

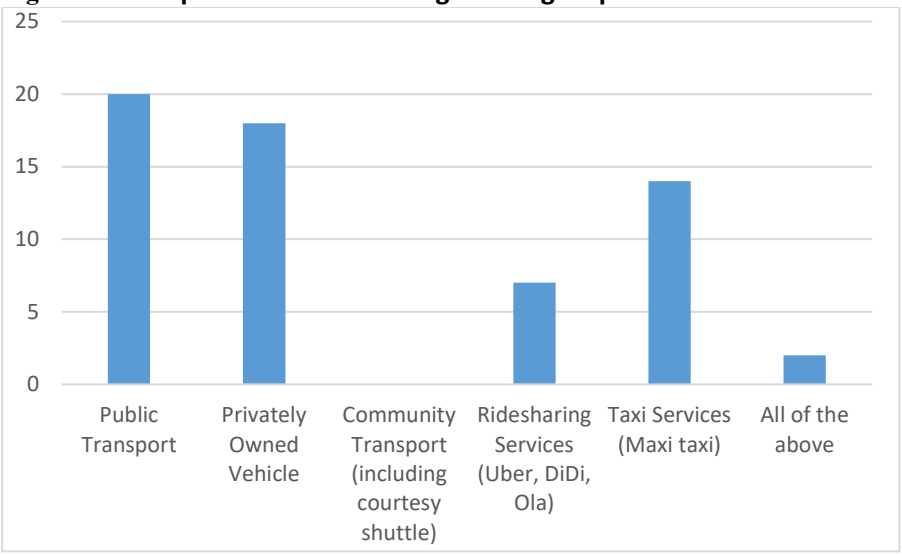
3. Results

This section of the report outlines the Study One survey results. The areas covered within this section include general exploratory analysis, seat preferences for different disabilities, assistance in boarding and disembarking, and preferences for different vehicle features.

General Exploratory Analysis

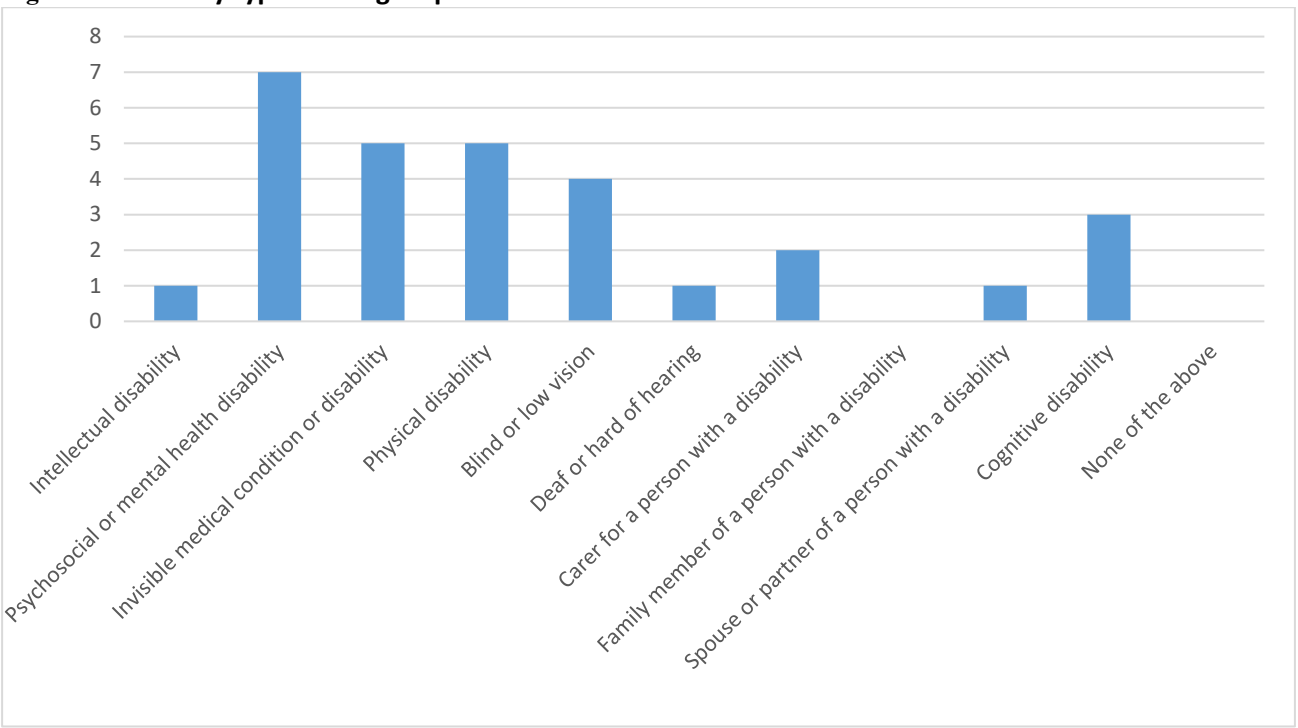
After filtering for legitimate responses, 22 participants responded to the survey including 12 males, 7 females and 3 non-binary individuals with an age range of 25 years to 71 years of age. Figure 1 represents the number of responses to different transportation services. From the diagram, we can understand that the service that most respondents used is public transportation, followed by privately owned vehicles and taxi services. In contrast, the least used service is community transport.

Figure 1: Transportation service usage among respondents.



The counts of the disability types of the respondents are represented in Figure 2. The figure shows that Psychosocial or mental health disability accounts for the most, with Invisible medical conditions or disabilities and Physical disability following.

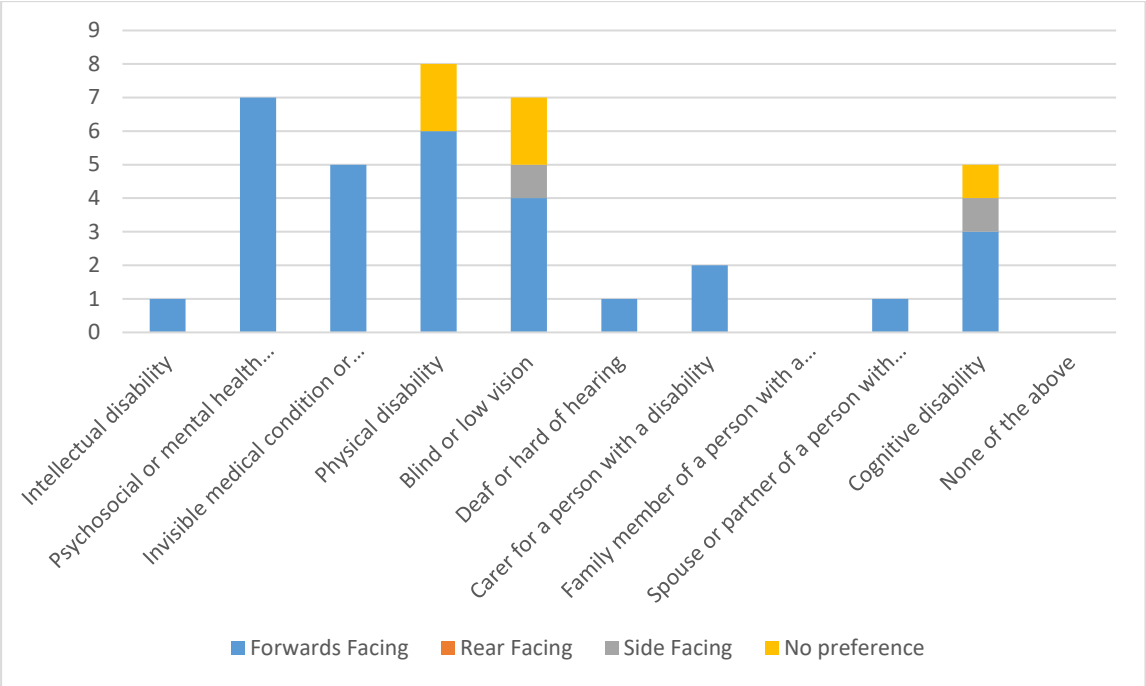
Figure 2: Disability types among respondents.



Seat Preferences for Different Disabilities

Figure 3 demonstrates the relationship between the preference for seat design and disability type. From the diagram shown, forward-facing seating was seen to be preferred by each community represented. Rear-facing was not chosen as a preferred design. In contrast, side-facing and no preference were only chosen by blind or low vision individuals and those with cognitive and physical disabilities.

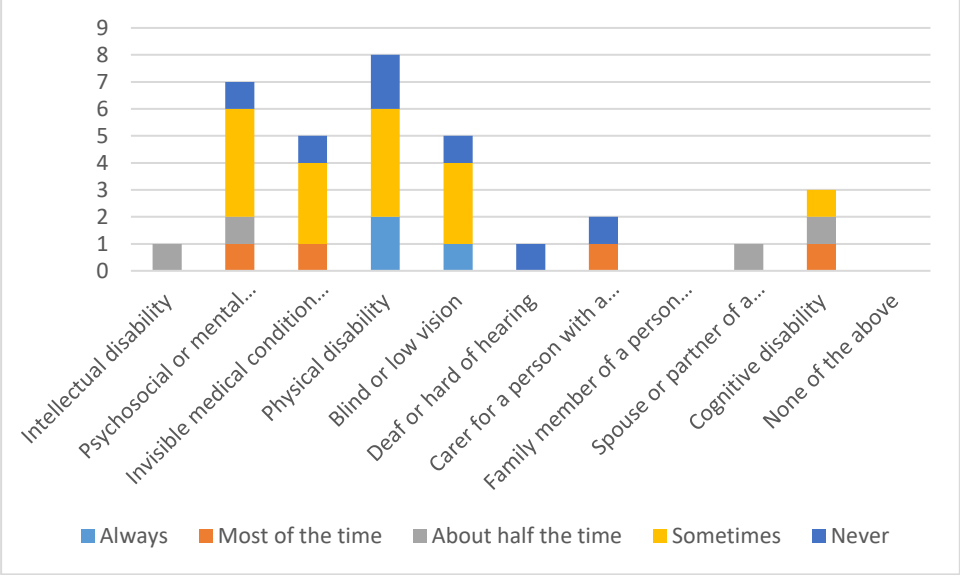
Figure 3: Seat preference for different disabilities.



Assistance in Boarding and Disembarking

The chart in Figure 4, illustrates the frequency of support needed when getting on and off vehicles based on different disability types. From the results shown, we can understand that respondents who are deaf or hard of hearings report never needing help. At the same time, the other communities represented require different levels of assistance. Notably, physical disability has the highest rate of always needing help, followed by blind or low vision compared to the rest of the types.

Figure 4: Support needed frequency when getting on/off vehicles on different disability type.

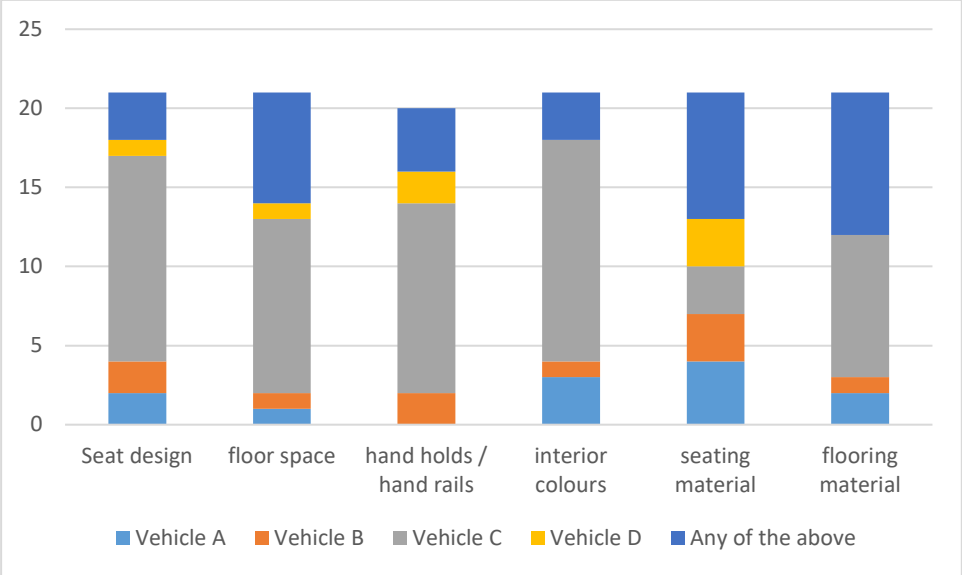


Preferences for Vehicle Features

A series of production and concept autonomous vehicle interior images were shown including the Volkswagen Sedric, Local Motors Olli, Toyota E-Palette and Renault EZ-GO, labelled A, B, C and D respectively. Participants were asked to identify their preferences in relation to a series of questions relating to interior features such as seat design, seating material, floor space,

hand holds and interior colours. We can observe in Figure 5, that most respondents prefer vehicle C in terms of seat design, floor space, hand holds and interior colours. However, no specific preference was shown regarding seating materials. In contrast, options “C” and “Any of the above” each account for 43% of responses for flooring material.

Figure 5: Vehicle preference based on different features.



4. Discussion and limitations

The response rates for the survey were lower than those required to achieve statistical significance or to obtain enough depth of information to formulate any reliable conclusions about PwDs experience of transport use and access or design preference for autonomous vehicles. This low response rate may be due to several factors, including distribution strategy, which will be discussed further, and survey fatigue, a common issue within research (Olson, 2014). While the use of raw counts in our data visualizations aimed to represent to low participant response rate more accurately, this approach can give disproportionate weight to categories with more respondents. This might underrepresent the unique preferences or experiences of these smaller groups in comparison to larger groups in the study. Due to the vulnerable nature of the target population, there were limitations in the recruitment strategy the research team was able to employ. This restricted access required the research team to attempt participant recruitment through indirect means, which may have limited the visibility of the survey to the target population throughout the study. This presents an interesting challenge for research within this space, as a large body of evidence suggests that the best approach to future Accessible AV design is co-design, so that vehicle development and prototyping are tested and guided by direct input from PwDs to ensure equal access (Asha et al., 2021; Carvalho et al., 2020; D’Souza, 2013). In pursuit of this goal and to address the limitations of this initial recruitment strategy alternative distribution methods have been employed. This process involved engaging survey recruitment agencies which had existing relationships with the target population and appropriate recruitment methods in place to ensure the safety and integrity of participants. Since implementing our new recruitment strategy, we have garnered responses from over 300 participants. Our team is in the process of analyzing this expanded dataset to delve deeper into various facets: current modes of transportation, associated challenges, perceptions of autonomous vehicle (AV) technology, and design preferences in relation to disability types. Preliminary results already shed light on several key issues. They reveal shortcomings in existing public transit systems, ride-sharing services, and private vehicles,

pinpointing specific areas that could be addressed in the design of AVs, such as boarding procedures, seating arrangements, and privacy concerns. The data also indicates a significant portion of respondents who are either unfamiliar with or opposed to AV technology, suggesting a need for educational initiatives and alleviation of concerns, particularly those related to emergency situations, cost, and the need for trained attendants. Furthermore, we have gained insights into preferences for design elements like floor space, handrails, and interior colors, which will help guide the future accessible AV design.

5. Conclusions

This paper discussed the outcomes of an online survey which aimed to recruit PwDs across Australia to gain insight into the needs and perspectives of PwDs in Australia around current transport use and future AV technologies. The outcomes of this process provided early insights into seat preferences for different disability groups, needs for assistance in boarding and disembarking, and preferences for different vehicles and features. This research study also highlighted the difficulties of engaging with a vulnerable population and illustrated the need for further development of appropriate engagement strategies to ensure PwDs are involved in the design and development process of future AV technologies. However, the research team were able to identify and employ alternative methods of recruitment to overcome these challenges. We look forward to presenting these findings in future work.

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