TOWARDS DESIGN PRINCIPLES FOR AN ACCESSIBLE AUTONOMOUS VEHICLE: PROMOTING INCLUSIVITY, INDEPENDENCE AND WELL-BEING

A Focus Group with domain experts

Gomez, R.[1], Dwyer, J.[1], Peterson, A.[1], Bubke, A.[2], Cocks, K.[2], & Paz, A.[1]
[1] Queensland University of Technology
[2] Department of Transport and Main Roads, Queensland Government

This paper presents a domain-expert focus group conducted as part of a larger study commissioned by the Queensland Government, Australia. The overall study focuses on improving transportation and mobility access for people with disabilities (PwDs) by developing design principles for accessible autonomous vehicles (AAVs). The objective of the Phase 1 focus-group with domain experts was to understand critical factors and develop initial recommendations that form the basis for a set of design principles from the perspective of domain experts.

Findings revealed the following key Themes as important elements:

- COMMUNICATION, including face-to-face, human-machine & human-environment;
- reduce STRESS for PwDs in accessing and using AVs;
- improve SAFETY throughout the transport experience;
- INTERFACE with the vehicle physically and digitally; and
- providing and considering INDEPENDENCE of PwDs

However, there is a need for further research in co-design prototyping, analysis of standards, and current design best practices. The focus group, alongside the larger ongoing research, aims to provide a comprehensive set of design principles for AVs that cater to the diverse needs of PwDs including blind and low-vision, deaf/hard of hearing, mobility impaired, intellectual, and developmental disability, and elderly populations.

INTRODUCTION

The cumulative disadvantage faced by people with disabilities (PwDs) has a detrimental effect on their physical, financial, emotional well-being and health [1,2,3,4,5]. An autonomous future has potential to provide accessible transport options improving access to medical care, employment, social inclusion, and safety.

This is a long-term project including 3 phases.

Phase 1: literature review, data review, surveys with disability users, and focus-groups with domain experts (presented here).
Phase 2: detailed benchmarking and expert analysis of existing and in-development autonomous vehicles followed by an AAV concept design.
Phase 3: development of a 1:1 prototype for testing by end users and domain experts leading to final AAV design and design principles.

OBJECTIVE

Develop initial recommendations that form the basis for a set of design principles from the perspective of domain experts.

APPROACH

This study involved a 2-part focus-group between five experts to determine the potential opportunities and challenges of achieving accessible AV implementation within Australia. Table 1 provides an overview of the study and outlines the two focus group sessions.

Two 2-hour sessions were conducted across two weeks. Session One included four participants who returned the following week. Session Two included an additional participant who was not available for the first session.

Session 1 included a Semi-structured interview, followed by a Photo Elicitation activity. Following this session, initial themes were identified and presented back to experts at the beginning of the second session.

Session 2 began with a Reflective task including additional targeted Photo Elicitation based on the Session 1 discussion. This was followed by a Design Activity using a 'dollhouse' approach in which images are used to assemble vehicles within Miro.

The qualitative data collected included video and audio recordings from the session and visual data in the form of images. The research team undertook several steps to analyse the data (Figure 1). Otter.ai software was used to support analysis and generate an accurate transcription. Figure 2 shows the overall structure of the focus groups.

The coding process was used to generate a co-occurrence matrix. These results were analysed using Flourish Studio to highlight the frequency of the theme and topic occurrences, the relationship between key themes and underlying topics, and the relationship between the topics (Figure 3). For example, *Seating* appeared with the greatest relational frequency to *Restraints* (21.6%), *Children* (13.7%), *Regulation* (13.7%), *Design* (11.8%), and *Configurable* (9.8%).

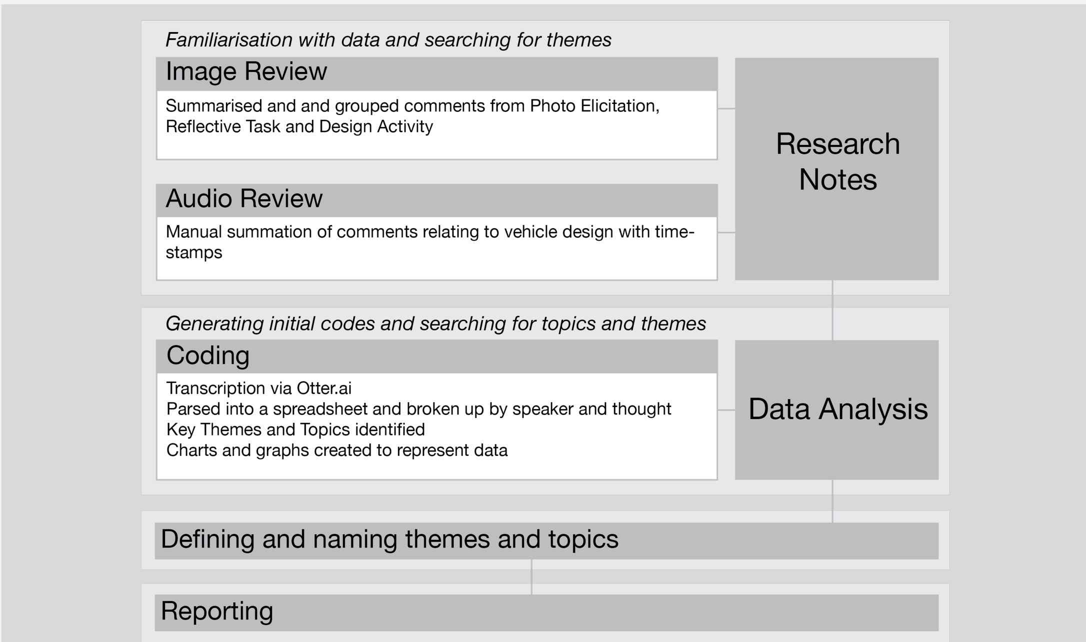

Figure 1: Thematic analysis process

Table 1. Focus Group Study

FOCUS GROUP OVERVIEW	DESCRIPTION
Setting	Online via Zoom
Participants	5
Duration	Two 2-hour sessions
Study	Focus Group with Design Activities
Data Collection Method	Video and Audio Recording
Data Analysis Tool	Thematic Analysis
SESSION ONE	
Induction: 20 min	Greet and introduction to Zoom software, troubleshoot connection and audio issues.
Semi-structured Interview: 40 min	Have participants engage in a "round table" discussion with prompts.
Break: 10 min	10-minute break.
Photo Elicitation: 40 min	Photo Elicitation activity in which AV concepts and production vehicles from different vehicle manufacturers are used to stimulate discussion.
SESSION TWO	
Induction: 20 min	Greet and introduction to Zoom software, troubleshoot. Run through Miro features induction exercise.
Reflective Task: 40 min	Review key findings and themes from Photo Elicitation activity. Identifying positive and negative features of different vehicles based on key findings and themes.
Break: 10 min	10-minute break.
Design Activity: 40 min	Engage in a vehicle concept generation activity using a "dollhouse" approach in which images are used to assemble vehicles within Miro before having participants review and critique these concepts.
Debrief: 10 min	10-minute debrief.

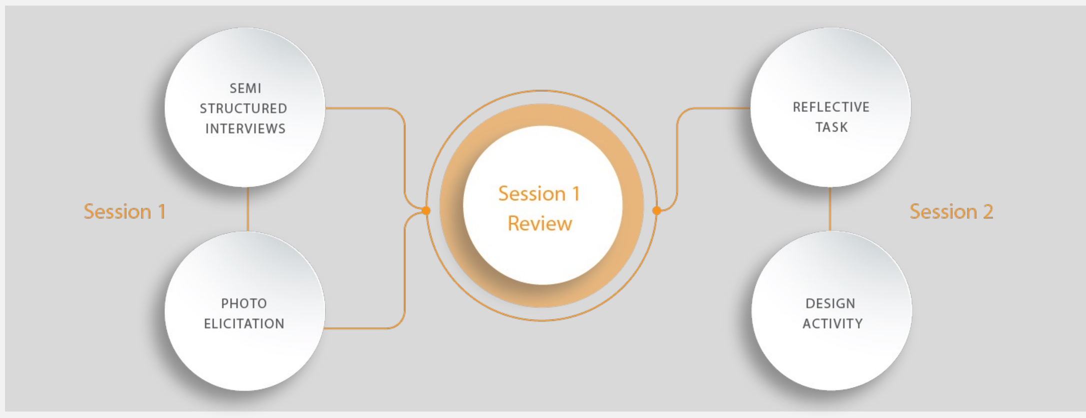

Figure 2: Focus group structure

Figure 3: Topic frequency and relationships

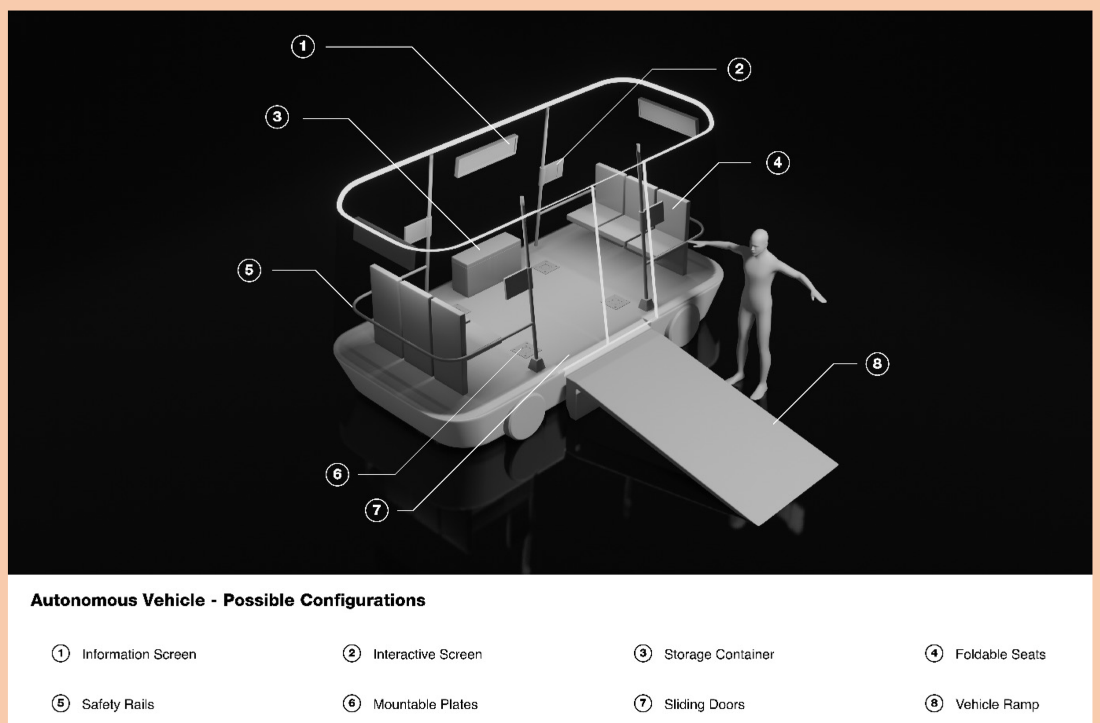

Figure 4: Key design elements to consider for accessible AVs

DISCUSSION

Each topic mentioned did not occur in isolation but rather as part of a complex set of relationships. The rationale for these three domains is due to the complexity of the problem:

1. *High Frequency Topics*: topics with high conversational occurrence, such as **seating**, frequently emerged throughout the focus group session.
2. *High Relational Topics*: topics with low conversational occurrence but high topic relational frequency such as **risk**.
3. *Limiting Factor Topics*: topics without high conversational occurrence or high relational frequency but which were seen as limiting factors, such as **cost**.

Figure 4 shows a simplified visual representation of an accessible AV with labels to assist in understanding general part/s of a vehicle identified as critical based on findings. These form the basis of the initial design principles developed.

Seating is a significant consideration for accessible AVs. Design, orientation during travel, and interface methods were often discussed alongside SAFETY. INDEPENDENCE would often focus on how PwDs could secure themselves without assistance [6]. The topic of **restraints** had clear connections to the theme of SAFETY and would generally centre around appropriate methods for restraining wheelchair users [7].

Several additional areas were identified within the paper that represent impactful design opportunities, such as configurability, controls, and storage, that are also reflected and supported by prior research.

These design opportunities need to consider the following high relational topics: anthropometrics, visibility, wayfinding and route navigation, stewards/attendants or assistance through automation. Several limiting factors were identified to have a strong impact on the success of any accessible AV design implementation, including infrastructure, barriers, risks, regulation, and cost.

Figure 5: Image of current AAV concept development (Phase 2)

RESEARCH OPPORTUNITY

Future research into:

- comparison between anthropometrics and vehicle dimension
- testing full-scale AAV prototypes
- co-design approach
- development of vehicle prototypes (test human-machine interactions, human-environment interactions, and interface design)
- AAV interaction and interface is required to meet the needs of diverse user groups
- research investigating the interaction between an AAV and infrastructure is needed

FUTURE WORK

Phase 2 (i) detailed benchmarking of existing autonomous vehicle, and (ii) AAV concept design (**Figures 5 & 6**) *COMPLETE*

Phase 3 (i) 1:1 prototype (**Figure 7**), (ii) expert and end-user workshops, and (iii) updated AAV concept design *IN PROGRESS*

Figure 6: Images of current AAV concept development (Phase 2)

Figure 7: Images of 1:1 prototype based on Phase 2 concept design (Phase 3)

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Transport Research Arena, 10th Conference. 15-18 April 2024. Dublin, Ireland.
Poster Board 083, Paper Number 805

Queensland Government
Queensland University of Technology

Corresponding author: Dr Rafael Gomez – r.gomez@qut.edu.au