



AutismCRC

# Enhancing capacity of autistic individuals to use public transport

## FINAL REPORT

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**AusIndustry**  
Cooperative Research  
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[autismcrc.com.au](http://autismcrc.com.au)

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## **The Cooperative Research Centre for Living with Autism (Autism CRC)**

The Cooperative Research Centre for Living with Autism (Autism CRC) is the world's first national, cooperative research effort focused on autism. Taking a whole-of-life approach to autism focusing on diagnosis, education and adult life, Autism CRC researchers are working with end-users to provide evidence-based outcomes which can be translated into practical solutions for governments, service providers, education and health professionals, families and people on the autism spectrum.

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## **A note on terminology**

We recognise that when referring to individuals on the autism spectrum, there is no one term that suits all people. In our published material and other work, when speaking of adults we use the terms 'autistic person', 'person on the autism spectrum' or 'person on the spectrum'. The term 'autistic person' uses identity first language, which reflects the belief that being autistic is a core part of a person's identity.

Autism Spectrum Disorder (ASD) is diagnostic terminology used by the healthcare sector, and is used in the context of a person being 'diagnosed with Autism Spectrum Disorder'.

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# 1. The report

## 1.1 Aim of the study

The aim of the proposed research is to address community mobility challenges experienced by young adults on the autism spectrum by developing a technology solution and other resources to improve access to and use of public transportation for young autistic adults.

## 1.2 Setting

The project related to public transport access will be coordinated from Curtin University and be conducted across WA and NSW, and technology solution and other resources will be tested.

## 1.3 Significance

Australian young adults on the spectrum face inequalities in completing school education, participating in employment, and being included in society. An understanding of the complex issues faced by autistic individuals in accessing public transport needs to be explored from their perspective and key individuals in their lives. The proposed community mobility project will adopt an end-user driven approach to design, pilot test and evaluate the preliminary effectiveness of end-user driven products in promoting independence in planning and using public transportation among adults on the spectrum. The troubleshooting Technology solution and other related resources developed in the project will provide autistic individuals independence in planning and navigating the public transportation system in Australia. Improving community access has the potential to increase community participation for individuals on the spectrum, facilitate their participation in education, employment, and leisure pursuits and positively influence their mental health and wellbeing.

## 2. Introduction

Autistic individuals face social and cognitive difficulties that affect their ability to establish relationships, maintain employment and participate in community activities. Difficulties in community mobility act as barriers to their social inclusion. The independent use of public transport systems can be difficult and evoke anxiety, as the task requires planning, interpreting travel schedules, managing transfers and problem-solving unpredictable changes. Safety concerns on the part of their families further limit their independent use of public transport. There is also a

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limited understanding of the difficulties people on the spectrum face while planning for and accessing public transport.

There is limited participation in community activities such as employment, education and social interaction for individuals who are on the autism spectrum. A significant barrier preventing participation is the lack of transportation. More than 80% of autistic people are dependent on family members for their transportation needs. It is estimated that 72% of autistic individuals fail to participate in some activity due to the unavailability of a person driving them to that activity. To go with this, an estimated 73% of carers forgo their own activities so they can drive their autistic family member to an activity. Parents who have an autistic child work significantly less and often earn 50% less than their peers.

Public transport is an inexpensive, widely available form of transportation. Autistic individuals believe public transport is critical in assisting them to reach their community participation goals. Public transport using individuals on the spectrum are five times more likely to find employment compared to those who do not or have not used public transport. Unfortunately, significant numbers of autistic individuals have not used public transport to travel independently.

## 2.1 Public Transport

Public transportation is a preferred mode of independent transportation with more than 51% of autistic people believing public transport use is important for them to be able to achieve their goals. Autistic individuals who are able to use public transport are five times more likely to be employed. However, more than 60% of autistic people have never used public transport with more than 68% having never even considered public transport use.

Public transport requires the ability to read and understand timetables, manage transfers, and navigate complex routes. Public transport can be highly unpredictable, requiring problem solving of unexpected events and therefore can be highly stressful. There is also concern that autistic people may be victimised or bullied. More than 40% of autistic people are worried how drivers and/or other passengers will treat them while using the service.

Another concern of autistic people is getting lost while using public transport. More than 40% of autistic individuals cannot find their way to the bus stop or train station and more than 30% cannot manage transfers nor disembark at the correct stop.

Anxiety can often lead to a reduction in the ability to predict a situation. Public transport involves a lot of uncertainty that prevents this ability to predict an outcome and hence an increase in anxiety

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occurs. Interactions with people on public transport can also be unpredictable, increasing ones anxiety. Many autistic people also exhibit extreme sensitivity to sensory stimuli and within the use of public transport, sensory overload can be a common occurrence. Hence, anxiety and sensory overload often result in autistic people choosing not to use public transport.

## 3. Methodology

With these challenges to public transport usage this project aimed to design, develop, and evaluate a public transport trip planning mobile application that facilitates public transport use for autistic individuals. The research was co-produced, meaning that at each step of the research, the team were working with autistic individuals, their families, and carers to ensure that any solution that arose from the research was one that was built together with the wider autistic community.

The project was set out in three phases:

1. Requirements gathering and design
2. Implementation and evaluation
3. Pilot the technology solution

The completion of the three listed phases would result in an evidence based piloted technology solution to assist autistic individuals to use public transportation.

### 3.1 Phase One: Requirements gathering and design

In this section the research aim was to:

1. Define the challenges individuals on the autism spectrum face when using public transport.
2. Generate a list of software requirements for a mobile application that address these challenges.
3. Validate these requirements with autistic individuals and their families.
4. Design and propose a mobile application addressing the identified requirements.

#### 3.1.1 The realisation of the four aims in Phase One

An extensive literature review was conducted to understand where this project really sat within the body of knowledge for young autistic individuals using public transportation. A survey of the mobile applications that were available at the time was conducted to understand if there was already an App in existence that could be used or leveraged off of.

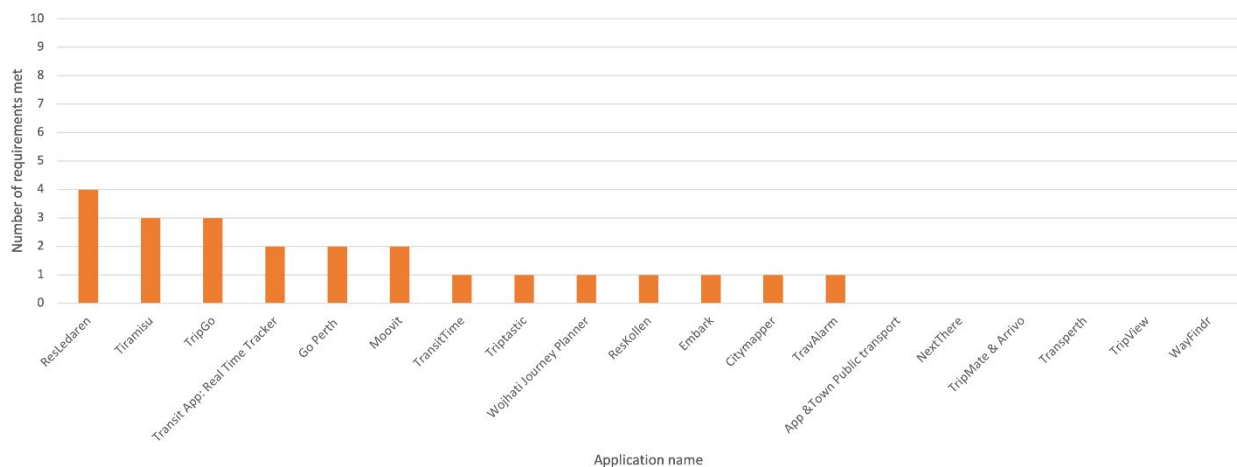


A total of 19 Apps were found and they were evaluated against ten requirements, listed below. No single mobile application was found to meet all ten requirements.

The ten requirements:

- Ability to alert if smartcard balance is low
- Ability to provide pre-trip assistance such as alerts to pack bag, leave, and guide to the nearest station to assist with sensory issues during a public transport journey
- Ability to assist with anxiety issues during a public transport journey
- Ability to provide alternative routes when a planned trip has been disrupted
- Ability to take and retrieve photos of stops and services along the journey
- Ability to optimise future trips based on previous trips
- Ability to provide walking direction to the destination after the public transport part of the journey has ended
- Ability to provide real-time location of user
- Option for voice assistance

**Figure 1: Survey of current public transport applications**



The graph shows each App across the horizontal axis and the requirement across the vertical axis.

From understanding the challenges autistic individuals have and encounter when using public transport, 18 possible requirements for a technology solution were identified that may assist facilitating young autistic individuals to use public transport.

Several focus groups were conducted with autistic individuals, their families and carers within New South Wales (NSW) where the 18 possible requirements were discussed and ranked. Similar focus groups were conducted with Transport for NSW and requirement ranking occurred.

The designed functionalities were distributed to autistic individuals, aged between 18-30 years old, and their families. Participants were asked to rank these functionalities based on importance to their needs. A total of 27 young adults and 19 family members took part in these groups.

From these focus groups, the 18 requirements were ranked in order of importance.

The order of ranking is shown in the table below.

**Table 1: Proposed application functionalities ranked by autistic individuals and their families**

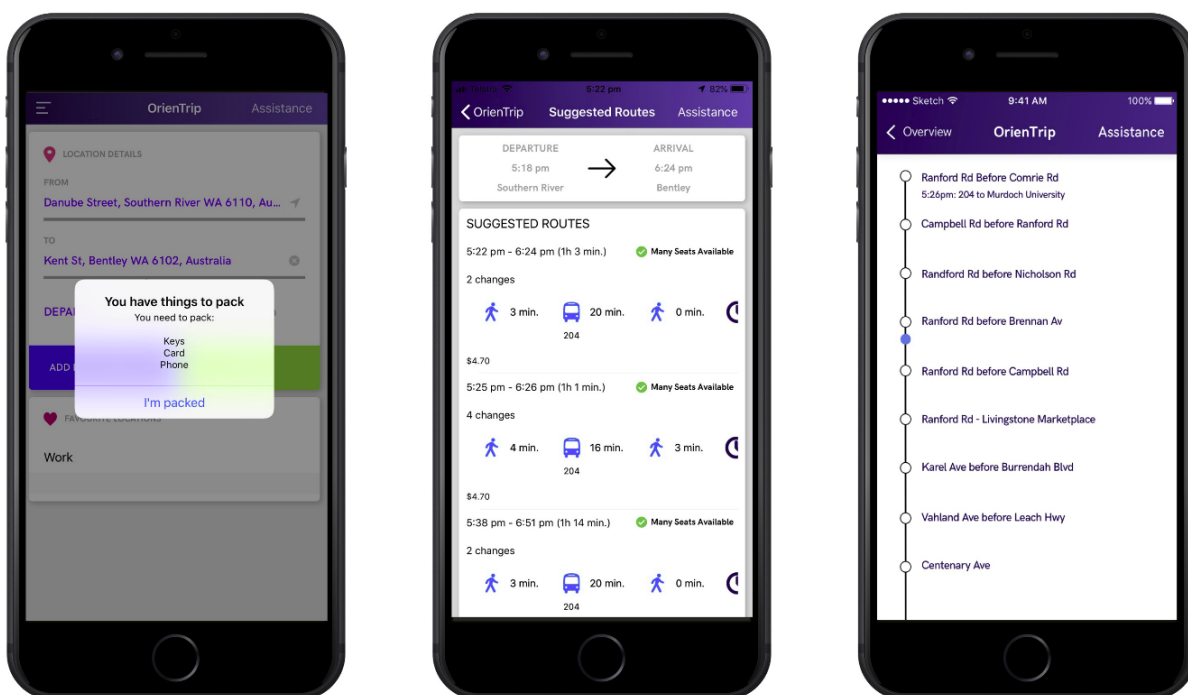
<b>Functionality description</b>	<b>Median</b> (young autistic adults) n – 26	<b>Median</b> (family) n – 19	<b>Median</b> (families and young adults) n – 45	<b>Barrier addressing</b>
Tell me or show me how to get to the bus stop or train station to start my trip, and how to get from the bus stop or train station at the end of the journey to the exact place I want to go.	4.00	3.00	4.00	Spatial awareness/ navigation
When I am on the bus, tell me when the bus is getting close to the stop where I want to get off, so that I know when and where to get off my bus, so I don't miss my stop.	5.00	4.00	5.00	Spatial awareness/ navigation, anxiety and stress
When I start my journey but something unexpected happens and I need to change my trip, tell me what to do to recalculate a revised trip.	6.00	5.00	5.00	Spatial awareness/ navigation, anxiety and stress
Tell me how crowded the train is before it arrives, and if the train is too crowded for me, give me other travel options.	6.50	11.00	8.00	Social anxiety, sensory overload
When I miss my stop, help me work out how to get to my destination.	6.50	6.00	6.00	Spatial awareness/ navigation and anxiety/ stress
Tools and alerts to plan my trip, get ready and leave on time for my trip.	7.50	6.00	6.00	Complex service schedule/ anxiety/stress
When I am planning my bus trip or waiting for my bus, tell me exactly where the bus is now and when it will arrive at my stop.	7.50	7.00	7.00	Anxiety and stress

<b>Functionality description</b>	<b>Median</b> (young autistic adults) n – 26	<b>Median</b> (family) n – 19	<b>Median</b> (families and young adults) n – 45	<b>Barrier addressing</b>
When in an emergency or when I panic during my trip, help me easily contact someone I know to get their help.	7.50	6.00	6.00	Anxiety and stress/communication limitations
When I need help during my trip, give me tools so I can get help in the way that best suits me.	9.00	9.00	9.00	Anxiety and stress
When I feel sensory overload on my trip, help me to cope and to feel better.	10.50	13.00	12.00	Sensory overload
Help me manage my travel card balance in one place. Let me top up my card. Tell me how much money I have on my card. Tell me how much a trip will cost.	11.00	10.00	10.00	Complex service schedules/anxiety and stress
Tell me all the services available to me at different train stations.	11.00	17.00	13.00	Spatial awareness/navigation
When I feel anxious on my trip, help me to cope and to feel better.	12.00	10.00	10.00	Anxiety and stress
When the lift at the train station is not working, find me solutions and help me to get to my destination.	12.50	15.00	14.00	Spatial awareness/navigation
When I am walking to or from a bus stop or trains station, tell or show me where it is safe for me to cross the road.	13.00	10.00	12.00	Safety and spatial awareness/navigation
Remind me to tap my card when I am getting on and off the bus.	13.50	11.00	13.00	Anxiety and stress
Let me take and store pictures of places and things along my trip, so that I have visual reminders of where I am during my trip	13.50	13.00	13.00	Spatial awareness/navigation
Auto correct my spelling when I type into the App	16.50	16.00	16.00	Usability feature

The first user interfaces for the *OrienTrip* App were then developed from the 18 requirements. These can be seen in the images that follow. *OrienTrip* is the name that was chosen for the App. This name was chosen within the co-production and was the one most autistic individuals and their families chose as the appropriate App name.

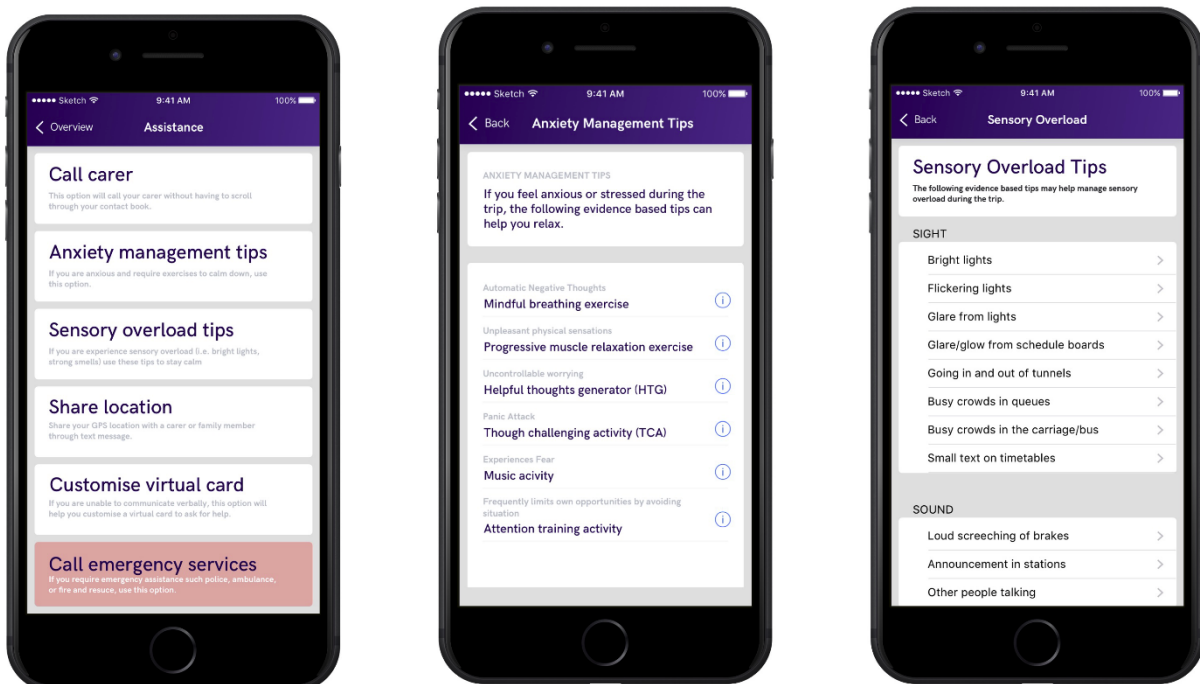
The first image shows a possible reminder that would occur prior to departing, reminding the user of things that they need to take with them. Image 2 is a reasonably standard suggestion of possible routes the user can select from. Image 3 shows the trip underway with the filled in dot demonstrating where the user is on their current journey.

**Figure 2: Images 1-3 of *OrienTrip* UI**



Images 4 - 6 demonstrate some of the specific features designed for autistic individuals to use while on their journey. Image 4 shows the Assistance screen where the user can interact with the App to receive different types of assistance. Image 5 is the screen for Anxiety Management which the user selected in Image 4. Image 6 shows the Sensory Overload screen which the user selected in Image 4. These screens show the fundamental requirements of the *OrienTrip* App.

Figure 3: Images 4-6 of *OrienTrip* UI



## 3.2 Phase Two: Implementation and evaluation

In this phase of the project, we sought to measure how autistic individuals interacted with *OrienTrip*.

The three aims clearly identified were:

- To develop *OrienTrip* into a fully functional mobile application
- Evaluate the user interface and usability of *OrienTrip* through eye movement analyses
- Propose guidelines to design improved software user interfaces for individuals on the autism spectrum

To do this, an eye-movement analyses was conducted using both autistic and non autistic groups to evaluate *OrienTrip*'s user interface and user experience.

### 3.2.1 Eye movement study

Currently, technology is increasingly used to aid autistic individuals in learning and performing everyday tasks. However, user interface (UI) design has often been overlooked when it comes to designing this technology for autistic individuals. There are only a limited number of studies examining improving user interfaces through empirical evidence. This section of the project aimed to evaluate the user interface and usability of *OrienTrip* through eye movement analysis.

For the study a total of 39 participants were recruited:

- 21 autistic individuals aged between 16-35 years old
- 18 non-autistic individuals

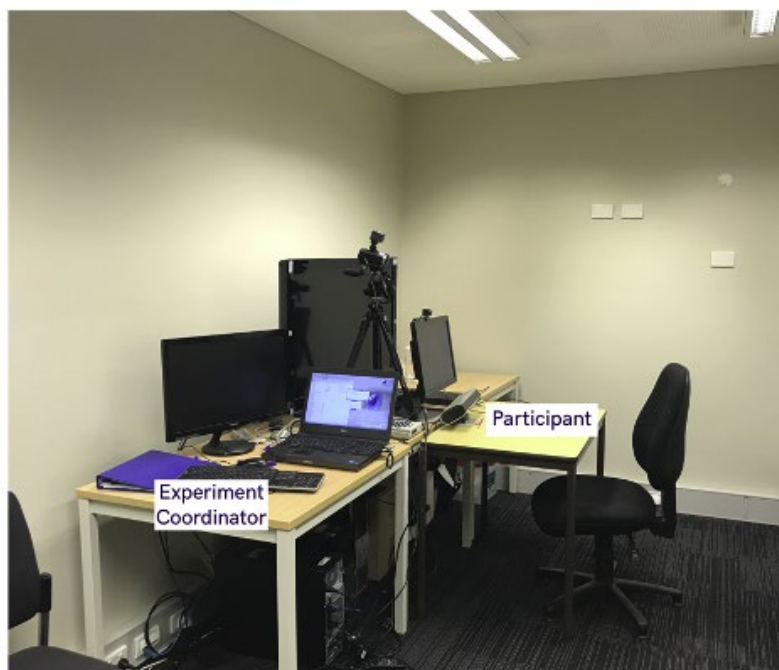
In carrying out the study, first the purpose of the study was described to the participants giving them an understanding as to the possible importance of understanding user interface design for autistic individuals. Participants were provided with the purpose of *OrienTrip* along with a detailed description of the functionalities of *OrienTrip*. No screens were shown at this stage of the study. Participants were then asked to complete a pre-study questionnaire to gather insights on the participants' background and experiences with common technologies.

The procedure of the study was as follows:

- Participants were seated 80cm from the display monitor;
- The eye tracker was calibrated for each participant;
- The experiment coordinator read out the tasks one by one in a clear and understandable way; and
- Upon completing the experiment participants were asked to complete a post-study questionnaire.

The image shows the setup of the study room.

**Figure 4: Setup of the study room**

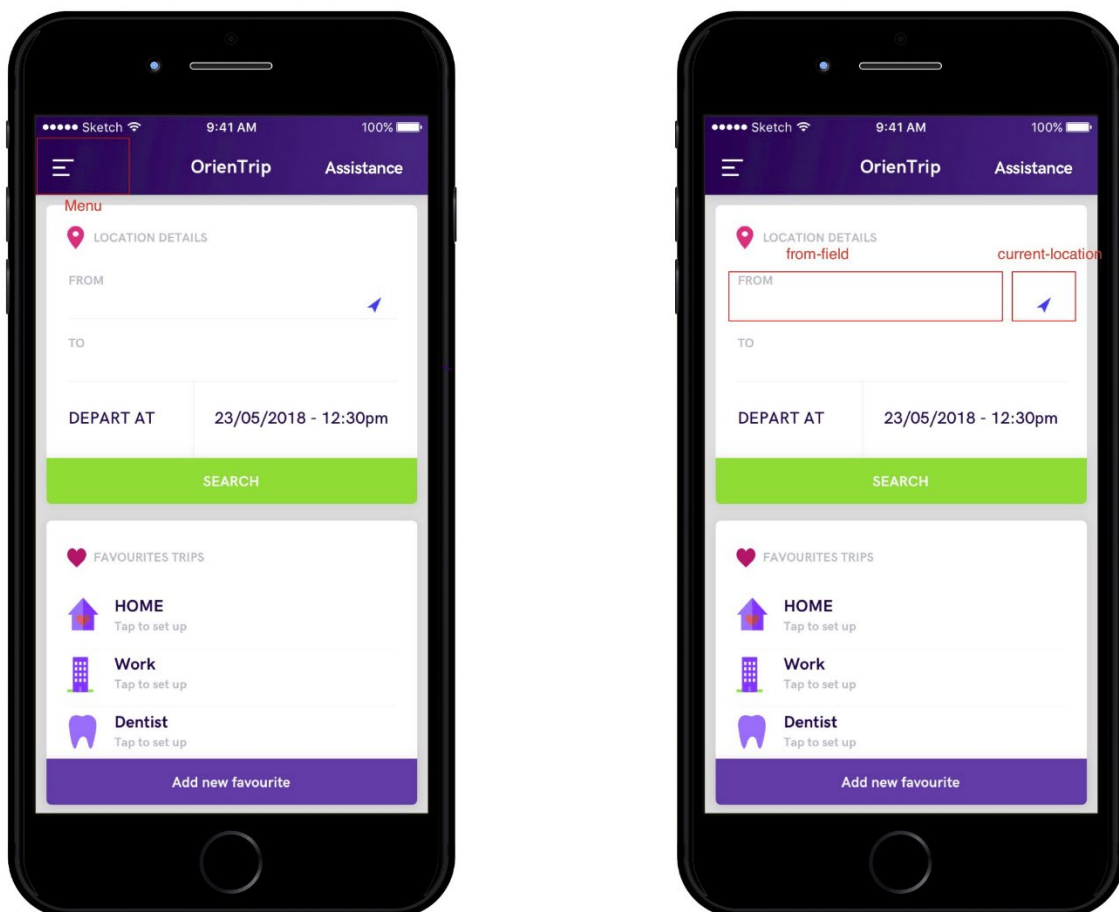


### 3.2.2 Data analysis

The image below shows an example of some of the screens shown to participants. Each screen contained one or more Area of Interest (AOIs). In analysing the data the following things were examined:

- Number of fixations
- First fixation latency
- First fixation to mouse click
- Total fixation time

Figure 5: Screen used to analyse eye gazes



The IBM SPSS Statistics 25 software package was used to analyse the eye gazes. The participants' eye gazes were entered for analyses of variance (ANOVA) to test for main and interaction effects with Bonferroni corrections being applied to the significance level where necessary.

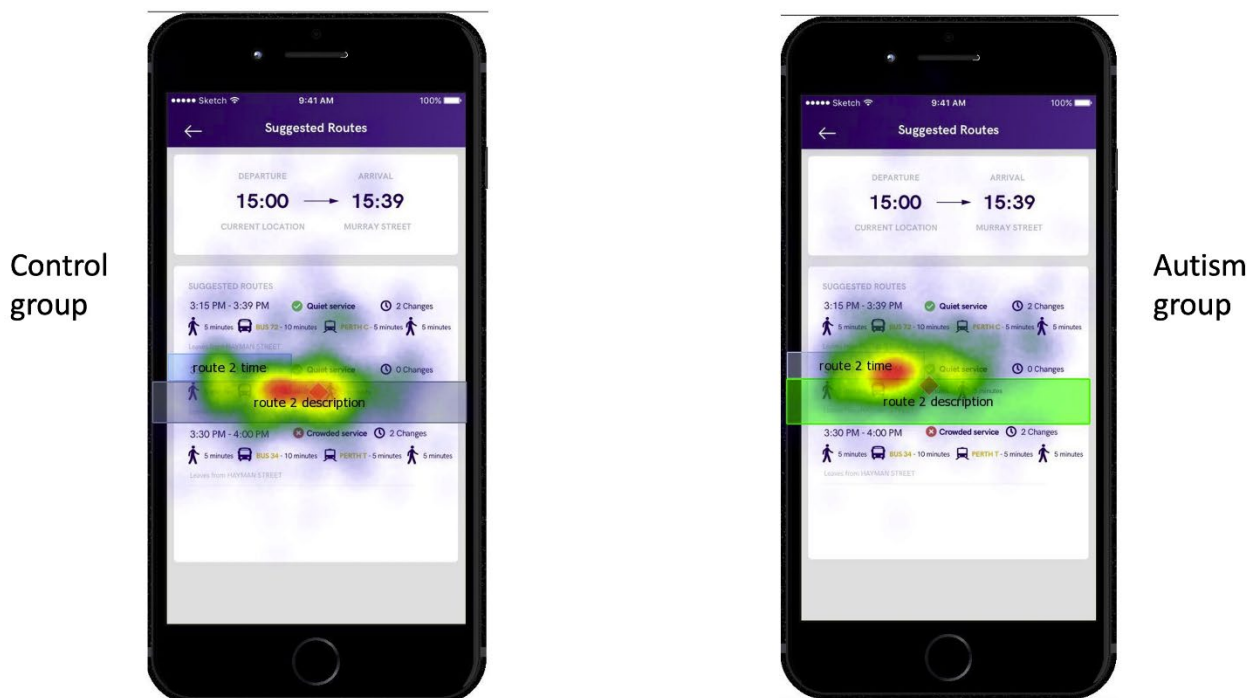


### 3.2.3 Findings

The image below shows hotspots of the two different groups as they looked at and interacted with the *OrienTrip's* interfaces. A summary of the findings from this study were:

- Autistic individuals focused more on irrelevant elements of the interface
- Autistic individuals showed greater interest in the icons and images rather than the written text
  - Crowdedness AOI (number of fixations and total fixation time similar in both groups)
  - Time and detailed info AOIs
    - Autism group showed significantly more fixations and had longer total fixation time on the time AOI than the detailed info AOI

Figure 6: Heatmap of eye gazes for control and autistic groups



### 3.2.4 UI design recommendations

From the analysis of the study's findings the following recommendations arose when it comes to creating user interfaces for autistic individuals.

- Use images or icons that clearly and accurately describe the given context
- Use common icons that are frequently used in other applications
- Icons and text should complement each other
- Text should be brief and concise
- Be consistent in your design.



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### 3.3 Phase 3: Pilot the technology solution

The aim of phase three was to evaluate the efficacy and effectiveness of *OrienTrip* in facilitating public transport use for individuals on the spectrum. To do this, a pilot study with *OrienTrip* was conducted with two groups in Western Australia and New South Wales, containing both autistic individuals and allied health professionals. Participants were asked to download and use the App to plan and manage their public transport journeys for two to four weeks. After this period, they were requested to complete a comprehensive survey to share their experiences.

The findings were to inform how effective *OrienTrip* is in making public transport easier for autistic individuals. It was also to provide important insights on how *OrienTrip* can be improved to better address the requirements of autistic individual travellers.

Hence the aims:

- Evaluate the effectiveness of *OrienTrip* with autistic individuals in the real-world through a pilot study
- Evaluate *OrienTrip* with allied health professionals and gather feedback to improve *OrienTrip* through a parallel pilot study

In this pilot phase a total of 38 participants took part:

- 16 autistic individuals (8 male and 8 female participants)
- 22 allied health professionals (19 females and 3 male participants)

The pilot study's procedure was quite simple:

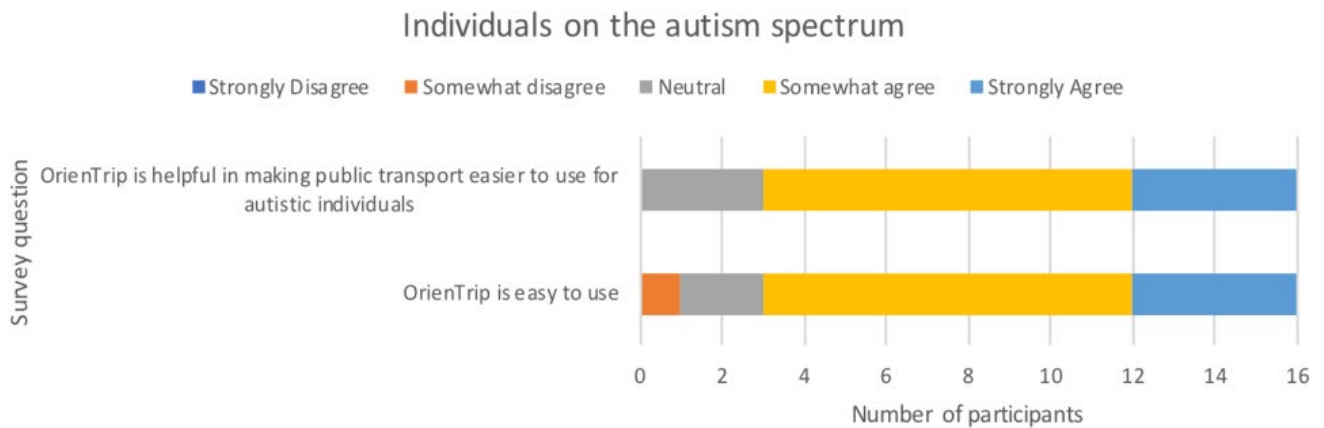
- Download and use *OrienTrip* on public transport trips for 4-6 weeks;
- Complete a Questionnaire through Qualtrics.

#### 3.3.1 Findings

For autistic individuals, the pilot showed that *OrienTrip* facilitated public transport usage and that the App was well received by the 16 autistic individuals and the 22 allied health professionals who participated. Individuals on the autism spectrum expressed that they 'somewhat agree' (4), on a scale of 1 ('strongly disagree') to 5 ('strongly agree'), that *OrienTrip* makes public transport easy to use (see Figure 5.3). Moreover, these participants scored the App an overall rating of 4 out of 5. Similarly, allied health professionals indicated that they also 'somewhat agree' (4) on App helpfulness, based on the same five-point Likert scale (see Figure 5.4). They also gave *OrienTrip* an overall score of 4 out of 5.

The graph below shows the autistic individuals' responses to the question of if *OrienTrip* makes public transport easier to use and if *OrienTrip* is easy to use.

**Figure 7: Survey results for individuals on the autism spectrum**



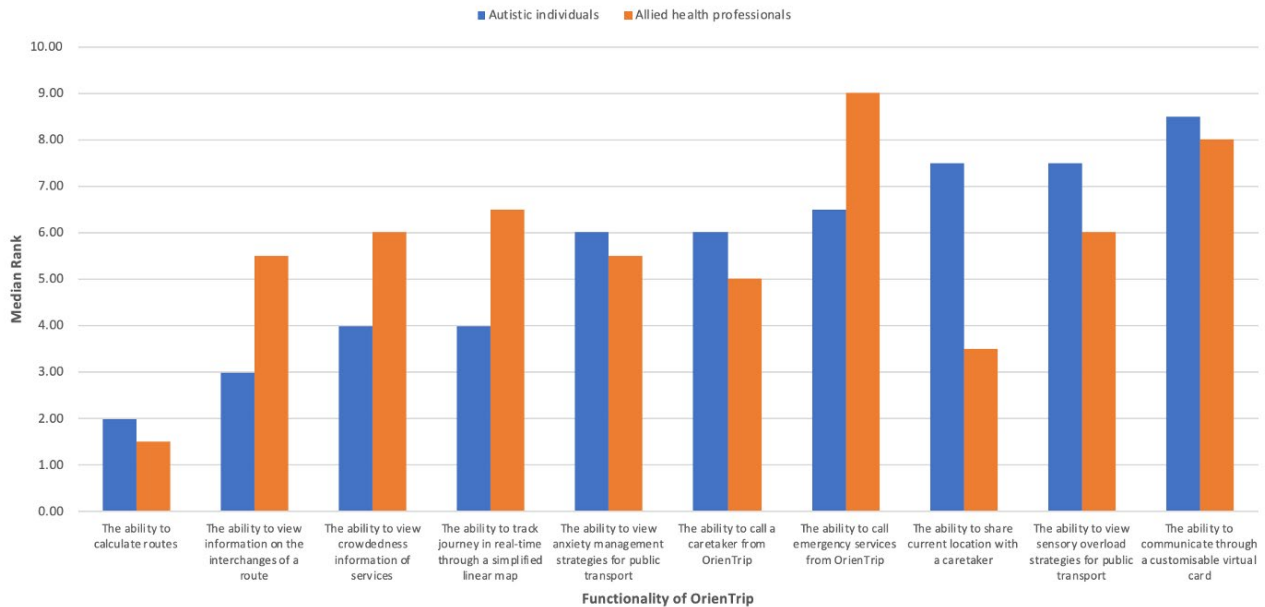
The graph below shows the Allied Health Professionals' responses to the question of if *OrienTrip* makes public transport easier to use and if *OrienTrip* is easy to use.

**Figure 8: Survey results for Allied Health Professionals**



The graph below shows the prioritisation of *OrienTrip*'s features as seen by the autistic individuals and the Allied Health Professionals.

**Figure 9: Prioritisation of functionalities of OrienTrip by autistic individuals and allied health professionals**



### 3.3.1.1 The qualitative findings of autistic individuals from the questionnaire summarised

- Primary benefits:
  - Makes planning trips easy
  - The support *OrienTrip* provides
  - Managing an existing journey
- Who would benefit from *OrienTrip*:
  - People on the autism spectrum
  - People with cognitive disabilities
  - People with anxiety issues
  - People who are new to public transport
- Biggest issues with *OrienTrip*:
  - Missing features
  - Difficult to use
  - Did not show the best route

### 3.3.1.2 The qualitative findings of health professionals from the questionnaire summarised

- Primary benefits:
  - Planning trips
  - Coping strategies
  - Support options
  - Independent mobility
  - Trip management
- Who would benefit from *OrienTrip*:
  - People with high-functioning autism
  - Individuals with anxiety disorder
  - Individuals with other disabilities
  - Youth and children
- How to improve *OrienTrip*
  - Simplify *OrienTrip*
  - Add more features
  - Support people with other disabilities

## 4. Summary and Key Findings

This section summarises the key findings from each phase of the research in point format.

### 4.1 Phase One key findings

- Using public transport requires skills such as understanding and processing navigations including maps, schedules, landmarks, signs, and problem solving unexpected events.
- These tasks can be challenging for autistic individuals due to the differences in their cognitive abilities

Phase One defined six areas of difficulties that autistic individuals face when using PT:

- Safety
- Limited spatial awareness
- Anxiety
- Sensory overload
- Difficulty with planning trips
- Differences in communication skills

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Phase one also:

- Designed the functionalities of mobile application that address the defined issues
- Validated these functionalities with autistic individuals and their families
- Presented *OrienTrip*, a mobile application that aims to facilitate public transport use for individuals on the autism spectrum

## 4.2 Phase Two key findings

- Software tools are increasingly being developed to assist autistic individuals with learning and everyday activities
- However, the usability and the user interfaces of these tools is hardly investigated. Most effort is placed on designing the functionalities and the development of the tool.

Phase two developed *OrienTrip* on the iOS platform and evaluated the usability and user interface of the application through eye movement analyses:

- Found that autistic individuals interact with user interfaces differently than non-autistic individuals
- Autistic users show greater interest in icons and images over text
- However, abstract or vague icons can cause further confusion
- Autistic users take longer and require more effort to process texts

Phase two then proposed autism-specific user interface design guidelines.

## 4.3 Phase Three key findings

The effectiveness of *OrienTrip* was evaluated in two pilot studies with the following participants:

- 16 autistic individuals
- 22 allied health professionals

It was found that:

- *OrienTrip* is helpful in facilitating public transport use for autistic individuals *OrienTrip* can improve autistic individuals' ability and confidence to use public transport independently
- *OrienTrip* can be improved by making it easier to use

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## 5. Strengths and Limitations

As with all research, there are strengths and limitations to it. This section summarises these strengths and limitations.

### 5.1 Strengths

This research:

- Was one of the first in the world that looked to define and address the challenges of public transport use for autistic individuals.
- Was conducted using a participatory research method.
- Demonstrated excellent interdisciplinary research.
- Utilised a unique empirical method to evaluate the usability of *OrienTrip* with autistic individuals
- Used triangulation of data from multiple sources to improve the overall reliability of the research
- Used different participant groups who were recruited at every stage of the research process.

The findings of this research are not limited to the autistic community but can be applied to various domains such as:

- Public transport providers
- Developers and researchers
- Software designers

### 5.2 Limitations

Some identified limitations within this research are:

- *OrienTrip* was developed and tested based on insights from two Australian states: WA and NSW.
- Participants self-nominated to take part in the studies
- Relatively small sample sizes
- Autism diagnoses were verbally confirmed which can be considered as self-reported

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## 6. Recommendations

From conducting this research the following is a list of recommendations that has been created.

### 6.1 Recommendations for making public transport accessible

Public transport providers can use the evidence in this research to implement long-term changes in the public transport system:

- Door-to-transit-station service
- Make more data available to developers and researchers
- Two versions of the service schedules and information
  - Simpler version for autistic individuals
  - Detailed for those who prefer more information
- Travel training
  - Very few autistic individuals receive formal travel training

### 6.2 Recommendations for future studies to improve *OrienTrip*

- Develop an Android version of the App
- Evaluate the App and its usage in all Australian states and territories
- Evaluate *OrienTrip* with autistic individuals who have never used public transport
- Implement the feedback from phase two and phase three and re-evaluate *OrienTrip*
- Tailor *OrienTrip* for people with other disabilities and evaluate
  - Two approaches for this are possible:
    - Cousin application
    - Tailor the current version of *OrienTrip* available to autistic individuals and people with other disabilities
- Evaluate *OrienTrip* through a large-scale Randomised Control Trial (RCT)

## 7. References and Awards

The material in this report can be found, in an expanded manner spread across the published papers, conference presentations and PhD thesis listed below. A list of awards this research won are also listed below.

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## 7.1 PhD Thesis

Rezae, Mortaza ; Curtin University, School of Earth and Planetary Sciences The Cooperative Research Centre for Living with Autism (Autism CRC). Thesis (PhD) -- Curtin University. 2020.

## 7.2 Journal Articles

Rezae, M., McMeekin, D., Tan, T., Krishna, A., Lee, H., & Falkmer, T. (2019). Public transport planning tool for users on the autism spectrum: From concept to prototype. *Disability and Rehabilitation: Assistive Technology*. Advance online publication.

<https://doi.org/10.1080/17483107.2019.1646818>

Rezae, M., Chen, N., McMeekin, D., Tan, T., Krishna, A., & Lee, H. (2020). The evaluation of a mobile user interface for people on the autism spectrum: An eye movement study. *International Journal Of Human-Computer Studies*, 142, 102462.

<https://doi.org/10.1016/j.ijhcs.2020.102462>

Rezae, M., McMeekin, D., Tan, T., Krishna, A., & Lee, H. (2020). Evaluating the effectiveness of an autism-specific public transport app for individuals on the autism spectrum: a pilot study. *Disability and Rehabilitation: Assistive Technology*, 1-16.

## 7.3 Conference Presentations

Rezae M., & McMeekin, D. (2017). Empowering people on the autism spectrum through spatial information. Presented at the Western Australian Surveying and Spatial Sciences Conference, Perth, WA.

Rezae, M., McMeekin, D., Tan T., & Lee, H. (2016, 8-9 December). Environmental scan to review existing public transport mobile technologies. Poster presented at the Australasian Society for Autism Research Conference, University of Western Australia, Perth, WA.

## 7.4 Awards

- Winner of the New South Wales Smart Cities & Accessibility Challenge, 2017 Winner of the 2017 Australian Falling Walls Lab, Canberra
- Finalist of the 2017 International Falling Walls Lab, Berlin
- Winner of the 2018 Western Australian FameLab, Perth
- Finalist of the 2018 National Australian FameLab, Perth



## Our values



### Inclusion

Working together with those with the lived experience of autism in all we do



### Innovation

New solutions for long term challenges



### Evidence

Guided by evidence-based research and peer review



### Independence

Maintaining autonomy and integrity



### Cooperation

Bringing benefits to our partners; capturing opportunities they cannot capture alone



AutismCRC

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