School of Earth and Planetary Sciences

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

The Development and Evaluation of a Mobile App to Facilitate Public Transport Use for Individuals on The Autism Spectrum: A Co-Production Approach

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This thesis is presented for the Degree of

Doctor of Philosophy

of

Curtin University

March 2020

Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number # HRE2016-0086.

Signature: …….

Date: 1 March 2020

Acknowledgements

My deepest gratitude to everyone who devoted knowledge, time and money to this project.

First and foremost, I am forever grateful to my supervisors, Dr David McMeekin, Professor Tele Tan, Associate Professor Hoe Lee, and Associate Professor Aneesh Krishna, for their unparalleled support and guidance. David, thank you for the incredible generosity with your time and knowledge. I have learned so much from you that has made a better researcher and thinker *and* a better person. Tele, thank you for your thoughtful feedback and always encouraging me to do better. I am forever indebted to you for your generosity and kindness. Hoe, thank you for helping me see challenges from a different perspective. This project would not have been the same without your support and knowledge. Aneesh, thank you for your mentorship and for presenting me with opportunities. I am very lucky to have had you as my mentor for many years.

I am endlessly grateful to Professor Torbjorn Falkmer for his extreme generosity and kindness. Torbjorn, thank you for your encouragement and guidance. I am honoured to have met you and worked under your leadership.

Cheryl Mangan -- thank you for believing in this project and always willing to help. I can confidently say this project would not have been the same without your unwavering support.

I feel incredibly honoured and privileged to have briefly met Emeritus Professor Sylvia Rodger. This project would not have been possible without her support and guidance at the beginning.

My sincere thanks go to to the individuals on the autism spectrum, their families and allied health professionals who participated in this research. Your valuable insights and comments are the core of this thesis which I hope makes the world a little friendlier for people on the autism spectrum.

A special thanks to Matt Lavender for all his work and commitment to this project. Matt, thank you for the incredible work you have done to take OrienTrip from concept to reality.

I would also like to give a sincere thanks to the many people who have contributed to this project: Dr Nathan Wilson for his valuable feedback; Ms Kaaren Haas for assisting with the recruitment of study participants in NSW; Dr Nigel Chen for his advice on statistical analysis; Dr Sharmila Vaz for her encouragement and positivity; Associate Professor Reinie Cordier for his guidance in getting this project off the ground; Ms Julia Tang and Dr Melissa Black for their help with recruitment; and Dr Elinda Lee for her invaluable assistance with submitting ethics applications, recruiting study participants and promoting the project.

I would like to acknowledge the financial support and the many opportunities provided by the Autism CRC and the New South Wales Government, Transport for NSW and the Department of Finance.

Endless thanks to my family. My parents for teaching me to be kind, honest, patient and hardworking. I owe everything to your unfaltering support and encouragement. My siblings for supporting me with laughter and a shared passion for books.

Finally, Arazu, I love you more than anyone. You gave me the confidence to pursue research. Thank you for always supporting and believing in me. I am lucky beyond measure.

Capstone Editing provided copyediting and proofreading services, according to the guidelines laid out in the university-endorsed national ‘Guidelines for Editing Research Theses’.

Dedication

For Nawid, my brother

Abstract

Individuals on the autism spectrum have limited participation in community activities such as employment, education and social interaction. Lack of transportation is one key barrier that limits participation, with more than 80% of autistic people currently relying on family members for their travel needs. This dependence is costly for both parties. For example, more than 72% of individuals on the autism spectrum forgo some activity because the person responsible for their transportation is not available. Further, more than 73% of families miss their own activities, including employment, due to commitments to provide transportation for the autistic individual. Public transport is an inexpensive and widely available form of transport, which autistic individuals themselves believe is critical in fulfilling their community participation goals. Notably, those on the spectrum who can use public transport are five times more likely to find employment compared to those who cannot. However, more autistic individuals have never travelled independently using public transport, let alone consider the thought. To date, the challenges they face in using public transport have not been clearly defined, and this has resulted in lacking solutions that currently support people on the spectrum to freely navigate the community.

The overarching aim of this thesis is to develop and evaluate an autism-specific mobile application, co-produced with individuals on the autism spectrum, that facilitates public transport use for individuals on the autism spectrum. This was achieved through continuous collaboration with the autism community and their allies, including families and health professionals, at all stages of the research process.

As such, this thesis comprises three phases, the first of which deals with requirements gathering and design (Chapters 2 and 3). The objectives of this phase were to (1) conduct a literature review to understand the challenges individuals on the autism spectrum face when using public transport, (2) conduct an environmental scan evaluating the capacity of existing public transport tools in addressing the challenges of independent travel, (3) conduct interviews and surveys with those on the spectrum and their families to validate the challenges of public transport, and (4) design and propose a mobile application called 'OrienTrip' to address the challenges of public transport use.

Phase 2 was the implementation and user-interface evaluation phase (presented in Chapter 4). The objectives were to (1) implement OrienTrip from Phase 1 and (2) evaluate the user interface and user experience through eye-movement analyses of autistic individuals.

Finally, Phase 3 was the pilot phase (Chapter 5). This sought to (1) evaluate the effectiveness of OrienTrip in facilitating public transport use through a pilot study with individuals on the spectrum, and (2) gather insight and feedback to improve the app through a parallel pilot study with allied health professionals, who have extensive experience working autistic people.

The outcomes of this thesis demonstrated that OrienTrip is effective in facilitating public transport use for individuals on the spectrum. Both pilot studies revealed that the app assists in making public transport easy to use. Individuals on the autism spectrum expressed that they benefitted from its trip-planning functionality and the autism-specific assistance options it provides. This includes the evidence-based anxiety-management and sensory-overload strategies, and the ability to share one's location with a caregiver. Similarly, allied health professionals praised

OrienTrip and highlighted its ability to improve one's capacity to use public transport independently. Valuable insight and feedback were collected to better develop OrienTrip and simplify its use for autistic individuals with varying skills and abilities.

This thesis clearly defined the challenges individuals on the spectrum face when travelling. It also presented the first evidence-based, autism-specific trip-planning mobile application, OrienTrip, co-produced with individuals on the autism spectrum, to facilitate public transport use in the Australian context. Further, the research provides, through a unique eye-movement study, empirical-based insights to improve the user interfaces of mobile apps for autistic persons. Importantly, this work is among the first to utilise a novel approach to evaluate and improve user interfaces in this context. Overall, OrienTrip was determined to be effective in facilitating public transport use for autistic individuals. The outcomes of this research can significantly improve their quality of life, as the ability to independently use public transport can present people on the autism spectrum numerous opportunities for employment, education and social interaction.

Contents

List of Figures

List of Tables

List of Appendices

List of Abbreviations

ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
APA	American Psychiatric Association
ASD	autism spectrum disorder
Autism CRC	Cooperative Research Centre for Living with Autism
CDC	Centers for Disease Control and Prevention
DSM-5	Diagnostic and Statistical Manual of Mental Disorders
US	United States

List of Publications

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*. Under review

List of 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.

List of Awards

The following awards were presented to the author for the work related to this thesis:

- 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

Statement of Author Contribution

The nature and extent of the intellectual input by the candidate and co-authors has been validated by all authors:

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Professor Tele Tan (Secondary supervisor)

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Associate Professor Aneesh Krishna (Secondary supervisor

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Chapter 1: Introduction

1.1 Context of the Study

This research aims to design, develop and evaluate a trip-planning mobile application, through a co-production approach, that facilitates public transport use for individuals on the autism spectrum. It explores their current transportation habits and examines existing technologies that make independent travel easier. It also seeks to define the challenges these individuals face when using public transport and further designs an app, in collaboration with autistic individuals and their allies, that addresses the key hardships. Finally, the thesis develops and evaluates a trip-planning application that aims to streamline public transport for less stressful travel experiences.

This research was conducted and evaluated in the Australian context, with particular focus on Western Australia and New South Wales. Divided into eight states and territories, and with a population of over 25.2 million people, Australia has an estimated 205,200 individuals on the autism spectrum (Australian Bureau of Statistics [ABS], 2018).

The latest edition of the American Psychiatric Association's (APA) *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) uses 'autism spectrum disorder (ASD)' to describe individuals who meet the diagnostic criteria. However, such terms as 'on the autism spectrum' and 'autistic individual' are more accepted by the autism community (Kenny et al., 2016). As such, in this thesis both terms are used interchangeably to describe persons with ASD.

1.2 Statement of the Problem

Autism is characterised by differences in social communication and interaction skills, repetitive behaviour, and extreme sensitivity to sensory stimuli in the environment (APA, 2013). These differences can limit one's capacity to perform

everyday activities. According to the 2018 ABS Survey of Disability, Ageing and Carers, one in 120 people is on the autism spectrum (Australian Bureau of Statistics [ABS], 2018). In the United States (US), an estimated one in 59 children were identified in 2014 as being autistic (Centers for Disease Control and Prevention [CDC], 2019). Similarly, studies in Asia, Europe and North America have reported that an estimated 1% of the respective population has autism (CDC, 2019; Ehsan et al., 2018).

Diagnosis has increased considerably over the years. For example, in Australia, the number of people identified with ASD rose from an estimated 64,400 in 2009 to 164,000 people in 2015 and then to 205,200 people in 2019 (AIHW, 2017; Australian Bureau of Statistics [ABS], 2018). Although it is not completely clear what has caused this spike in autism diagnosis, some studies have attributed it to the expansion in diagnostic criteria and through increased awareness (King & Bearman, 2009, 2011).

Participation in community activities, including education, employment and social events, is associated with various benefits including physical health, emotional wellbeing and skills development (Schiavone, Szczepanik, Koutras, Pfeiffer, & Slugg, 2018; Tint, Maughan, & Weiss, 2017). However, individuals on the autism spectrum are reported to participate in significantly fewer activities than those who are not on the spectrum (Ashbaugh, Koegel, & Koegel, 2017). In fact, autistic individuals have the lowest community participation rate among all developmental disability groups (Schiavone et al., 2018). According to the 2017 National Autism Indicators Report, only 14% of people on the autism spectrum hold paid employment, while more than 54% work without pay and in segregated settings (Roux, Shattuck, Rast, Rava, & Anderson, 2015). The statistics are similarly

concerning in the educational context. Notably, only 12% attend university after graduating from high school (Zeedyk, Tipton, & Blacher, 2016), while only 1.9% of undergraduate university students are reported to be on the autism spectrum (White, Ollendick, & Bray, 2011).

One of the most common barriers that limit community participation is lack of transportation. Undeniably, travel is critical for access to activities such as education, employment and social events, regardless of neurology (Gallup, Lamothe, & Gallup, 2015). In fact, individuals on the autism spectrum who can travel independently are five times more likely to attain employment than those who rely on others for transportation (Zalewska, Migliore, & Butterworth, 2016). However, most heavily rely on family members and friends for their travel requirements (Deka, Feeley, & Lubin, 2016), and this dependence can cause significant challenges for both autistic individuals and their families. For example, more than 72% of people on the spectrum cannot attend a planned event because the person who drives them is not available (Lubin & Feeley, 2016). Similarly, 73% of family members have to forgo other activities, including work, to fulfil transportation duties (Lubin & Feeley, 2016).

Public transport is a widely utilised mode of travel that enhances independence and access to the community. The various benefits of public transportation have been well established, notably regarding its lack of expense. For example, in the US, it has been reported that parents of autistic children spend more than USD$700 each month and over USD$85,000 in 10 years on their child's transportation needs (Lubin & Feeley, 2016). Another study showed that individuals with disabilities who can use public transport rather than relying on paratransit can save over USD$4,500 each year on travel (Stock, Davies, Wehmeyer, & Lachapelle,

2011). Second, those on the spectrum widely regard public transport as their preferred mode of travel. Concretely, previous studies have shown that autistic people who can use public transport report improved independence and quality of life (Falkmer et al., 2015; Lubin & Feeley, 2016).

Third, public transport encourages superior physical health. For example, a 40% decrease in car trips can significantly reduce cardiovascular diseases and type 2 diabetes (Rojas-Rueda, de Nazelle, Teixidó, & Nieuwenhuijsen, 2013). Consequently, the increase in physical activity connected with public transport, such as walking and cycling, can improve physical wellbeing (Litman, 2016; Rojas-Rueda et al., 2013). Finally, studies have shown that public transport can reduce emotional and economical stress through improved access to education, employment and social opportunities at an affordable cost (Litman, 2016).

That said, using public transportation requires skills such as time management, high literacy, the capacity to problem-solve unexpected events and wayfinding (Lindsay, 2018). As such, differences in the abilities of people on the autism spectrum can make independent travel challenging. For example, more than 61% of autistic individuals have never used public transport and among them more than 69% have never considered it as a possible mode of passage (Deka et al., 2016). Some studies have reported that people on the spectrum also have difficulties in planning public transport trips, getting to transit stations and managing transfers (Deka et al., 2016; Feeley, Deka, Lubin, & McGackin, 2015). However, the specific challenges that these individuals face have not been clearly defined. Due to the paucity of literature, public transport accessibility for autistic individuals has not been addressed.

Therefore, it is important to explore and address the challenges individuals on the spectrum face when using public transportation. This can lead to greater independence and improved wellbeing through access to education, employment and social opportunities.

1.3 Overall Aim

The main objective of this research is to develop a mobile application tool that facilitates public transport use for people on the autism spectrum. The outcome is informed through a co-production approach that involves close collaboration with autistic individuals and their allies at every stage of the research process.

1.3.1 Phases and objectives of the study

This research consists of three phases, which all contain their own unique set of objectives (Figure 1.1). Subsections 1.3.1.1 to 1.3.1.3 describe and connect each research phase.

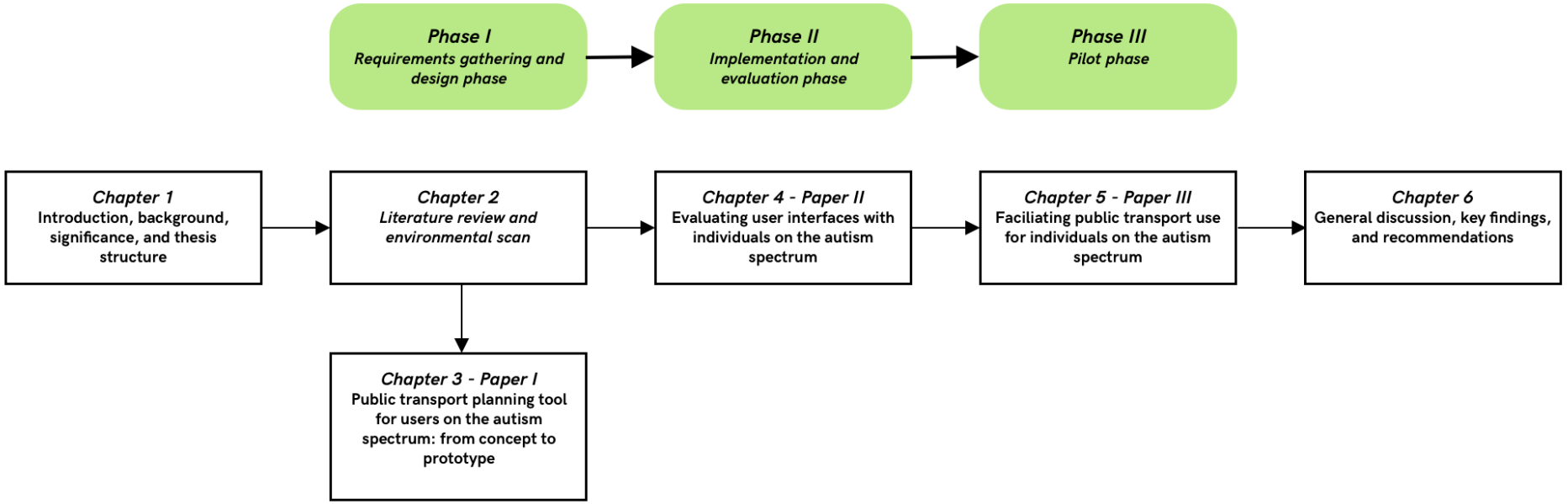

Figure 1.1. Overview of thesis structure.

1.3.1.1 Phase 1: Requirements gathering and design

Developing an evidence-based tool should begin with understanding the existing research. This is best achieved through a literature review and by performing an environmental scan to identify and examine similar tools. The first stage of the software-development process is to recognise what the software tool will do (Figure 1.2). This process is called 'requirements gathering', where the goal is to identify and validate the end users' needs (Saiedian & Dale, 2000). The focus should be on helping people recognise what they require and prioritising their needs over their wishes (Young, 2002).

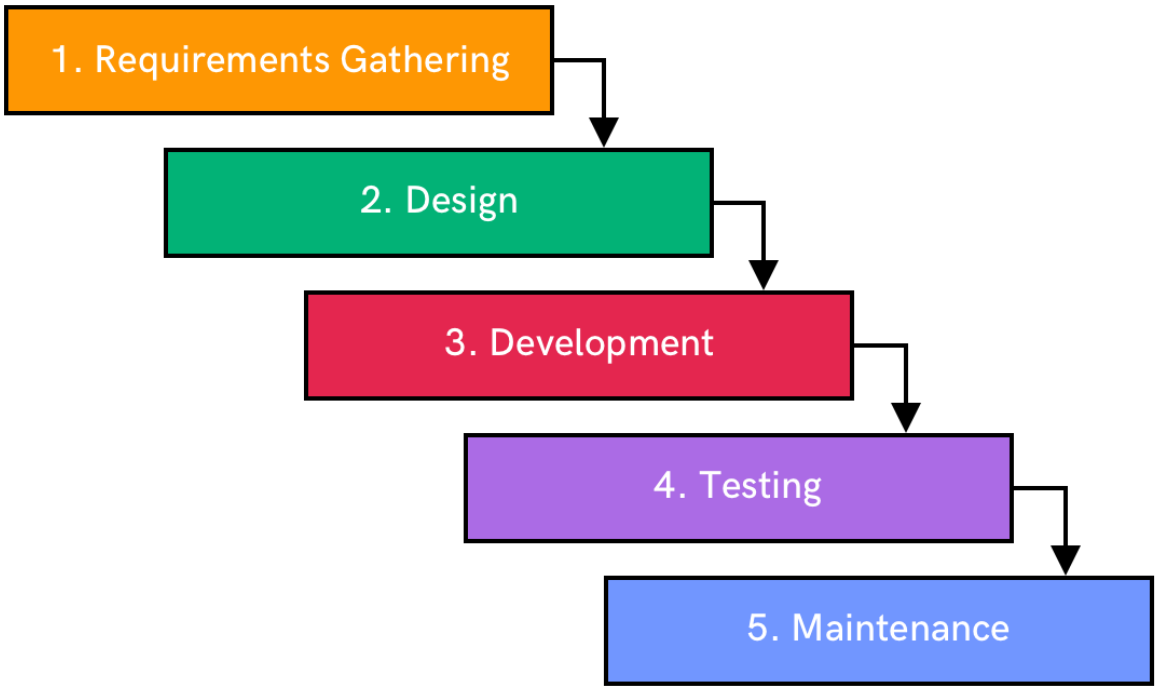

Figure 1.2. The first phase of the software-development life cycle is 'requirements gathering'.

The research objectives addressed in Phase I are as follows:

- *Objective 1:* Conduct a literature review to examine the public transport use of individuals on the autism spectrum.

- *Objective 2:* Conduct an environmental scan examining the capacity of current public transport tools in making travel easier for people on the spectrum.
- *Objective 3:* Conduct interviews and surveys with autistic individuals and their allies, including family, to validate the challenges they face when using public transport.
- *Objective 4:* Utilise the findings from Objectives 1 and 3 to design a trip-planning tool that facilitates public transport use for people on the autism spectrum.

1.3.1.2 Phase II: Implementation and evaluation

Phase II utilised the findings from Phase I to develop and evaluate a public transport planning tool called OrienTrip, which facilitates public transport use for individuals on the autism spectrum. The research objectives addressed in Phase II are as follows:

- *Objective 1:* Develop the designed public transport tool from Phase I in the form of a functional, minimum-viable mobile application.
- *Objective 2:* Evaluate the user interface and the user experience of OrienTrip using eye-movement analyses to improve usability.

1.3.1.3 Phase III: Pilot study

The purpose of Phase III is to evaluate the efficacy and effectiveness of OrienTrip in facilitating public transport use for individuals on the autism spectrum. The research objectives addressed are as follows:

- *Objective 1:* Trial OrienTrip through a pilot study with autistic individuals and evaluate how effective the app is in facilitating public transport use.

- *Objective 2:* Conduct a parallel pilot study with allied health professionals who have experience working with individuals on the spectrum. The purpose is to gather feedback on OrienTrip to inform how it can be improved.

1.3.2 Study setting

This research is an initiative of the Cooperative Research Centre for Living with Autism (Autism CRC). Established in 2013, the centre is believed to be the world's first national cooperative research effort focused on autism. Autism CRC aims to develop and deliver evidence-based autism research outcomes through unique collaborations with the autism community, research organisations, industry and the government. Its research projects fall under three programs: Program 1 is for early years, Program 2 is for school years and Program 3 is for adulthood. This research project falls under the third category.

In particular, the aim of this program was to improve opportunities for autistic people to successfully participate in higher education and employment, and to identify best practices for physical and mental health management. The research efforts were led from Curtin University in Western Australia, with data informing the findings collected from two Australian states: New South Wales and Western Australia.

1.4 Significance of the Study

One intended outcome of this study was to identify and define the challenges individuals on the spectrum face when using public transportation. This proved particularly important, as there is a paucity of literature on autism and independent travel, including the issues commonly encountered. A second intended outcome was to develop a software tool, co-produced with autistic individuals and their allies, that

facilitates independent public transport use in this context. Access to adequate and independent transportation can bring about many opportunities for community participation, including better education and employment outcomes. This can consequently lead to enhanced independence, improved financial situation, and superior physical and mental wellbeing.

A third intended outcome of the research was to define user-interface design guidelines to help researchers and software developers craft better app interfaces for autistic people. With recent advancements in technology, more software is being developed to address the challenges the autism community faces every day; however, the user-interface component remains completely overlooked. This is important because the interface is the window that allows people to use and reap the benefits of an app. As such, poor design can cause autistic users, in particular, to abandon a tool, despite its many benefits.

A fourth intended outcome was to promote greater engagement of autistic people in autism research. According to Bergold and Thomas (2012), participatory research involves 'planning and conducting the research process *with* those people whose life-world and meaningful actions are under study' (p. 192). To date, most autism studies have been conducted without proper representation or tokenistic involvement from individuals on the spectrum, including their allies. This lack of representation from the autism community can deprive the research from unique insights that only these individuals can provide (Searle et al., 2019).

1.5 Structure and Overview of the Thesis

This thesis contains five additional chapters. The information presented in this section outlines the purpose and contribution of each chapter to the overall aim

of the thesis—that is, facilitating public transport use for individuals on the autism spectrum.

1.5.1 Chapter 2: Background

This chapter situates the current research in relation to the literature through a review of autistic individuals' transportation habits. Specifically, this review aims to explore their current travel practices, discuss the challenges people on the spectrum face when using public transport (as reported in the literature), and further investigate methods commonly employed to design assistive tools. Concurrently, an environmental scan was conducted to assess the capacity of existing public transport planning tools in making travel easier for individuals on the autism spectrum.

1.5.2 Chapter 3: Paper I

This chapter defines the challenges autistic people face when using public transport, and next designs and proposes a mobile application, called OrienTrip, in collaboration with individuals and their families. The app intends to make public transport easier by reducing stress during independent travel.

1.5.3 Chapter 4: Paper II

Chapter 4 implements the fully functional OrienTrip app from the design documents described in Chapter 3. Thereafter, it assesses the user interface and the user experience of OrienTrip through a unique eye-tracking technique, and reports guidelines to craft better software design for individuals on the spectrum.

1.5.4 Chapter 5: Paper III

Chapter 5 evaluates the efficacy and effectiveness of OrienTrip in facilitating public transport assistance. To do this, two pilot studies were conducted: first, OrienTrip was piloted with individuals on the spectrum to understand how effective it is in real-world contexts; second, a parallel pilot study with allied health

professionals, who have experience working with autistic individuals, gathered feedback to improve the app.

1.5.5 Chapter 6: General discussion

Chapter 6 synthesises and summarises the findings, describes the implications of the results, critically reviews the strengths and limitations of the research, and suggests recommendations for future investigations.

1.6 Summary of Introduction

Community participation including employment, education and social events are all essential for maintaining a healthy physical and emotional wellbeing. However, those on the autism spectrum have one of the lowest community participation rates among all development disability groups (Schiavone et al., 2018). In particular, lack of transportation is one key barrier that hinders active involvement in social activity. As such, many autistic individuals rely heavily on family members for their transportation needs (Deka et al., 2016), but dependence can lead to significant difficulties for both groups (Lubin & Feeley, 2016). For example, people on the spectrum often miss out on activities due to the unavailability of those responsible for their travel. Similarly, families often forgo important obligations, including work, to drive their autistic counterparts, as required.

Although public transport is an inexpensive and reliable mode of transportation—with noted preference among autistic individuals (Falkmer et al., 2015; Lubin & Feeley, 2016)—most do not use and have never considered this mode of travel (Deka et al., 2016). This is because, according to the literature, many experience significant difficulties with trip planning, navigating service stations or stops, and managing transfers (Deka et al., 2016; Feeley et al., 2015). Despite this prevalence, the specific challenges autistic people face when using public transport

have not been clearly defined. Further, there are no existing tools or solutions that facilitate travel in the Australian context. Therefore, there is demand for an autism-specific tool that facilitates public transport use for individuals on the spectrum

Chapter 2 conducts a literature review to understand and outline the challenges autistic people face when using public transportation. It also reports the findings of an environmental scan conducted to assess the capacity of current public transport tools in addressing the challenges individuals on the autism spectrum experience when travelling independently.

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Chapter 2: Literature Review and Environmental Scan

2.1 Preface

This chapter includes a literature review on how people on the autism spectrum use public transport. It aims to understand the current state of travel for those on the spectrum and further identify the missing gaps in existing knowledge. Chapter 2 also reviews the literature to grasp the role that intervention tools play in improving their overall independence. Further explored is participatory research as a methodology for developing intervention tools.

Chapter 2 also conducts an environmental scan to analyse the capacity of current public transportation tools in addressing the requirements of people on the autism spectrum. Thereafter, the findings are summarised and the focus of Chapter 3 is specified (see Figure 2.1).

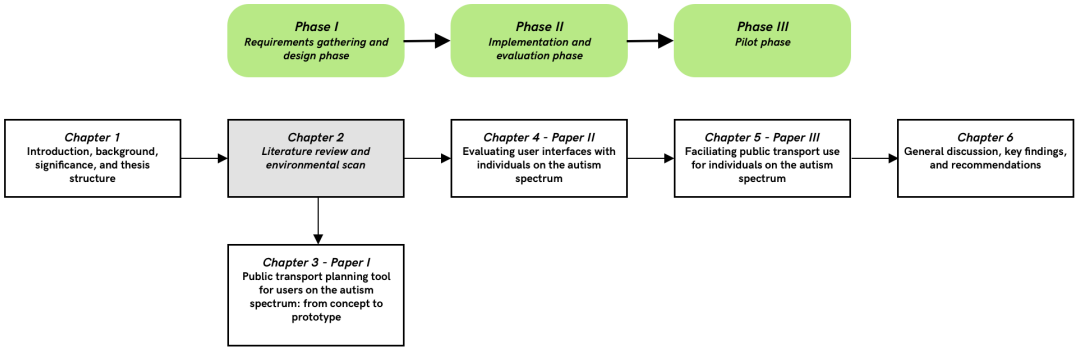

Figure 2.1. Chapter 2 includes a literature review and an environmental scan.

2.2 Background

Autism is a lifelong neurodevelopmental condition characterised by deficits in communication and social interaction, repetitive behaviour, and insistence on sameness (APA, 2013). Individuals on the autism spectrum are also commonly affected by co-occurring conditions such as anxiety disorder and sensory sensitivity (APA, 2013). In fact, it has been reported that more than 80% of autistic people have

sensory issues (Baum, Stevenson, & Wallace, 2015; Sinha et al., 2014) and an estimated 40% have anxiety problems (Hedley, Uljarević, & Hedley, 2017). Due to these characteristics, this group is less likely to perform everyday tasks independently.

Participation in the community is vital for an individual's physical and emotional wellbeing. Notably, engagement in social activities has been demonstrated to aid skill acquisition and encourage the development of interpersonal relationships (Chan et al., 2018; Schiavone et al., 2018). That said, individuals on the spectrum are significantly less engaged in the community than non-autistic people.

In the literature, Solish, Perry and Minnes (2010) (n = 65) reported that children on the spectrum participate in significantly fewer social activities than their typically developing counterparts. Later, Schiavone et al. (2018) noted the same trend among older cohorts when compared to their neurotypical peers. In fact, autistic individuals have the lowest social engagement rate among all disability groups. Concretely, Orsmond, Shattuck, Cooper, Sterzing and Anderson (2013) reported that autistic adults are more likely to be socially isolated than those with intellectual disability (Shattuck et al., 2012). Evidently, autism traits have been branded in the literature as a major contributing factor to isolation (Tint et al., 2017).

Employment is another factor with known links to improved wellbeing, increased independence and sense of self-worth, and enhanced quality of life (Chen, Sung, & Pi, 2015; Orsmond et al., 2013). Yet, despite the established benefits, individuals on the autism spectrum have significantly low employment rates (Chan et al., 2018; McLaren, Lichtenstein, Lynch, Becker, & Drake, 2017; Nicholas, Mitchell, Dudley, Clarke, & Zulla, 2018; Roux et al., 2015; Wehman et al., 2019). For example, Sanford et al. (2011) showed that only 45% of autistic people hold paid

employment—which is one of the lowest rates of work among all disability groups. The authors further reported that those in paid positions earn less than their neurotypical colleagues (Sanford et al., 2011). Similarly, Roux et al. (2017) found that only 14% of autistic individuals have paid employment, and more than 54% work without pay and in isolated conditions. More recently, Wehman et al. (2019) showed that current working status has remained low at only 37% and even worse (14%) for those who *also* have an intellectual disability (Chan et al., 2018). In the Australian context, unemployment rates are no different, with only 40.8% of autistic people in 2015 reported to work (ABS, 2015; Hedley et al., 2017).

Independence in everyday living has been associated with higher community participation and employment. For example, Shattuck et al. (2012) measured the functional independence (e.g., ability to use public transportation, manage one's finances, look up telephone numbers, etc.) of youths on the spectrum and found that a one-point increase in these skills can raise one's chances of gaining employment by 10%. Similarly, Chan et al. (2018) emphasised that independence in daily living is of great importance for securing work.

2.3 Current State of Transportation

Transportation is a common barrier for people on the spectrum attempting to participate in community activities. Upon examining the vocational experiences of autism, Coleman and Adams (2017) found that travel issues are one of the most recurring obstacles in attaining and sustaining employment. Similarly, Nowell, Brewton, Allain and Mire (2015) reported that the lack of transportation practices among autism communities limits them from accessing appropriate care. Indeed, the importance of travel was further highlighted in Anderson and Butt (2018) by one parent of an autistic individual:

> I think what has made the single biggest difference in his life is being independent on transportation. He takes that so seriously … He books all his own trips … That really has meant a lot to him, not to have mom or dad take you everywhere. (p. 6)

2.3.1 Reliance on family members

The lack of access to independent transportation causes people on the autism spectrum to rely on others to fulfil their travel needs (Anderson & Butt, 2018; Graetz, 2010; Lubin & Feeley, 2016). In fact, it has been reported that more than 80% of individuals will depend on family members or friends for transport (Deka et al., 2016; Lubin & Feeley, 2016). Some families do not have access to a vehicle or another form of on-demand transportation, and, as such, will forgo most community activities, including therapy sessions, completely (Anderson & Butt, 2018).

That said, individuals on the autism spectrum most commonly miss community activities due to the unavailability of able persons providing round-the-clock transportation. According to Deka et al. (2016), more than 72% of individuals on the spectrum fail to participate in some activity due to this problem. Similarly, caretakers have reported (73%) that they will neglect their own responsibilities, including work, to fulfil their travel duties (Deka et al., 2016). This reliance also has a significant effect on caretakers' general productivity and wellbeing. Concretely, Lubin and Feeley (2016) found that parents of autistic individuals work far less than their peers and earn more than 50% less than those who do not care for an autistic child. Schiavone et al. (2018) similarly reported that parents of autistic children tend to forgo all leisurely activities to nurture their child's therapeutic needs. Hence, to better understand this reliance, it is important to examine other forms of travel including driving and public transportation.

2.3.2 Driving

The ability to drive a vehicle is widely recognised as a facilitator of independence for people on the autism spectrum (Bishop, Boe, Stavrinos, & Mirman, 2018; Daly, Nicholls, Patrick, Brinckman, & Schultheis, 2014; Sheppard, Ropar, Underwood, & van Loon, 2010). Despite this insight, a significantly low percentage of autistic individuals are reported to drive. Sheppard et al. (2017) found that only 25% of people on the autism spectrum have a driver's licence, while in Daly et al. (2014), only 24% were noted to drive independently. Those on the spectrum also take longer (i.e., at least two years later than neurotypical drivers, according to Daly et al., 2014), to acquire a driving permit. Even then, autistic drivers are said to drive significantly less frequently, avoiding heavy traffic, night-time driving and unfavourable weather conditions (Daly et al., 2014).

These numbers are understandable. Previous studies have shown that individuals on the autism spectrum face myriads of challenges in learning how to drive. For example, Sheppard et al. (2017), in studying the attentional differences in driving-risk perception among those on the spectrum, found that these individuals display unusual processing of on-road hazards. As a result, the authors concluded that autistic people are slower to respond to danger than neurotypical drivers. Several other studies have also supported this finding. Notably, Huang, Kao, Curry and Durbin (2012) showed that drivers on the autism spectrum struggle to focus on the road and respond slower to hazards and risks. Further, upon evaluating driving behaviour and autism, Chee, Lee, Patomella and Falkmer (2017) noted a slowed response rate in the visual scanning of roads and poor performance in vehicle-manoeuvring tasks. This is despite that licenced drivers are expected to have reached competency in these core driving skills.

Difficulties with driving have been associated with impaired executive functioning in people on the autism spectrum (Bishop et al., 2018). Executive functions are cognitive operations driven by the prefrontal cortex, including planning, inhibition, flexibility and working memory (Ozonoff, Strayer, McMahon, & Filloux, 1994). In the driving context, an impaired executive function results in inattention and poor coordination (Bishop et al., 2018; Cox et al., 2016; Walshe, McIntosh, Romer, & Winston, 2017; Wilson, Lee, Vaz, Vindin, & Cordier, 2018). Hence, the findings in Chee et al. (2017)—which showed that drivers on the spectrum underperform in selective-attention tasks during driving—and Sheppard et al. (2017)—which emphasised a general failure to focus on hazardous objects, but an increased likelihood to concentrate on trivial objects while driving—are relatively unsurprising. In mentioning the latter study, Reimer et al. (2013) further examined driving behaviour and autism through eye movements and found that autistic people fixated less on high-stimulus areas (e.g., cars in front of them, pedestrians, etc.) and focused more on low-stimulus areas (e.g., the horizon). Lindsay and Stoica (2017) observed a similar pattern through a systemic review, noting that individuals on the autism spectrum focus on their own specific interests during driving, a repetitive behaviour that is a core characteristic of the ASD community.

Impaired executive function also results in cognitive inflexibility and deficits in inhibition (Bishop et al., 2018; Cox et al., 2016; Walshe et al., 2017; Wilson et al., 2018). This can affect how one reacts to the environment and is especially important in relation to driving, which requires active responses according to the changing surrounds. As such, cognitive inflexibility and deficits in inhibition can make driving a dangerous practice for people on the spectrum. It is perhaps unsurprising, then, to note the higher incidence of traffic accidents among autistic drivers compared to

their neurotypical peers (Sheppard et al., 2017). Elsewhere, Cox et al. (2016) echoed this finding, observing, using virtual reality technology to improve driving skills, that people on the autism spectrum commit a high rate of traffic offences. A statement in Silvi and Scott-Parker (2018) by one autistic driver succinctly highlights the challenges they face on the road: 'I am still a poor driver, still have spatial awareness issues and have crashed at least 10 time (every time my fault)'. While learning how to drive safely is possible for some autistic individuals, it is worth exploring the current state of public transport accessibility for people on the spectrum.

2.3.3 Public transport

The ability to use public transport is considered by those on the autism spectrum to be an important facilitator of independence (Gaona, Palikara, & Castro, 2019; Lubin & Feeley, 2016). Upon exploring transportation needs, Feeley (2009) found that more than 51% of autistic individuals deem public transport a critical factor in achieving one's employment and community participation goals.

Other studies have emphasised this viewpoint. Notably, Zalewska et al. (2016) found that autistic people who can use public transport are five times more likely to be employed than those who cannot, while Lindsay (2018) highlighted that travel independence can improve access to other opportunities including education, leisure and employment. Therefore, the benefits of public transport use have been well established in the literature, but individuals on the autism spectrum continue to face significant challenges when attempting to venture solo (Deka et al., 2016; McMahon, Cihak, & Wright, 2015).

Evidently, using public transportation requires skills such as the ability to read and understand service schedules, timely management of transfers, the capacity to navigate complex routes, and problem-solving of unexpected events (Davies,

Stock, Holloway, & Wehmeyer, 2010; Lubin & Feeley, 2016; Wasfi, Steinmetz-Wood, & Levinson, 2017). However, these skills can be particularly challenging for people on the autism spectrum. Sinha et al. (2014) described their tendency to exhibit compromised prediction skills, which render the world around them 'magical'—as though things seem to happen unexpectedly. Undoubtedly, immersion in this disorderly and unpredictable environment can be highly stressful. Sinha et al. (2014) continued, reporting that environmental unpredictability is strongly correlated with anxiety. This is particularly important in the public transport context, as it fundamentally requires coping with and managing unforeseen situations. As such, the potential volatility of public travel makes it very difficult for those with disabilities to manoeuvrer, including people on the autism spectrum (Bjerkan & Øvstedal, 2018).

How, then, do individuals on the spectrum currently manage their public transport journeys? Deka et al. (2016) explained that more than 61% of people on the autism spectrum have never used public transport, let alone considered the idea of travelling independently (68%). The authors also reported that more than 40% of autistic individuals cannot get to transit stations without assistance (Deka et al., 2016). Another study by Lubin and Feeley (2016) supported this insight, reporting that people on the spectrum rely on family members to cross streets. Here, Sheppard et al. (2017) also found that autistic individuals are significantly less accurate at predicting which of two vehicles would arrive first at an intersection than their neurotypical counterparts. Thus, it can be argued that most individuals on the spectrum do not use public transport due to significant challenges.

Safety concerns with public transport use is one of the most common barriers reported in the literature. For example, Lubin and Feeley (2016) found that

individuals on the spectrum and their parents commonly cite safety in preventing certain modes of transportation other than being a passenger in a family member's vehicle. In particular, victimisation is one key safety concern. The unique behavioural challenges of autism have been noted as a strong cause of victimisation (Hebron & Humphrey, 2014). According to Hebron, Oldfield and Humphrey (2017), it is a key reason for why autistic people are often victims of bullying instead of neurotypical individuals (Maïano, Normand, Salvas, Moullec & Aimé, 2016). Interestingly, previous studies have examined bullying in the public transport context relative to autism, with some, such as Hebron and Humphrey (2014), reporting an increased risk of maltreatment in open travel situations. Similarly, Deka et al. (2016) found that more than 40% of autistic people are worried about how they will be treated by transit drivers and other passengers in public. Falkmer et al. (2015) also established that others tend to avoid crowded public transport services due to anxiety.

Getting lost is another safety concern commonly reported in the literature. Deka et al. (2016) found that more than 40% of people on the autism spectrum do not know how to find their way to the correct service stop. Further, 26% do not know how to navigate a service transfer. This might be because managing transfers requires complex skills such as disembarking at the correct transit station, finding the correct stop for the subsequent service, and boarding the correct service. Upon studying the abilities of individuals with intellectual disabilities to use buses, Davies et al. (2010) found that only one out of 12 participants was able to disembark at the correct stop. Similarly, Bezyak, Sabella and Gattis (2017) found that people with intellectual disabilities have difficulties identifying upcoming stops, which can pose significant problems, as understanding when to leave a service is fundamental for

travel success. Overall, the literature on individuals with intellectual disabilities provides important insight that partly informs the (even greater) difficulties autistic people face when attempting to use public transport (Dudley, Emery, & Nicholas, 2012; Friedman & Rizzolo, 2016).

Anxiety disorder is a common comorbidity among individuals on the autism spectrum (APA, 2013). Recall the Sinha et al. (2014) study, which reported that the reduced ability to predict a situation is directly correlated with anxiety, and that individuals on the spectrum have impaired prediction skills. As such, anxiety levels can be exacerbated in highly unpredictable environments and situations, including the public transport context. Thus, it is perhaps unsurprising that Lubin and Feeley (2016) connected anxiety among autism communities as a barrier to independent travel, but appropriate attention to address the issue can become a facilitator of increased public transport use.

Bjerkan and Øvstedal (2018) reported a similar finding. They showed that changes to a planned journey, including schedule and route changes, can unease autistic travellers, but added that this anxiety can be reduced through effective communication. The authors concluded that changes to a planned trip should be communicated early, along with travel alternatives, to alleviate stressful situations (Bjerkan & Øvstedal, 2018).

According to the APA (2013) DSM-5, individuals on the autism spectrum also suffer from sensory issues. These manifest in two forms: hypersensitivity, where the individual exhibits negative reaction to the sensory aspects of the environment; and hyposensitivity, where the individuals displays a diminished response to sensory stimuli. Importantly, most autistic individuals are extremely sensitive to the latter (APA, 2013). Previous studies have examined strategies to manage sensory overload

in various contexts. For example, Freedman (2010) was able to reduce sensory overload in students on the spectrum by allowing them to choose their seats in class. Similarly, Coleman and Adam (2017) suggested employers making tailored adjustments to work environments to reduce exposure to sensory stimuli (e.g., bright lights, noise, smell, etc.) for their autistic employees. Recent studies have also investigated sensory issues in aspects of health care, including physical examinations (Gerber et al., 2017). Some limited literature has even looked at sensory overload in the transportation context in relation to autism. Notably, Deka et al. (2016) reported that more than 41% considered sensory issues as a barrier to travel. Similarly, Feeley (2009) showed that more than 54% of individuals on the spectrum experience sensory issues with transportation, while 15% experience sensory overload on public transport. In addition, Falkmer et al. (2015) found that autistic travellers tend to avoid crowded and peak-hour services. The authors concluded that this might be due to sensory issues in people on the autism spectrum.

2.4 Assistive Technologies

In recent years, technology has increasingly been used to support individuals on the autism spectrum—with the literature further proving its acceptance among the community (Chien et al., 2015; De Leo, Gonzales, Battagiri, & Leroy, 2011; Hatfield, Murray, Ciccarelli, Falkmer, & Falkmer, 2017; Hourcade, Williams, Miller, Huebner, & Liang, 2013; Serret, 2012). Several studies have argued that technology appeals to the repetitive trait of autism (Grynszpan, Martin, & Nadel, 2008; Yaneva, Ha, Eraslan, & Yesilada, 2018). As these tools tend to produce the same repeated output for given actions, this makes them particularly compatible with the predictable nature of ASD.

Applications of these technologies have also been demonstrated in several areas. For example, some research has shown that the tools can eliminate the challenges of face-to-face communication (a core deficit of autism). Notably, Boucenna, Narzisi and Tilmont (2014) found that technology provides a predictable platform that eliminates social expectations, including factors of judgement. A good example of these platforms are messaging apps, which have been shown to make communication easier and less stressful for autistic individuals (Parsons, Yuill, Good, & Brosnan, 2019). According to Davidson (2008), facial expressions and linguistic articulation render face-to-face interaction very unpredictable and confusing. As such, technological tools, in eliminating this process, can facilitate effective communication and further present new opportunities to support individuals on the spectrum in many domains.

Technology has been utilised in various sectors to support individuals on the spectrum. Previous studies have evaluated its use in areas including, but not limited to, emotion recognition, communication and social interaction, spatial planning and functional activities. For example, Serret (2012) utilised a video game called 'Jestimule' to improve social cognition in young children on the autism spectrum. The author found that those who used the game displayed an increased ability to recognise facial emotions, gestures and emotional situations. In addition, Serret (2012) reported that even autistic individuals with comorbid intellectual disabilities showed improvements in these areas. Similarly, Golan et al. (2010) evaluated the emotion-recognition DVD 'Transporters' (an educational recording that uses animated vehicles with real human faces grafted onto them: see Figure 2.1) with children on the spectrum. The authors concluded that autistic participants could recognise emotions as well as their typically developing peers after viewing the

DVD. Further demonstrated, the autistic children could now apply their newly learned emotion-recognition skills in new contexts.

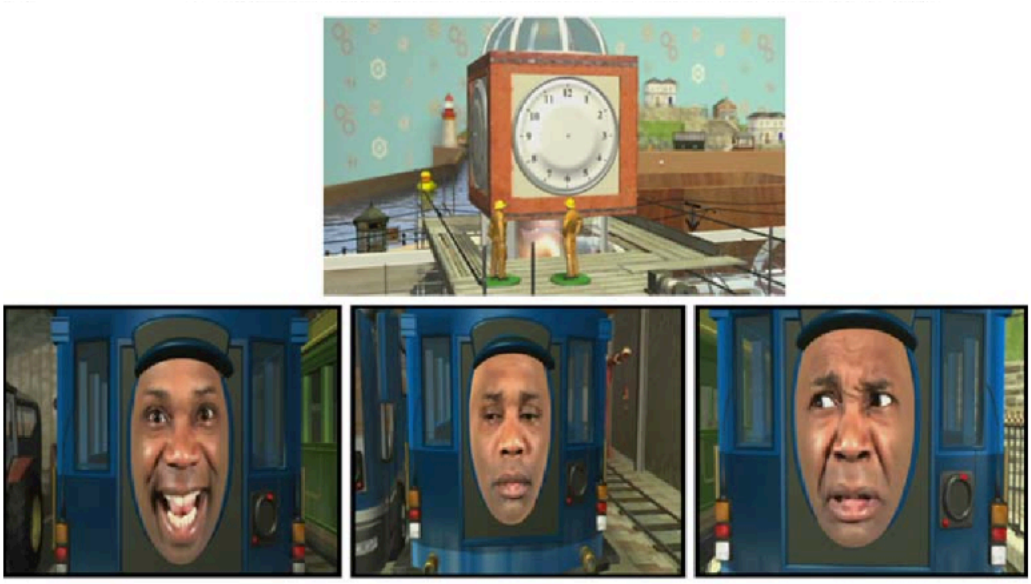

Figure 2.2. Examples of vehicles from the Transporters DVD.

Source: Golan et al. (2010)

Technology has also been used to improve communication. For example, Hourcade et al. (2013) evaluated four tablet applications from Open Autism Software to encourage social interaction in children with ASD. The authors reported that the participants spoke more sentences, engaged in more verbal exchanges, and displayed greater physical engagement in activities that involved the tablets compared to similar activities that did not. Similarly, De Leo et al. (2011) assessed the effectiveness of PixTalk, a mobile application that helps individuals on the autism spectrum communicate through pictures. The authors reported that participants were able to communicate more effectively as a result. The functionalities of PixTalk can also be simulated through a paper-based approach; however, as concluded, participants were more engaged with the app than when using the non-technological approach. Finally, Chien et al. (2015) evaluated the iCAN tablet application aimed at

improving communication skills in children on the spectrum. After a four-week evaluation period, the authors reported that participants could use language more effectively to communicate with other people. The children were also more patient and motivated to learn these skills following use.

In summary, technological tools have been successfully applied and integrated in various domains, including (but not limited to) education, emotion recognition, and communication and social interaction, aiding individuals on the autism spectrum, in turn. Studies evaluating the effectiveness of these technologies have demonstrated their overall success in delivering the intended benefits. Their predictable and repetitive nature to produce the same result for a given action has been attributed as a core value, with equal regard among autistic individuals themselves. As such, these technologies can be harnessed as effective tools through which to address the challenges faced by individuals on the autism spectrum when using public transport.

2.5 Participatory Research

Cornwall and Jewkes (1995) defined participatory research as an approach that incorporates the views of those whose life and actions are under study about what research should be conducted and how it is designed and implemented. Fundamentally, participatory research is the belief that the experiences and knowledge of people connected to a topic are crucial to drive positive outcomes. The values of this approach have been widely reported in the literature. For example, Björgvinsson, Ehn and Hillgren (2010) posited three core benefits. First, participatory research ensures improved understanding of the research requirements; second, it builds realistic expectations in the given target group; third, it empowers marginalised groups. Recent work has also aimed at tailoring the participatory

approach to autism research. Notably, Chown et al. (2017) proposed a draft framework for conducting inclusive autism study. This emphasised four main requirements. First, the authors proposed that one or more autistic researchers should validate a project designed by non-autistic researchers. Second, projects should be based on the belief that autistic people are not to be blamed for the challenges they face every day. This requirement states that society has made the world a difficult place for autistic individuals to navigate, and that society is responsible for addressing these barriers. Third, the research should have outputs that directly benefit the lives of people on the spectrum. Finally, all projects should be owned by persons on the autism spectrum, as this demonstrates a concrete commitment to the research.

The benefits of participatory research have been clearly validated in the literature. For example, in Martin (2015), three researchers on the spectrum were engaged for study. After this, they discovered that their research title, 'Navigating the Outside World', was not always understood by autistic readers due to its use of metaphor. As a result, the author, in close collaboration with the researchers, changed the title to 'Dealing With the Outside World', which was better understood by the target group. Outcomes such as those reported in Martin (2015) would not have been realised without the direct engagement of autistic participants. Similarly, Parsons et al. (2019) reported that involving target cohorts in their study to develop a software system allowed them to design a user interface that caters to the sensory needs of people on the autism spectrum—a requirement the authors had not previously considered (see Brosnan, Parsons, Good, & Yuill, 2016).

Participatory research has also been shown to have other unexpected outcomes. For example, Searle et al. (2019) found that autistic research participants

display greater trust and confidence in a project that involves researchers on the spectrum. They concluded that this connection elicits more relevant information from respondents and, therefore, significantly benefits the outcomes of a study.

Despite the well-established benefits, participatory research in autism studies is limited. Jivraj, Sacrey, Newton, Nicholas and Zwaigenbaum (2014) conducted a literature review that investigates the involvement of individuals on the spectrum in autism research. Overall, they found that only seven out of 636 studies actively included autism community members. Others have argued that researchers only make a symbolic effort to be inclusive or, according to Fletcher-Watson et al. (2018), tokenistic at best, so as not to influence the outcome. This lack of representation has been shown to deprive researchers from unique insights that people on the spectrum can bring to academia (Searle et al., 2019). More significantly, individuals and their allies have expressed great concerns about not being taken seriously in the autism research (Fletcher-Watson et al., 2018).

Concerns among the community are justifiable, as the lack of representation in academia directly affects autistic people's lives. Accordingly, Pellicano, Dinsmore and Charman (2014) highlighted a mismatch between the research that is needed versus the focus of most research funding. The authors described that most individuals on the spectrum require study in areas such as education and support services, whereas most financial support is allocated for brain and biological research. Fletcher-Watson et al. (2018) reported a similar finding in the United Kingdom context, showing that national output does not address the views and priorities of autistic individuals and their allies. Parsons et al. (2019) further argued that the dominant approach in autism research is one that is done 'on' individuals on the spectrum rather than 'with' the community. Despite these shortcomings,

participatory research should be promoted to produce effective research outcomes that genuinely improve the lives of people on the autism spectrum (Fletcher-Watson et al., 2018).

In summary, the benefits of participatory research have been clearly highlighted in the literature. Both the experiences and knowledge of people connected to the topic are essential in driving positive research outcomes. However, despite the well-established benefits, individuals on the spectrum are still rarely engaged in autism-related work. Further, many (including their allies) have expressed significant concerns about the lack of engagement and not being taken seriously in autism research. As such, to effectively address the unique challenges individuals on the autism spectrum face when using public transport, they, together with their supporters, must be engaged through(out) the research process. This study aims to do just that by adopting a participatory research approach that facilitates public transport use for people on the spectrum.

2.6 Survey of Current Public Transportation Apps

The environmental scan was conducted in 2016 to analyse existing public transport applications and determine whether they address the requirements of individuals on the autism spectrum. The findings were presented as a poster at the Australasian Society for Autism Research Conference in Perth, Western Australia.

2.6.1 Background

Everyday practices such as public transport use are effortless for neurotypical people. However, this is not the case for individuals on the autism spectrum, who otherwise find rudimentary tasks challenging due to unique requirements. Fortunately, burgeoning technologies are being used to simplify many daily practices, with public transport planning tools making travel increasingly easier to

navigate. In particular, numerous applications are currently available in mobile app stores to improve transport accessibility for all individuals, regardless of ability.

As such, this environmental scan aims to examine existing public transport apps to observe whether they address the unique requirements of autistic people when travelling independently. The outcome of these analyses will determine whether new developmental research is required to address the challenges individuals on the spectrum face when using public transport.

2.6.2 Methodology

Android and iOS app stores were queried using the following search terms to find relevant applications:

- **‘**Public transport’
- ‘Public transport planner’
- ‘Public transport application’
- ‘Best public transport application’
- ‘Autism public transport application’
- ‘Public transit Australia’
- ‘Public transport alarm’
- ‘Public transit planner’
- ‘Bus planner’
- ‘Train planner’
- ‘Public transit scheduler’
- ‘Top public transport applications’
- ‘Recommended public transport applications’
- ‘Must-have public transport applications’

Similarly, a Google search was performed to find blog posts, journal articles and news articles that either discussed or reviewed any public transport applications. This strategy returned a large number of mobile apps from different app stores.

Applications were used in the study if they supported at least four of the following functionalities. This included the ability to:

- plan trips
- provide real-time service information
- save favourite trips
- check smartcard balance
- track live journeys
- share trips with other people.

These were called ‘conventional features’, which denote core functionalities of effective public transport apps, and were determined to exclude those that provide no additional qualities beyond transport services information. For example, there are many applications that aggregate travel schedules and present them in app form with little or no additional functionalities that utilise these data. As such, these were defined to exclude such applications.

Similarly, another set of functionalities was defined and aimed to address the unique challenges that individuals on the autism spectrum face when using public transport. These autism-specific qualities were called ‘specialised features’ and were determined through a preliminary literature review of the difficulties of travel. The specialised features included the ability to:

- alert if smartcard balance is low
- provide pre-trip assistance such as alerts to pack bag, leave and board services at the nearest station

- assist with sensory issues during a public transport journey
- assist with anxiety issues during a public transport journey
- provide alternative routes when a planned trip has been disrupted
- take and retrieve photos of stops and services along the journey
- optimise future trips based on previous trips
- provide walking direction to the final destination after the public transport part of the journey has ended
- provide real-time location of users
- dictate text and provide voice alerts.

The capacity for all included applications to address the challenges autistic individuals face when travelling independently was measured by assessing the number of specialised features they supported.

2.6.3 Result

The table in Appendix X shows the outcome of the environmental scan. It is comprised of rows and columns, where each row represents an application and each column represents conventional and specialised functionalities. A tick (√) in a cell signifies that the app supports the functionality defined in the relevant column, while a cross (x) indicates the application does not support the corresponding functionality.

The analysis found that 19 apps met the inclusion criteria. Table 2.1 lists the applications and the number of features each supports from the conventional features and specialised features functionality. All 19 apps were analysed against six conventional features and 10 specialised features, with each shown to support at least four of the six conventional features.

Table 2.1:

Public Transport Applications Analysed for Conventional Features and Specialised Features

Application	Number of features satisfied from the conventional feature category (out of 6)	Number of features satisfied from the specialised category (out of 10)
ResLedaren	5	4
Tiramisu	5	3
TripGo	5	3
Transit App: Real Time Tracker	4	2
Go Perth	4	2
Moovit	4	2
TransitTime	5	1
Triptastic	5	1
Wojhati Journey Planner	5	1
ResKollen	5	1
Embark	4	1
Citymapper	4	1
TravAlarm	4	1
App&Town Public Transport	5	0
NextThere	5	0
TripMate and Arrivo	4	0

Transperth	4	0
TripView	4	0
Wayfindr	In development	In development

As discovered, no single application had all 10 specialised features. Instead, the analysis showed that one supported four specialised features, two supported three features, another three supported two features, seven supported one feature, five did not support any of the 10 specialised features, and one application—Wayfindr, designed for people with visual impairments—showed promise but was under development and, thus, had little information available online.

2.6.4 Discussion

According to the environmental scan, no applications currently exist that facilitate public transport use for individuals on the autism spectrum. The top three most autism-friendly applications were (1) ResLedaren (the only app that supported the highest number of specialised features: four), (2) Tiramisu and (3) TripGo. Both Tiramisu and TripGo supported the second highest number of functionalities (three out of 10) from the specialised features category.

ResLedaren is a Swedish transport-planning tool that is built specifically for individuals on the autism spectrum (see Figure 2.2). As discovered, the app supports the most specialised features. First, it has the ability to provide pre-trip assistance, such as alerts to pack a bag and leave home for the nearest stop. Second, it assists users in automatically searching for a new route if they forget to board or disembark at a desired stop. Third, it offers the ability to track users' current location, and further provides walking directions to the desired destination after a transport service ends.

Figure 2.3. Swedish trip-planning mobile application ResLedaren, built specifically for autistic individuals.

Tiramisu is another public transport application built (in the US context) for commuters with 'visual or mobility impairments' (Figure 2.3). It supports key specialised features, including (1) the ability to add annotations to service stops along a trip, (2) the ability to track one's current location, and (3) the ability to provide voice alerts.

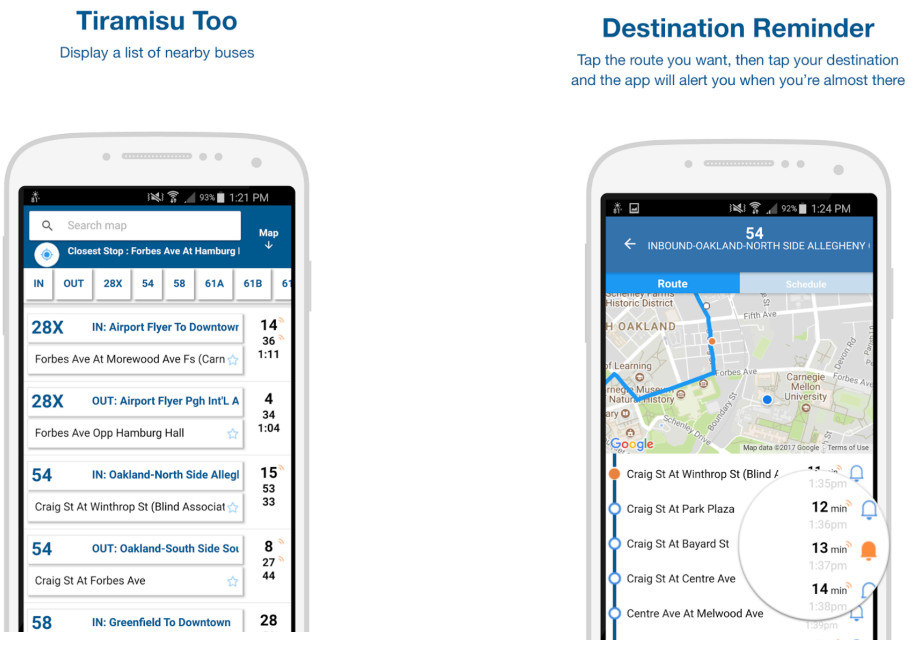

Figure 2.4. Public transport app Tiramisu, built for commuters with 'visual or mobility impairments'.

Finally, TripGo is a highly downloaded public transport application built for everyday commuters (Figure 2.4). It works in over 200 cities. The app supports three specialised features, including (1) the ability to provide departure alerts to the planned bus or train station, (2) the ability to provide walking directions after a trip has ended, and (3) the ability to track one's current location.

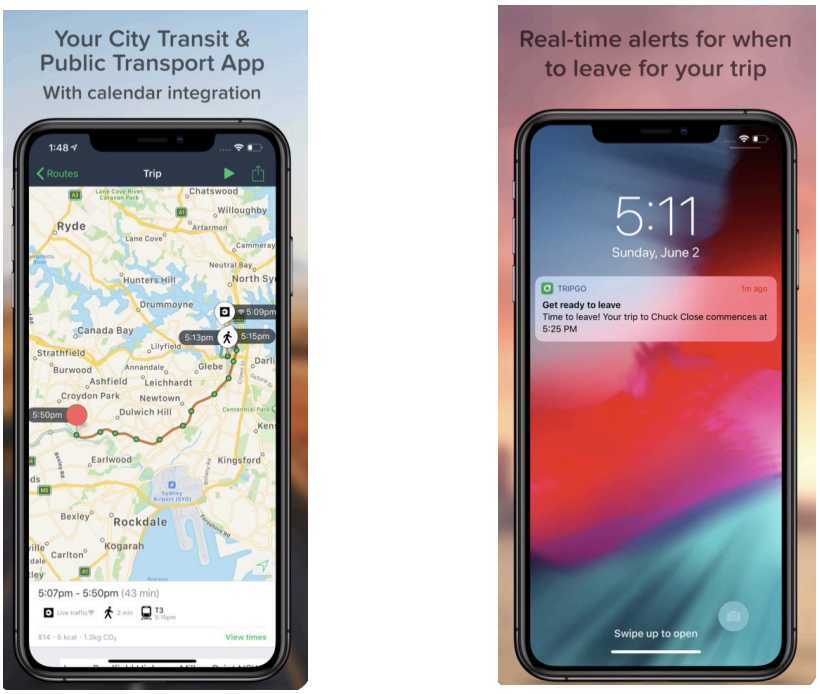

Figure 2.5. The highly downloaded trip-planning app TripGo, built for everyday commuters.

Overall, the analysis found a major gap in understanding and addressing the needs and requirements of people on the autism spectrum. Features such as managing and/or eliminating stressful situations during a trip, providing support to users with sensory issues, and the ability for family members to locate a user if lost proved essential to ensure the safe passage of autistic commuters.

2.6.5 Limitations

A number of factors should be highlighted as having potentially affected the outcome of this environmental scan. First, applications in languages other than English may not have been discovered using the set keywords. Although our search did discover ResLedaren, a Swedish app, it is likely that the scan may have missed other non-English applications. Another limitation regards the possibility of not finding apps with a very small installed user base, apps not yet mentioned in online articles and blogs, and ones that cannot be found easily in the app stores. Finally, the environmental scan may not

have found public transport applications that are not available for purchase and/or are still under development.

2.6.6 Summary

Aware that individuals on the autism spectrum face many difficulties when using public transport, the environmental scan in this study sought to understand whether current mobile applications address the key challenges in a real-world context. To do this, 19 apps were identified (in mobile app stores and using Google) to match the initial inclusion criteria. These were then evaluated based on the number (out of 10) of 'specialised features' they supported. Importantly, these qualities were characterised as autism-specific mobile application functionalities that were determined through a preliminary literature review covering the challenges autistic people face when travelling independently.

The environmental scan found that no apps support all 10 specialised features. The top three autism-friendly mobile applications were ResLedaren (which supported four specialised features), Tiramisu (which supported three features) and TripGo (which also supported three features). This finding highlights a major gap in current technical efforts to facilitate public transport use for autistic individuals. Specifically, the obstacles they encounter when travelling remain unclear and, thus, no solutions currently address their unique transport difficulties and needs.

2.7 Chapter Summary

Individuals on the autism spectrum experience significant difficulty to participate in community activities, including employment, education and social opportunities (Schiavone et al., 2018; Shattuck et al., 2012; Solish et al., 2010). As established, autistic people also have one of the lowest employment rates among other developmental disability groups (Chan et al., 2018; McLaren et al., 2017; Nicholas et

al., 2018; Roux et al., 2015; Sanford et al., 2011; Wehman et al., 2019). Transportation is but one barrier that commonly limits their community participation (Coleman & Adams, 2017; Nowell et al., 2015). Most autistic individuals depend on family members for their travel needs, and this, in turn, not only limits opportunities for participation, but also causes families to miss their own activities, including work, to fulfil their transport duties (Deka et al., 2016). Indeed, driving is one mode of transportation that can empower autistic individuals to become more independent. However, past studies have demonstrated a litany of significant challenges many face when learning to drive (Chee et al., 2017; Huang et al., 2012; Lindsay & Stoica, 2017; Sheppard et al., 2017). As a result, only 25% of autistic individuals hold a driver's licence, and this takes, on average, longer to acquire compared to non-autistic cohorts (Daly et al., 2014; Sheppard et al., 2017). Hence, public transport remains a reliable and inexpensive mode of transportation (Lubin & Feeley, 2016) with general preference among autism communities, as well as equal value in providing passage to employment and greater community participation (Falkmer et al., 2015; Feeley, 2009; Lubin & Feeley, 2016; Zalewska et al., 2016). Despite the benefits, more than 60% of autistic people have never used public transport and more than 68% have never considered this mode of travel (Deka et al., 2016). Public transport requires skills such as the ability to read and understand service schedules, timely management of transfers, navigating complex routes, and problem-solving unexpected events (Davies et al., 2010; Lubin & Feeley, 2016; Wasfi et al., 2017)—all of which are noted sources of struggle for those on the spectrum (APA, 2013; Bjerkan & Øvstedal, 2018; Deka et al., 2016; Lubin & Feeley, 2016; Sinha et al., 2014). In particular, these difficulties also include victimisation (Hebron & Humphrey, 2014; Maïano et al., 2016), getting lost (Bezyak et al., 2017; Davies et al., 2010; Deka et al., 2016), dealing with anxiety-provoking situations (Lubin

& Feeley, 2016; Sinha et al., 2014) and managing sensory sensitivity (APA, 2013; Deka et al., 2016; Falkmer et al., 2015; Feeley, 2009).

The literature review too confirmed that public transport poses a significant problem for people on the autism spectrum. Similarly, no autism-specific solutions currently exist that fully address the challenges of independent travel. It was also demonstrated that technological tools such as apps or DVDs are effective in delivering assistive programs to aid autistic individuals (De Leo et al., 2011; Golan et al., 2010; Hourcade et al., 2013; Serret, 2012), while active engagement in research proved crucial in delivering genuine and successful research outcomes for the community (Björgvinsson et al., 2010; Chown et al., 2017; Cornwall & Jewkes, 1995).

Chapter 3 clearly defines and categorises the challenges autistic people face when using public transport. The study was performed in close collaboration with community members and their families. Further proposed is a mobile application that aims to facilitate independent travel for people on the spectrum.

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Chapter 3: Paper I

Public Transport Planning Tool for Users on the Autism Spectrum: From Concept to Prototype

3.1 Preface

Chapter 2 conducted a literature review that describes the current state of transportation for individuals on the autism spectrum. It sought to understand the challenges people face when using public transport, as described in the literature, and further identified the missing gaps in knowledge. As discovered, the specific issues that make travel difficult for those on the spectrum have not been clearly defined. Therefore, no solutions are currently available.

The aim of this chapter is to clearly define and validate these obstacles in collaboration with ASD members and their families, and, therefore, design a tool that addresses the challenges of independent travel. To do this, an extensive literature review was conducted to identify the specific barriers that make public transport use difficult. Based on this, a list of functionalities for a mobile application was devised. These functionalities were then put forward to individuals on the autism spectrum and their families to discuss and prioritise based on importance and helpfulness. Informed by these findings, the chapter designs and proposes an app called OrienTrip, which aims to address the struggles of independent travel (see Figure 3.1).

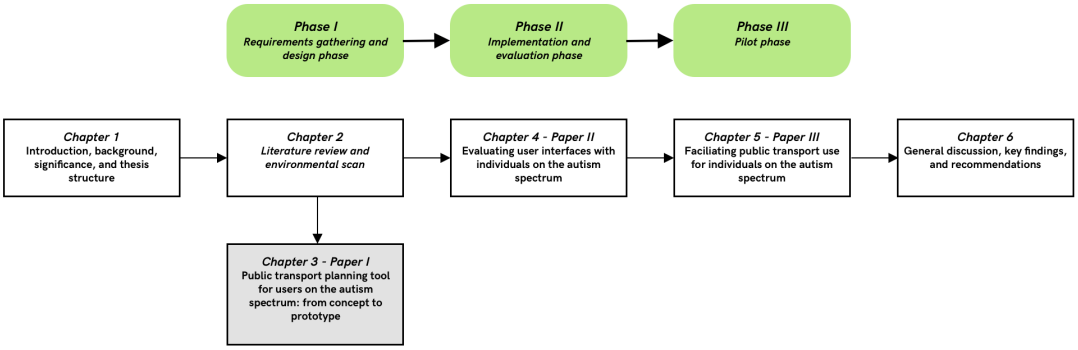
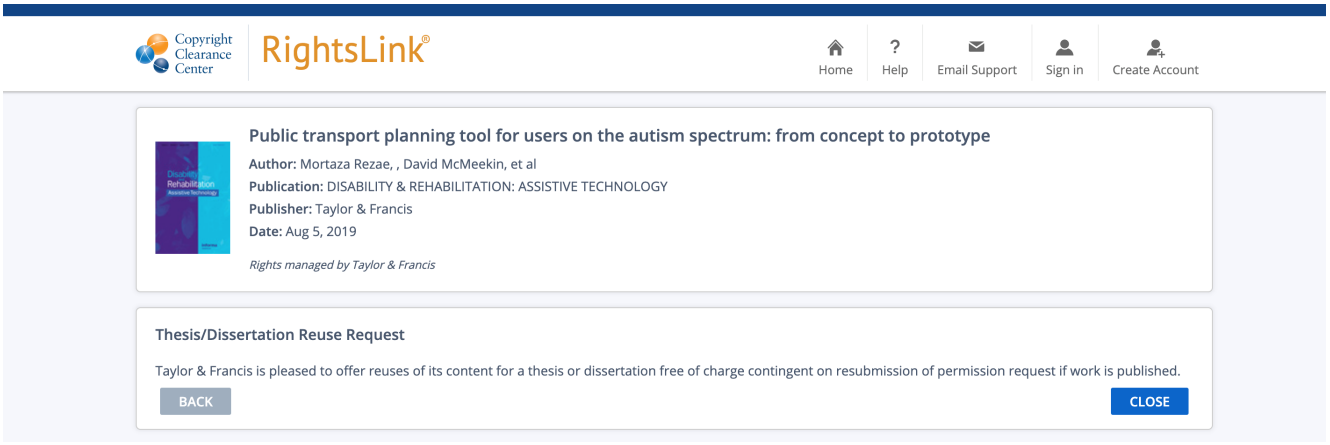


Figure 3.1. Chapter 3 includes validating the issues autistic individuals face and designing a tool that address the issues.

The following manuscript was accepted for publication on 9 May 2019 and first published online on 18 July 2019:

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



Disability and Rehabilitation: Assistive Technology

ISSN: 1748-3107 (Print) 1748-3115 (Online) Journal homepage: https://www.tandfonline.com/loi/iidt20

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To cite this article: Mortaza Rezae, David McMeekin, Tele Tan, Aneesh Krishna, Hoe Lee & Torbjorn Falkmer (2019): Public transport planning tool for users on the autism spectrum: from concept to prototype, Disability and Rehabilitation: Assistive Technology, DOI: 10.1080/17483107.2019.1646818

To link to this article: https://doi.org/10.1080/17483107.2019.1646818

Published online: 05 Aug 2019.

DISABILITY AND REHABILITATION: ASSISTIVE TECHNOLOGY
https://doi.org/10.1080/17483107.2019.1646818

Taylor & Francis
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ORIGINAL RESEARCH

Public transport planning tool for users on the autism spectrum: from concept to prototype

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ABSTRACT

Purpose: This research explored the challenges of public transport use for individuals on the autism spectrum. It, subsequently, proposed a mobile application solution, coproduced by individuals on the autism spectrum, to facilitate public transport use.

Methods: We, first, conducted a review of the literature to highlight the challenges people on the autism spectrum face when utilizing public transport. We, then, designed a list of mobile application functionalities that address the identified problems. To validate these functionalities, 27 young autistic adults and 19 families of autistic individuals were employed. Finally, based on the findings, we designed a mobile application that helps facilitate public transport use for those on the autism spectrum.

Results: We found that the most prevalent concerns, in public transport use, amongst autistic individuals and their families are safety and spatial awareness. Specific problems include finding one's way to the bus stop, boarding the correct service and disembarking at the correct stop. Interestingly, anxiety about unexpected events was also a barrier. Sensory sensitivity, similarly, was found to be an obstacle.

Conclusions: This study defined the challenges of public transport use for autistic individuals and proposed a technological solution. The findings can also inform innovators, public transport providers and policymakers to improve public transport accessibility.

➤ IMPLICATIONS FOR REHABILITATION

- People on the autism spectrum heavily rely on other individuals, namely family and friends, for their transportation needs. This dependence results in immobility for the autistic individuals and significant time and economical sacrifice for the person responsible for the transportation.
- Public transport, a cheap and widely available form of transportation, has not yet been clearly studied with individuals on the autism spectrum.
- We clearly define the challenges of using public transport and put forward a trip planner mobile application, coproduced by autistic individuals, that facilitate it.
- In the long term, this enhanced travel independence can lead to greater education and employment opportunities and an overall improved quality of life.

ARTICLE HISTORY
Received 9 May 2019
Accepted 18 July 2019

KEYWORDS
Autism spectrum; public transport; transit app; mobility; mobile application; ASD

Introduction

Autism is characterized by difficulty in communication and social skills, repetitive behaviour, and an inability to self-regulate [1]. These characteristics cause heavy reliance on other people for everyday activities. Transportation is one of these tasks that is burdened, commonly, on family members and caretakers [2–4]. Public transport is an independent, low cost, reliable and accessible form of transportation [2,5]. However, it presents unique challenges such as route complexity, information overload, timely management of transfers, effective decision making and problem-solving of complex situations [2,3]. While existing studies have investigated the individual experiences and viewpoints of autistic persons on public transport use, the specific barriers, limiting accessibility, have not been clearly defined. As a result, there is limited technology assistance available that facilitates public transport use for autistic individuals.

Community engagement is a vital element of a healthy and prosperous life [2,3,6]. Active involvement in activities, such as education, employment and social events can produce meaningful relationships, healthy wellbeing and a social status [6,7]. Some form of transportation is almost always needed to take part in these activities [2,3], but for individuals on the autism spectrum, heavy reliance on family members for transportation often leads to immobility and social exclusion [3,5,8].

When individuals on the autism spectrum do travel, they commonly travel as a passenger in a vehicle, frequently, driven by a parent or another family member [2,3,9,10]. This dependence adversely affects these individuals, as well as their families. Indeed, 72% of individuals on the autism spectrum miss out on activities because the person who drives them is not available [4]. Similarly, more than 73% of family members have to forgo other activities, including work, to assist in these situations [4]. Parents have also reported that they were not able to maintain

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employment, due to their role as a transportation provider to their autistic family member [4]. More broadly, raising and caring for an individual on the autism spectrum is known to significantly affect the parents' productivity [11]. In order to reduce such high dependence, alternative modes of transportation including public transport have to be explored.

Public transport promotes independence and self-efficacy [3]. In general, it enhances the wellbeing of community members as it allows access to health goods and services, work, education and social networks – elements that are vital in fostering a healthy life [5]. Public transport is also a preferred mode of transportation by some individuals on the autism spectrum as they believe it enhances their independence [3,4,10]. To use it, however, travellers must understand, manipulate and process vital navigation artefacts including:

a. *maps*: to identify spatial relationship between one's current location and the destination, determine routing options and track the overall trip progress;
b. *schedules*: to assess route availability on a given day and time;
c. *landmarks*: to confirm trip progress and anticipate important events such as preparing to disembark;
d. *labels and sign*: to comprehend the local environment including current location, where to purchase tickets, where to expect service vehicles, identifying the correct service to board and when and where to disembark; and
e. *clocks*: to coordinate schedules with vehicle arrivals and departures [12].

The process to understand and extrapolate information related to one's journey, from these abstract representations, requires an effective executive function, commonly impaired in people on the autism spectrum [12,13]. This, therefore, renders cognitively demanding tasks difficult undertakings [10,12,14,15].

While existing studies [3,4,9,14] have briefly shown that public transport use is a daring journey for individuals on the autism spectrum; the specific challenges and anxieties have not been clearly defined. By defining these problems, a deeper understanding of these issues will help enhance the abilities of those on the autism spectrum to use public transport.

To learn and address the challenges of public transport use for individuals on the autism spectrum, the aims of the current study were:

a. to design a list of mobile application functionalities that address the identified problems;
b. to validate and prioritize the designed functionalities through a survey of individuals on the autism spectrum and their families; and
c. to design and present the initial prototype of a mobile application that aims to facilitate public transport use for individuals on the autism spectrum.

Methods

Requirements gathering

The first stage of the software development process is to discover what the mobile application shall do. This process is called requirements gathering where the goal is to identify and validate the end-users' needs. [16]. Particularly, the focus should be on helping the users identify what they need and prioritizing the needs over wishes. [17]. Interviews, focus groups, questionnaires are the standard techniques used in requirements gathering [16]. These approaches are, however, not well suited for individuals with potential speech and communication challenges, commonly associated with autism [1,16,18].

The initial list of user needs, in our study, was collected through a literature review. We searched for articles investigating public transport use of individuals on the autism spectrum using ProQuest, Science Direct and Scopus databases. This, however, returned a very small number of journal articles, highlighting the limited availability of research on public transport use by autistic individuals. Therefore, the search was expanded to include articles on public transport use by individuals with cognitive impairments including those post stroke.

Defining mobile application requirements

After documenting the issues individuals on the autism spectrum and those with cognitive impairments face with public transport use, we sought to design mobile application requirements that address these problems.

First, the research team aimed to visualize the identified issues through a journey map. Concretely, we sought to construct a persona of a typical user on the autism spectrum who has to use public transport to travel to the bank from their home. The journey map highlighted how the documented issues may affect the persona's trip. For example, if our traveller misses their bus, how will they react to the situation based on the issues we have documented through the literature review? The intent of the journey map was to assemble the identified barriers into a single public transport context. This activity made possible to design 18 mobile application requirements that remedied the pain points of this users on the spectrum faced in their trip to the bank. See Table 1 for complete list of features.

Survey

To validate and prioritize the designed features based on the order of importance, the 18 mobile application features were administered in a survey and distributed to young adults, aged between 18 and 30 years old, on the autism spectrum and their family members. They were asked to rank from 1, being the most important, to 18, the least important, based on their needs.

Participants

Using purposive sampling, the survey, distributed through research groups and non-governmental organizations, was administered via SurveyMonkey, a survey distribution platform. Overall, 27 young adults on the autism spectrum and 19 family members participated in the survey.

Data analysis

The data were analysed and prioritized using median ranks. First, the median for each functionality was calculated. Then, the 18 functionalities were ranked, lowest (most important) to highest (least important), based on their median score. The complete list of sorted functionalities is shown in Table 1.

Rank by median was chosen for this analysis to account for the varying responses. Since every individual on the autism spectrum is different, and therefore has different needs, it can be expected that the rankings will vary greatly. As a result, outliers can greatly skew the data. Median ranking is very effective in muting the effect of outliers.

Ethics

Ethical approval was obtained from Human Research Ethics Committee (HREC) at Curtin University (HRE2016-0086) in Perth, WA, Australia.

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

Item #	Functionality description	Median (young autistic adults) $n = 26$	Median (family) $n = 19$	Median (families and young adults) $n = 45$	Barrier addressing
2	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
6	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 and anxiety and stress
8	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	Anxiety and stress and Spatial awareness/navigation
5	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
12	When I miss my stop, help me work out how to get to my destination.	6.50	6.00	6.00	Anxiety and stress and Spatial awareness/navigation
1	Tools & alerts to plan my trip, get ready and leave on time for my trip.	7.50	6.00	6.00	Complex service schedule/anxiety and stress
4	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
13	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
9	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
16	When I feel sensory overload on my trip, help me to cope and to feel better.	10.50	13.00	12.00	Sensory overload
15	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
18	Tell me all the services available to me at different train stations.	11.00	17.00	13.00	Spatial awareness/navigation
7	When I feel anxious on my trip, help me to cope and to feel better.	12.00	10.00	10.00	Anxiety and stress
10	When the lift at the train station is not working, find me solutions and help to get to my destination.	12.50	15.00	14.00	Spatial awareness/navigation
3	When I am walking to or from a bus stop or train 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
11	Remind me to tap my card when I am getting on and off the bus.	13.50	11.00	13.00	Anxiety and stress
14	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
17	Auto correct my spelling when I type into the App.	16.50	16.00	16.00	Usability Feature

Participants were provided with an information sheet describing their role in the research. They were informed that they could withdraw at any time without any negative consequences. Participants then provided digital consent confirming their participation. All study data were confidentially stored and maintained in line with the Western Australian University Sector Disposal Authority.

Results

Requirements gathering

Based on the findings from literature, 18 software requirements were designed to meet the needs of individuals on the autism spectrum to use public transport. Below we describe how the literature review informed these requirements.

1) Tools & alerts to plan my trip, get ready and leave on time for my trip.

Planning a trip is, generally, the first step in utilizing public transportation. It requires understanding and processing essential navigational artefacts including, maps and service schedules [12]. This task is, however, demonstrated to be challenging for individuals on the autism spectrum. For example, in a survey of 195 autistic transit users, Deka et al. [9] found that more than 50% of respondents had difficulties planning public transport trips. Similarly, Dudley et al. [19] concluded that barriers in using public transport for individuals on the autism spectrum included difficulty with planning trips and the lack of information about services.

People with cognitive impairments report similar difficulties. Carmien et al. [12] observed high school students with cognitive disabilities ($n = 13$) and derived that the participants lacked the ability to process navigational tools, such as a maps and schedules, to use the bus. In fact, only one out of eight students, who were selected for this particular task, were able to successfully use a map to navigate to and from the bus stop. Risser et al. [20] examined the public transport experience of post-stroke individuals with cognitive impairments ($n = 8$) and found that the participants criticized service timetables and schedules as difficult to understand. Wallergård et al. [21], using virtual reality technology to teach public transport use to individuals with brain injury, observed that difficulty with timetables discourage public transport use.

2) 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.

3) When I am walking to or from a bus stop or train station, tell or show me where it is safe for me to cross the road.

Spatial navigation has been demonstrated to be particularly challenging for individuals on the autism spectrum. Ring et al. [22] found that participants on the autism spectrum performed worse than neurotypicals, on a previously studied route, when asked to indicate the direction they needed to travel. The authors concluded that this navigation difficulty can be related to differences in attention and less use of landmarks as cues [22]. Similarly, Deka et al. [9] ($n = 195$) found that more than 40% of adults on the autism spectrum have difficulty getting to the bus stop without help and more than 53% do not know how to safely cross a road without assistance from others. Difficulties with wayfinding has also been demonstrated with individuals with cognitive disabilities [23]. Mengue-Topio et al. [23] ($n = 36$), concluded that it takes longer for individuals with cognitive impairments to learn a fixed route and that they are inflexible in their wayfinding abilities. Similarly, Risser et al. [20] ($n = 8$) found that individuals post-stroke also have difficulty walking to and from the bus stop.

4) 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.

5) Tell me how crowded the train is before it arrives, and if the train is too crowded for me, give me other travel options. – 5

Anxiety is a comorbid condition attributed to autism [3]. Intolerance of uncertainty (IU) has been demonstrated to increase anxiety levels for those on the autism spectrum [24]. The uncertainty involved with public transport use has also been demonstrated to exacerbate anxiety. For example, Deka et al. [9] found that more than 42% of individuals on the autism spectrum ($n = 195$) worried about unanticipated interactions with the bus drivers and passengers. Similarly, Falkmer et al. [3], surveying the experiences of individuals on the autism spectrum ($n = 55$), discovered that respondents avoided crowded services for causing discomfort and unease. Interestingly, this viewpoint was held by the group of respondents who wished to use public transport more than they currently did. Ståhl and Månsson Lexell [25], investigating the experiences of stroke survivors with cognitive impairments ($n = 6$), found that participants displayed feelings of worry and unease about unpredictable events occurring as a result of public transport use (e.g., missing the bus). These individuals avoided crammed services, thinking they being too difficult to cope with. Similarly, Carmien et al. [12] ($n = 13$) observed that individuals with cognitive impairments may abort a route when not foreseen situations (e.g., service delays and cancelled service), emerge.

6) 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.

8) 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.

12) When I miss my stop, help me work out how to get to my destination.

14) 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.

Disembarking a service at the correct stop or station, without assistance, is one of the most frequent issues related to public transport use. Individuals on the autism spectrum and persons with cognitive impairments may fail to identify landmarks as cues to disembark a service and miscalculate when to press the stop button [2,22,26–28]. Deka et al. [9] ($n = 195$) surveyed adults on the autism spectrum, 32 expressed getting on and off the bus a barrier. In the Davies et al. study [2] ($n = 12$), only one participant with cognitive impairment was able to successfully get off the bus at the correct stop. Rosenkvist et al. [15] ($n = 14$) found that individuals with cognitive impairments cannot identify the correct time to press the stop button to signal to the driver that they need to disembark. Risser et al. [20] ($n = 6$) looking at the experiences of post-stroke survivors with cognitive impairments described getting off the bus at the correct stop as the "the most difficult task".

7) When I feel anxious on my trip, help me to cope and feel better.

9) When I need help during my trip, give me tools so I can get help in the way that best suits me.

Anxiety can be exacerbated by behavioural problems common in individuals on the autism spectrum. For example, behavioural issues include having automatic negative thoughts (e.g., missing

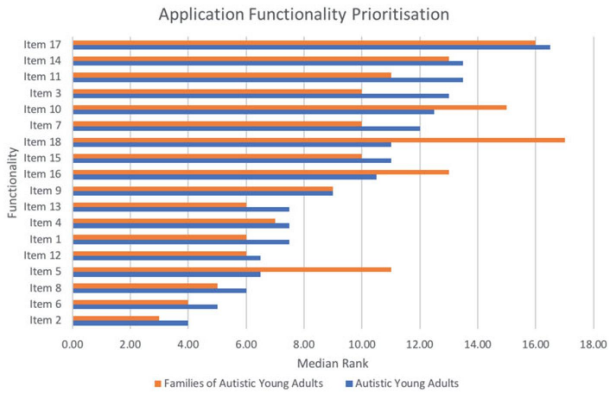

Figure 1. Bar graph ranking comparison between young autistic adults and family members, please note that lower rank is better.

the bus, boarding the wrong service) [29] and uncontrollable worrying (e.g., not being capable of using public transport) [30]. Learning to manage and reduce negative feelings can be a major facilitator of independent travel [25,31]. Specifically, cognitive behaviour therapy (CBT) has been demonstrated to significantly reduce anxiety symptoms in individuals with high functioning autism [32,33]. Therefore, CBT techniques embedded in an accessible device, for example in a smartphone, can help lower anxiety levels.

> 11) Remind me to tap my card when I am getting on and off the bus.

> 15) 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.

It has been demonstrated that the problems with executive function contributes to deteriorating memory in people on the autism spectrum [34]. Furthermore, the complex information processing disorder theory of autism suggests that progressively complex information can cause memory deficits [34]. Similarly, the rapid progression of event in a public transport journey (e.g., packing needed items, leaving home on time, walking to the bus stop, finding the correct service, boarding, managing the payment process, finding a seat and disembarking at the correct stop) can also give rise to forgetting smaller tasks such as tapping off travel card to indicate end of journey.

> 16) When I feel sensory overload on my trip, help me to cope and to feel better.

Public transport can also give rise to sensory overload, a common issue in autism [9,35,36]. For example, public transport services are often highly crowded, filled with bright and flickering lights, loud sounds and announcements, and many and various smells from passengers and vehicle fumes. Falkmer et al. [3] ($n = 55$) demonstrated that avoiding peak hours, for persons on the autism spectrum, could be linked to the sensory sensitivity from the excessive noise and cramming.

Ranking/prioritization

The survey data were ranked and prioritized by medians (Table 1).

Overall, young adults and the families ranked and prioritized the features similarly – see bar graph comparison of the two groups (Figure 1) and box plot representation of the rankings of young autistic adults (Figure 2). Parents, however, emphasized "safety" features more consistently.

The three highest ranked functionalities for a potential public transport application, respectively, were:

1. *item 2*, 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 (young adults median = 4.00, families median = 3.00);
2. *item 6*, 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 (young adults median = 4.00, families median = 5.00);
3. *item 8*, 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 (young adults median = 6.00, families median = 5.00).

Both the autistic group and family members ranked these three functionalities in the same order. Interestingly, all three are safety related functionalities, namely getting lost.

Item 5, tell me how crowded the train is before it arrives, and if the train is too crowded for me, give me other travel options, was ranked 4th (median = 6.5) by the young adults and 12th by the family members (median = 11). Individuals on the autism spectrum, commonly, exhibit limited social interaction skills and avoid overly social or crowded situations. This insight can explain the high request for crowdedness information, e.g., full service, standing room available only and seats available, of services ahead of a trip by autistic individuals. Families, however, did not view "crowdedness" information as highly important and ranked this particular functionality much lower compared to their autistic child.

Item 16, when I feel sensory overload on my trip, help me to cope and to feel better, was prioritized much lower, 15th (median = 13.00), by the families than by the young adult group, 10th (median = 13.00). Sensitivity to noise, light, smell and touch is extremely common in individuals on the autism spectrum. The result of the survey suggests that autistic adults think managing

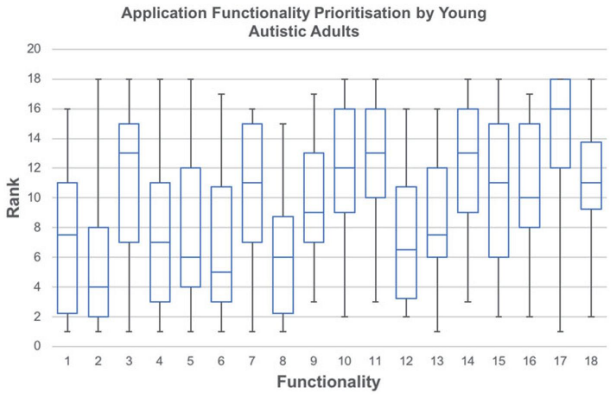

Figure 2. Box plot of the rankings by young autistic adults.

sensory overload can help facilitate public transport use. Family members, however, did not hold the same view. Furthermore, the prioritization of this functionality varied greatly amongst the autistic individuals. For example, some respondents ranked it as critical as 2nd and 3rd most important, while others prioritized it at 15th and 16th. This discrepancy can be because some individuals have greater sensitivity to sensory stimuli compared to others.

Similarly, item 7, when I feel anxious on my trip, help me to cope and to feel better, was ranked 13th and 10th by the young autistic adults and their family members, respectively. The literature review found anxiety and stress being a key barrier in public transport use amongst persons on the autism spectrum and those with cognitive impairments. The overall survey results, however, did not echo the same insight. It is interesting to note that six autistic respondents prioritized this functionality as highly important by ranking it 1st, 2nd, 5th and 6th. This difference in prioritization amongst the young adults on the autism spectrum can be because some individuals, particularly those who ranked this functionality as important, have greater levels of anxiety compared to the rest of the respondents.

Parents prioritized item 3, when I am walking to or from a bus stop or train station, tell or show me where it is safe for me to cross the road, higher, 9th (median = 10.00), than the young adults on the autism spectrum, 14th (median = 13.00). This viewpoint can be reflective of the insight that safety concerns, such as getting hurt is more commonly emphasized by parents than the individuals themselves [23].

Interestingly, item 14 was ranked 17th and 14th, respectively, by the young adults and family members. Item 14 allows users to take pictures of landmarks along a journey to help remember when to disembark a service. Previous studies have demonstrated that remembering landmarks can help individuals with cognitive impairments navigate and use public transport more effectively [4,23,27,31]. This view was, however, disputed in the present study. One possible explanation for this outcome can be that item 6, the ability to notify users when to disembark a service (median = 5.00), rendered item 14 unnecessary as it was ranked in the top 2.

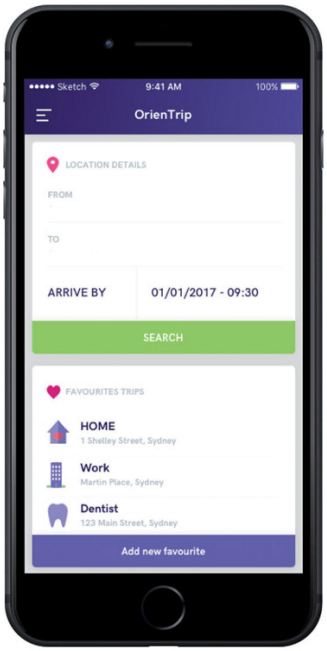

Figure 3. Home screen.

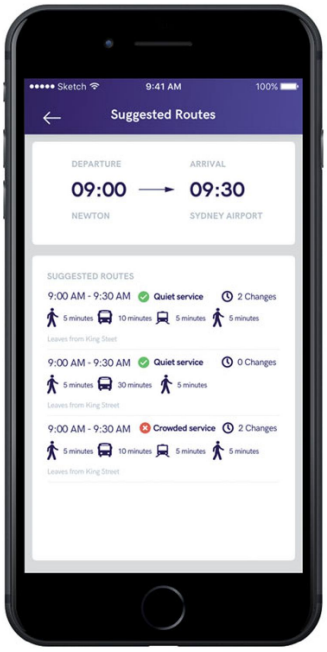

Figure 4. Suggested route and crowdedness.

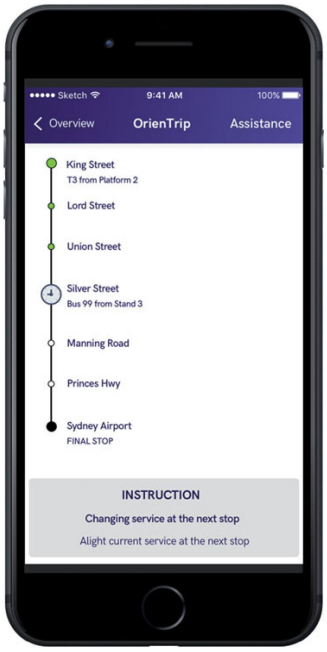

Figure 5. Trip tracking and overview.

Mobile application design

The mobile application prototype shown in Figure 3 has been designed in line with the findings of the requirements gathering and the prioritization survey.

Trip planning

The ability to facilitate trip planning, without sifting through an overwhelming wealth of data, can help manage the complexity associated with understanding navigation artefacts. Figure 3 shows the user interface that will facilitate trip planning using three variables: (1) the current location, (2) final destination and (3) the desired time of departure or arrival. The application will automatically analyse the relevant public transport schedules and calculate multiple routes that satisfy the user's request.

More importantly, the suggested information, trip data, are displayed back to the user in an intuitive manner. This simple and easy operation can significantly reduce the cognitive load involved in reading and processing service schedules and maps to plan trips, as shown in Figure 4.

Service crowdedness information

Crowdedness information related to a calculated route is also displayed to the user. The ability to foresee and avoid crowded services and journeys can reduce the unpredictability of the experience.

Trip tracking

After the journey has begun, the application will automatically track the user's current location with respect to the overall journey. This information is displayed back in a simple and easy to understand user interface – see Figure 5. A linear map with all the stops along the current journey is rendered on the screen. This mechanism can enable them to intuitively process when their stop is approaching. In addition, as seen in Figure 5, textual instructions are shown to the user to further guide in navigation.

Problem-solving disruptions: automatic rerouting

If the user misses their stop or deviates from the journey, the application will automatically detect the event and prompt to calculate a new route – see Figure 6. If a disruption occurs on a journey, autistic travellers can become anxious and may panic, thus making it very difficult to manually problem-solve the disruption. This functionality will automate the process and remove the cognitive load and the anxiety that is involved with planning a new trip.

Assistance options

An "assistance" button is accessible to the user at all times, from anywhere, in the application – see Figure 5. This button embeds six vital assistance options: (1) call caregiver, (2) anxiety management tips, (3) sensory overload tips, (4) share location, (5) customize virtual card and (6) call emergency services (partially seen due to screen size) – see Figure 7.

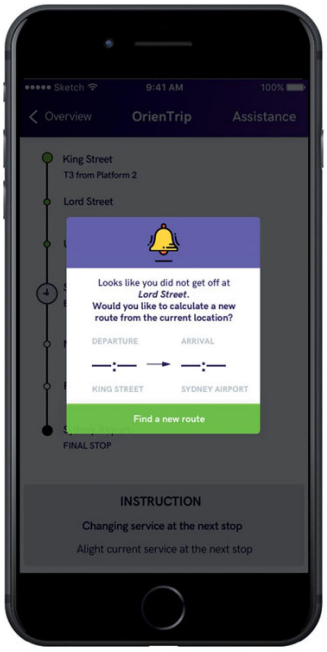

Figure 6. Reroute alert.

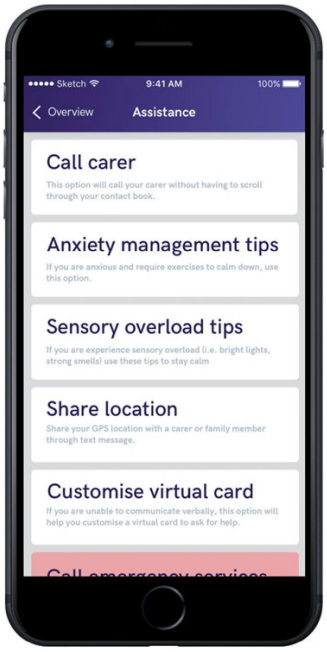

Figure 7. Assistance option.

The call carer option allows users to quickly speak to a caretaker in any situation – the caretaker is programed into the application prior to the journey.

The anxiety management and sensory overload assistance options show a list of evidence-based strategies, tailored to public transport, that can help alleviate anxiety and sensory overload during a journey. These options can be accessed from anywhere in the application; as a result, studying them before a journey can also help the user become better prepared.

The ability to share one's location allows users to share their precise geolocation when they are lost or for assurance when they have reached their final destination.

Difficulty with communication and social interaction is one of the core characteristics of autism [1]. For example, in a survey of adults on the autism spectrum ($n = 703$), Deka et al. [9] found that two-thirds of the participants had difficulty with social interactions, which in turn affected how the individuals travelled. Wallergård et al. [21], in a study of four subjects with acquired brain injury, found that individuals with language impairments not only were not able to clearly communicate with the driver, but also had difficulty explaining their concerns. A solution for this important need was not, however, designed in the requirements gathering phase. As such, this requirement was not included in prioritization survey.

The customized virtual card functionality, integrated into the application after the survey was conducted, is particularly beneficial for persons on the autism spectrum who have communication difficulties. The user can type a message (i.e., ask for assistance) in a virtual card in the application and show it to another person (e.g., a fellow passenger or the driver). This can also be highly effective in overwhelming circumstances when the user is unable to communicate verbally.

Finally, the user can quickly contact emergency services, from the application, when the circumstance demands it.

Discussion

In this paper, we have clearly defined the challenges and needs of persons on the autism spectrum in using public transport. Furthermore, we have developed a mobile application that enhances the abilities of these individuals to use public transport.

First, the application solves the complexity of public transport trip planning through an integrated routing algorithm that automatically finds the most efficient route between two points. The inability to process abstract representation, such as maps, landmarks and service schedules, is attributed to the impaired executive function in autism spectrum and intellectual impairments [10,12–15]. Planning trips, therefore, becomes a challenging a task for those on the autism spectrum. In fact, more than half of autistic individuals have difficulties planning public transport trips [9]. Travellers with cognitive impairments, who do use public transport, have reported to spend a lot of time making arrangements before a journey [25]. For example, they, first, identify the stops along a route, write down these stops and possible departure times, note shops along the course, as well as things they will need to bring for the journey.

Second, the mobile application provides step-by-step walking navigation to guide the user to the initial stop to begin their journey. The functionality to guide the user to the initial stop to begin their journey was also the most prioritized functionality in the survey. This requirement is sufficiently great to be worthy of attention because individuals on the autism spectrum have an impaired spatial memory that contributes to their inability with wayfinding [22]. More than 40% of those on the autism spectrum cannot get to the bus stop without help and more than 50% do not know how to safely cross the road [9].

Third, the proposed mobile application predicts the crowdedness of services to make trips more predictable. It does this through an algorithm that analyses historical data and mathematically estimates the crowdedness of an upcoming service. It is not uncommon for travellers on the spectrum to avoid public transport for being too crowded and difficult to cope [3,9]. In fact, this need, item 5, was prioritized fourth in importance in our survey (see Table 1). This intellectual foresight can alleviate the anxiety that arise from unpredictable social settings, a barrier that frequently discourages public transport utilization.

One of the core functionalities of the proposed mobile application is that it facilitates spatial awareness. Specifically, it makes it easier for users to know where they are in their journey. Without this functionality, users on the autism spectrum have to cognitively encode landmarks as cues to remember where to disembark, a process that is weakened in these individuals [9,22]. The application, in addition, can automatically detect and alert when a user deviates from a planned route (e.g., forgets to disembark at an intended stop) and calculates new routes to the reach the final destination. The anxiety and panic that can arise from the occurrence of unexpected user errors can significantly be reduced through this functionality. Our survey also validated this requirement. Specifically, functionalities including "the ability to notify users when to disembark the service", "the ability to recalculate a revised trip if something unexpected happens" and "the ability to guide users get to their destination if they miss their stop" were prioritized second, third and fifth, respectively.

We have already emphasized that anxiety plays a sufficient role to be worthy of attention in public transport use for persons on the autism spectrum. This was also reflected in our survey as every functionality listed in Table 1 is associated with anxiety issues. Concretely, the top four of these features address common anxiety problems, including getting lost when walking, missing an intended stop, fear of encountering an unexpected event and coping in social situations. Anxiety can be caused by numerous actions and events including behaviour issues, such as negative thoughts and uncontrollable worrying, often attributed to autism [29,30,37], as well as external influences, such as public transport disruptions. The anxiety management option, in the application, integrates evidence-based anxiety coping strategies, namely CBT techniques [37], Helpful Thought Generator [38] and Thought Challenging activities [38], to assist in lowering anxiety levels.

Sensory overload, a common characteristic of autism, can prevent public transport use, similar to anxiety [3,9]. The sensory overload strategies in the applications attempt to make this problem smaller. The evidence-based strategies are specifically tailored for public transport, containing as part of a whole techniques to deal with, loud screeching of brakes, glow from schedule boards, fuel fumes, fatigue from standing, and perspiration from lack of air flow in service.

In addition to concerns on the part of the travellers on the autism spectrum, parents or care givers show great concerns in placing their child in an out of reach situation [4,9,12]. To address this concern, the proposed mobile application allows travellers to contact a designated caregiver without leaving the trip tracker. This functionality can be particularly useful in high stress situations when the autistic traveller is not fully calm or settled to browse their mobile phone contacts, a multi-step process, to call to a "safe" person. This functionality, item 13, was also ranked highly important, particularly by family members (median = 6.00). In addition, the application also allows users to share their precise geolocation, through a text message, with a designated person. These measures can protect travellers on the spectrum from getting lost as well as instating greater confidence in parents to encourage their child's independence.

Finally, communication and interaction restrictions, a core characteristic of autism, is addressed through a functionality referred to customizable virtual card. Users can type a message (e.g., buying a ticket) into a virtual card, even when preparing for a journey, that can then be shown to other people (e.g., other passengers, bus drivers or customer service representatives) asking for assistance. This facilitates social interaction for, both, individuals who cannot cope in social settings, as well as those with severe communication deficits.

The mobile application we have developed, and currently testing with a pilot group, is a novel attempt to facilitate public transportation for individuals on the autism spectrum. This critical first step can promote a deeper understanding of the needs of these individuals to use public transportation. Future studies will assess the efficacy of the proposed mobile application, in the real world, to understand how it can be improved to produce the intended outcome.

This research may also inform innovators and public transport providers. Innovators can design and implement independent solutions, particularly digital solutions, to help make public transport less stressful for neurodiverse groups including those on the autism spectrum. Public transport providers, furthermore, can utilize this information to plan long-term changes in the infrastructure to cater to the needs of a wider array of travellers. Such improvements can lead to significant enhancements in the independence of these individuals as well as their ability to move freely in one's community. In the medium and long term, it can allow greater participation in education and employment [10,23].

Limitations

In the literature review section of this study, journal articles related to both individuals on the autism spectrum and persons with cognitive impairments, including post-stroke patients, were included. This is because the research on the use of public transportation by persons on the autism spectrum is scarce. While this study summarizes the challenges encountered by both groups, one needs to be further aware of the fact that the challenges and needs of autistic individuals and persons with cognitive impairments, including post-stroke individuals, may differ. Another limitation of the literature review is that more relevant publications and reports, not included in the study, may exist. For example, studies published in languages other than English were not included.

A limitation of the testing sample could be that the participants recruited in this study may not be representative of the entire autistic population. This is because every individual on the autism spectrum is different, thus every person has varying needs. Furthermore, the survey participants were based in two Australian states: Western Australia and New South Wales. These two states have different public transport infrastructures, as such, the

experiences and challenges of the individuals may be based on two different environments. It is, however, important to note that the purpose of this study was to define the challenges of public transport use in general and does not consider the difference in public transport systems.

Finally, autism diagnoses in the testing sample was entirely self-reported. It is unlikely that the participants included people who did not fulfil the autism spectrum diagnosis criteria; however, it cannot be ruled out.

Acknowledgements

The authors want to sincerely thank the participants for their time and effort. We, furthermore, like to express our sincerest gratitude to Kaaren Haas, Reinie Cordier and Nathan Wilson for their assistance with the data collection.

Disclosure statement

The authors report no declarations of interest.

Funding

This study was financially supported by the Cooperative Research Centre for Living with Autism (Autism CRC).

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Chapter 4: Paper II

User Interface Processing In Autism Spectrum: An Eye Movement Study: An Eye-Movement Study

4.1 Preface

Chapter 3 defined the challenges autistic people face when using public transport and introduced OrienTrip, an evidence-based mobile app, which aims to address these issues. Now, Chapter 4 seeks to measure how individuals on the spectrum interact with OrienTrip. More specifically, eye-movement analyses were performed with both autistic and neurotypical groups to evaluate the user interface and user experience of the app. The findings highlight the differences in user interaction, which subsequently inform how the app can be improved and streamlined for users on the spectrum. Thereafter, the chapter proposes some general user-interface design guidelines that can be used to create more intuitive software tools for people on the autism spectrum (see Figure 4.1).

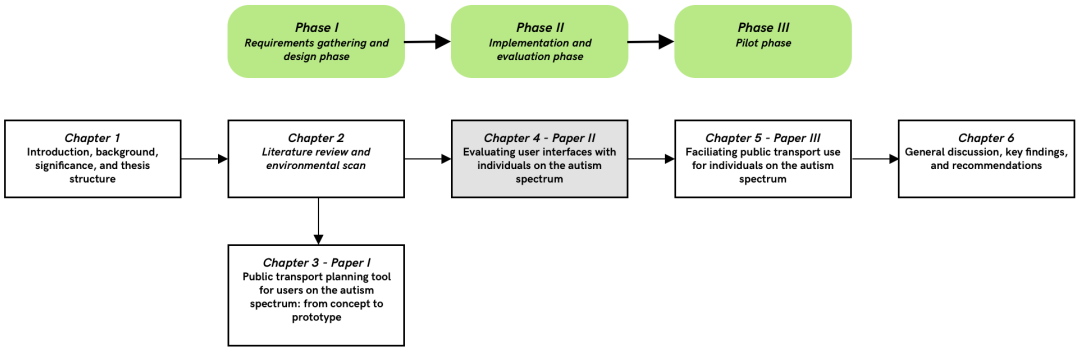

Figure 4.1. Chapter 4 includes evaluating the user interface of OrienTrip through eye movement analyses.

The following manuscript was accepted for publication on 30 April 2020 and first published online on 12 May 2020:

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

Chapter 5: Evaluating the effectiveness of an autism-specific public transport app for individuals on the autism spectrum: a pilot study

5.1 Preface

Chapter 4 evaluated the user interface and user experience of OrienTrip. Using individuals on the autism spectrum and a control group, the findings inform how these components can be improved. Further proposed were some general user-interface design guidelines that researchers and software developers can utilise to create more intuitive app interfaces for people on the autism spectrum.

The aim of Chapter 5 is 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 will inform how effective OrienTrip is in making public transport easier for people on the autism spectrum. It will also provide important insights on how OrienTrip can be improved to better address the requirements of autistic travellers (see Figure 5.1).

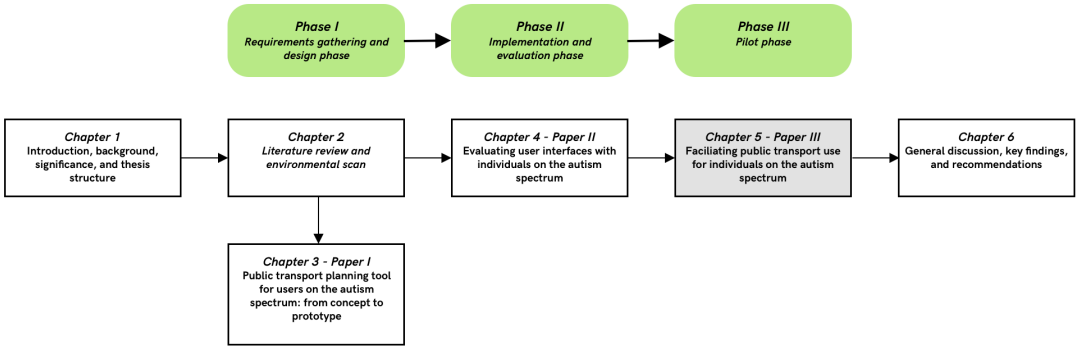

Figure 5.1. Chapter 5 sought to evaluate the efficacy and effectiveness or OrienTrip through two pilot studies.

This chapter was submitted for publication on 1 March 2020 and is currently under review. It has been edited and reproduced here with the permission of the journal for examination only:

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*****. Under review**

5.2 Introduction

As established in the previous chapters, individuals on the autism spectrum commonly rely on family members for their transportation needs (Davies et al., 2010; Falkmer et al., 2015; Lubin & Feeley, 2016). Public transport is an inexpensive form of mobility (Davies et al., 2010), which facilitates independence and frees the burden of assisted travel (Falkmer et al., 2015). However, public transport presents unique challenges for individuals on the spectrum, as it requires skills including, but not limited to, understanding abstract information (such as maps, service schedules, signs and landmarks), problem-solving unexpected situations, and timely management of transfers (Carmien et al., 2005; Davies et al., 2010; Falkmer et al., 2015). We, therefore, developed an autism-specific public transport trip-planner mobile application called OrienTrip, that was co-produced with autistic individuals, to make public transport use easier for people on the autism spectrum. In this chapter we evaluate the effectiveness and efficacy of OrienTrip through two pilot studies.

Using public transport requires complex executive functioning and cognitive abilities. Notably, one needs to utilise and understand navigational artefacts including, but not limited to, maps, schedules, landmarks, signs and clocks to manage public transportation (Carmien et al., 2005). More than 50% of autistic individuals have reported difficulty in planning public transport trips (Deka et al., 2016), while more than 40% of people on the spectrum struggle to reach a transit stop without assistance (Deka et al., 2016). Common irregularities in public transportation such as system errors, roadworks and unfavourable weather conditions can also result in excessive anxiety and stress (Carmien et al., 2005; Miles, 2011). As such, these factors discourage many from travelling independently.

Despite these challenges, public transport offers unique benefits to individuals on the autism spectrum. First, it is an inexpensive travel option that can save individuals with disabilities over USD$4,500 a year on transportation (Stock et al., 2011). Other studies have reported that parents spend more than USD$700 each month and over USD$85,000 in 10 years to cater to their autistic child's transportation needs (Lubin & Feeley, 2016). Second, public transport is a preferred mode of independent travel by individuals on the spectrum. That is, people on the autism spectrum have reported that being able to use public transport improves their independence and quality of life (Falkmer et al., 2015; Lubin & Feeley, 2016). Concretely, it has been shown that those on the spectrum who can travel alone are five times more likely to find and maintain employment than those who rely on others for transportation (Zalewska et al., 2016).

Finally, public transport aids personal health. According to the literature, a 40% decrease in car trips can significantly reduce risks of cardiovascular disease and type 2 diabetes (Rojas-Rueda et al., 2013). As such, the resultant increase in physical activity, including walking and cycling, associated with public transport use can support general health (Litman, 2016; Rojas-Rueda et al., 2013). Similarly, public transport has been shown to reduce emotional and economical stress through improved access to education, employment and social opportunities at an affordable cost (Litman, 2016).

5.3 OrienTrip

OrienTrip is a public transport trip-planning mobile application co-produced by autistic individuals to facilitate independent travel for people on the autism spectrum.

Five principles guided the development process. These are (1) safety, (2) increasing spatial awareness, (3) facilitating communication, (4) alleviating anxiety and sensory overload, and (5) simplifying trip planning.

Safety is a primary concern for individuals on the spectrum when using public transportation. Safety concerns include getting lost (Deka et al., 2016; Mengue-Topio et al., 2011), boarding the wrong service (Risser et al., 2012; Ståhl & Månsson Lexell, 2018) and being victimised (Deka et al., 2016). In the literature, studies have reported that more than 40% of people on the autism spectrum have difficulties finding their way to bus stops without assistance (Deka et al., 2016). Moreover, more than 43% worry about how other passengers will treat them while travelling (Deka et al., 2016).

Limitations in spatial awareness also pose barriers for individuals on the autism spectrum. These abilities include finding the correct stop, boarding the correct service and disembarking when appropriate. One previous study reported that more than 26% of autistic people do not use public transport because it requires too many transfers (Deka et al., 2016); this can be indicative of the difficulties faced in terms of time and route management. Further, the same survey revealed that more than 16% of autistic people do not use public transport because they have difficulty boarding and disembarking services (Deka et al., 2016).

Differences in communication and social skills—a core characteristic of autism—can also be a barrier in using public transport, as it requires dealing and being in the presence of large groups of people. Notably, travel demands the ability to communicate with the driver (e.g., when buying a ticket), interact with other passengers (e.g., asking them to remove their belongings from a seat before sitting down), and ask for assistance when required (Falkmer et al., 2015; Parsons et al., 2006; Wallergård et al., 2008). As such, the inability to clearly and concisely converse with people can cause significant anxiety and make public transport difficult to navigate (Bellini, 2006).

Anxiety, a comorbid condition with autism, is expressed by the disproportionate fear of environmental stimuli (Falkmer et al., 2015; Lang et al., 2010); this can directly

affect an autistic individual's ability to use public transport. Although anxiety in this context has not been clearly studied, similar research with persons with cognitive impairments have reported that irregularities (such as late services, missing buses and poor weather conditions) can induce stress (Ståhl & Månsson Lexell, 2018).

Similarly, hypersensitivity to stimuli (which can arise and affect one's experiences during travel) is extremely common in individuals on the autism spectrum (Cermak et al., 2010). For example, using public transport require dealing with loud noises, rowdy kids, bright lights and billboards, and different smells. As such, it is common for autistic people to avoid crowded services due to sensory issues (Falkmer et al., 2015).

Further, the ability to plan public transport trips requires travellers to understand complex navigation artefacts including service schedules and maps (Carmien et al., 2005). Evidently, difficulty planning travel is a common barrier for individuals on the autism spectrum, as more than 50% have struggled to plan a transport journey (Deka et al., 2016). People with cognitive disabilities have also been reported to criticise service schedules as being difficult to understand (Ståhl & Månsson Lexell, 2018). In turn, the logistical complexity of public transport can cause autistic individuals to avoid independent travel altogether.

As such, OrienTrip was created to address these challenges and make public transport easier to use. The core functionalities of the app, in its current version (1.0), allow users to (See Appendix E for screens of OrienTrip):

1. plan public transport trips based on (a) current or source location, (b) destination and (c) arrival or departure time and date
2. find real-time crowdedness information of services

3. find detailed information about a planned trip, including the number of interchanges, estimated cost and estimated travel time
4. track their current location, updated in real-time, in reference to the stops on the journey
5. quickly call a designated contact without leaving OrienTrip
6. quickly share their current location with a designated contact
7. view evidence-based anxiety-management and sensory-overload strategies tailored for public transport use
8. quickly customise a virtual card to communicate with other people through written text.

To assess the effectiveness and efficacy of OrienTrip in facilitating public transport use, the purpose of this chapter is twofold:

1. To conduct a pilot study with individuals on the autism spectrum to understand their experiences with OrienTrip.
2. To conduct a parallel pilot study with allied health professionals, who have experience working with individuals on the autism spectrum, to gather insight that improves OrienTrip.

5.4 Methods

5.4.1 Participants

A total of 16 individuals on the autism spectrum were recruited for the study. This included eight male and eight female participants, with a mean age of 22 (*std* = 4.97 years). Seven participants reported public transport as their primary mode of transportation, seven relied on family members for travel, and two reported driving. The participants were asked to rank along a five-point Likert scale (1 = do not use public transport to 5 = use public transport more than eight times each week) the frequency of their public transport use each week. The median ranking was 2, signifying three to four times weekly.

In addition, 22 allied health professionals were recruited for the pilot study. This included 19 females and three male participants. Overall, 14 participants were occupational therapists, one was a psychologist, two were speech pathologists, and five participants classified themselves as social workers and carers. The mean age of this group was 31 years (*std* = 8.93 years), and the median experience, on a five-point Likert scale from 1 (0–5 years) to 5 (21+ years), with people on the autism spectrum was 1.

5.4.2 Data collection

Autistic participants were recruited through multiple channels including internal email lists, social media groups and autism groups. Overall, the recruitment process took over 12 months to complete. Based on the feedback gathered from those who were invited to participate in the study, most individuals on the autism spectrum neither used public transport, nor intended to do so. Due to this barrier, recruiting people who met the inclusion criteria was particularly challenging.

Allied health professionals were also recruited through multiple channels including social media groups and autism organisations. Overall, the process produced a good response rate over the six-month recruitment period.

Complete information about what the study entails and registrations for participation were presented and collected through Qualtrics. Two forms were set-up to collect separate enrolments for individuals on the autism spectrum and allied health professionals.

5.4.3 Procedure

Following enrolment, individuals in the autistic group were invited to download OrienTrip through TestFlight, an online service for over-the-air installation and testing of iOS applications. Participants were asked to use the app on their regular public transport journeys for two to four weeks. This process ensured that OrienTrip was consulted in different situations and that participants became fully familiar with the functionalities. After the trial period, the group was asked to complete a Qualtrics survey to share their experiences with the research team. All participants were given a AUD$50 gift card as a token of appreciation for their time.

Similarly, allied health professionals were, following enrolment, invited to download OrienTrip through TestFlight and use the app for the same 2–4-week period for familiarisation purposes. After this, participants were asked to complete a Qualtrics survey to share their thoughts about OrienTrip. Participants were also given a AUD$50 gift card as a token of appreciation.

5.4.4 Data analysis

Quantitative data analyses were performed using IBM SPSS Statistics 26 with the significance level set at $p < 0.05$. Participants' demographic data and their responses

to the five-point Likert scale questions were entered for assessment to calculate the median and frequencies.

Qualitative data analyses were performed using NVivo version 11, and thematic analysis was completed using the principles outlined in Braun and Clarke (Braun & Clarke, 2006). These included (1) familiarisation with data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, and (5) defining and naming themes. After the Qualtrics survey results were uploaded to NVivo 11, team members read through the responses multiple times and took notes to organise and generate frequented words and codes to develop the thematic framework. The research team then discussed and shared themes and keywords. This process continued until all team members agreed on the overall themes and subthemes. The team then interpreted the survey responses by analysing the findings.

5.4.5 Ethics

Ethical approval was obtained from the Human Research Ethics Committee at Curtin University (HRE2016-0086) in Perth, Western Australia.

5.4.6 Consent

Participants were provided a digital information sheet through Qualtrics describing their role in the research. They were informed that their withdrawal from the study was acceptable at any time without negative consequences and were subsequently provided digital consent confirming their participation. All study data were confidentially stored and maintained in line with the Western Australian University Sector Disposal Authority.

5.5 Results

5.5.1 Individuals on the autism spectrum

Autistic individuals were asked to rank the statement ‘OrienTrip is easy to use’ on a five-point Likert scale, with 1 being ‘strongly disagree’ and 5 being ‘strongly agree’. Analysis found that the median response was 4 (‘somewhat agree’).

Further, participants were asked whether they required more instructions to use OrienTrip. Seven needed more guidance on using the app, while nine did not.

Autistic participants were then asked to rank the statement ‘OrienTrip is helpful in making public transport easier to use for individuals on the autism spectrum’ on a five-point Likert scale, with 1 being ‘strongly disagree’ and 5 being ‘strongly agree’. Again, the median response was 4 (‘somewhat agree’). Similarly, participants ranked their satisfaction with OrienTrip from 1 (‘extremely dissatisfied’) to 5 (‘extremely satisfied’), which again averaged at 4 (‘somewhat satisfied’).

Thereafter, participants indicated on a four-point Likert scale their level of disappointment should OrienTrip no longer exist (0 = N/A, 1 = not disappointed, 2 = somewhat disappointed, 3 = very disappointed). The median was 2 (‘somewhat disappointed’). Finally, when asked to rate OrienTrip out of 5, the median score was 4, while the mean score was 3.63 (*std* = 0.62).

5.5.1.1 Feature ranking

After using OrienTrip for two to four weeks, autistic participants were asked to prioritise the functionalities of the app based on helpfulness. Table 1 shows the ranking of functionality from highest (most helpful) to lowest (least helpful).

Table 5.1: Ranking of functionalities of OrienTrip by individuals on the autism spectrum, sorted from highest (most important) to lowest (least important)

Rank	Functionality description	Median (*n* = 16)
1	The ability to calculate routes	2.0 (IQR = 3)
2	The ability to view information on the interchanges of a route	3.0 (IQR = 3)
3	The ability to view crowdedness information of services	4.0 (IQR = 3)
4	The ability to track journeys in real time through a simplified linear map	4.0 (IQR = 4)
5	The ability to view anxiety-management strategies for public transport	6.0 (IQR = 5)
6	The ability to call a caretaker from OrienTrip	6.0 (IQR = 3)
7	The ability to call emergency services from OrienTrip	6.50 (IQR = 4)
8	The ability to share current location with a caretaker	7.50 (IQR = 3)
9	The ability to view sensory-overload strategies for public transport	7.50 (IQR = 6)
10	The ability to communicate through a customisable virtual card	8.50 (IQR = 4)

Interquartile range (IQR)

5.5.1.2 Primary benefit

When autistic participants were asked about the primary benefits they received from OrienTrip, three themes emerged. This covered (1) comparative ease when planning trips, (2) the support OrienTrip provides, and (3) tracking an existing journey.

5.5.1.3 Streamlining trip planning

The ability to plan trips easily was a prominent benefit of using OrienTrip. Participants expressed that the app simplified travel preparation, particularly, according to one, 'because it's easy to plan when I need to leave'. In addition, OrienTrip further streamlined the 'timing of public transport', and clarified 'the planning process of working out' a journey due to the 'straightforward [and] easy-to-use' nature of the app.

5.5.1.4 The support OrienTrip provides

Some participants indicated that they benefitted from the support OrienTrip provided them. For example, the app allows users to call their carer, share their location, view anxiety-management and sensory-overload strategies, and communicate through a virtual card. One participant expressed that 'being able to use public transport with the support I am receiving' makes the 'experience enjoyable', particularly through the 'assistance tab' (available on the app).

Another assistance option that was widely praised was the ability to manage anxiety during public transport travels. Notably, this provided 'easy access' and 'advice on how to calm down', as well as the opportunity 'to gain good experience' while travelling. In addition, OrienTrip offered users 'transporting skill[s] and tips to become less anxious', including 'advice on how to cope with being on public transport'. Indeed, this was a common view held among participants who had indicated their dislike for the crowdedness, anxiety, 'drama' and being around rowdy passengers when using public transport.

5.5.1.5 Tracking a journey in real time

The ability to actively track one's public transport journey was also widely praised. Participants found the feature had helped them 'organise travel times more effectively' and better 'visualise where I need to go and how' using the 'saved trips'

function. Other benefits included increased time management and the option to simplify travel routes.

5.5.1.6 People who would benefit from OrienTrip

When asked who, in their opinion, would benefit most from using OrienTrip, four categories emerged. This covered (1) people on the autism spectrum, (2) people with cognitive disabilities, (3) people with anxiety issues and (4) people who are new to public transport.

People on the spectrum proved the most common suggestion to this question. This was anticipated, as OrienTrip is designed and advertised for this particular cohort. Other responses ranged from ‘people with autism or ADHD’, ‘autistic people and people with anxiety issues’, ‘those that find it hard to keep track of time or those on the spectrum’, and ‘ASD [autism spectrum disorder] individuals with filtering difficulties’ because the features are ‘so simplified’.

Some participants suggested that people with other disabilities (which, according to one participant, can ‘affect their ability to plan things’) could also benefit from OrienTrip. These responses included people who cannot travel independently and people with planning and ‘executive functioning problems’. This further covered individuals who get ‘confused using modes of transport by themselves’ and ‘those that find it hard to keep track of time’.

Some participants indicated that people with anxiety issues—that is, ‘who need to take public transport but are unable to due to anxiety’—could also find the app useful. These responses may have emerged because OrienTrip offers a comprehensive list of anxiety and sensory-overload management strategies that are tailored specifically for public transport use. Notably, one participant even suggested that ‘people who might need the very useful “assistance option” ’ could be of benefit.

Finally, autistic participants suggested that individuals who are new to public transport and those who cannot travel independently might value the app. In particular, 'people who like visual … maps when they are on public transport' and 'help when to know to get off', as well 'people who use public transport on new routes', will find OrienTrip useful. Further, 'someone who needs help planning trips', struggles 'to keep track of time' or 'has not caught public transport before' might value a tool like OrienTrip to streamline safe travel.

5.5.1.7 Limitations of OrienTrip

Participants were asked about the biggest problems they experienced when using OrienTrip. Here, the aim was to understand how the app can be improved to make the user experience more pleasant and stress-free. The responses can be categorised under three themes, covering (1) missing features, (2) difficulty to use and (3) inability to provide the best route.

5.5.1.8 Missing features

This category of responses highlighted the missing features participants wished the app contained. For example, one suggested we integrate 'features with music and books … to limit what one needs to take' with them, such as additional devices or having to switch apps, while travelling.

Another suggested we add visuals of landmarks on the journey map to help users better understand where to disembark on existing services, particularly by knowing 'when to push the bell'. This also included 'commands for busy, crowded buses'. That said, OrienTrip does, in its current state, provide a straightforward linear map that lists every stop on a journey, with users' locations updated in real time (see Figure 5.2).

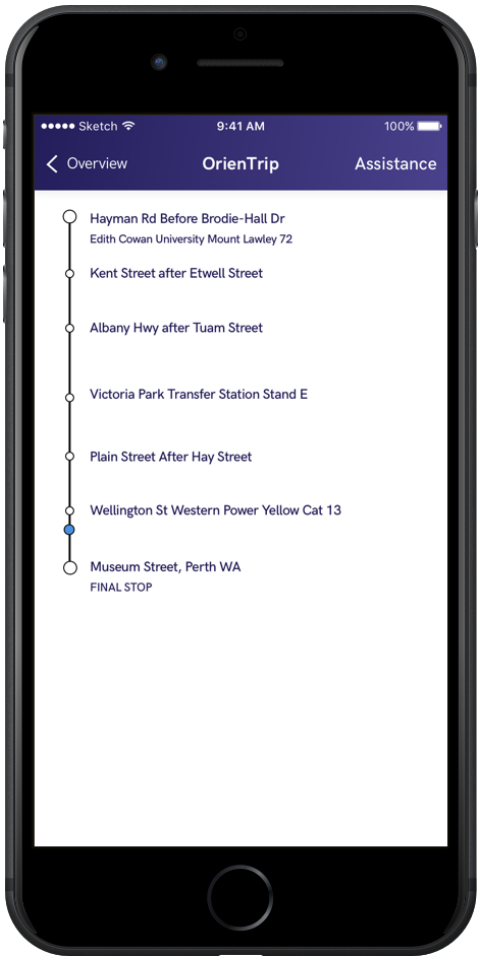

Figure 5.2. OrienTrip allows users to track their journey through a linear map with their current location, blue circle, updated in real-time.

Another suggested that the map should automatically zoom in to their current location after opening: 'When walking and tapping on the list to see the map, it doesn't show you where at this stage you are walking. If it zoomed in after tapping to your walking route, that would be good to have.'

5.5.1.9 Difficult to use

One theme that emerged regarded the level of app usability. Participant responses centred around the app's user interface, with comments ranging from confusion 'to navigate' OrienTrip, to its general absence of visual appeal 'due to the lack of visual aids'. This regarded 'colours [and] word choices', 'boring' interface and failure to display 'some of the bus routes', which 'were not clearly marked'. Overall,

these comments highlight that the app interface can be improved to make OrienTrip more intuitive and stimulating for users.

5.5.1.10 Routing problem

Finally, some participants reported that OrienTrip did not display the travel routes they usually take. For example, one respondent explained that the app 'did not show the route I usually take on footy match days, as it was a special event bus that only runs on match days'. Others claimed that when unable to locate their bus timetable, 'there wasn't somewhere I could get some help on the app' for assistance.

This issue can be a routing-algorithm problem, which causes OrienTrip to ignore some travel routes. Another possible explanation can be that the routes participants were expecting to locate were deemed 'inefficient' as a result of the app locating more logical routes with shorter travel times. This issue can be investigated in future studies.

5.5.1.11 Stressful experiences with public transport when using OrienTrip

Only four reported that they experienced some form of anxiety and stress when using public transport. In particular, participants identified crowded services as the source of their anxiety, mainly with 'certain people coming onto [the] bus', thus, inviting 'anxiety thoughts' to arise. Another explained that 'it's more the rushing and amount [of] people in … public transport' that triggers unease.

When asked if OrienTrip was helpful in managing their anxiety, one participant stated that it provided 'advice on how to calm down'. Another described their anxiety as such:

> I had to tell the bus driver where I wanted to go, then I had to give him the money and my purse was hidden in my bag so I was fumbling, trying to find it and then I had to get the coins and give them to him; then I had to take the ticket

and the change and I just felt like I was going to mess up but that's how I always feel when I'm buying something.

Public transport requires performing quick, successive tasks (e.g., boarding, asking for a ticket, handing others cash, pocketing the change, getting the ticket and finding a seat). When queried if OrienTrip was helpful in alleviating stress, one responded, 'no, [but] maybe if someone else did it for me … now that I think about it, that's probably not helpful to me overall'.

Others expressed that 'the stress mainly came from the boredom' of travel and expressed that the app's ability to manage anxiety was not helpful in this situation. However, when asked what would be helpful, they wished for features that would alleviate or even 'solve boredom issues'.

5.5.2 Allied health professionals

Allied health professionals were asked to rank, on a five-point Likert scale, the statement, 'OrienTrip is easy to use'. The responses ranged from 1 ('strongly disagree') to 5 ('strongly agree'), and returned a median score of 4 ('somewhat agree').

Similarly, participants were asked to rank whether 'OrienTrip is helpful in facilitating public transport use for individuals on the autism spectrum' on a five-point Likert scale, with 1 being 'strongly disagree' and 5 being 'strongly agree'. Again, the median rank was 4 ('somewhat agree').

Upon asking the participants to indicate their level of overall satisfaction with OrienTrip on a five-point Likert scale (1 = extremely dissatisfied, 5 = extremely satisfied), analyses found a median of 4 ('somewhat satisfied'). In subsequently rating the app out of 5, participants scored OrienTrip a 4 (IQR = 1), returning a mean rating of 3.7 (*std* = 0.72).

5.5.2.1 Feature ranking

After using OrienTrip for two to four weeks, allied health professionals were asked to prioritise the app functionalities based on helpfulness (in their opinion) to those on the spectrum. Table 2 shows the ranking of functionalities from highest (most helpful) to lowest (least helpful).

Table 5.2: Ranking of functionalities of OrienTrip by allied health professionals, sorted from highest (most important) to lowest (least important)

Rank	Functionality description	Median (n = 22)
1	The ability to calculate routes	1.5 (IQR = 4)
2	The ability to share current location with a caretaker	3.50 (IQR = 4)
3	The ability to call a caretaker from OrienTrip	5.0 (IQR = 4)
4	The ability to view anxiety-management strategies for public transport	5.5 (IQR = 4)
5	The ability to view information on the interchanges of a route	5.5 (IQR = 5.25)
6	The ability to view crowdedness information of services	6.0 (IQR = 4.25)
7	The ability to view sensory-overload strategies for public transport	6.0 (IQR = 3.5)
8	The ability to track journeys in real time through a simplified linear map	6.5 (IQR = 4)
9	The ability to call emergency services from OrienTrip	9.0 (IQR = 5)
10	The ability to communicate through a customisable virtual card	8.0 (IQR = 5.0)

5.5.2.2 Primary benefit

Allied health professionals were asked about the primary benefits people on the spectrum would receive from using OrienTrip. The responses were thematically organised into five categories, covering (1) trip planning, (2) coping strategies, (3) accessible support options, (4) independent mobility and (5) trip tracking.

5.5.2.3 Planning trips

One of the most prominent benefits of using OrienTrip was the ability to plan and manage trips. Specifically, respondents valued the capacity to plan a detailed travel journey to reduce uncertainty, either listing 'all stops [a] bus will be making … so [users] can follow whilst travelling' or providing 'stability and clear directions' during a trip. In addition, participants praised the app's value as a 'resource to assist the majority of the [travel] process', which is 'easy to use and simple to navigate to ascertain info on train scheduling, facilitating public transport use'. Finally, one respondent liked 'how specific it is with locations for walking, streets and bus stops so that an individual can plan their whole trip' while 'reducing any unexpected situations'.

5.5.2.4 Coping strategies

The ability to manage anxiety and sensory overload during transport journeys was cited as equally beneficial for autistic individuals. Participants emphasised the importance of being able cope with overwhelming situations 'when in the community', including the provision of 'helpful tips to manage anxiety while travelling' and 'holistic … strategies given to support individuals with ASD'. Finally, one participant praised OrienTrip's novelty among other travel apps:

> The factors I feel set apart this app from other orientation apps are the helpful tips. I find this a great idea for particular clients who experience high anxiety

around public transport to simply read and remind them of tips to assist with sensory overload and anxiety.

5.5.2.5 Accessible support options

Allied health professionals also praised the support options available on OrienTrip. Specifically, their responses cited features such as the ability to call a caregiver, share location with a caregiver, and the option to communicate via virtual card, which would be useful to those on the autism spectrum. Notably, 'the fact that their caregivers can also check up on their locations is very handy, as this will reduce carers' anxieties and increase independence'.

In terms of assistance, OrienTrip offers 'support options readily available within the app', which are 'very useful to have … all in the one space'. One respondent expressed that they 'liked the option of a virtual assistance card', while another praised the 'carer/emergency contact options, and the ease of planning a trip (times, routes, costs)'. The 'safety features … that can alert caregivers and reduce stress associated with public transport' were further praised, as well as the convenience of having 'one app for multiple necessary functions'.

5.5.2.6 Independent mobility

Some responses indicated that OrienTrip can facilitate 'independent mobility' for those on the autism spectrum. In particular, the app provides 'one resource to assist the majority of the process involving public transport', as well as 'confidence in travelling alone'. Further, individuals can 'gain more independence' by empowering users 'to plan a trip from start to finish, as well as problem-solve any issues that may arise specific to someone on the spectrum'. Overall, the health professionals emphasised that OrienTrip provides autistic individuals with the tools required to navigate public transport safely.

5.5.2.7 People who would benefit from OrienTrip

Participants were asked to list groups that would benefit most from using OrienTrip. Responses were organised into four categories, covering (1) people with high-functioning autism, (2) individuals with anxiety disorders, (3) individuals with other disabilities, and (4) youth and children.

5.5.2.8 People with high-functioning autism

Respondents acknowledged that autistic individuals would value OrienTrip but emphasised its true benefit for people with high-functioning autism and those with some autonomy. In particular, respondents believed that people with 'the skills and level of independence to take public transport safely on their own' or 'someone with higher literacy skills and … reasonable tech literacy' could use OrienTrip successfully. Further, those in their 'late teens and adults with autism or anxiety' would value the app, 'as long as they have good literacy skills' or 'higher cognitive capabilities [such as] relatively good receptive language skills, [and the] ability to read and utilise functions'.

Other participants explained that OrienTrip better suits 'someone who is quite high functioning, as it requires a fair bit of ability to access the application'. They would also have to possess 'good insight to look at prompts that will help them manage sensory overload [and] anxiety'.

5.5.2.9 Individuals with anxiety disorder

This theme emerged with respect to people on the spectrum 'who may struggle to independently take public transport due to anxiety, sensory overload and communication difficulty', including neurotypical individuals. Notably, responses suggested that anyone with anxiety issues 'and is wanting to be more independent' can benefit from OrienTrip. In addition, people, particularly 'young adults with social anxiety' or someone either 'learning to use public transport' or experiences 'anxiety

around travelling on public transport', might find the app helpful in terms of alleviating stress.

5.5.2.10 People with disabilities

Some respondents indicated that individuals with special needs and those who require navigation assistance could benefit from OrienTrip. The app can support a 'verbal person with special needs', as well as 'individuals with any disability who use public transport, especially trains on a daily or weekly basis to get around cities'. Further, OrienTrip simplifies travel for people 'needing precise and clear instructions for getting [to destinations] and back again', and individuals 'with exec function difficulties, anxiety [and] communication difficulties'.

5.5.2.11 Young people and children

Finally, some responses highlighted that 'youths and children' can also benefit from the tools and support available on OrienTrip. Notably, 'teenagers and young adults transitioning from school to work, individual[s] engaging in transport training, [and] anyone wanting to increase their independence in the community' may find the app useful.

5.5.2.12 Suggestions to improve OrienTrip

Participants were asked to explain how OrienTrip can be improved to better cater to the needs of individuals on the autism spectrum. The responses were thematically organised into three categories aimed at (1) simplifying OrienTrip, (2) adding more features, and (3) supporting people with other disabilities.

5.5.2.13 Simplify OrienTrip

This theme emphasised that OrienTrip is text heavy and can be challenging to use for people with literacy difficulties. Comments indicated that the app can be further simplified by utilising more visuals and removing unnecessary user-interface elements:

I think literacy skills can sometimes be a challenge for people with ASD, and that even when literacy skills are strong, it can be difficult to process written text when under stress or sensory overload. I think including a pictorial display option for sections like 'assistance' may broaden the range of individuals that this could be used with—for example, [an] image or GIF of someone breathing calmly within anxiety-management tips. Individuals could choose which method of display was most helpful.

[Put] categories in for the sensory overload tips, [as] there is a lot of writing and you have to click and scroll. Consider adding … visuals on the assistance tab [and] … the ability to limit just to a region (i.e., Perth only). [It] can be overwhelming when all of the places come up.

When searching locations, international destinations come up first as suggestions. This may frustrate someone with ASD and limited literacy skills, as they need to put in more info to get the Australian destinations to show up.

Overall, respondents provided clear suggestions to help streamline the user experience. These included:

- 'more visuals to support text', as 'this would not be good for someone with lower literacy'
- 'more symbols [instead of] writing, so that individuals who have reading difficulties can access the app'
- 'icons that individuals who can not read will understand', as well as 'speech output'

- decluttering ‘the layout slightly to help those with visual scanning difficulties’ and possibly adding ‘graphics [and] symbols for low-literacy clients’, including the ‘option to increase [and] decrease font’.

5.5.2.14 Additional features

Some responses highlighted additional features that can assist users when taking public transport. For example, participants suggested we enable the option to customise the app interface to suit individual needs, adding voice recognition and text dictation for those with low literacy skills, as well as the possibility to manage and top-up one’s travel card. In particular, one explained that OrienTrip needs a ‘customisation aspect for customers who are non-verbal and respond well to visual-based tools’. This includes:

> customisable features to suit each individuals’ personal requirements (e.g., add images of stops), text-to-speak function (for customers with literacy deficits), ability to add keyword[s] [and] requests as a virtual assistance card (for non-verbal customers (e.g., ‘excuse me’, ‘would you mind pressing the bell for me’, ‘my stop is next’), [and a] personal detail section within the app (e.g., if customer gets lost, can show details to others for assistance).

The respondents also suggested that we add ‘locations to access additional assistance, help [and] additional problem-solving strategies in the form of visuals’. For example, an ‘I am lost’ feature will help users ‘find an adult and show [their] virtual card’, including ‘what to do if your SmartRider runs out of money’.

Others suggested OrienTrip include:

- ‘voice recognition of queries or in-calling caregiver, caretaker, emergency services [and] Transperth info’, as well as ‘notification alerts [for] delays in scheduling, price of journey, link integration with SmartRider, Siri-type voiceover for those that may have poor reading

literacy, [and] change in font size and colour for those with visual impairment or colour blindness'

- 'options for different states like Transperth for checking money on cards'
- 'basic communication commands on crowded buses and trains'
- 'stop numbers in detailed journey plan to help [a] person track which stop they are at'
- 'a locked section for holding a card or carers card to provide them with discounted fares, as this information could be saved safely on the app'.

5.5.2.15 Support people with other disabilities

Some responses indicated that additional features might benefit individuals with other disabilities. For example, participants suggested we make the user interface accessible 'for individuals with sensory loss' and visual impairments through 'contrasting background colours', the 'option to increase [and] decrease font sizes', enable 'screen rotation', and include voice recognition capability as well as the 'option of using dictation for people who can't read [and/or] write'. The latter functionality was also suggested for those with low literacy skills.

5.6 Discussion

This pilot study has shown that OrienTrip facilitates public transport use for individuals on the autism spectrum. The findings show that the app was well received by all 16 autistic individuals and all 22 allied health professionals who participated for analysis. 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 professional indicated that they also

'somewhat agree' (4) on app helpfulness, based on the same five-point Likert scale (see Figure 5.4). They gave OrienTrip an overall score of 4 out of 5.

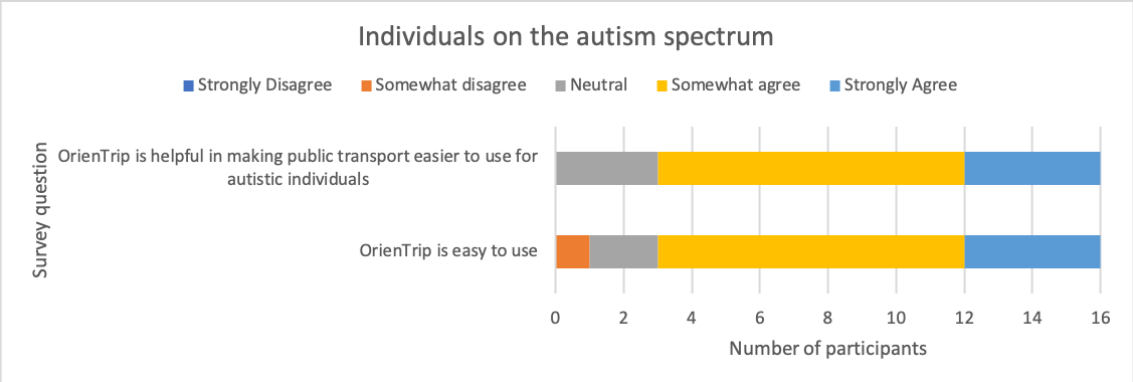

Figure 5.3. Individuals on the autism spectrum agreed that OrienTrip is easy to use and makes public transport more accessible.

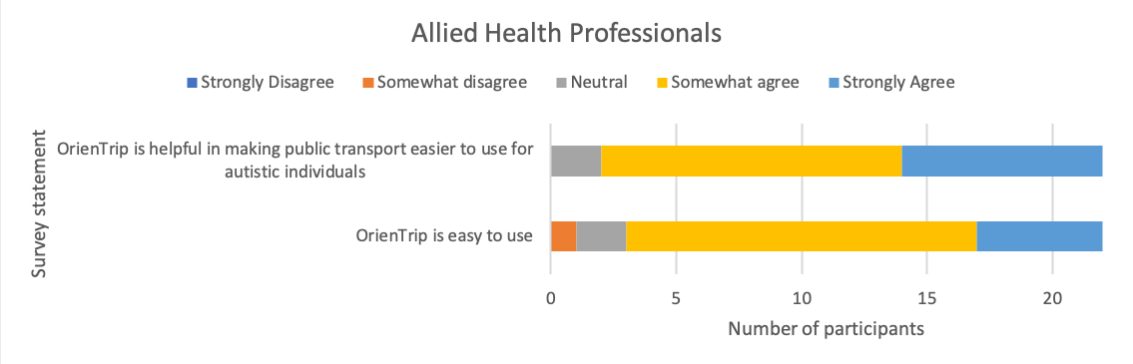

Figure 5.4. Allied health professional agreed that OrienTrip is easy to use and facilitates public transport use for autistic individuals.

Autistic individuals agreed that planning public transport trips was easy with OrienTrip. This opinion was evident when the participants expressed that they benefitted most from the app's 'calculating routes' functionality. This finding supports previous studies that report 50% of autistic individuals have difficulty planning public transport trips (Deka et al., 2016). The participants further emphasised this perspective when they ranked the 'ability to calculate routes' functionality the highest (most important) in helpfulness by the autistic individuals (see Figure 5.5). Allied health professionals expressed a similar opinion. Overall, they regarded the ability to plan detailed trips as one of the primary benefits users on the spectrum can receive from

OrienTrip. Similarly, this perspective was reiterated in further analyses, in which health professionals also ranked 'the ability to calculate routes' functionality highest (see Figure 5.5), clearly highlighting its usefulness to people on the autism spectrum.

The findings also revealed that individuals on the spectrum strongly desire predictability when using public transportation. Autistic participants ranked 'the ability to view information on the interchanges of a route' and 'the ability to view crowdedness information' second and third in usefulness, respectively. Indeed, past studies have also shown that predictability is a strong regulator of anxiety (Sinha et al., 2014). For example, it has been reported that an autistic individual's improved ability to foresee a situation is correlated with decreased anxiety levels (Sinha et al., 2014). Evident in this study, the findings support this perception. Allied health professionals also expressed a similar opinion, ranking 'the ability to view information on the interchanges of a route' and 'the ability to view crowdedness information' fourth and fifth, respectively.

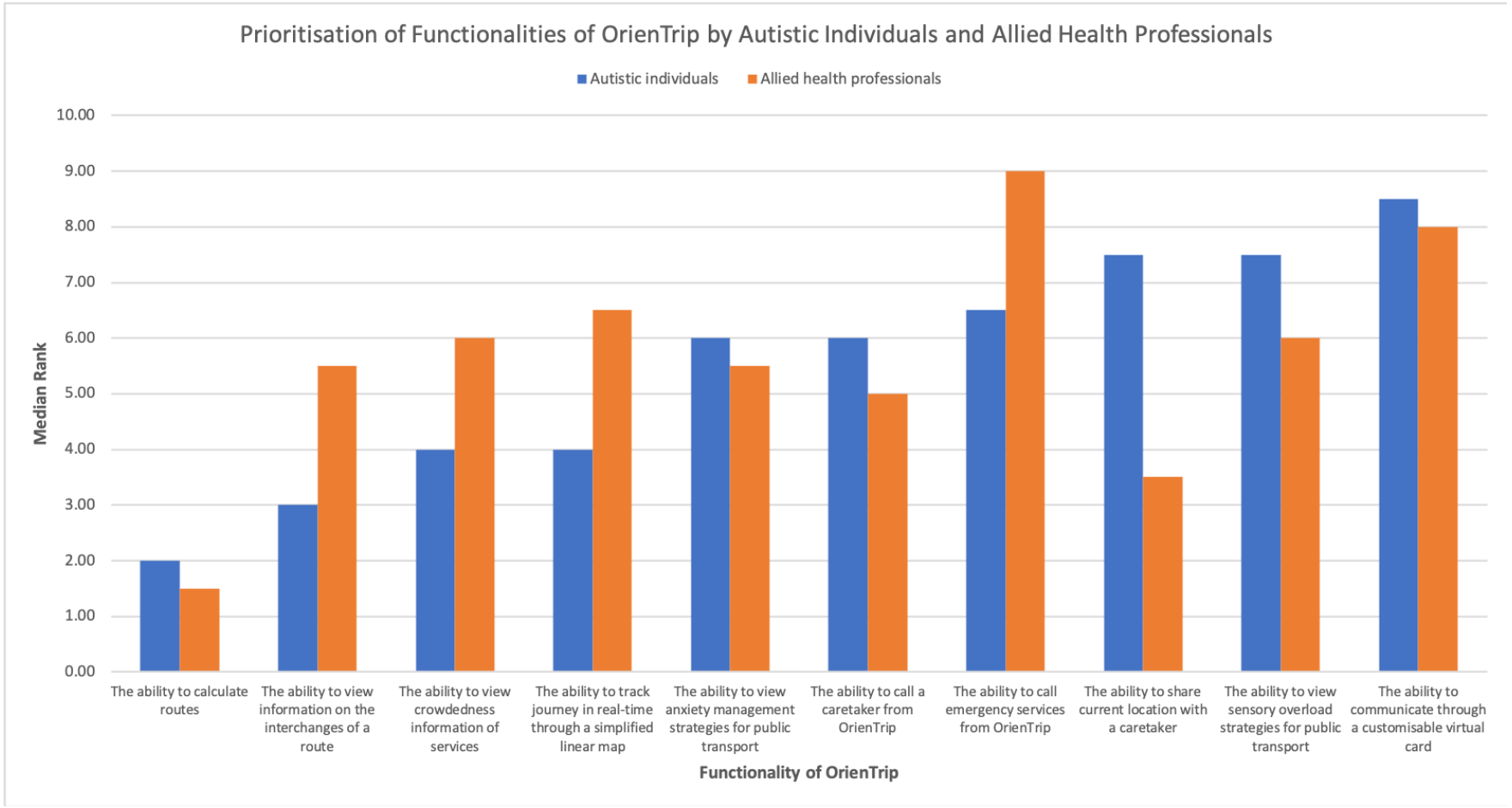

Figure 5.5. Participants on the autism spectrum and allied health professionals prioritise the functionalities of OrienTrip based on helpfulness to them (lower median rank means more important)

Autistic individuals also highlighted that OrienTrip's assistance options helped them experience more enjoyable public transport trips. For example, participants expressed that they benefitted from the anxiety-management strategies, ranking them fourth in terms of usefulness. One participant reported that the anxiety-management assistance option helped them to alleviate a stressful situation on one of their journeys.

When examining the literature, anxiety management has been shown to facilitate independent travel (Livingstone-Lee et al., 2014), while maintaining control over negative thoughts (e.g., 'I am not capable of using public transport') makes public transport more manageable (Ståhl & Månsson Lexell, 2018). Similarly, allied health professionals emphasised the usefulness of the app's anxiety-management assistance option, deeming it one of the core distinguishing features of OrienTrip. Overall, they ranked the feature fourth in terms of usefulness.

Other functionalities were reportedly helpful for travel purposes. For example, individuals on the spectrum ranked the journey map (shown in Figure 5.5) equal third in importance and usefulness. The purpose of this map was to facilitate spatial awareness through an intuitive user interface, particularly because (according to previous studies) people with intellectual disabilities have difficulty disembarking at the correct stop (Davies et al., 2010; Risser et al., 2012). Similarly, another functionality, the 'call caretaker' feature, was ranked equal forth, highlighting its importance for autistic users. Allied health professionals expressed that this functionality enables OrienTrip to increase autistic people's confidence to travel independently, and, as such, ranked the 'share current location with caretaker' and 'call caretaker' functionalities second and third, respectively. These safety measures ensure a safe journey and peace of mind for carers (Deka et al., 2016; Feeley, 2010).

Finally, we sought to understand how OrienTrip could be improved to more effectively aid and encourage public transport use. Here, the investigation revealed a recurring theme: autistic participants found the app difficult to use. Their responses included comments such as ‘not very visually appealing’, ‘difficult to navigate’ and ‘boring user interface’. Evidently, the interface is one the most important aspects of a software application, which has been shown, for example, to support positive user experience when effective and negative user experience when poorly designed. Indeed, a ‘bad’ interface can even cause users to give up the software completely despite its many benefits (Darejeh & Singh, 2013; Pavlov, 2014).

Second, the responses from allied health professionals revealed a similar theme, in that most felt the app was too complicated. For example, responses indicated that the user interface is text heavy and can be difficult to understand and process for some autistic individuals, especially under stressful situations. Suggestions to improve OrienTrip included making the text bigger, using visual aids and implementing text dictation to improve accessibility for autistic individuals with low literacy skills and/or individuals with other disabilities.

Overall, the findings suggest that OrienTrip successfully facilitates public transport use for people on the autism spectrum. Both groups—that being autistic individuals (see Figure 5.6) and allied health professionals (see Figure 5.7)—expressed their satisfaction with the app, and generally agreed that its functionalities (including the detailed trip-planning feature, anxiety and sensory coping strategies, and safety functionalities such as the ability to share one’s location) can enhance the capacity of autistic users to navigate public transport independently.

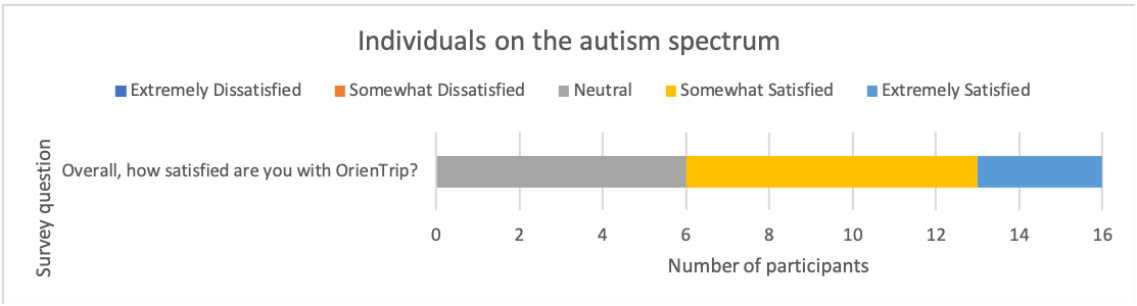

Figure 5.6. Individuals on the autism spectrum expressed overall satisfaction with OrienTrip.

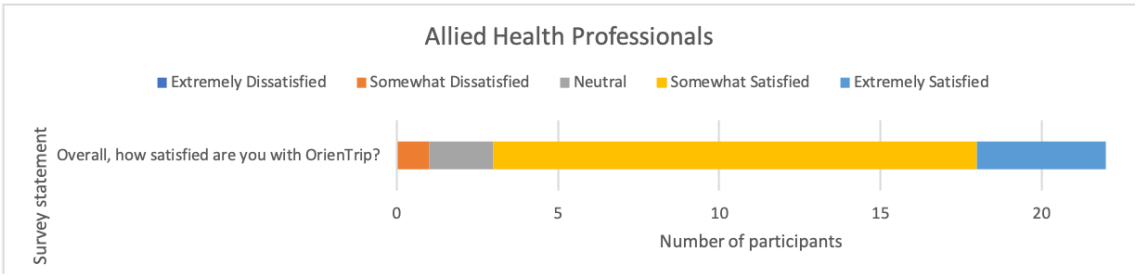

Figure 5.7. Allied health professionals expressed overall satisfaction with OrienTrip.

However, the study also found that OrienTrip, in its current version, can be difficult to use and is visually unappealing. Nonetheless, this user-interface issue can be improved through increased image and icon use and improved colour selection. Future studies can investigate this and improve the app using the feedback collected in this study.

It can be concluded that technological tools such as OrienTrip can be utilised to assist individuals on the autism spectrum travel autonomously, without reliance on other people, using public transport. Independent mobility can improve community participation opportunities for individuals on the autism spectrum, including enhanced education, employment and social outcomes.

5.7 Limitations

A limitation of the study regards the deficient sample size of the autism group, which may not adequately represent the entire autism population. This is because all autistic individuals are different and their experiences with public transport will vary. Similarly, the health professionals group was equally limited in number and, thus, representation.

It is also important to note that participants in the autism group had self-reported their autism diagnosis. Although it is unlikely that the sample included individuals who did not meet the autism diagnosis criteria, the possibility cannot be ruled out.

Overall, the pilot studies conducted in this paper had relatively small sample sizes, which could be regarded as a limitation. Future studies can investigate the effectiveness of OrienTrip through a large-scale study, such as a randomised control trial, which involves a larger number of participants.

5.8 Acknowledgements

The authors would like to thank the participants for their involvement in this study, as well as Dr Melissa Black for assisting with the recruitment process.

5.9 Declaration of Interest

The authors report no declarations of interest

5.10 Funding

This study was financially supported by the Cooperative Research Centre for Living with Autism (Autism CRC).

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Chapter 6: General Discussion

6.1 Preface

The previous chapters defined the challenges individuals on the autism spectrum face when using public transport. To address these travel difficulties, a mobile application called OrienTrip was proposed, with the user interface and user experience assessed using eye-movement analyses. The outcome of two pilot studies, conducted to evaluate the efficacy and effectiveness of OrienTrip, was thereafter described.

The aim of this chapter is to provide a synthesis and summary of the findings. It describes the implications of the results, critically appraises the strengths and limitations of the thesis, and makes recommendations for future research (see Figure 6.1).

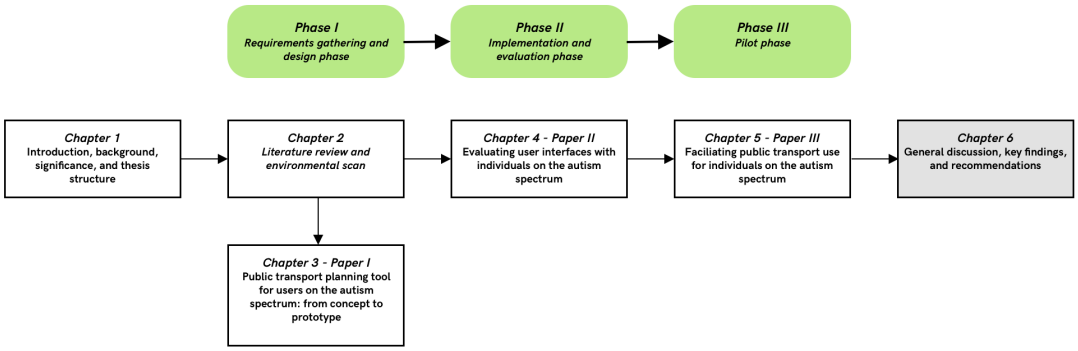

Figure 6.1. Chapter 6 provide a synthesis and summary of the findings.

6.2 Overview

This thesis developed an autism-specific tool, in close collaboration with individuals on the spectrum and their allies, to facilitate public transport use. Study 1 defined the challenges people on the autism spectrum face when travelling independently, and further proposed a mobile application that makes public transport easier to manoeuvre. The findings were informed by a literature review and surveys

of individuals on the spectrum, including their families. Study 2 then developed a fully functional, autism-specific public transport trip-planning mobile app called OrienTrip, and evaluated the user interface and user experience through an eye-movement study. This showed that individuals on the autism spectrum interacted differently with the user interface compared to neurotypical cohorts. Concretely, users on the spectrum also engaged more with images and icons than text.

Finally, Study 3 evaluated the efficacy and effectiveness of OrienTrip in facilitating public transport use. The app was piloted with individuals on the spectrum to measure their experiences with public transport when consulting the app. Similarly, a parallel pilot study was conducted with allied health professionals to understand how OrienTrip can be improved from the perspectives of people who work closely with autistic individuals. The findings showed that the app effectively streamlines public transport use for ASD communities, with both study groups praising its trip-planning functionality and assistance options, and further providing recommendations for improvement. This information will facilitate the user experience, such that all autistic individuals with varying skill levels can utilise OrienTrip without difficulty.

6.3 Key Findings and Implications

This section describes the key findings and implications of the research.

6.3.1 Challenges of using public transportation

Using public transportation requires understanding and managing navigational artefacts including maps, schedules, landmarks, signs and clocks (Carmien et al., 2005). However, these processes can be challenging for individuals on the autism spectrum due to differences in their executive functioning skills (Carmien et al., 2005; Ozonoff et al., 1994). This is especially critical, given that

over 60% have never used or considered using public transportation (Deka et al., 2016). The literature review in Chapter 2 found that there is a paucity of research on transport practices among individuals on the autism spectrum. While some studies have briefly described some of the challenges faced when travelling independently (Deka et al., 2016; Falkmer et al., 2015; Lubin & Feeley, 2016; Parsons, Leonard, & Mitchell, 2006), specific issues were not clearly defined.

The requirements gathering and design study in Chapter 3 aimed to define and address the difficulties autistic people encounter on public transport. Six major issues were identified: (1) safety, (2) limited spatial awareness, (3) anxiety, (4) sensory overload, (5) difficulty with planning trips and (6) differences in communication skills. Eighteen software requirements were then designed and proposed to address the identified issues. Individuals on the spectrum and their families were subsequently asked to discuss and prioritise these requirements based on personal importance. The highest-ranked requirements (most important) were as follows:

1. 'Tell me how to get to the bus stop or train station to start my trip and how to get from the final bus stop or train station to the place I want to.'
2. 'When I am on the bus, tell me when the bus is getting close to the stop I want to get off so I do not miss my stop.'
3. 'When something unexpected happens during my trip, help me calculate a revised trip.'
4. 'Tools and alerts to plan my trips, get ready, and leave on time.'
5. 'When I panic during my trip, help me contact someone I know easily.'
6. 'When I need help during my trip, give me tools so I can get help in the way the suits me.'

The highest-ranked requirements were then implemented into a minimum-viable product. This analysis not only proposes a solution for the difficulties identified, but also highlights the most urgent issues in a methodical way. Overall, the findings show that there is a need for solutions to support people on the autism spectrum to use public transport independently.

6.3.2 User interface of autism-specific mobile applications

Software tools are increasingly used to support learning and independence in individuals on the autism spectrum (Chien et al., 2015; De Leo et al., 2011; Hatfield et al., 2017; Hourcade et al., 2013; Kagohara et al., 2013). Yet, most commonly, when developing solutions, most attention is placed on devising the functionalities of the tool and implementing it in practice. As a result, the effort required to research, inform and evaluate the user interface is diminished due to the additional costs involved (Pavlov, 2014). User interfaces are one of the most crucial components of a software tool, particularly as accessibility permits users of different abilities and skill levels to use the functionalities in a way that reflects their mode of thinking (Darejeh & Singh, 2013; Kamaruzaman, Rani, Nor, & Azahari, 2016; Wood, 1997). On the contrary, inaccessible user interfaces can confuse people and cause them to abandon software despite its many benefits (Darejeh & Singh, 2013; Pavlov, 2014). Some studies have investigated how information should be presented to autistic individuals in other contexts. For example, it has been reported that multimedia content can support learning and concentration in children on the spectrum (Grynszpan et al., 2008; Kamaruzaman et al., 2016; Pavlov, 2014; Yaneva, Temnikova, & Mitkov, 2015). However, none have yet used empirical evidence to inform user-interface design for the ASD community.

Thereafter, Chapter 4 aimed to evaluate the user interface of OrienTrip through eye-movement analyses. Specifically, the chapter tracked and analysed the eye movements of both neurotypical subjects and autistic individuals when using the app. The findings showed that the latter group processed information differently in comparison and exhibited increased engagement with icons and images than with text. Further, the study highlighted that abstract icons can be a source of confusion for people on the autism spectrum. Users on the spectrum also required more time and effort to process long text than their neurotypical counterparts. Overall, these results highlight the importance of tailoring the user-interface design of autism-specific software tools. The outcomes of this study are especially timely, given the rapid growth of technology to support and improve the quality of life for individuals on the autism spectrum.

6.3.3 Effectiveness of an autism-specific public transport tool

Access to reliable transportation has reportedly improved access to education, employment and social opportunities (Gallup et al., 2015). However, for individuals on the autism spectrum, travel remains one of the most challenging problems in relation to community engagement (Feeley, 2010). Public transport is a widely used and inexpensive mode of transportation that, despite its many benefits (Bezyak et al., 2017; Deka et al., 2016; Falkmer et al., 2015; Stock et al., 2011), has little to no practice among autism communities (Deka et al., 2016). Interestingly, most of these individuals want to use public transportation and believe that it can improve their independence and personal prospects (Falkmer et al., 2015).

To address these challenges, OrienTrip was developed in collaboration with autistic individuals and their allies (see Chapters 2 and 3). The app sought to support people on the spectrum to use public transport independently through mobile

technology. Thereafter, Chapter 4 discussed the outcomes of two pilot studies, conducted with both ASD cohorts and allied health professionals, to evaluate the efficacy and effectiveness of OrienTrip. The findings showed that the app is effective in facilitating public transport in this context. Concretely, both groups expressed that OrienTrip made independent travel an easier and more viable option. Overall, the outcomes of this study suggest that the app improves autistic individuals' ability and confidence to use public transport. This research, and specifically OrienTrip, is especially timely given the paucity of evidence-based tools that support the travel prospects of people on the autism spectrum.

6.4 Strengths

This research is among the first, to the author's knowledge, that defines and addresses the challenges individuals on the autism spectrum face when using public transport. One of its strengths is that it adopts a participatory approach, in that individuals on the autism spectrum were closely involved at every stage of the research process. Another strength of the study regards its interdisciplinary nature. In fact, this work provides an excellent example of interdisciplinary collaboration, as it utilises methods and techniques from the engineering, health sciences, computing and spatial sciences sectors. Past studies have shown that academic collaboration is essential in addressing complex scientific and societal problems that require the expertise of more than one discipline (Klein, 2008; Klein & Falk-Krzesinski, 2017).

Another strength of this research regards its unique empirical method to evaluate the usability of OrienTrip with the target cohort and further compare the findings with a control group. Software applications are rapidly used to support learning and independence in individuals on the autism spectrum; however, their usability component is scarcely investigated. Chapter 4 also showed that people on

the autism spectrum process information differently than their neurotypical counterparts. This insight adds further weight to the importance of the topic. As such, some best-practice guidelines were defined that can be used to design more intuitive app interfaces for autistic users.

Another important strength derives from the triangulation of data from multiple stakeholders to improve the overall reliability of the research outcomes. For example, when defining the challenges of public transport use in Chapter 3, data were collected from both individuals on the autism spectrum and their families. Then, when evaluating the user interface of OrienTrip in Chapter 4, eye-movement data were gathered from autistic participants and subsequently contrasted with those of neurotypical individuals. Chapter 5 also presented a pilot study on OrienTrip with both ASD and health-professional groups, with the outcome informed through data analyses.

The study also benefitted from recruiting different groups at every stage of the research process, from requirements gathering to the evaluation phase. This can improve the generalisability of the outcomes and ensure that OrienTrip is not closely tailored to a specific group of participants.

Finally, the outcomes of the research can be applied in several domains. For example, public transport providers can use the findings to implement long-term changes in public transport infrastructure and make travel more accessible to individuals with cognitive differences. In fact, a public transport provider has already contacted the authors to use OrienTrip as a case study to improve public transport accessibility for neurodivergent people in one Australian state. Further, developers and researchers can use the findings to develop technological tools that make public transport more accessible.

6.5 Limitations

OrienTrip was developed and tested in two Australian states: Western Australia and New South Wales. As each area has a different public transport system, it is possible that the research may have addressed only the challenges autistic people encounter in two unique parts of Australia. In addition, the lack of equal representation from each state and territory may present a biased view of participants' experiences in using public transport. Concretely, the outcomes of OrienTrip may differ in other parts of Australia that have different public transport systems. Nonetheless, it is important to highlight that the research does *not* focus on the differences in transport structure but defines and addresses the overall issues individuals on the spectrum face when attempting to travel independently, as these may be similar regardless of location.

Another limitation concerns sampling. As the participants self-nominated to take part in the studies and were interested in the research, this may have potentially led to recruitment bias. This means that the participants representing autistic individuals may use or have used public transport in the past. As such, people on the autism spectrum who had never travelled independently were likely under-represented in the research. Indeed, this may have produced a more reliable outcome because the experiences and feedback expressed by participants were based on firsthand observations and not theoretical knowledge.

Further, research participants were continuously enlisted through various channels throughout the course of study. Recruitment spanned eight months for the pilot study in Chapter 4 and over 12 months for the study in Chapter 5. Despite these efforts, the sample sizes were relatively small. That is, 27 autistic young adults and 19 families participated in Chapter 3, 21 autistic individuals and 18 neurotypical

individuals participated in Chapter 4, and 17 autistic individuals and 22 allied health professionals were involved in Chapter 5. As the sample in each study was too small to represent the larger autism population, it can be suggested that the findings lack generalisability.

Difficulty to recruit larger samples can be due to several reasons. First, as most individuals on the spectrum do not use or consider using public transport, it is possible that this may have significantly reduced the number of people who were interested in participating. Second, the eye-movement study in Chapter 4 required respondents' physical presence in the laboratory due to the high-tech equipment required for data collection. This obstacle may have excluded autistic individuals who wanted to participate but were unable to travel to the lab. Third, OrienTrip was developed for the iOS platform, so participants required an iPhone to download the software. This may have been a significant recruitment barrier for the pilot study in Chapter 5, as Android users, for example, did not satisfy the inclusion criteria. Finally, as the pilot study required that participants use OrienTrip on public transport journeys for four to six weeks, the relatively long trial period may have discouraged some due to feelings of discomfort associated with the ongoing public transport use.

Another limitation regards the questionnaire used in the requirements gathering phase in Chapter 1, developed specifically for this study. It would have been preferable to use an existing questionnaire that has been validated for reliability; however, there are currently no tools or resources that address this unique topic.

Finally, autism diagnosis in the testing samples was verbally confirmed with each participant, and, thus, can be considered self-reported data. It is unlikely that the

studies included people who did not fulfil the autism spectrum diagnosis criteria; however, the possibility cannot be ruled out.

6.6 Recommendations

This thesis presents new knowledge and a unique tool that facilitates public transport use for individuals on the autism spectrum. This section discusses how the findings can hereafter inform future research that seeks to improve the accessibility of independent travel. The insights and feedback obtained in Chapters 4 and 5 further inform the development of OrienTrip.

6.6.1 Recommendations for making public transport accessible

The research findings obtained highlight significant barriers in the public transport system that prevent individuals on the autism spectrum from travelling independently. Chiefly, public transport providers can utilise the evidence discussed in this thesis and addressed in OrienTrip to understand the challenges of public transport, and further implement long-term infrastructural changes to make travel more accessible for people with different abilities. For example, walking to a transit station is a common issue for people on the spectrum. In fact, more than 40% of autistic individuals cannot travel to the initial stop or station to begin their journey (Deka et al., 2016). To address this problem, public transport providers can supply a special door-to-transit-station service for people with navigational issues, including those on the spectrum. Autistic travellers can then book this special service to reach the initial transit station to begin their public transport journey.

Difficulty with trip planning is another common barrier reportedly encountered by more than 50% of autistic people (Deka et al., 2016). One approach to address this issue is to simplify the information required to plan and manage trips. For example, public transport providers can present artefacts (e.g., service schedules,

maps and timetables) in two forms: a simplified version for individuals with differences in processing abilities, and a descriptive version for those who prefer detailed information. This approach can significantly reduce the barriers individuals on the autism spectrum face when using public transport, especially those who do not own or cannot use a smart device.

The sophistication of public transport trip-management tools is dependent on the quality of data they utilise and manipulate. In the Australian context, little data, beyond service schedules and timetables, are available to developers. Predictability is a core influencing factor of anxiety in people on the autism spectrum; yet, many aspects of the public transport system remain unpredictable due to the lack of adequate information. Notably, most Australian states and territories do not have real-time data on the crowdedness of services, and this adds to the unpredictability of public transport and further heightens anxiety for travellers on the autism spectrum. Public transport providers can address this problem by deploying data collection apparatuses (such as sensors) on buses and trains, and making this information openly accessible to everyone. Researchers and developers can also utilise and manipulate the data to develop more advanced tools that support liberal travel for people with different skills and requirements.

Training is one effective approach to gain travel independence. However, very few individuals on the autism spectrum receive formal travel guidance before venturing onto public transport (Lubin & Feeley, 2016). To address this problem, more investments should be focused on providing appropriate training options to these individuals, particularly as most have never considered using public transport. Adequate travel training can reduce the initial overwhelming fear or misconceptions associated with independent travel, with OrienTrip (in this case) providing an

effective preliminary tool to assist the training process initially. After this, autistic individuals can then use the app to manage their trips for an even smoother and safer public transport experience.

6.6.2 Recommendations for future research and further development of OrienTrip

One of the major issues encountered when recruiting participants for the pilot study was the restricted choice of platform. As mentioned in Section 6.5, OrienTrip was developed for the iOS platform, meaning that users require an iPhone with the latest operating system for download and use. This barrier can be addressed in future research by developing an Android version of the app. This will make OrienTrip significantly more accessible to individuals who do not have an iPhone, and further enable more people on the autism spectrum to meet the pilot study inclusion criteria—thus, resulting in improved research outcomes.

OrienTrip was developed and evaluated based on insight gathered from autistic individuals and their allies in Western Australia and New South Wales. Future studies can assess the efficacy and effectiveness of OrienTrip in other parts of Australia to better inform each state's and territory's unique public transport infrastructure. For example, tram services are a core component of the public transport system in Victoria, but are not available, as of the writing of this thesis, in Western Australia and New South Wales. Working with individuals on the autism spectrum from other states or territories may elicit new challenges and requirements in public transport use that would not have been discovered otherwise. In addition, new insights can help improve OrienTrip to better cater to the needs of autistic individuals in different contexts.

Most people on the spectrum who participated in the pilot study reported that they use or have used public transport. Future research can investigate the efficacy of OrienTrip in facilitating public transport use with autistic cohorts without prior experience. Individuals who have never travelled independently are often hesitant to try a new mode of transportation and may face more challenges than those who have used public transport. As such, these inexperienced individuals can benefit more from the various functionalities of OrienTrip. Further, their feedback can also reveal new insights that would not have been derived from groups with some public transport experience.

Chapters 4 and 5 revealed vital feedback to improve OrienTrip, which highlighted certain usability issues that complicate app use. Specifically, participants suggested improvements to the user interface that may inform how future studies investigate, implement and re-evaluate OrienTrip. Accessible interface design allows people with different skills to effectively reap the benefits of a software tool (Darejeh & Singh, 2013; Kamaruzaman et al., 2016; Wood, 1997). While difficult to use, app interfaces can confuse individuals and force them to abandon technology despite its many well-established benefits (Darejeh & Singh, 2013; Pavlov, 2014).

This thesis designed and evaluated OrienTrip specifically with individuals on the autism spectrum in mind. However, many responses in the Chapter 5 pilot study indicated that people with intellectual disabilities can also benefit from the app. Future studies can investigate this further, perhaps reimagining OrienTrip as a new software tool that addresses the needs of those with cognitive differences and deploying it as a separate, or sister, application. Thereafter, researchers can evaluate the updated software using individuals with intellectual disabilities and tailor it to their requirements. Another approach can be to modify the current app to consider

the requirements of both autistic people and those with intellectual disabilities when using public transport. Researchers can then gauge this new and expanded version of OrienTrip with both target groups.

As the sample size in Chapter 5 was relatively small, future studies can also assess the effectiveness of OrienTrip through a randomised control trial. In academia, this form of testing is widely regarded as the gold standard for evaluating the effectiveness of an intervention (Cartwright, 2007). That said, the pilot study in this thesis has been critical in preparing for a future large-scale evaluation. Specifically, the findings provide essential insights to refine and improve OrienTrip to support a full-scale assessment.

6.7 Summary

In summary, lack of transportation is a key barrier that limits autistic individuals' capacity to participate in important community activities including employment, education and social interactions. Most individuals rely on family members for their transportation requirements. Public transport is an inexpensive and widely available form of transport, which autistic individuals themselves believe is critical in improving their quality of life. Notably, those on the spectrum who can use public transport are significantly more likely to find employment compared to those who cannot. However, more autistic individuals have never used public transport or considered the thought. The implementation of OrienTrip, the first evidence-based, co-produced, autism-specific trip-planning mobile application in the Australian context, can deliver important benefits for individuals on the autism spectrum. The evaluation of OrienTrip showed that it is effective in making public transport easy to use and less stressful for autistic individuals. Further, it was highlighted that

OrienTrip enhances the capacity of autistic individuals to travel independently using public transport. These findings are timely given the paucity of research on the development and evaluation of tools to assist individuals on the autism spectrum travel autonomously. Lack of access to transportation and heavy reliance on other people deprives autistic individuals of opportunities that can significantly improve their quality of life. A perfectly tailored education or employment program becomes irrelevant if one cannot travel there. The findings of this thesis address this issue and expands on the existing literature to improve public transport accessibility and make the world a friendlier place for individuals on the autism spectrum.

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Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged.

Appendices

Appendix A: Curtin University Human Research Ethics Committee Approval Letter

Office of Research and Development

GPO Box U1987
Perth Western Australia 6845

Telephone +61 8 9266 7863
Facsimile +61 8 9266 3793
Web research.curtin.edu.au

23-Jun-2016

Name: Hoe Lee
Department/School: School of Occupational Therapy and Social Work
Email: H.Lee@curtin.edu.au

Dear Hoe Lee

RE: Ethics approval
Approval number: HRE2016-0086

Thank you for submitting your application to the Human Research Ethics Office for the project **Enhancing capacity of individuals with Autism Spectrum Disorder to use public transportation**.

Your application was reviewed by the Curtin University Human Research Ethics Committee at their meeting on **07-Jun-2016**.

The review outcome is: **Approved**.

Your proposal meets the requirements described in National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007).*

Approval is granted for a period of one year from **07-Jun-2016** to **06-Jun-2017**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
Lee, Hoe	CI
Cordier, Josef	Co-Inv
Vaz, Sharmila	Co-Inv
Tan, Seng	Co-Inv
McMeekin, David	Co-Inv
Lee, Elinda	Co-Inv
Rezae, Mortaza	Co-Inv
Wilson, Nathan	Co-Inv

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
    - proposed changes to the approved proposal or conduct of the study
    - unanticipated problems that might affect continued ethical acceptability of the project
    - major deviations from the approved proposal and/or regulatory guidelines
    - serious adverse events
3. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)
4. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
5. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
6. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
7. Changes to personnel working on this project must be reported to the Human Research Ethics Office
8. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
9. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
10. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
11. Ethics approval is dependent upon ongoing compliance of the research with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research, applicable legal requirements, and with Curtin University policies, procedures and governance requirements
12. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Special Conditions of Approval

This letter constitutes ethical approval only. This project may not proceed until you have met all of the Curtin University research governance requirements.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely

Professor Peter O'Leary
Chair, Human Research Ethics Committee

Appendix B: Public Transport Planning Tool for Users on the Autism Spectrum From Concept to Prototype Survey

A public transport App for young adults on the autism spectrum

1. Check if you are elegible to take part in this quick survey

Thank you for your interest in taking part in this survey.
First check if you're eligible to take part.

* Do you match any of the following?

- ◯ I am a young adult who has who has been diagnosed with an autism-related condition* by a medical professional, who has left high school and I am aged under 30 years. (*For this study, an autism-related condition includes Autism, Autism Spectrum Disorder, Asperger's syndrome, & PDD-NOS).
- ◯ I am a family member who cares for or supports a young adult who has been diagnosed with an autism-related condition* by a medical professional, has completed high school and is aged under 30 years (*For this study, an autism-related condition includes Autism, Autism Spectrum Disorder, Asperger's syndrome, & PDD-NOS).
- ◯ No, I do not match either of these

1

2. INFORMATION FOR PARTICIPANTS

Good news - you're eligible to take part in this survey.
Here's what that you need to know about the survey.
Please read this information, and if you're happy to complete the survey, please tick YES to continue.

What is the survey about?
This aim of this survey is to find out how an App may be able to help young adults on the autism spectrum to use public transport independently and successfully.

Who is conducting this survey?
This survey is part of a larger research study study funded by the Cooperative Research Centre for Living with Autism (Autism CRC). Researchers from Curtin University, Western Sydney University and Aspect (Autism Spectrum Australia) are working together on this study.

What will I be asked to do?
You will complete a short online survey to tell us what features you think would be useful for you (or your adult child with autism) to have in a public transport App. It will take about five to ten minutes to complete.

Are there any risks or costs for you?
There are no associated risks and no cost for you to take part. Your participation in this study is entirely voluntary. All data will be stored securely and used confidentially. No personal data will be collected from you in this survey. This research study has been approved by Curtin University Human Research Ethics Committee (HRE2016-0086) and the Aspect Research Approvals Committee (Approval #1627).

* **YOUR CONSENT TO PARTICIPATE**

If you are happy to take part in the study, please tick YES to continue.

- I have been informed of and understand the purpose and nature of the study.
- I understand that there are no known risks involved in the study.
- I understand that I can stop participating with no consequence for me.
- I understand that no information that can identify me will be collected in this survey.

◯ Yes

◯ No

3. What will help you most in a public transport App?

To help us design an App that will give you the help you want when you are travelling on public transport, we're asking you to tell us what features you would find MOST helpful to have in a public transport App.

Here's what to do:

1. Imagine that you already have an App to help you use public transport, such as the *TripView* App. The App already has trip planning, trip calculation and you can store your favourite trips.

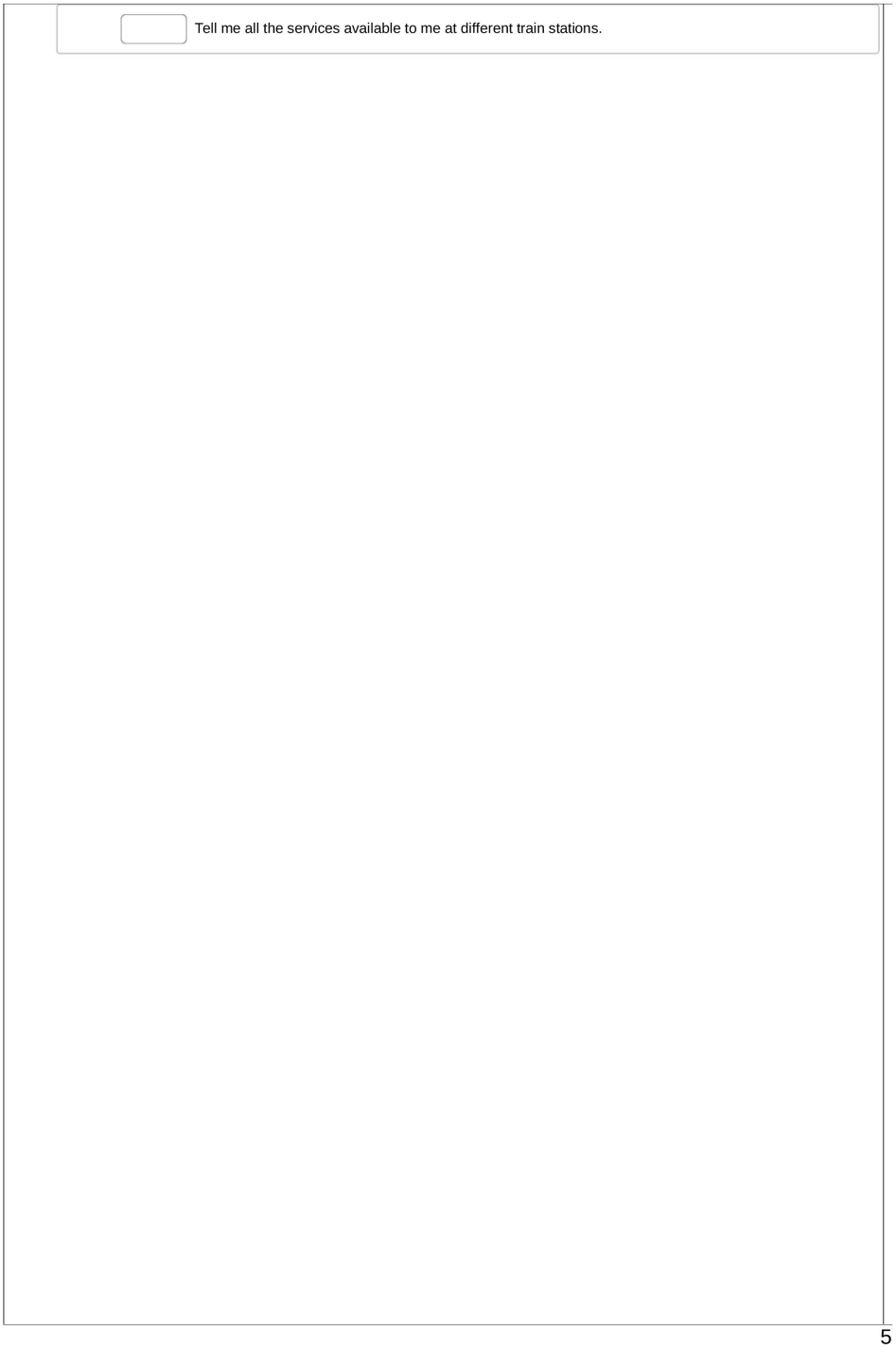
2. Now imagine that you can add any of the following 18 functions in the list below.

3. Using the list below, rank each function based on how helpful this feature will be to you, compared with all the other functions. you will need to place a number next to each function. Put 1 next to the function that you think will be the most help to you, then rank all the other functions, through to 18 for the function that you think will be least helpful for you.

* Mark your answers here.

- [ ] Give me tools & alerts to help me get ready and leave on time for my trip.
- [ ] Tell me or show me how to get to the bus or tram stop or train station to start my trip. Show me how to get from the bus or tram stop or train station at the end of the journey so I can easily get to the exact place I wa to go.
- [ ] When I am walking to or from a bus or tram stop or from a train station, tell or show me where it is safe for me to cross the road.
- [ ] When I am planning a bus or tram trip and when I am waiting for my bus or tram, tell me exactly where the bus or tram is now and when it will arrive at my stop.
- [ ] Before the train or tram arrives, tell me how crowded the train or tram is. If the train or tram is too crowded for me, give me other travel options.
- [ ] When I am on the bus or tram, 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, so I don't miss my stop
- [ ] When I feel anxious during my trip, help me to cope and to feel better.
- [ ] 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.
- [ ] When I need help during my trip, give me tools so I can get help in the way that best suits me.
- [ ] When the lift at the train station is not working, find me solutions and help to get to my destination.
- [ ] Remind me to tap my card when I am getting on and off the bus or tram.
- [ ] When I miss my stop, help me work out how to get to my destination.
- [ ] When I feel in an emergency or when I panic during my trip, help me easily contact someone I know to get their help.
- [ ] 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.
- [ ] 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. Tell me if my balance is enough for any particular trip.)
- [ ] When I feel sensory overload on my trip, help me to cope and to feel better.
- [ ] Auto correct my spelling when I type into the App.

4


Tell me all the services available to me at different train stations.

5

A public transport App for young adults on the autism spectrum

4. Thank you.

Thank you for completing this survey.
Your opinion will help us understand how a public transport App could help young adults on the autism spectrum to travel independently.

6

Appendix C: User Interface Processing In Autism Spectrum: An Eye Movement Study: An Eye-Movement Study Surveys

Curtin University

Enhancing Capacity of Individuals on the Autism Spectrum to Utilise Public Transportation

Participant Information Sheet

Adult and Adolescent

What is the study about?

We are a research team trying to understand how individuals with autism spectrum use and interact with mobile applications. We have developed a mobile app that facilitates public transport use through step-by-step assistance, anxiety and sensory overload management, and safety features. In this study, we will be assessing the usability of the app to understand how intuitive it is and what we can do to make it easier to use.

We invite you to participate

You have been invited to participate in this study because you currently do or currently do not use public transport and you have high functioning autism.

What will you be asked to do?

We need your help to understand how people with autism spectrum use mobile apps. You will be asked to perform a series of tasks on a computer that mirrors the app. An eye tracker will record your eye movements and interactions with the app. This data will help us understand how to make the app more intuitive and easier to user. At the end of the study you will be prompted to complete a questionnaire about the app's usability.

The interview will take between 30 to 45 minutes. We will meet at Curtin University.

Are there any risks?

There will be no associated risk and/or cost to take part. Participation is completely voluntary. You may decide to withdraw at any time without having to provide a reason. We will ask for permission to use the information you have already provided. If this is not given, then the information will be destroyed.

Why should I help?

Your participation will help us develop an intuitive and easy to use public transport app that enables people on the autism spectrum use public transport safely. In the long term, we anticipate this will lead to an improvement in the community mobility of people on the autism spectrum.

Rights

Your participation in this study is entirely voluntary. When you have signed the consent form, the researcher will assume that you have agreed to participate and that you allow the use of your data in this research. You have the right to not participate in this study and to withdraw your participation at any time without reason or justification and without incurring any negative consequences. Should you have any queries or concerns regarding the study you may contact the researcher using the contact details below.

Confidentiality

All data will be stored and used confidentially. Results will be presented so that your name and personal details cannot be linked to your answers and opinions. The data gathered will be published as scientific articles and presented at relevant conferences.

Thank you!

As a token of our appreciation for your time participating in this study we would like to give you a $20 JB HI-FI gift card.

What if I want more information on the study?

You can contact Dr Hoe Lee, Chief Investigator, School of Occupational Therapy and Social Work, Curtin University, GPO Box U1987, Perth, WA 6845.

Phone: 9266 4652

Email: H.Lee@curtin.edu.au

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2016-0086). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au

Thank you for your time and consideration.

Curtin University

Enhancing Capacity of Individuals on the Autism Spectrum to Utilise Public Transportation

Participant Information Sheet

Adult and Adolescent

What is the study about?

We are a research team trying to understand how individuals with autism spectrum use and interact with mobile applications. We have developed a mobile app that facilitates public transport use through step-by-step assistance, anxiety and sensory overload management, and safety features. In this study, we will be assessing the usability of the app to understand how intuitive it is and what we can do to make it easier to use.

We invite you to participate

You have been invited to participate in this study because you currently do or do not use public transport.

What will you be asked to do?

We need your help to understand how people with autism spectrum use mobile apps. You will be asked to perform a series of tasks on a computer that mirrors the app. An eye tracker will record your eye movements and interactions with the app. This assessment will evaluate how **neurotypical** individuals interact with mobile apps compared to individuals **on the autism spectrum**. At the end of the study you will be prompted to complete a questionnaire about the app's usability.

The interview will take between 30 to 45 minutes. We will meet at Curtin University.

Are there any risks?

There will be no associated risk and/or cost to take part. Participation is completely voluntary. You may decide to withdraw at any time without having to provide a reason. We will ask for permission to use the information you have already provided. If this is not given, then the information will be destroyed.

Why should I help?

Your participation will help us develop an intuitive and easy to use public transport app that enables people on the autism spectrum use public transport safely. In the long term, we anticipate this will lead to an improvement in the community mobility of people on the autism spectrum.

Rights

Your participation in this study is entirely voluntary. When you have signed the consent form, the researcher will assume that you have agreed to participate and that you allow the use of your data in this research. You have the right to not participate in this study and to withdraw your participation at any time without reason or justification and without incurring any negative consequences. Should you have any queries or concerns regarding the study you may contact the researcher using the contact details below.

Confidentiality

All data will be stored and used confidentially. Results will be presented so that your name and personal details cannot be linked to your answers and opinions. The data gathered will be published as scientific articles and presented at relevant conferences.

Thank you!

As a token of our appreciation for your time participating in this study we would like to give you a $20 JB HI-FI gift card.

What if I want more information on the study?

You can contact Dr Hoe Lee, Chief Investigator, School of Occupational Therapy and Social Work, Curtin University, GPO Box U1987, Perth, WA 6845.

Phone: 9266 4652

Email: H.Lee@curtin.edu.au

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2016-0086). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au

Thank you for your time and consideration.

Curtin University

Consent to Participate (Adult)

Enhancing Capacity of Individuals on the Autism Spectrum to Utilise Public Transportation

- I agree to participate in the study as outlined to me.
- I have been informed of, and understand, the purpose of the study.
- I have had the opportunity to ask questions about the study and am happy with the answers.
- I understand that there are no known risks involved in the study.
- I understand that I can stop participating any time without reason and consequence.
- I have been informed that all personal information will be kept confidential and any identifiable information will not be used in published material.

I am happy for the interview to be audiotaped. ☐

I am not happy for the interview to be audiotaped. ☐

Name: _____

Email Address: _____

Telephone numbers – Day time: _____ Night time: _____

Signature: _____ Date: _____

Curtin University

ADOLESCENT

Assent to Participate

Enhancing Capacity of Individuals on the Autism Spectrum to Utilise Public Transportation

- I agree to participate in the study.
- I understand the reason for the study.
- I have been the chance to ask questions about the study and am happy with the answers.
- I understand that there are no known risks involved in the study.
- I understand that participation is my choice and that I can pull out of the study at any time I like and without giving a reason.
- I understand that all personal information will be kept private.

I am happy for the interview to be audiotaped. ☐

I am not happy for the interview to be audiotaped. ☐

Name: _____

Signature: _____

Date: _____

Curtin University

Parent Consent Form for Adolescent

Enhancing the Capacity for Individuals on the Autism Spectrum to Utilise Public Transportation

- I consent for my child to participate in the study as outlined to me.
- I have been informed of, and understand, the purpose of the study.
- I have had the opportunity to ask questions about the study and am happy with the answers.
- I understand that there are no known risks involved in the study.
- I understand that I can stop my child's participation any time without reason and consequence.
- I have been informed that all personal information will be kept confidential and any identifiable information will not be used in published material.

Name: _____

Signature: _____

Date: _____

Telephone contact: _____

Default Question Block

Full Name

Unique Identifier Code

Do you use public transport?

- Yes
- No

If yes, how often? One round trip (i.e. from A-B and B-A) counts as 2 times

- 1-4 times per week
- 5-8 times per week
- More than 8 times per week

Do you use a mobile app to plan your public transport trips?

- Yes
- No

What do you use to plan your journeys? (i.e. transperth website, paper timetables, etc.)

How often do you shop online or make online payments using smartphones?

- Never
- Every week
- Every month
- Three or four times a year
- Once or twice a year

How often do you access social networking sites such as Facebook, Twitter, LinkedIn, or others?

- Never
- Every day
- Once a week
- Once a month
- One or twice a year

Default Question Block

I thought the amount of information presented about planning a journey was sufficient.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

Why or why not?

I thought the colours used in the app were appropriate. (i.e. not distracting or easy on the eyes)

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

Why or why not?

I thought the font and font size used in the app were appropriate. (i.e. easy to read and understand)

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

Why or why not?

I thought the terminologies used within the app were easy to understand and consistent throughout?

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

Why or why not?

It was very easy to find important information.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

Why or why not?

I thought the feedback/display messages were accurate and adequate.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

Why or why not?

I thought the illustrations and icons were accurate and easy to understand.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

Why or why not?

I thought the text and illustration/icons matched.

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

Why or why not?

I thought the terminology of buttons were self-evident and accurate.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Why or why not?

I thought the flow of the app was logical.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Why or why not?

Overall it was easy to use the app.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

Final thoughts, comments, concerns, or feedback?

Appendix D: Facilitating Public Transport Use for Individuals on the Autism Spectrum Through a Mobile Application A Pilot Study Surveys

Default Question Block

Enhancing the capacity of individuals on the autism spectrum to utilise public transportation

Curtin University Ethics approval HRE2016-0086

Participant Information Sheet and Consent form

What is this research study about?

We are a team of researchers from Curtin University, Western Sydney University and Autism Spectrum Australia (Aspect) who are assessing the effectiveness of OrienTrip, **an iOS app** that enables individuals on the autism spectrum to use public transport more independently.

What will I be asked to do?

You will be asked to download OrienTrip on **your iPhone** and use it to plan your public transport trips for a period of 2 to 4 weeks.

After you have used OrienTrip for 2 to 4 weeks, we will ask you to complete a short online survey about your experience.

The study will take place between March and July 2019.

Confidentiality

All data will be stored and used confidentially. Results will be presented so that your name and personal details cannot be linked to your answers and opinions. The data gathered will be published as scientific articles and presented at relevant conferences.

More information

You can contact Dr Hoe Lee, Chief Investigator, School of Occupational Therapy and Social Work, Curtin University, GPO Box U1987, Perth, WA 6845, telephone 08 9266 4652, email H.Lee@curtin.edu.au

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2016-0086). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au

Thank you!

As a token of our appreciation for your time participating in this study, we would like to offer you a **$50 JB HI-FI or Big W gift card.**

Consent to participate

- ☐ I have read and I understand the information above about this study.
- ☐ I have had any questions about the study answered to my satisfaction, and I understand I can contact the research team if I have any further questions.
- ☐ I confirm that I am aged between 16 and 35 years, I identify as having autism or as being on the autism spectrum and I own an iOS device for my personal use.

- [ ] I understand that when I consent to participate I will be provided with the OrienTrip app to download and use on my iOS device to plan and track my public transport journeys for a period of 3 to 6 weeks and I will then be asked complete a short online survey about my experience of using OrienTrip.
- [ ] Yes, I agree to take part in this study.

My contact details are:

Name	
Suburb/City/town	
Postal code	
Email	
Telephone	

Default Question Block

. Thank you for testing OrienTrip, a mobile app that aims to make public transport use less stressful for individuals on the autism spectrum.

Please complete the following questionnaire to help us understand your experience with OrienTrip and public transport. Your feedback will help us improve OrienTrip and make public transport less stressful for individuals on the autism spectrum.

Q1. **Are you on the autism spectrum?**

- ◯ Yes
- ◯ No

Q2. **What is your full name?**

Q3. **What is your date of birth (dd/mm/yyyy)?**

Q4. **What is your gender?**

- ◯ Male
- ◯ Female
- ◯ Other

Q5. **What is your email address?**

Q6. **Which State of Australia are you testing OrienTrip in?**

- ◯ Western Australia
- ◯ New South Wales
- ◯ Victoria
- ◯ South Australia
- ◯ Queensland
- ◯ Northern Territory
- ◯ Australian Capital Territory
- ◯ Tasmania

Q7. **What device have you been using to test OrienTrip? (i.e. iPhone 7 plus)**

Q8. **What is your current primary mode of transportation? (i.e. driving, relying on family or friends, public transport)**

Q9.
Overall, how many times per week, on average, do you use public transport? (A round trip counts as 2 trips)

- ◯ 1-2 times
- ◯ 3-4 times
- ◯ 5-6 times
- ◯ 7-8 times
- ◯ More than 8 times
- ◯ Do not use public transport

Q10. **What do you like about your experiences with public transport?**

Q11. **What don't you like about your experiences with public transport?**

Q12. **How would you rate OrienTrip? (from 5 stars)**

1	2	3	4	5
◯	◯	◯	◯	◯

Q13.
How disappointed would you be if OrienTrip no longer existed tomorrow?

- ◯ Very disappointed
- ◯ Somewhat disappointed
- ◯ Not disappointed (it really isn't that useful)
- ◯ N/A - I no longer use it

Q14. **What would you likely use as an alternative to OrienTrip if it were no longer available?**

- ◯ I probably wouldn't use an alternative
- ◯ I would use:

Q15.
What is the primary benefit that you have received from OrienTrip?

Q16.
What type of person do you think would benefit most from OrienTrip?

Q17.
Why did you originally decide to try OrienTrip?

Q18.

What problem did you expect OrienTrip to solve?

Q19.
Which of the issues below was the biggest problem during your experience with OrienTrip? (you can select multiple answers)

- [ ] The app was missing features I needed
- [ ] The app was visually unappealing
- [ ] The app was confusing to use
- [ ] The app crashed
- [ ] I experienced bugs
- [ ] Other (please specify)
- [ ] I did not experience any problems with the app

Q20.
Please describe the problem you encountered in more detail?

***Q21.* OrienTrip is easy to use**

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

***Q22.* Did you feel like you needed more instructions to use OrienTrip?**

- ◯ Yes
- ◯ No

***Q22a.* What instructions would have been helpful to you?**

***Q23.* OrienTrip is helpful in making public transport easier to use for individuals on the autism spectrum**

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

***Q24.* Did you experience any stressful situations during any of your public transport trips when using OrienTrip?**

- ◯ Yes
- ◯ No

Q24a. **What was the stressful situation/s and how did you feel?**

Q24b. **Was OrienTrip helpful in reducing your stress?**

- ◯ Yes
- ◯ No

Q24c. **Which feature/s of OrienTrip helped you during these stressful situations?**

Q24d. **What would have been helpful to you in that stressful situation?**

Q25. **Please rank the following features of OrienTrip based on helpfulness to you: (click and hold an item to re-position it)**

- Calculating routes
- Information on the number of interchanges of a planned journey
- Information on the expected crowdedness of a journey
- Linear journey map with real-time current location
- The ability to call a caretaker from within the app
- The ability to share current location with caretaker
- Anxiety management tips
- Sensory overload tips
- The ability to ask for assistance through the virtual card
- The ability to call emergency services within the app

Q26.
How would you rate the quality of OrienTrip?

1	2	3	4	5
◯	◯	◯	◯	◯

Q27.
Overall, how satisfied are you with OrienTrip?

- ◯ Extremely satisfied
- ◯ Somewhat satisfied
- ◯ Neither satisfied nor dissatisfied
- ◯ Somewhat dissatisfied
- ◯ Extremely dissatisfied

Q28.
Have you recommended OrienTrip to anyone?

- ◯ No
- ◯ Yes (please explain how you described it)

Q29.
How likely are you to recommend OrienTrip to a friend?

Not at all likely										Extremely likely
0	1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

Q30.
How can we improve OrienTrip to better meet your needs?

Q31.
Do you have any other comments or concerns?

Q32. **We would like to offer you a choice of a $50 JB Hi-Fi OR $50 Big W gift card as a token of our appreciation for your time and effort.**

Please select a gift card. This gift card will be emailed to you in the coming days.

- ◯ $50 JB Hi-Fi gift card
- ◯ $50 Big W gift card

Description

Default Question Block

This survey is intended for Allied Health Professionals who took part in evaluating our public transportation application, OrienTrip.

Thank you so much for your help.

What is your full name?

What is your gender?

- Male
- Female
- Other

What is your date of birth? (dd/mm/yyyy)

Which State of Australia are you based in?

- Western Australia
- Northern Territory
- South Australia
- Queensland
- New South Wales
- Victoria
- Australian Capital Territory
- Tasmania

What is your qualification?

- Occupational Therapist
- Psychologist
- Speech Pathologist
- Other

What is your qualification?

What is your experience (in years) working with individuals on the autism spectrum?

- 0-5 years
- 6-10 years
- 11-15 years

- ◯ 16-20 years
- ◯ 21+ years

How would you rate OrienTrip?

1	2	3	4	5
◯	◯	◯	◯	◯

What is the primary benefit that OrienTrip can provide to someone on the autism spectrum?

What type of person do you think would benefit most from OrienTrip?

What problem did you expect OrienTrip to solve?

OrienTrip is easy to use

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

OrienTrip is helpful in facilitating public transport use for individuals on the autism spectrum

- ◯ Strongly agree
- ◯ Somewhat agree
- ◯ Neither agree nor disagree
- ◯ Somewhat disagree
- ◯ Strongly disagree

Please rank the following features of OrienTrip based on helpfulness to someone on the autism spectrum (click and hold on an option to re-position it):

- Calculating routes
- Information on the number of interchanges of calculated routes
- Information on the expected crowdedness of calculated routes
- Linear journey map with current location in real-time
- The ability to call a caretaker from within the app
- The ability to share current location with caretaker
- Anxiety management tips
- Sensory overload tips
- The ability to ask for assistance through the virtual card

- The ability to call emergency services from within the app

How would you rate the quality of OrienTrip?

1	2	3	4	5
○	○	○	○	○

Overall, how satisfied are you with OrienTrip?

- ○ Extremely satisfied
- ○ Somewhat satisfied
- ○ Neither satisfied nor dissatisfied
- ○ Somewhat dissatisfied
- ○ Extremely dissatisfied

Have you recommended OrienTrip to anyone?

- ○ No
- ○ Yes (please explain how you described it)

How likely are you to recommend OrienTrip to someone on the autism spectrum?

Not at all likely — Extremely likely

0	1	2	3	4	5	6	7	8	9	10
○	○	○	○	○	○	○	○	○	○	○

How can we improve OrienTrip to better meet the needs of those on the autism spectrum

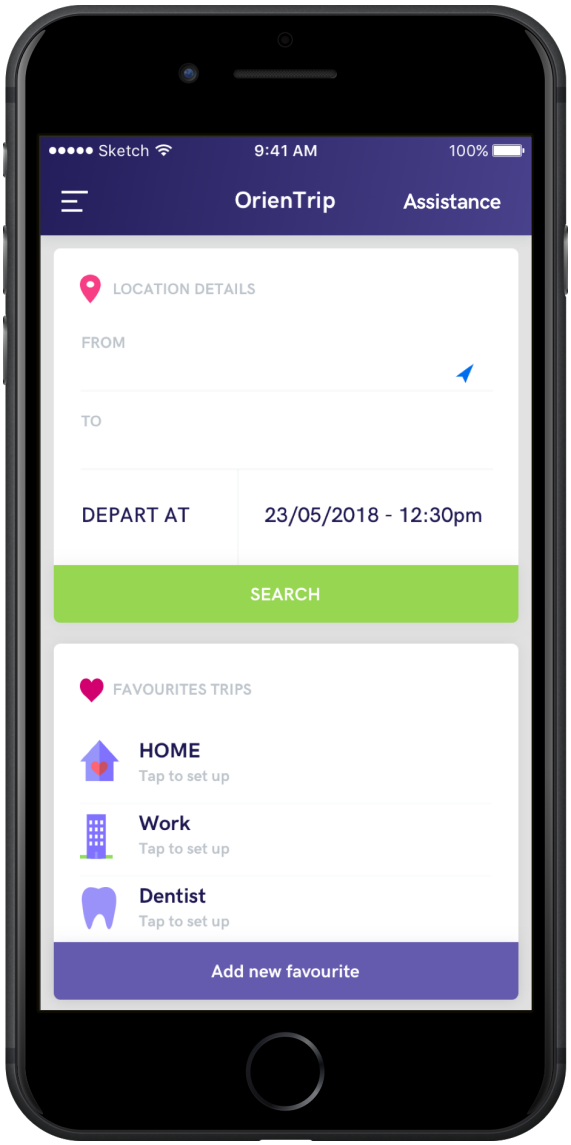
Do you have any other comments or concerns?

We would like to offer you a choice of a $50 JB Hi-Fi OR $50 Big W gift card as a token of our appreciation for your time and effort.

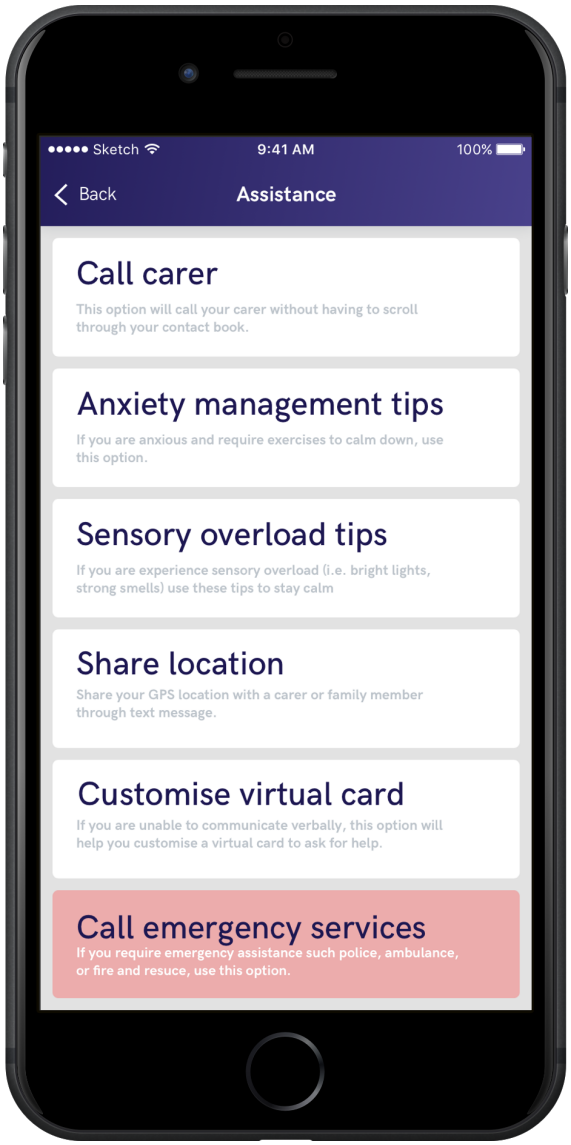
Please select a gift card. This gift card will be emailed to you in the coming days.

- ○ $50 JB Hi-Fi Gift Card
- ○ $50 Big W Gift Card

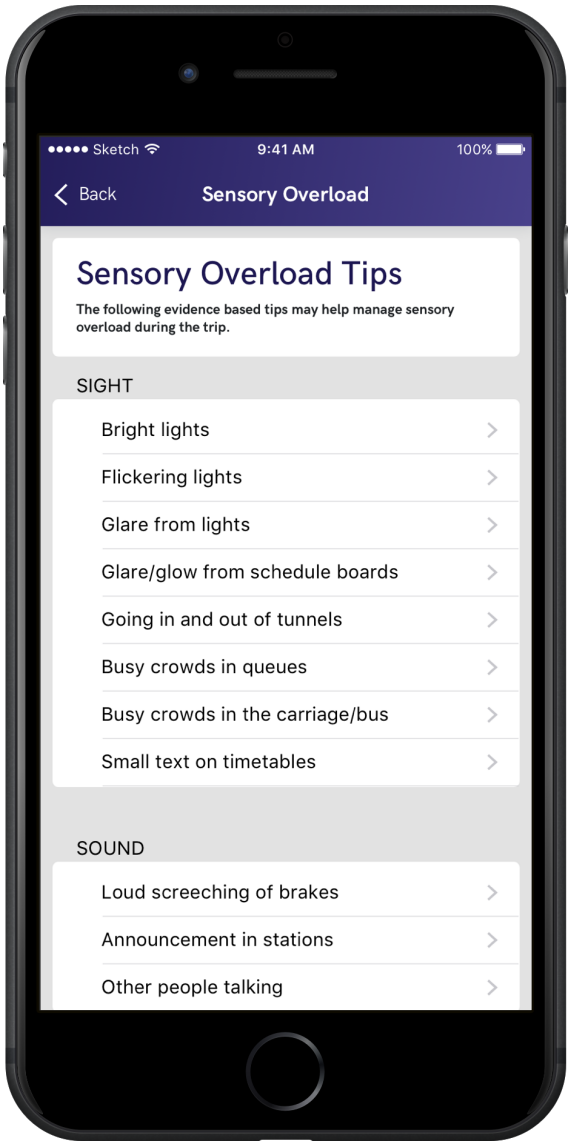
Appendix E: OrienTrip (v1.0)



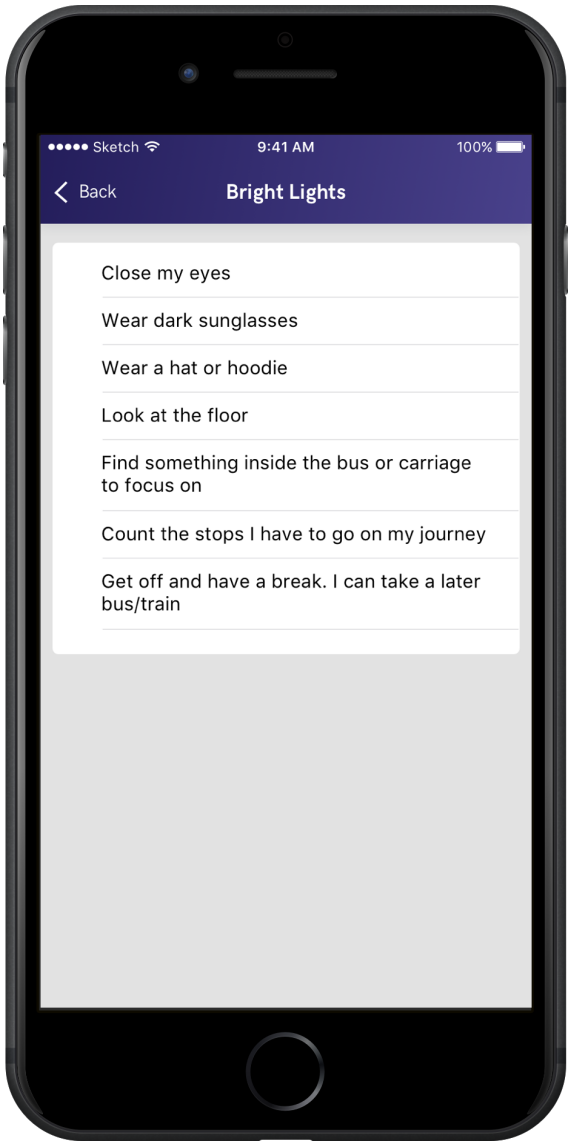
Users are greeted with the home screen when OrienTrip is opened for the first time



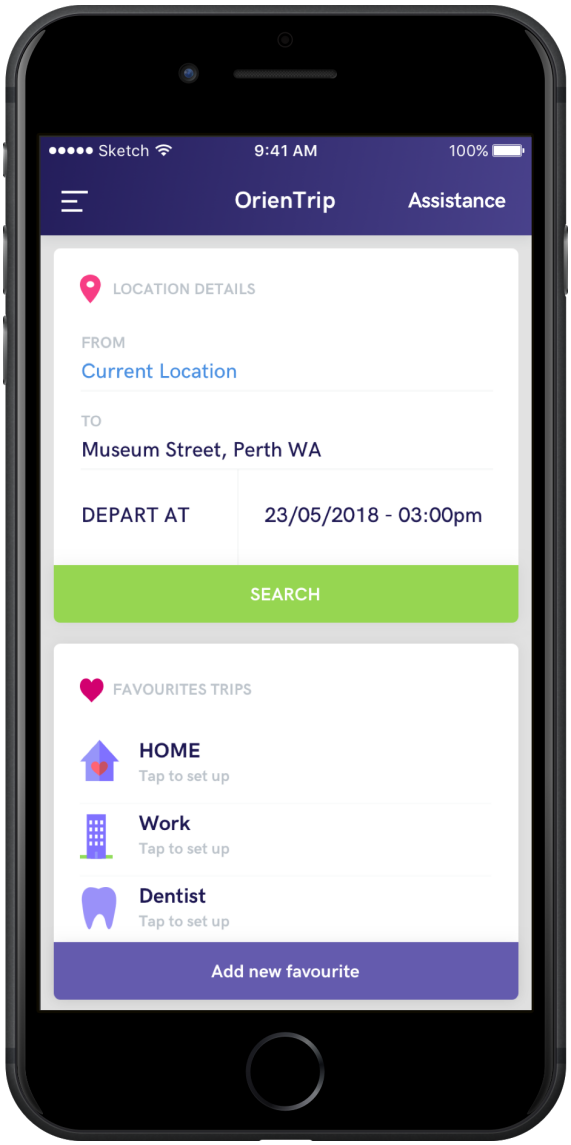
The assistance options that OrienTrip provides by tapping the ‘Assistance’ button. Users can call a designated carer without leaving OrienTrip, find evidence-based anxiety management and sensory overload tips tailored for public transport, share their current location with a designated carer, communicate via a customisable virtual card, and call emergency services without leaving the app.



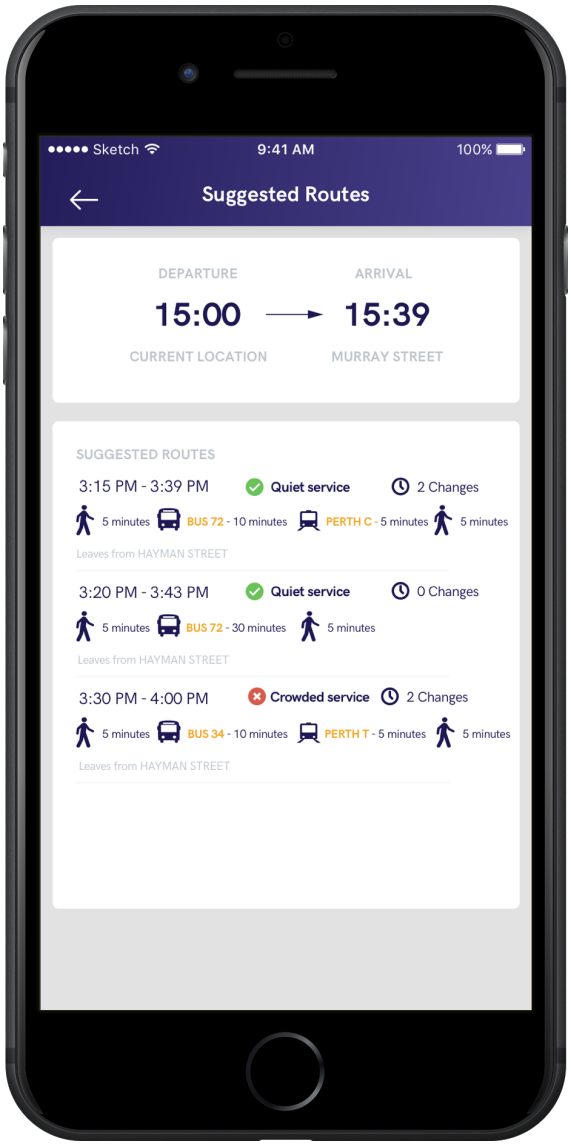
Evidence-based sensory overload tips for various situations that can be accessed from the assistance menu



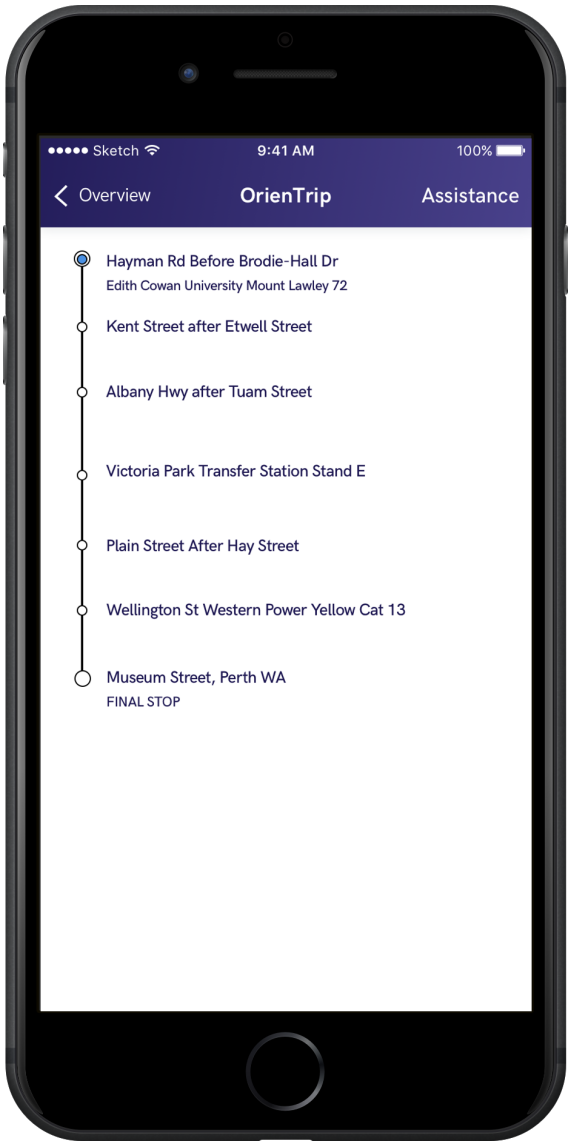
Evidence-based sensory overload tips for ‘Bright Lights’



Home screen populated with trip details

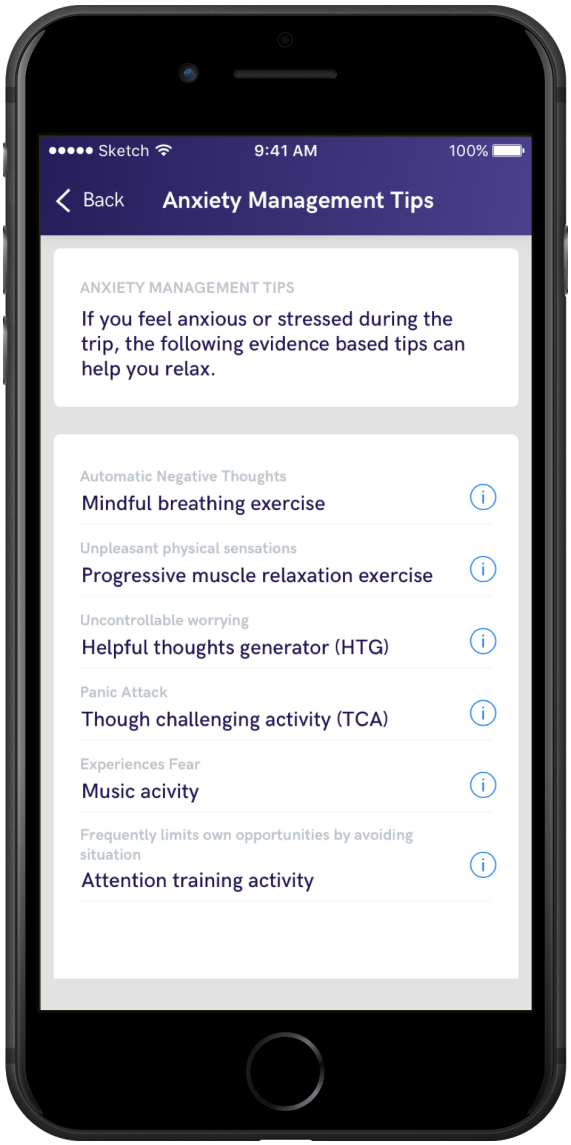


OrienTrip provides detailed route suggestions to reach a destination



OrienTrip allows users to track their trip on a simple journey map (blue dot signifies the users current location which is updated in real-time)

The journey map shows that the user is three stops away from their final destination



Evidence-based anxiety management tips that can be accessed at anytime on the app through the 'Assistance' button

Appendix F: Attribution Tables

Paper #1 -- 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

Paper #2 -- Rezae, M., Chen, N., McMeekin, D., Tan, T., & Krishna, A., Lee, H. (2019). User interface processing in autism spectrum: An eye movement study. *International Journal of Human-Computer Studies*. Under review

Paper #3 -- 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*. *Under Review*

Mortaza Rezae (PhD Candidate)

	Paper #1	Paper #2	Paper#3
Conception and design	X	X	X
Acquisition of data & method	X	X	X
Data conditioning and manipulation	X	X	X
Analysis & statistical method	X	X	X
Interpretation & discussion	X	X	X
Final approval	X	X	X

I acknowledge that the table above represent my contribution to the research output.

Signature

Mortaza Rezae

Paper #1 -- 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

Paper #2 -- Rezae, M., Chen, N., McMeekin, D., Tan, T., & Krishna, A., Lee, H. (2019). User interface processing in autism spectrum: An eye movement study. *International Journal of Human-Computer Studies*. Under review

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Dr D McMeekin

	Paper #1	Paper #2	Paper#3
Conception and design	X	X	X
Acquisition of data & method	X	X	X
Data conditioning and manipulation			
Analysis & statistical method		X	
Interpretation & discussion	X		X
Final approval	X	X	X

I acknowledge that the table above represent my contribution to the research output.

Signature

Dr D McMeekin

Paper #1 -- 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

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Paper #3 -- 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. Under Review*

Professor T Tan

	Paper #1	Paper #2	Paper#3
Conception and design	X	X	X
Acquisition of data & method	X	X	X
Data conditioning and manipulation			
Analysis & statistical method			
Interpretation & discussion	X		X
Final approval	X	X	X

I acknowledge that the table above represent my contribution to the research output.

Signature

Professor T Tan

Paper #1 -- 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

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Paper #3 -- 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. Under Review*

Associated Professor A Krishna

	Paper #1	Paper #2	Paper#3
Conception and design	X	X	X
Acquisition of data & method	X	X	
Data conditioning and manipulation			
Analysis & statistical method			
Interpretation & discussion			
Final approval	X	X	X

I acknowledge that the table above represent my contribution to the research output.

Signature

Associate Prof. A Krishna

Paper #1 -- 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

Paper #2 -- Rezae, M., Chen, N., McMeekin, D., Tan, T., & Krishna, A., Lee, H. (2019). User interface processing in autism spectrum: An eye movement study. *International Journal of Human-Computer Studies*. Under review

Paper #3 -- 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*. *Under Review*

Associate Professor H Lee

	Paper #1	Paper #2	Paper#3
Conception and design	X	X	X
Acquisition of data & method	X	X	
Data conditioning and manipulation			
Analysis & statistical method			
Interpretation & discussion	X		
Final approval	X	X	X

I acknowledge that the table above represent my contribution to the research output.

Signature

Associate Prof. H Lee

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Dr N Chen

	Paper #1	Paper #2	Paper#3
Conception and design			
Acquisition of data & method			
Data conditioning and manipulation		X	
Analysis & statistical method		X	
Interpretation & discussion		X	
Final approval			

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03/03/2020

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Professor T Falkmer

	Paper #1	Paper #2	Paper#3
Conception and design			
Acquisition of data & method			
Data conditioning and manipulation			
Analysis & statistical method			
Interpretation & discussion	X		
Final approval	X	X	X

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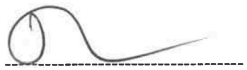

Professor T Falkmer