Curtin University

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Using smartphones to navigate urban spaces

People with disabilities and the role of mobile technologies in Western Australia

Using Smartphones to Navigate Urban Spaces: People with disabilities and the role of mobile technologies in Western Australia

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Cover page:

Curtin Access Map (Curtin University, 2012),

Man in wheelchair (Getty Images, 2016).

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Glossary

AT	Assistive technologies
DSC	Disability Services Commission
OCR	Optical character recognition
W3C	World Wide Web Consortium
WCAG	Web Content Accessibility Guidelines 2.0.

Acknowledgements

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Executive summary

People with disabilities report a number of consistently disabling access issues while moving through urban environments. These can result in social isolation and cause people with disability to avoid going to new or hard to get to places, often being late due to public transport issues, getting disoriented, experiencing fatigue, having to ask strangers for help, and needing a support person to accompany them.

Mobile devices and accessible applications (apps) are becoming an integral part of navigating urban space for all Australians, including those with disabilities. Mobile phones increasingly characterise our experiences of public spaces, replacing both interpersonal interactions and transforming the way we traverse these spaces. The participants in this research were therefore recruited to determine whether it is possible for people with disabilities to become more adept at navigating urban environments using technological advances like Google Maps and Google Street View, technology which is easily accessible via their smartphones.

This report details findings of the research project *Using smartphones to navigate urban spaces – People with disabilities and the role of mobile technologies in three WA locations*. This 9-month *pilot study* was carried out to test the feasibility of this type of research before undertaking a larger scale study. It reviewed prior research in this area, tracked how people with disabilities used their smartphones via focus groups, gathered data from one-on-one interviews, and designed and monitored the use of a unique research app (the Urban Spaces app) to discover initial answers to the following key questions

- How are people with disabilities using smartphones to mitigate the effects of their impairments and compensate for inaccessibility in urban spaces?
- Are people with longer term impairments more adept at this navigation?
- Does the use of smartphones improve social inclusion?

The research focused specifically on two cohorts – people with vision impairments and wheelchair users – in two distinct Western Australian locations, namely the Perth metropolitan area and in the less urbanised southwest region of Western Australia around the regional city of Bunbury.

This report begins with a brief overview of the history and current use of smartphones – by the general population and by people with disabilities. A comprehensive literature review then follows, covering the two main foci of current research in this area – the design of smartphones and their use as assistive technology (AT), and the use of smartphones as a socially empowering device. The report then considers the methodology used in the study.

The findings of the pilot report are then outlined. These are divided into three sections. The first details findings from focus groups held in Perth at the disability support centre VisAbility and Curtin University. These groups captured insights from a total of ten people with disabilities living in the Perth metropolitan area – three wheelchair users and seven with a vision impairment. Participants acknowledged that their smartphone was an essential requirement for navigating urban spaces and decreasing social isolation. Key benefits mentioned included:

- GPS built-in functionality – examples include the ability to provide your location to taxis and other transport services and the ability to identify the location of objects and places nearby such as accessible toilets.
- Mapping – specific guidance on going to a particular place.
- Quick web search – use of digital assistants such as Siri to provide an easy hands-free option to perform quick searches and find locations.
- Environment monitoring – identification of specific weather conditions in a localised area.
- Optical character recognition (OCR) and image recognition – identification of documents, signage and landmarks for blind and low vision users.

The second details findings from focus groups and interviews with people with disabilities living in the southwest region of Western Australia. Five people participated in this stage of the research – three participants that used wheelchairs, one who was blind and one who was an orientation and mobility specialist with Guide Dogs WA. These participants believed the smartphone was a useful tool and a number of essential smartphone features were noted, including GPS – for example Apple maps – and route finding, voice over and text-to-speech technology, SMS messages, simple phone calls, weather apps or websites, digital assistants such as Siri, in-built voice recognition services and the notetaking function. However, participants determined that these features did not necessarily *change* how accessible spaces were for them, although they did note the usefulness of apps such as Snap Send Solve which could be used to report on inaccessible spaces.

The results section concludes with an assessment of the apps available to people with disabilities that may improve their navigation of urban spaces. These apps are categorised into three distinct groups – direct navigation, environment awareness and object identification.

The study then considers the findings in relation to the project aims and highlights some limitations related to research methodology such as privacy concerns and the importance of paying people with disabilities for their expertise. It then goes on to consider future research directions and concludes with recommendations that emerged based on the findings of the focus groups and interview discussions as well as on analysis of existing literature. These include:

- Service providers and particularly the Disability Services Commission (DSC) must embrace app-based communication, particularly to assist their clients navigate the urban environment.
- While web resources such as Access WA are vital to this group and are still accessed via smartphones, we recommend the DSC create an app version of this resource for greater ease of use.
- Local councils need to integrate public access with mobile access. Councils should work towards free public Wi-Fi access modelled on the ACROD parking system for the disabled population.
- Further training for people with disabilities about which apps are available and how this group can use their smartphones for greater public accessibility is vital. We recommend two approaches – create more specific tip sheets (Appendices 1-3) and conduct public training sessions. As discussed throughout this report, people with disabilities who are active smartphone users are the ideal facilitators for this training; however, they must be paid.

Introduction

A commuter with vision impairment uses the mobile app Stop Announcer to plan and complete his public transport journey to work in Perth. Meanwhile a wheelchair user in Bunbury uses their mobile navigation system in combination with the city's electronically available ACROD parking map to plan their car journey (Figure 1). Students with disabilities locate accessible taxi ranks and wayfinding pathways across the Curtin University campus using the Curtin smartphone app. Throughout Australia people with limited mobility use mobile apps to plan journeys by taking into account elevation and gradients of ramps, numbers of steps, internal routing in stations, proximity to accessible parking, ground surfaces etc. Internationally, people with vision impairments sync their phones to crosswalks which then transmit instructions audibly, based on where the user wants to go.

Figure 1. ACROD access map of Bunbury (City of Bunbury, 2014)

This opening vignette paints a picture of how mobile devices and accessible apps are becoming an integral part of navigating urban space for people with disabilities.

Mobile phones increasingly characterise our experiences of public spaces, replacing both interpersonal interactions and transforming the way we traverse these very spaces. Smartphones could potentially be a key enabler for people with disabilities traversing the urban environment in a number of different ways – by removing the 'disability divide' between people with disability and those without (Morris, Mueller, Jones, & Lippincott, 2013); by increasing independence (Spinks, 2014); by allowing access to previously inaccessible information (Hollier, 2013) and by providing assistance to navigate cities (Ellis & Goggin, 2015a/b; Spinks, 2014).

The rise of smartphones has also had a significant impact on the social inclusion of people with disability – that is, this population use mobile media in the same way as the non-disabled population (McNaughton & Light, 2013). With the rise of new forms of social and locative media prompting calls for smarter cities, how we understand and experience disability, access and social interaction is undergoing a dramatic shift. Researchers internationally are addressing this issue – for example the Inclusive Cities 2015 conference in Switzerland (Geissbühler, Demongeot, Mokhtari, Abdulrazak, & Aloulou, 2015) looked at user experience focusing on both wheelchair access and how people with vision impairments use smartphones to access public space.

The current project represents the first Western Australian-based research into this topic. It details findings of the research project *Using smartphones to navigate urban spaces – People with disabilities and the role of mobile technologies in three WA locations*. This 9-month pilot project reviewed prior research in this area, tracked how people with disabilities used their smartphones via focus groups, gathered data from one-on-one interviews, and designed and monitored the use of a unique research app to begin to discover answers to the following key questions:

- **How are people with disabilities using smartphones to mitigate the effects of their impairments and compensate for inaccessibility in urban spaces?**
- **Are people with longer term impairments more adept at this navigation?**
- **Does the use of smartphones improve social inclusion?**

Comparisons have been made across locations and impairments, for example how do the needs of people with vision impairment differ to those of wheelchair users? Do people in the Perth Metropolitan area, experience a different level of urban and smartphone accessibility to those located in the southwest?

This introduction considers these questions through an analysis of the history of mobile phone usage – from initial launch, to new generation models, to the present day dominance of smartphone technology – from both a general and disability perspective.

Mobile telephones have had a significant cultural impact on the way we communicate and live our lives. The first US patent for a wireless telephone was issued in Kentucky in 1908; however, it was not until 1973 that Motorola realised the vision of a portable personal handheld phone. As the timeline below illustrates (Figure 2), the history of mobile phones can be traced back to the 1930s when portable AM radios and so-called walkie talkies were developed for use by the US military. Moving through the 1940s and 1950s, military necessity continued to be the focus of mobile telephony advancements. Then, with improved mobile telephone technology emerging during the 1960s, more advanced mobile car phones with push buttons began to appear; however, cost meant that they remained outside the reach of ordinary citizens. Then in April 1973 Motorola Vice President Martin Cooper made the now infamous phone call to his competitors at Bell Labs from a portable handset on a busy Manhattan street. Throughout the 1980s the use of handheld phones became increasingly widespread in the Western world. During the 1990s the idea of a mobile phone as an item people took out of the house with them increased in popularity. From the 2000s onwards mobile phones began to diversify beyond a device from which people 'just' made phone calls to a sort of integrated fashion accessory, camera, gaming console etc. With the release of the Apple iPhone in 2007, phones became increasingly associated with apps covering a diverse range of perceived needs such as social media access, navigation, shopping, banking and even instructions for cooking the perfect steak (see Appendix 4). This technology posed many opportunities and challenges for the disability community.

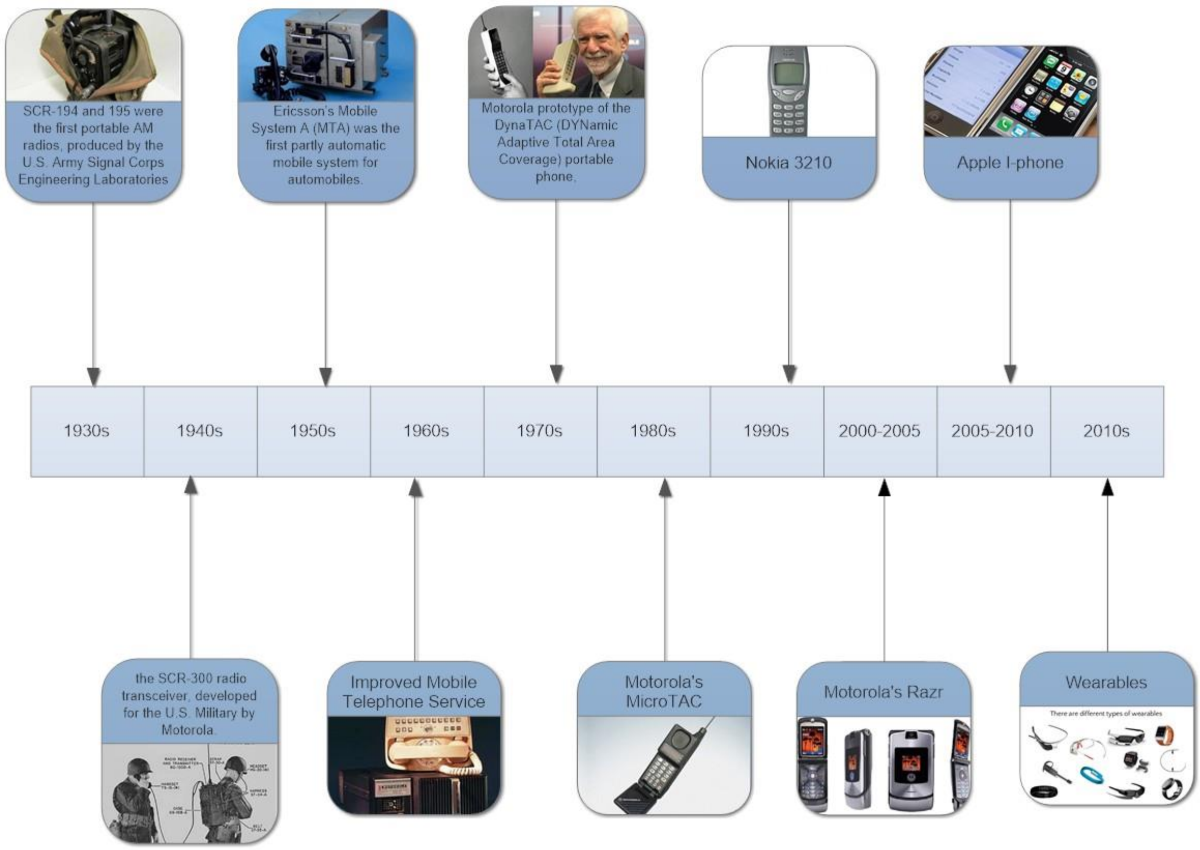


Figure 2. Timeline of mobile phone technology

From a disabled person's perspective, Gerard Goggin traces people with disability's uptake of mobile telephones between the 1970s and 2006 in his book *Cell Phone Culture* (Goggin, 2006). In the 1980s when handheld phones became available, many people with disabilities found they were too bulky to use. Then, as phones became smaller with advances in computer miniaturisation, they became both easier and more difficult for people to use depending on the specifics of their impairment. Second generation mobile phones again opened possibilities for both inclusion and exclusion, and subsequent generations have seen the rise of smartphone technology dominating the market. Today, as Figure 3 illustrates (timeline adapted from Agar, 2013; Goggin, 2006, 2011b), we are moving closer to a 5th generation of mobile technology. As can be seen, the two main contenders in today's marketplace are Apple's iOS system (the iPhone) and Google's Android phones (produced by a number of different manufacturers).

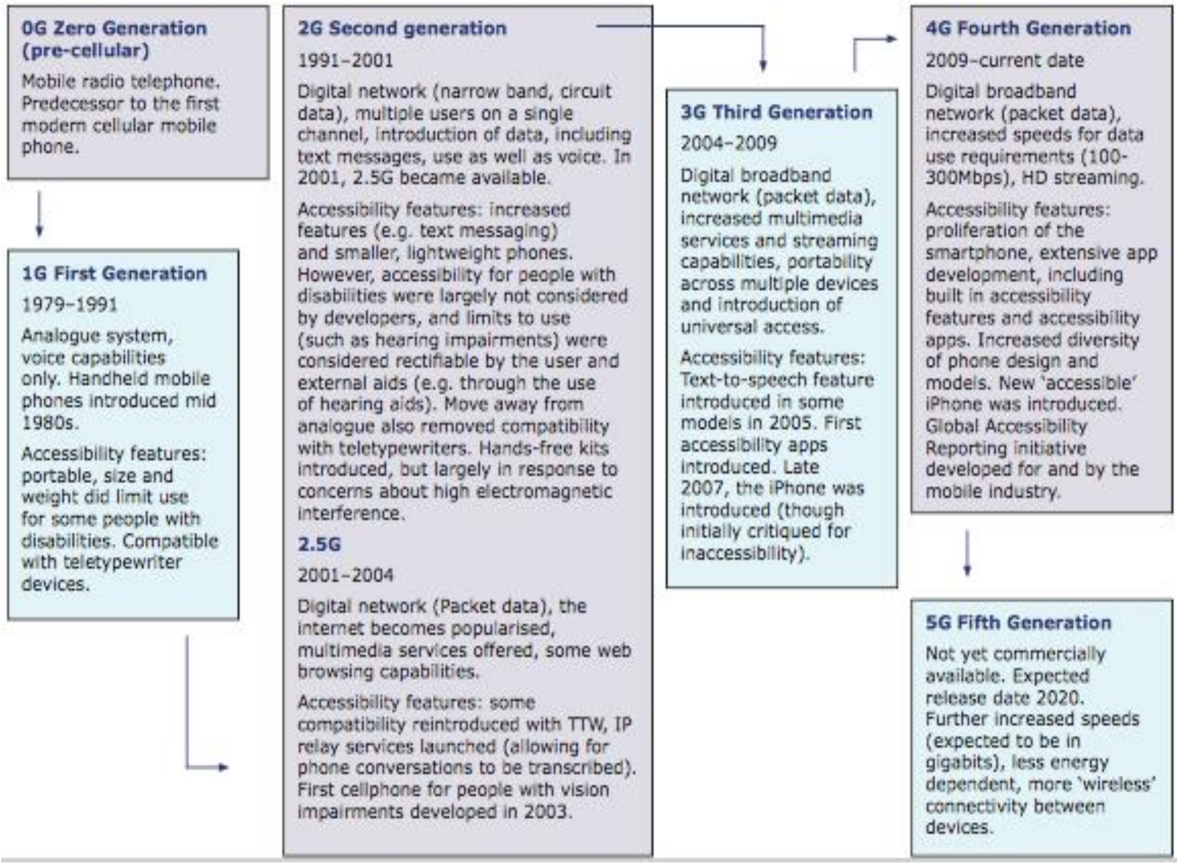
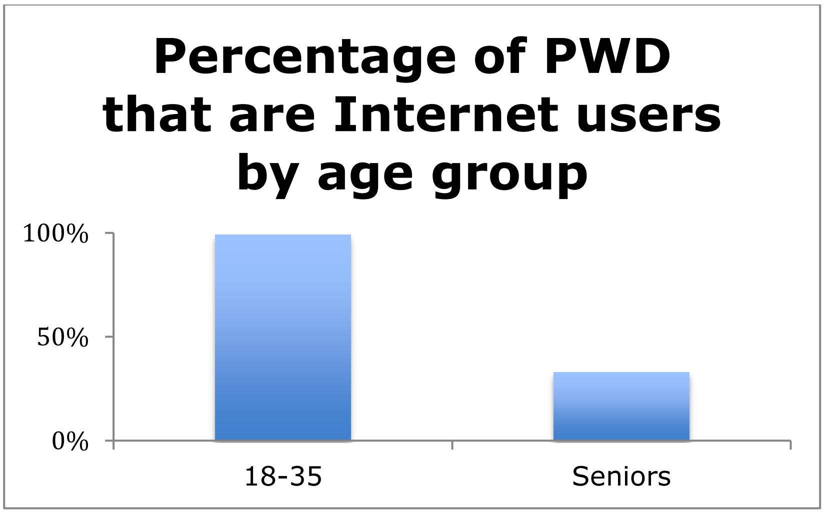


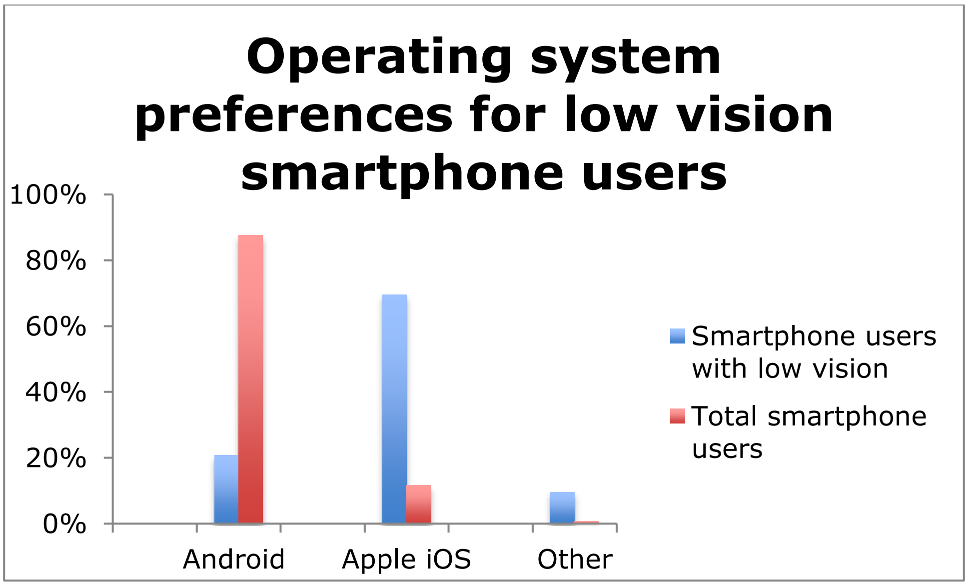
Figure 3. Timeline of mobile phone 'generations'

This technological advancement has seen both a greater uptake of mobile technology amongst the wider population and greater recognition of people with disability as a consumer group who could benefit from this technology. As a result, there are ongoing improvements in their accessibility – consequently, current statistics suggest a high take up of smartphone technology by people with disabilities. Research in the UK appears to be the most recent and indicates that among people with disabilities aged between 18-35 approximately 99% use the internet (Office for National Statistics GB, 2016). While that figure is much less in seniors with disabilities - only approximately one in three - there is a trend whereby the figure is increasing. It is predicted that sales of smartphones in comparable market-saturated countries such as the UK, the US, Canada and Australia (A. Smith, 2015; Budde, 2016) will drop off slightly in 2017 due to in part to their already widespread use. For example, in Australia, there are already 15 million smartphone users and not much room to expand until people upgrade. So while it's likely that people with disabilities are using smartphones, more specific statistics on numbers is needed.



Graph 1. Percentage of people with disability that are Internet users by age group

Ongoing research by WebAIM (Web Accessibility In Mind), one of the leading providers of web accessibility expertise internationally, offers some insight. Their most recent screen reader survey highlights that people who are blind or have low vision are relying on smartphones for access (Web Access In Mnd, 2016) with Apple representing 69.6% of respondents compared with Android with 20.8% of respondents. Importantly though, while the global trends are similar – in that Apple and Android dominate the market – user preferences are quite different, with Apple representing 11.7% of users and Android representing 87.6% of users (International Data Corporation, 2016). However, despite the obvious preference for one over the other, as both Apple and Android contain a wealth of accessibility features (Apple, 2016; Google, 2016) any information regarding accessible apps needs to be provided for both Apple and Android users. While there is little data specifically referring to the smartphone preferences of wheelchair users, the accessibility built into the two operating systems, and the dominance of the two operating systems in the smartphone market, suggests that wheelchair users would also use either Apple or Android systems.



Graph 2. Operating system preferences for low vision smartphone users

It is therefore important to consider how people with disabilities are actually using their smartphones in everyday life – for example the type of apps and websites they access – and in particular how they use them to navigate the urban environment.

This project aimed to provide a background to this by investigating smartphone use by people with disability in Western Australia. Five participants engaged in an entry interview for this project. All of the participants had their impairment from birth, with two of the five experiencing a deterioration of their condition over time. The consistent issues experienced while moving through urban environments included avoiding going to new or hard to get to places, often being late due to public transport issues, getting disoriented, experiencing fatigue, having to ask strangers for help, and needing a support person to accompany them when out.

Four of the five participants stated that navigating urban environments had improved over time. This was due to three main factors – the participants' greater experience at navigating, predicting delays and anticipating obstacles; building and street access improving over time; and technological advances like Google Maps and Google Street View. The participants had been using smartphone technology from 3-8 years and had had their current phones for an average of 12 months. All of the phones were Android phones as in this part of the study that was a criterion. These participants agreed to install a data collection app – the Urban Spaces app – on their phones; however, for reasons we discuss later in this report, this was the least successful aspect of the research project.

All participants described themselves as having a high ability of expertise with their phones. They used their smartphones to access a number of apps, websites and features including Google Maps, banking technology, Snap Send Solve, Health Direct, SMS, Facebook, Messenger, Twitter, web browsers and GPS technology. Participants used their smartphones specifically for navigating urban environments using Google Maps, GPS and Street View.

We pitched this research project to the DSC Dr Louisa Alessandri Research Grant as a pilot study to test the feasibility of this type of research before undertaking a larger scale study. The research team has secured $187,222 funding from the Australian Research Council to extend this research over 3 years, taking in a larger number of locations and disability types. This report discusses the results of the pilot study only.

The pilot aimed to produce results that people with disabilities could use in the short-term to aid in the selection of mobile apps to navigate urban space. It also aimed to identify key areas for future research and evaluation based on our findings and offer significant insights for other researchers attempting research on smartphone usage by people with disability. Specifically, any perceived limitations of the pilot study are discussed and, while the project definition has been met in this regard, this pilot study identified a number of logistical issues that need to be addressed before the larger project can be attempted. These are outlined in detail later in the report.

Figure 4 (Getty Images, 2016)

Literature review

A significant body of critical disability research has developed over the past 15 years concerning the relationship between people with disability and digital media (Boellstorff, 2008; Davidson, 2008; Dobransky & Hargittai, 2006; Ginsburg, 2012; Goggin, 2006, 2011a; Goggin & Newell, 2003), including a substantial body of work by this project's chief investigators Katie Ellis and Mike Kent (Ellis & Goggin, 2014, 2015a, 2015b; Ellis & Kent, 2011, 2015). Together with Gerard Goggin, Kent and Ellis have introduced research into the relationship between mobile technology and disability to both the international and national research community (Ellis, Goggin, & Kent, 2015).

Lupton and Seymour's (2000) seminal study of people with disability's use of technology – broadly defined as tools that assist human action – continues to offer important insights regarding the ways technology allows people to 'transcend' disability but equally marks disabled people as 'different'. However, of note is that their study took place prior to the smartphone generation of mobile technology. In the current technological climate, people with disability are no longer marked as different as they can use their smartphones as a form of assistive technology in the same way as the rest of the population (McNaughton & Light, 2013).

The impact of smartphone technology for people with disabilities remains under researched. What exists expands across two main research areas – the design of mobiles/mobile technology for people with disabilities (both the application of universal design principles and the use of AT), and the mobile as a socially empowering device. The evidence is, to date, mainly concentrated on how smartphones may aid those with visual and hearing disabilities. However, of note, there is a growing body of research on the relationship between smartphones and their benefits for people with intellectual and developmental disabilities and hearing impairments. Although outside the scope of this study, we have received additional funding to conduct a national study which also includes people with intellectual disabilities.

There are also research contributions on the relationship between young people with disability and mobile use (Söderström, 2009). In general, the research suggests people with disability are afforded less access to smartphones and other similar technologies. With regards to social inclusion, there exists a significant body of critiques that highlights the 'digital divide', the exacerbation of existing power differentials, and the socially disenabling impact of mobile technology for people with disabilities.

This section will conclude with a summary of current – limited – research pertaining to how people with disabilities digitally access urban spaces, the main focus of this report.

Smartphone design

The AT approach differs from the universal design approach in that rather than framing mobile use for people with disability as simply requiring everyday access, it focuses on how they might *facilitate* everyday life, including access to and use of urban spaces. The literature surrounding this concept is wide ranging, encompassing both physical and mental disabilities, and the experiences of users is also broadly considered.

For example, Shen, Coughlan, Brabyn, and Chan (2008) and Livingstone-Lee, Skelton, and Livingston (2014) both explore the role of the smartphone in the navigation, access and use of urban space – the former focusing on the visually impaired and the latter on those with cognitive disabilities. However, it should also be noted that the former proposed a system that operated on a basic mobile. Since then, multiple apps and products have been created that utilise smartphone technology, the primary advantage of which is its camera which assists in space navigation for the blind using apps such as Ariel Object Detection, Georgiephone and ViaOptaDaily (Figure 4).

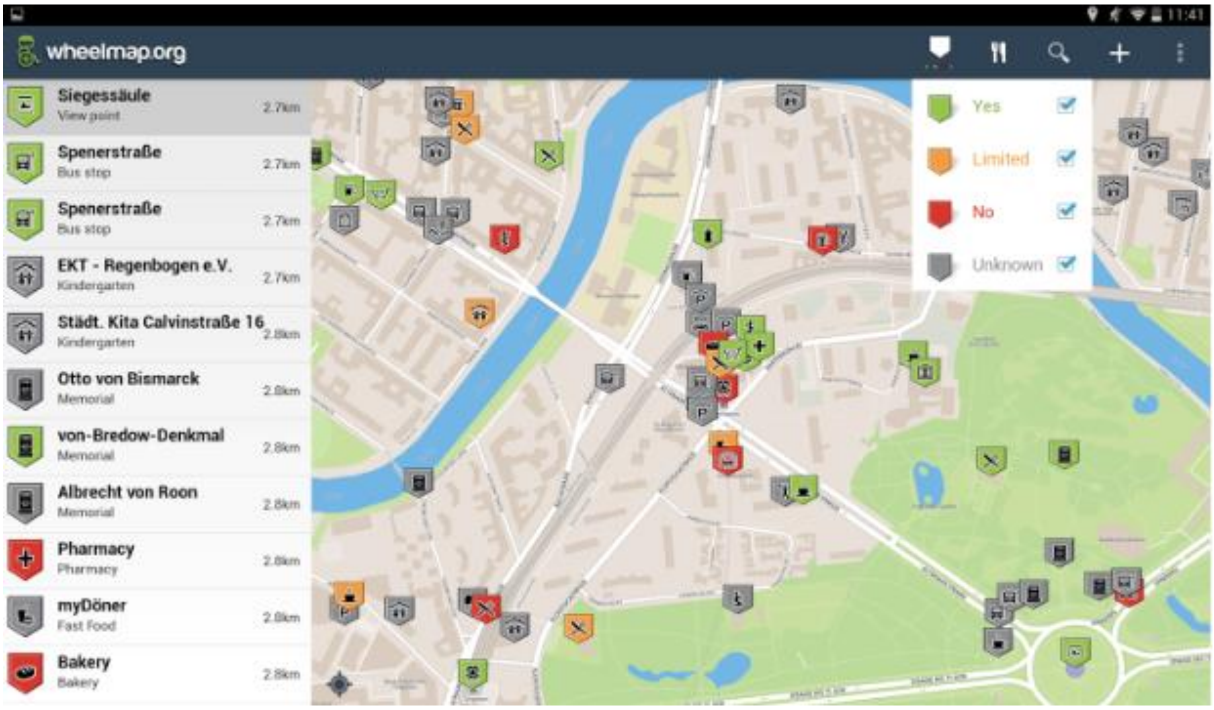


Figure 5 Screenshot of Wheelmap app on Andriod (Wheelmap, 2017)

Another example of the use of AT is offered by Abbott, Brown, Evett, and Standen (2013) who highlight the increasing role of smartphones as AT in assisting and enabling learning. They identify smartphones in particular as challenging providers of and research into ATs – "moving away from being solely oriented around product evaluation and towards a user-centred approach" (p. 453). Likewise, Doughty (2011) identifies the breadth and depth of areas in which smartphones act as an AT – from health service delivery, education facilitation, detecting accidents/incidents, aiding in personal communication, to mental health and wellbeing support. While not focusing solely on people with disabilities – his analysis of smartphone use as an AT encompasses "a range of vulnerable groups" – Doughty frames the smartphone and its apps as a low cost and "boundless" extension of existing telecare/health services. Network limitations – including rural access – battery reliance and possible security weaknesses are cited as some of the risks associated with the use of technology generally, not just affecting people with disabilities. There has also been some research on specific AT apps and their use. Guidance systems such as the Ebasr indoor guidance system have also been developed to aid navigation indoors. Outdoors, researchers focus specifically on large urban spaces such as parks and navigation around these (T. T. Smith et al., 2015), and there's also been some specific app development to assist people with vision-related disabilities specifically on Android (Wersényi, 2015). Finally, Hsu, Gu, Huang, and Kamijo (2016) take a combined approach to technology to look at how to offset issues with GPS for pedestrian navigation in cities where the signal gets reflected or blocked by large buildings.

Smartphones as a socially empowering device

Research by Söderström (Söderström, 2011; Söderström & Ytterhus, 2010) and Naslund and Gardelli (2013) add to these papers in exploring not only the benefits and limitations of smartphones for people with disability, but the relationship between information and communication technologies more broadly, including disability and agency and/or social empowerment, "revealing its twofold property as a mainstream technology simultaneously functioning as an assistive technology" (Söderström, 2011, p. 105). This work builds on the analysis of smartphones as AT to space/place access, with an emphasis on smartphones as socially and culturally "assistive". Interestingly, most research in this arena is focused on young people with disabilities use of smartphones. In these studies, smartphones and technology more broadly are shown to provide people with disabilities personal development, safety, empowerment, agency, independence, participation and the maintenance and generation of social ties and support.

Other studies have explored innovative cultures of smartphone use, highlighting ways in which mobile technology is adapted and customised to meet individual needs. As Söderström identifies, "the widespread dissemination of mobile phones may also hold other, unexpected, significances in people's daily lives" (2011, p.92). Goggin (2011a) also notes two key ways in which people with disability have adopted mobile technology in "'creative ways"' – blind users who use screen reader software to customise mobiles (Goggin & Newell, 2006) and are "now investigating new possibilities of mobile media [including] GPS and locative media" (Goggin, 2011a, p. 261), and D/deaf users who have created new possibilities and approaches to text messaging (Okuyama, 2013) and sign language video mobile telephony (Cavender, Vanam, Barney, Ladner, & Riskin, 2008).

Digitally accessing urban space

However, there is limited research to date regarding if and how people with disability use modern smartphone technology to access urban spaces. Work has been done on accessibility issues generally, but these have not had a technology focus. For example, Taylor and Józefowicz (2012) provide a focused analysis of people with disability's experiences (specifically in relation to access and mobility) of urban space for recreation and leisure via an extensive empirical study in the city of Bydgoszcz, Poland. Though the use of mobile phones within these experiences is not highlighted in the study, it nonetheless provides important comparative data on use and issues of access for those with and without disabilities. Other, earlier quantitative research includes Matthews, Beale, Pictone and Briggs' (2003) GPS mapping of wheelchair users in Northamptonshire, UK, although, again, mobiles were not used to capture this data. Casas (2007) tracked access for people with disability via a 'one-day travel diary' using GIS mapping across the Buffalo-Niagara region in New York. Other studies have looked at access issues for both people with disability and the elderly (see Schmöcker, Quddus, Noland, & Bell, 2005).

Only a few studies have combined the study of urban access with the use of smartphone technology. For example, projects such as the Megafone smartphone app aim to capture these experiences of urban space access – by both people with disability and other people marginalised within society – with the aim of creating a 'map' of current use and inaccessibility:

> *Producing a location-based taxonomy of obstacles, barriers, and 'incivilities' as well as points of accessibility (Montreal In/Accessible, 2014).*

The project, started in Barcelona by artist Antoni Abad around 2003 – now also working in conjunction with the Mobile Media Lab – now captures experiences across urban centres globally.

Figure 6. (Getty Images, 2016)

Previous research focusing on mobile use and disability demonstrates a consistent awareness that both context and methodology impact upon the responses of participants (Kane, Jayant, Wobbrock, & Ladner, 2009). Taylor and Józefowicz (2012), in focusing on urban space experiences specifically for recreation and leisure, recognise that travel behaviour is the resultant of "three kinds of variables referring to a spatial component, a socio-economic component and a personality component" and that experiences may not reflect/represent the accessibility of a space/place for people with disabilities. Automated data capture of large portions of a person's life via mobile and wearable technologies (so called Lifelogging), as highlighted by Jacquemard, Novitzky, O'Brolcháin, Smeaton, & Gordijn (2014), eliminate some of these issues.

Taking on board this prior research and suggestions for automated data collection, we attempted a novel methodology offered by smartphone technology as outlined in the methodology section next.

Methodology

This research set out to contribute to a new understanding of the experiences of people with disabilities in public space and how smartphones can offer new support and services. Specifically, the project aimed to

- Capture participants' use of their smartphones directly from the phones themselves via a specially designed data collection app, the Urban Spaces app.
- Pair the data with insights obtained from interviews.
- Visualise this data using Curtin University's Hub for Immersive Visualisation and eResearch (HIVE).

We also hoped to integrate an educational component to this research in order to:

- Identify active phone users with disabilities who could mentor newly disabled people seeking to use their smartphones more effectively in urban spaces.
- Create tip sheets.

The research aimed to identify the most popular apps and websites accessed by the cohort to assist them with navigating urban spaces. In researching popular apps beneficial to people with vision impairments and wheelchair users, it is useful to categorise these into three distinct groups including direct navigation, environmental awareness and object identification.

We developed an Android-based app which captured a participant's phone use at regular intervals to establish when and where people use different apps on their phones. The app would track people as they moved through space, noting time and location. The app exceeded the basic requirements needed for people with disabilities to effectively use it – Media Access Australia awarded it an AAA Web Content Accessibility Guidelines (WCAG) 2.0 rating. Built-in accessibility features were effective due to the app being designed in accordance with the World Wide Web Consortium's (W3C) WCAG 2.0 (W3C, 2008).

We recruited a number of people with disabilities who agreed to have the app installed on their phone for data collection. Several were excluded because they did not use Android phones. However, this stage of the research was least successful due to a reluctance among participants for a number of different reasons – these are outlined later in this report.

Two distinct groups were identified and researched. The first were focus groups held in Perth – two focus groups were established for the project to accommodate both wheelchair users and people with vision impairments, one during working hours and one after hours. In addition to this, one individual participated in a one-on-one interview. The first focus group contained six participants, the second contained three participants. Participants were asked about their general smartphone use and specifically, the apps they used when navigating urban environments and why. The focus group was also invited to look to the future and outline the kinds of apps or services they would like to see developed. Perth is one of the most isolated cites in the world. It is the capital city of Western Australia and has a population of just over two million people. It is notable for the high level of geographic dispersal of the city for its population size, as well as its hot climate over summer. Both these features present challenges to navigation of the city for people with disabilities.

Including the interview, there were three participants that used wheelchairs and seven that had a vision-related impairment; this included four that had no vision and three with low vision. The ten participants consisted of five men and five women across a mix of age groups. The groups were held at VisAbility in Victoria Park and on the Curtin University Bentley campus. All participants received a $100 Coles gift voucher for their participation.

The second cohort were focus groups held for people living in the regional southwestern part of Western Australia, including the small rural town of Harvey (half an hour from Bunbury), the new subdivision of Dalyelup (ten minutes from Bunbury), south Mandurah (one hour from Bunbury) and Bunbury city central. The greater Bunbury region has a population of approximately one hundred thousand people. The city of Bunbury has a stated aspiration to be recognised as the most accessible regional city in Australia. These locations had a significant impact on both the participants' ability to use (accurate) GPS mapping and the availability, and thus use, of public transport. Both wheelchair users and people with vision impairments were asked to participate. The group was held on the South Regional Tafe campus in Bunbury. In total, there were five participants. Two individuals who were unable to make the focus groups contributed via interviews – one face-to-face and one via the phone. Three participants used wheelchairs and one had a vision-related disability; this participant had no vision. Another participant was an orientation and mobility specialist with Guide Dogs WA. The participants consisted of three men and two women across a mix of age groups. All participants received a $100 Coles gift voucher for their participation.

Focus Group Findings

This section will look at the findings from the focus groups conducted as part of the study, focussing on which mobile devices were used to navigate urban spaces and how significant the device was to the user. Any similarities or differences between wheelchair users and people with vision impairments in the two studies will also be discussed.

Perth focus groups

Mobile devices used to navigate urban spaces

Apple versus Android

Nine of the ten participants used a relatively recent model of the Apple iPhone as their primary device for navigating urban spaces; only one participant used Android. This supports the literature that suggests that despite Android devices being significantly more popular globally, among disability groups Apple-based devices such as the iPhone are preferred.

While only one participant solely relied on an Android device, two other participants used Android devices in other contexts and hence were familiar with the operating system. These participants indicated that Apple products were generally easier to use, stating “it just works” and were more established than Android. The iPhone also has improved Braille support whereas Android has a separate Braille app meaning it is less integrated.

There was an acknowledgement that from an accessibility perspective both Android and Apple were effective in terms of built-in accessibility features. However, the inconsistencies of how Android is implemented between different manufacturers and versions of the operating system made it more difficult to use. The one participant that used Android exclusively, however, indicated that it was very effective.

Other portable devices

One participant also used an Apple Watch as a complementary navigation device and as such needed to stay in the Apple ecosystem for both the iPhone and Watch to work together. The benefit of the Apple Watch is that it can use its vibration features to indicate when a left-turn or right-turn needs to be made while using Apple Maps. The Apple Watch can also provide some personal security in that payments can be made with the Watch. As a result, it's not necessary to pull out money or a credit card in an unfamiliar or uncomfortable environment.

Another device highly recommended by three blind participants is a Bluetooth bone-conductor headset to hear audio feedback from the mobile device. As it does not require anything to be plugged into the ears, the blind participants found it particularly useful as they can still listen to the surrounding environment while also listening to their mobile device.

There was also some discussion by three blind participants on the Tracker and the Captain, third-party AT products for navigation. While the comments suggested the devices worked well and also provided some additional useful information for navigation, issues such as outdated maps and the fact that it is an additional device to be carried around meant they were no longer used on a regular basis.

Significance of mobile device

Participants acknowledged that their smartphone was an essential requirement for navigating urban spaces. Key benefits noted include:

- GPS built-in functionality – examples include the ability to provide your location to taxis and other transport services and the ability to identify the location of objects and places nearby such as accessible toilets.
- Mapping – specific guidance on travelling to a particular place.
- Quick web search – in particular the use of digital assistants such as Siri which provide an easy hands-free option to perform quick searches and find locations.
- Environment monitoring – identifies specific weather conditions in a localised area.
- OCR and image recognition – allows blind and low vision users to identify documents, signage and landmarks.

Further, the participants identified the following built-in features as essential for navigating urban spaces:

- Screen reader – for blind and low vision users, the Voiceover screen reader in Apple or Talkback in Android provide the necessary verbal and tactile feedback required to operate the device.
- Digital assistant – for example Siri in Apple which provides a hands-free mechanism for both wheelchair users and people with vision impairments to find out information quickly.
- Accessible touch features.
- GPS and route planning functionality – essential for navigation.

Specific apps which were identified as useful included:

- Direct navigation apps:
    - Google Maps – essential for navigation.
    - Uber – particularly useful for blind and low vision users when wanting to travel distances that taxis may consider too short.
    - Public transport app such as Transperth.
    - Should I Run? – provides real-time information on how much time is available before the next public transport option leaves.
    - Stop Announcer – Android app for public transport.
- Environment awareness apps:
    - KNFB Reader.
    - Third Eye.
    - Tap Tap See.
- Object identification apps:
    - Blind Square: identifies landmarks while moving around.
    - Guide Dogs ACT/NSW: initially good identification app.

Resources that are not app-specific include:

- National Toilet map – identifies accessible toilet locations.

- Access WA – a wheelchair-accessible resource created by the DSC.
- Weather information – specific weather information important for planning.

Case study*Stephanie is a Curtin University student who uses a wheelchair and an iPhone. She is very active within disability youth advocacy circles and was able to comment on her own smartphone use as well as that of her friends and colleagues.*

This group rely on their smartphones for information sharing, mainly through Facebook groups. Social media is immensely helpful when looking for solutions, advice and discussing topical issues like the NDIS. The connectivity is vital for Stephanie and her community and the information is generally more accurate and relevant.

While Stephanie usually drives her car everywhere, she would like to use public transport more due to environmental concerns; however, most of the time it is not practical.

Access regulations vary from council to council. Generally old buildings have access issues – problem areas tend to be Fremantle, Subiaco and Mount Lawley. Stephanie also noted Elizabeth Quay, which was built between 2012 and 2016 is very difficult to access.

For navigation, Stephanie uses Google Maps and Street View. She prefers Street View because you can see obstacles/stairs/angle of the road etc. Stephanie would like to see an app developed to highlight problem areas in local councils. She identified Black Spot as a possible template. Black Spot is used by cyclists to alert council to problem areas in cycling and the app has led to great improvements for this group. A public forum like this to highlight accessibility issues would allow a greater showing of common problem areas and highlight systemic issues.

Figure 7 (Getty Images, 2015)

Similarities and differences between users

The most notable common elements between the wheelchair users and people with vision impairments in the Perth cohort included the importance of route navigation using Google Maps and the general favouring of Apple over Android despite the popularity of the devices for the general population being reversed. Both groups also had a particular focus on the weather as that played an important role on decisions made when navigating urban spaces. For wheelchair users it related to the difficulty in quickly getting out of bad weather and protecting wheelchair equipment, while for people with vision impairments it was about being able to complete tasks in bad weather. The use of a digital assistant such as Siri was also useful for both groups as it allowed for quick access to information, with the results provided visually or audibly using a screen reader.

Southwest focus groups

Mobile devices used to navigate urban spaces

Apple versus Android

All participants used iPhones, except one who used an Android phone, a Samsung S7. The choice of this model of phone for this participant was related to the design and size of the home button which he found easier to use as it was larger than the other smartphone models on the market. All participants used their phone "everyday". Four out of five participants had been using their smartphone for multiple years. One participant had only started using her smartphone in the past year, but was already “finding it very easy” to navigate and engage the accessibility features.

Other portable devices

Other portable devices discussed included Trekker Breeze. This device was used in part so the smartphone could still be used for other purposes whilst the user maintained a GPS connection/navigation system. It was also noted that the GPS apps and software drained the phone battery quite quickly and that they also used phone data – the costs associated with data use were cited as a particular issue for participants. The ‘downside’ to this device was also discussed. The cost of each unit was $900 and it required updating externally – it had to be sent to Sydney, and this meant the user would be without it for a few weeks. The accuracy of the device also had limitations in a similar way to smartphone GPS mapping.

Significance of mobile device

All participants considered the smartphone as an essential device, enabling communication, socialisation and independence. All participants used the GPS function of their phone – either through Google Maps or Apple Maps – to navigate in different spaces, find the ‘best route’ or provide audio directions. Other key benefits for both sets of participants included voice over functions, voice to text, digital assistants – for example Siri – and weather apps.

However, not all participants expressed that a smartphone was integral to them for navigating urban spaces. For one participant, who was blind and had only just begun to use a smartphone, the confidence to walk independently and confidently in an urban space was not initially aided by the use of her smartphone. As the orientation and mobility specialist with Guide Dogs WA expressed:

> *I’ve never worked with anybody that just picks up a GPS and goes. We’ve gotta do cane training, lots of road crossing training, independent thinking for a while, and then we can introduce [navigation apps]. Once she’s got her confidence up and knows exactly where she’s going, we can use the app to reassure her that she’s on the right track.*

This perspective was reiterated by several participants – the smartphone was a useful tool but did not necessarily change how accessible spaces were for them.

Another participant – who used support workers on a daily basis – articulated this clearly, stating that he used his phone to report inaccessible spaces rather than as a tool to help him navigate space and used the Snap, Send Solve app to do this.

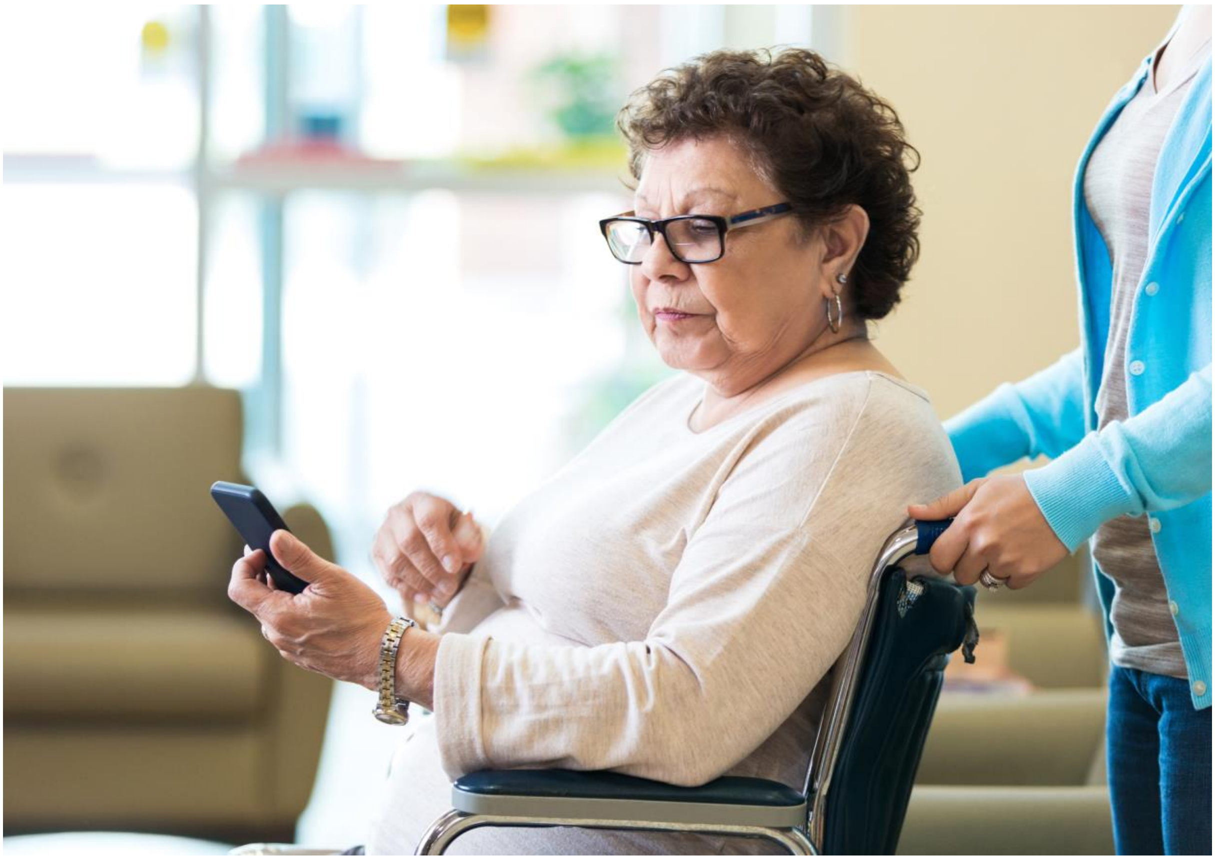


Figure 8. (Getty Images, 2016)

Further, the participants identified the following built-in features as essential for navigating urban spaces:

- GPS (for example Apple maps) and route finding.
- Voiceover.
- Text to speech.
- Messages.
- Phone.
- Weather.
- Siri.
- In-built voice recognition service.

- Notetaking function.

With regards to the specific apps which were identified as useful, all participants used some sort of accessibility or navigation app on their smartphones. There was also specific mention of media, social media and networking apps – from Facebook, to Youtube and Netflix – highlighting Söderström's (2011) argument that agency and social empowerment is often embedded in smartphone use.

Specific apps which were identified as useful included:

- Direct navigation apps:
  - Apple maps and Google maps.
  - TransPerth app.
- Environment awareness apps:
  - Blind Square – identifies landmarks while moving around.
  - Guide Dogs ACT/NSW – initially good identification app.
  - Be My Eyes – uses sighted volunteers and video to provide an audio description of a space.
- Object identification apps:
  - Image recognition – not specified.
  - Colour recognition – not specified.
- Other resources include:
- Snap Send Solve – allows users to take a photo of a fault in a location and send the image to the Council. Used by one participant to report inaccessible areas.
- Infrared remote – has the capacity to pair a smartphone with other devices (for example air conditioners and television) so it can act as a combined, remote control.
- Weather.

Similarities and differences between users

As noted, all participants used same the primary functions of the smartphone – text messages, phone calls, internet and GPS – regardless of their disability.

Likewise, all participants noted they used social media on their phones. The primary difference were the *methods* used to utilise these functions. For example, participants with a vision impairment used the audio description – or Voiceover – function extensively. However, it should be noted that all three participants who used a wheelchair also used talk to text functions – for two participants this was due to limited hand mobility, while for the third it was due to difficulties in reading and articulation.

Other notable points

Living in a regional area posed more challenges for participants – GPS accuracy was often unreliable, phone signal was not consistent, and the cost of running the phone was increased, partly due to the lack of a variety of service providers that had regional range and the higher cost of providers that do, and the lack of free Wi-Fi resulting in higher data use/cost. Both public transport and taxi services were limited in this area and, in one instance, non-existent, which meant participants relied heavily on individually arranged transport and support workers. Of note, support workers were consistently mentioned as aiding in participants' smartphone use – either directly or indirectly. One support worker noted during the discussion that this was sometimes "challenging" for her as she was not confident using smartphones and their accessibility functions. Likewise, the orientation and mobility specialist with Guide Dogs WA expressed the challenges associated with teaching people with a vision impairment how to use certain accessibility features:

> *I'm always showing people the accessibility features of voice over, I'm still not good at it because I'm looking at it and it's not how I'm used to using the phone, whereas someone that if I show and they can't see and they have to use the voice over, they get really good at it really quickly.*

Case study "Non-smart" phones and people with a vision impairment

While recruiting for participants for this research project, there was a notable response by people with a vision impairment that their smart phone had been difficult to use, "disabling, frustrating and, in some instances users decided to no longer use their smartphone, preferring instead to use "non-smart" phones. Out of six individuals who expressed interest in participating in the research project, only one (who eventually attended the focus group) expressed that their smartphone was useful for them when navigating urban spaces.

Bob was trialling a smart phone but found it very difficult to use. In particular, he found the voice recognition component did not always work for him, and he found this especially frustrating as the phone "is his lifeline". Likewise, it was suggested to Susan that she get a smartphone, but found it was "of little use" to her. The Disability Support Centre has found these examples to be common and, subsequently, are now resorting to using non-smart phones (that have not been updated since the smart phones came out) for some clients.

The duration and extent of a vision impairment appears to correlate with the amount a user successful uses their smartphone. Individuals who have lost all of their sight more recently found the smartphone more challenging/non useful (in contrast to people who have low vision or have had a vision impairment for most of their lives).

The need to consistently trial and review apps by support groups/workers was also noted as being important – minimising expenditure on 'ineffective' apps by their clients, and ensuring that the apps or GPS data was up-to-date. As previously mentioned, there was a general lack of awareness of the specialty accessibility apps available on the market, yet a keen interest by participants to trial or explore these apps.

Case Study

Stephen is a quadriplegic and an electric wheelchair user who uses a Samsung 7. He uses his phone a lot, for multiple purposes, including navigation. He specifically chose this phone for its design, in particular the large home button. He has previously used the Samsung 5, citing the inclusion of the Infrared feature was one of the most useful aspects of this model, and he was disappointed when the feature was not continued on the subsequent model.

The infrared feature allowed Stephen to pair his phone with other devides – such as his television or air conditioner – and use his phone to control these devices remotely. There are other accessibility features of the phone that Stephen found useful – such as the built-in voice recognition service.

The GPS function (via Google Maps) of Stephen's phone was cited as one of the most useful features for navigation. He mounts the phone on his electric wheelchair and this allows him no navigate through urban spaces. While he also uses mode specific apps (such as TransPerth public transport app), he finds Google Maps more precise.

When asked about specific accessibility apps, Stephen said he had not used them, and this was in part because he felt that most spaces he visited were accessible:

"I'm pretty confident that we have systems in place in WA to make sure things are pretty accessible for the most part. When they're not, it's usually a monumental stuff up." But he also noted that being in an electric (rather than manual) wheelchair gave him a lot more mobility.

Popular Apps

We conducted extensive research into popular apps in use by the disability community. This is an ongoing area of interest for service providers. For example, VisAbility have resources in place alerting members to apps they might find useful (see Appendix 4). In researching popular apps beneficial to people with vision impairments and wheelchair users, it is useful to categorise these into three distinct groups

- Direct navigation – these are a collection of apps that provide assistance in navigating from one place to another generally through the use of GPS outdoors and radio frequency identification (RFID) and/or Wi-Fi strength indoors. For people who are blind or vision impaired, the focus is generally on a direct path and the avoidance of obstacles. For wheelchair users, the focus is generally on finding wheelchair-accessible pathways such as the use of ramps.
- Environment awareness – this category of app tends to focus on alerting the user to key features nearby which may be of use. People with vision-related disabilities can use a variety of 'where am I?' apps which provide a specific location, or 'things near me' apps which have the closest eating places, closest bank, closest park, etc. For wheelchair users, helpful apps in their category tend to provide information such as location of accessible toilets and electric wheelchair charging bays.
- Object identification – this style of app is specifically helpful to vision impairments as these apps can provide spoken information on visual surroundings. The user takes a photo of an object or text which is then identified and then read out via an OCR app.

Some apps overlap between categories, for example Urban Spoon can both direct the user to an eating place and provide information about the place such as its wheelchair accessibility. The KNFB Reader ("KNFB Reader Garners AppleVis Golden Apple Award," 2016) falls loosely into the object identification category as its more used for reading print on a page such as a menu but, due to its effectiveness in reading text, users on AppleVis indicate it's an essential app to have when travelling. Sources used to access the information include AppleVis (2016), AppAdvice (2016), Appcessible (2014), BrailleWorks (2015) and Liebs (2016). Another app which may be of interest but debateable as to whether it's in the scope of this report is Be My Eyes (Hustad, 2015) which relies on a sighted user alerting a blind smartphone user in real-time as to what they are seeing through their smartphone camera. Popular apps are listed in Table 1 below.

Table 1. Popular apps by category.

Category	Availability:		Useful for:	
	Apple	***Android***	***Vision impaired***	***Wheelchair users***
Direct navigation				
BlindSquare	✓		✓	
Ariadne GPS	✓		✓	
Google Maps	✓	✓	✓	✓
Google Streetview	✓	✓	✓	✓
Wheelmap	✓			✓
PointFinder		✓	✓	
Stop Announcer		✓	✓	
Navigon	✓		✓	
GetHere		✓	✓	
Environment awareness				
Around Me - VI	✓		✓	
Urban Spoon	✓	✓	✓	✓
Wheelmate	✓			✓
Where the Hell Am I?	✓	✓	✓	
Eye-D		✓	✓	
Object identification				
Tap Tap See	✓	✓	✓	
oMoby	✓	✓	✓	
KNFB Reader	✓	✓	✓	

Assessment of the aims of the research

There were five main aims to the project:

1. Capture participants' use of their smartphones directly from the phones themselves via a specially designed data collection app, the Urban Spaces app.
2. Pair the data with insights obtained from interviews.
3. Visualise this data using Curtin University's Hub for Immersive Visualisation and eResearch (HIVE).
4. Identify active phone users with disabilities who could mentor newly disabled people seeking to use their smartphones more effectively in urban spaces.
5. Create tip sheets.

Firstly, there was an issue with regards to the use of the Urban Spaces app. Recruitment of participants was not as successful as had been hoped for, and this lead to subsequent limited data from this source. This is an important insight and an unexpected outcome of the research. This was seen to be due to:

- Concerns related to privacy.
- Technological issues with operating system updates on multiple types of phones happening at different times.
- Illness and injury.
- Inconsistent GPS in buildings, particularly in underground locations, such as Perth train station.
- A propensity for people with disability to use car-based rather than public transport.

Aims 1& 2

In order to understand why such concerns may be merited despite the app being accessible and usable, it's important to understand the issues surrounding common privacy and security, the way in which accessible online materials are produced and stored, and the significance of the smartphone as a personal device.

With regards to privacy and security issues, in 2008 the W3C published the definitive WCAG 2.0 (W3C, 2008) offering guidelines on the governance of internet sites. However, while WCAG 2.0 has some references to security, the intent of WCAG 2.0 was not specific to security and as such its implementation does not address most security and privacy concerns. Indeed, only minimal guidance is given in this area, namely to ensure that security features such as passwords are presented in an understandable manner and that security timeout features factor in the speed in which people with disabilities are likely to complete tasks (Brown & Hollier, 2015). Furthermore, as WCAG 2.0 is viewed as the primary mechanism for supporting people with disabilities in online content, non-WCAG issues such as security are often not considered for this group during the development process (Brown & Hollier, 2015).

One example of a security feature that is difficult for people with disabilities to access and one which is not effectively addressed in WCAG 2.0 is the Completely Automated Public Turing test to tell Computers and Humans Apart (CAPTCHA). The CAPTCHA is an online security feature designed to ensure that the data being entered into a website is from a real person (Figure 5).

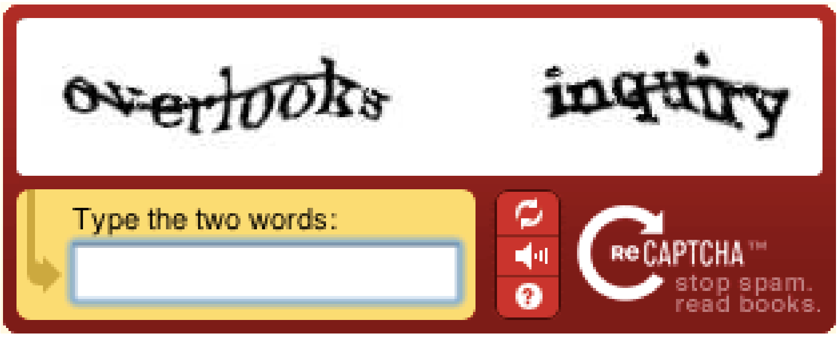


Figure 9. CAPTCHA image (Carnegie Mellon University, 2000-2010)

However, the very techniques used to prevent automated processes entering file data – and therefore ensuring a high level of security – also often prevent people with disabilities from entering in information using AT (Belk, Fidas, Germanakos, & Samaras, 2015; Bursztein, Martin, & Mitchell, 2011). In recent years a number of different CAPTCHA techniques have been developed to try and address this issue (Le, Baydin, & Wood, 2016) but the issues largely remain present.

A second example of how people with disability are affected by security issues relates to cyber safety. While phishing, dating scams and fake lottery winnings are commonplace for all online users, there is evidence to suggest that some scams specifically target people with disability. As an example, the WA Deaf Society applied for a grant to develop resources to educate their community on how to avoid being a victim of cyber bullying and, as a result, ran a successful video campaign (Australian Communications Consumer Action Network, 2010; WA Deaf Society, 2011).

There are also issues with regard to the way in which data is produced and stored. For example, the Raising the Floor initiative are an organisation that aims to make all technology as accessible as possible to all users, including those with a disability (Raising the Floor, 2017). They created the Global Public Inclusive Infrastructure (GPII), to overcome issues with access and security when storing users' accessibility preferences on the cloud. Using this system, if a user comes into contact with a device such as a ticket machine, the ticket machine identifies the user and their accessibility preferences, then sets up the AT required in real-time. In essence, this would potentially remove the need for CAPTCHAs and reduce the risk of phishing as both user and device would be able to communicate and authenticate directly.

However, the use of such a GPII-approach to supporting people with disabilities has in turn led to new privacy and security concerns, again particularly regarding storage (Brown & Hollier, 2015). In particular, people with disabilities raised concerns about how their personal accessibility preferences were to be stored on the cloud, what mechanisms would be put in place to access that data, and whether the personal accessibility preferences, combined with GPS data, could lead to the identification of individuals through their disability. As such, while GPII remains an internet concept, the practical implementation of GPII to date remains largely unrealised (Hollier, 2014).

As a result, the focus for accessibility has returned largely to the smartphone and its significance as a personal device. A smartphone is usually in the owner's possession, so there is a perceived comfort in having a large degree of control over the availability of personal information to others, similar to carrying a wallet or handbag. In addition, smartphones contain accessibility features and apps that can effectively support people with disabilities in their interaction with the world (Apple, 2017; Google, 2017). As most of these apps have their own security mechanisms, the need for CAPTCHAs and the potential for scams is also reduced, particularly if apps are downloaded from official app stores.

Further, looking beyond the current use of smartphones, there is also an additional benefit for people with disabilities in that smartphone technology is also expanding its usefulness by becoming a hub for controlling Internet of Things (IoT) devices as discussed by "Stephen" in the case study on page 39. For example, if a person in a wheelchair cannot reach the buttons on a microwave, it is possible that a microwave connected to the home network could be controlled by the smartphone. This additional functionality will significantly increase the importance and reliance of people with disabilities on their personal smartphone.

Taking these arguments into account, it becomes clear why the app designed for this particular study, while accessible and necessary for data collection, was not fully embraced by participants. People with disabilities are generally wary of third parties wanting their data, especially with specific attempts to scam being prevalent. With the smartphone now becoming a prized personal possession representing more than the sum of its parts, the fact that the Urban Spaces app required a large amount of data to be sent invisibly to a third party raised further understandable concerns for participants, even though the privacy and security processes were undertaken under strict ethical guidelines. Perhaps due to these factors, we were therefore able to collect app-based data from only one participant. However, the researchers conducted a number of focus groups and one-on-one interviews to satisfy the aims of the research project.

Possible resolutions of this issue for future research could include providing participants with a more transparent way of monitoring how their data is sent to researchers, a clear understanding as to what personal information is being provided to researchers and a greater assurance that the personal data cannot unintentionally go to another party.

Aim 3

We also aimed to visualise the data using Curtin University's HIVE. The HIVE consists of four screens with different capabilities and is designed to create new knowledge from the enrichment of research data; enable better and more efficient training environments and facilitate new modes of creative expression.

As discussed, we did not collect the large data set anticipated at the beginning of the research. We were successful in collecting data from one participant and used this information to refine our both our research and visualisation methodology going into the larger study.

We also took the opportunity to do further testing on the app by conducting "day in the life" data collection of a Curtin University student with a disability. The focus of the visualization going forward is plotting all journeys taken and analysing the most popular routes, nodes and intersections to demonstrate how the participants are navigating urban spaces in the focus areas. Depending on the cleanliness (precision of the GPS points) of the data the process may need substantial additional work to digitize regions for better visualization. This testing and visualisation preparation has been integral to the development of further research and evaluation.

In lieu of the HIVE visualisation the team has scheduled a blue-sky workshop and project launch to further explore the issues identified throughout the focus groups. This pilot study has identified several problems and opportunities that warrant further investigation by the disability sector, local government and our advisory panel. The blue-sky workshop will focus on the issues considered relevant by our research participants and again feed into further research and evaluation.

Aims 4 & 5

The final two aims were to promote the use of 'mentors' to share their smartphone knowledge and create easy to understand tip sheets. Throughout the research we met several active smartphone users with the skills to pass on their knowledge to people recently acquiring disabilities. For example, one research participant with a vision impairment had almost 300 apps in use on their Android phone. It became apparent that smartphone use was, as we suspected, becoming an increasingly important occupational therapy issue. This was reinforced in the focus groups where training in how to use phones in conjunction with other community-based navigation support was highlighted as an important strategy.

Preliminary research conducted in 2013 suggested that while smartphones may be empowering and equalising for people with disabilities, training was an important component:

> *People grab hold of a touchscreen like an iPhone and they try to use it and within the first five or ten minutes, "Oh, no. There's no way in the world I could use that." When there's hundreds, if not thousands, of blind people using them, but they all know they didn't learn use it in the first week. At least a week, if not two weeks, to really get comfortable. Once you're there, and once you got that spacial awareness and the muscle memory. Muscle memory is part of it as well. You know, in a way, he's gonna get – you just need advice [and training], just keep up with it, keep doing it, give people a little help along the way and all that sort of stuff.* (Ellis, 2015, p188)

It also became apparent that ongoing assessment of available apps was crucial to this group – who better to do this than other people with disabilities? While we identified that there were multiple benefits of this outcome, including benefiting the so-called mentors in terms of work and social participation, it must be emphasised that financial remuneration should also be considered an integral benefit to the contributions made by people with disability. There are several key issues surrounding the work of people with disability in new media, and specifically the lack of payment for work undertaken and skills provided. Katie Ellis argued that the premise that disabled workers should contribute to new media "for the love of it" or in a sense of "duty" to the broader disabled community continues to undermine the provision of financial compensation for work (Ellis, 2016, p. 119).

A dialogue that emerged in 2015 – branded #crippingthemighty in response to the employment of disabled writers for *The Mighty,* an online platform for articles about experiences of disability – exemplified these issues. As Carly Findlay, a disability writer and activist, explained, there were multiple problems with *The Mighty* which encompassed a complex relationship between representation, industry support and paid employment (Findlay, 2015). Dani Alexis Ryskamp, an academic with autism, further claimed, "The Mighty cannot be an ethical participant in the disability community without compensating the disabled writers from whose work the site generates its revenue. We are, as I mentioned, an exploited community" (Ryskamp, 2015).

The backdrop to this discourse is pertinent to relative income and expenditure comparisons between Australians with and without a disability. An ongoing theme behind the responses from people with disability to this project is that living with a disability is expensive, yet the median weekly income for people with a disability is less than half for those without (Australian Bureau of Statistics, 2016). Furthermore, 33% of people with a disability volunteer their time compared to 39% of people with no disability (Volunteering Australia, 2015).

These statistics and the example of the experience of writers for *The Mighty* holds relevance to the aims and focus of this research. If smartphone use is truly becoming both a significant part of everyday life and an integral AT for people with disability, then how the training, education and employment of people with disability in this field is considered will be imperative. Learning from the response to *The Mighty*, the value of the contribution from people with disability to both ends of this research – that is, both in the investigation of how people with disability use smartphones, and how people with disability can contribute to extending the knowledge and skills involved in smartphone use by others with a disability – must extend beyond 'lip service'. Their contribution should neither be taken for granted nor expected, but developed and remunerated.

Future directions

While the use of smartphones to navigate urban spaces was deemed essential by all participants, there are a number of issues and a 'wish list' for potential future technological developments.

For wheelchair users this 'wish list' included:

- More information on the accessibility of urban spaces such as topographical information about slopes, accessible buildings and wheelchair-specific access paths.
- Easier access to current information – resources such as the toilet map and Access WA are not produced as apps yet using the information on a website through a smartphone is less convenient.

The discussion of navigating urban spaces often came back to the inaccessibility of spaces themselves – either through inaccessible design, temporary faults, for example road works, or maintenance faults, for example pot holes. These environmental dimensions were also not typically included in mapping software used.

For people with vision impairments this 'wish list' included:

- Improved indoor navigation – at present this remains elusive and there is a frustration that, despite excellent and effective outdoor navigation solutions, current indoor wayfinding solutions are limited and largely ineffective.
- Regular update of useful apps – certain apps such as the Guide Dogs NSW/ACT and devices like the Captain are not being updated, meaning that once-useful options cannot be used any longer. This is another reason why resources such as Google Maps and Apple Maps are of particular use as they are always being updated.
- Reduction in cost of apps – a number of useful apps such as Blind Square and KNFB Reader are expensive compared to other apps which can make it challenging for some people to purchase the best access solution.

Of note, the use of smartphones for navigation was entwined with notions of "trust" and "safety", with vision impaired participants articulating that while they might feel confident navigating their phone, they felt less confident using their phone for navigation. The accuracy of the GPS function was discussed at length, specifically in relation to the inability to use it indoors and the diminished accuracy of digital maps in regional areas.

For both groups, shared identified issues included navigation app accuracy (whether this be out-dated GPS information or a lack of proximity accuracy), a lack of awareness of 'good' available accessibility apps (and changes to accessibility features of smartphones), and inaccessibility of spaces more generally. The cost associated both with data use and accessibility apps – which are consistently higher than 'non' accessible navigation apps – was a regular issue. Likewise, the need for people with a disability to have consistent and affordable Wi-Fi connections was noted – this was expressed as a 'wish list' item for the future:

> *Surely, in the future… it might be like the ACROD. You go to your doctor and get forms filled out that you require an ACROD sticker and you can go and you require accessibility for independence that that's somehow linked in for the government to pay Telstra for free Wi-Fi while people are out and about.*

Frustrations were also expressed at either out-dated apps with incomplete/inaccurate mapping data, or phone 'updates' which removed key accessibility features – for example the lack of infrared on the Samsung S7 that was present on the Samsung 5.

Other general observations included that while Apple Maps is built into the iPhone, all iPhone users had installed Google Maps. One participant mentioned this was partly due to the Google calendar being more accessible and it pushed its information out to Google Maps, but the inference from the focus groups is that Google Maps is superior. However, this technology is constantly changing – Apple Maps now includes the ability to describe points of interest during navigation, a feature only introduced late last year and one that might encourage its extended use and Google Maps now also includes information about the accessibility of buildings for wheelchair users. The latter was a feature that was known to a blind participant but not to the wheelchair users, suggesting information such as this may be an example of technology that is critical to share – perhaps using the aforementioned model of mentors – as a result of this research.

Conclusions

When this project set out to investigate the ways people with disabilities use their mobile phones to navigate urban spaces, existing research and media commentary suggested that so called 'smart' devices were becoming increasingly important to the everyday lives of this group. The results not only confirmed this, they underlined that smartphones are vital to the independence of people with disabilities.

The literature review established the benefits of smartphones as AT, socially empowering devices and as an important tool in navigating urban space. People with disabilities use smartphones every day – to navigate urban space and to engage in community and social activities. These devices have become an increasingly important tool in the everyday lives of this group. The focus groups, one-on-one interviews and app-based data collection also confirmed this for people with vision and mobility impairments living in the Perth metropolitan area and in the southwest region of Western Australia. However, we found key differences in approach between wheelchair users and people with vision impairments.

Wheelchair users tend to embrace the in-built GPS function via either Google Maps or Apple Maps extensively and confidently, particularly as a route finder. Mounting their phones on their wheelchair also allowed these participants to maintain phone use whilst still controlling their chair. While participants may have previously relied on support workers to aid in their smartphone use – sending texts or taking photos – digital assistant functionality embedded within the smartphone can now facilitate their practices more independently. In this regards, wheelchair users participating in this research focused on information that would provide wheelchair-accessible facilities such as the accessible toilet map and building access. The topographical environment was more significant for this group; for example, if a location appeared close by on a map, it may still not be accessible due to the ground sloping, steep inclines or other issue not necessarily featured on maps.

Participants with vision impairments, however, tended to use more specific apps designed for smartphone users with vision loss, and had "less confidence" in the GPS accuracy. This group also relied on support workers to help them to use their smartphone initially – either through specific training if the user was new to the phone or through the introduction of new apps. More accessibility apps, and a wider variety of apps for the vision impaired, were discussed by this group. Specifically in relation to identification and navigation apps, participants tended to trial and experiment more with both the apps and accessibility features of the phone. Smartphone users with vision impairment participating in this study focused primarily on navigation, but also found OCR features and general point of interest information useful to understanding the urban environment. They emphasised the need to have a variety of transport options, with public transport being a primary. However, participants with vision impairment demonstrated a stronger awareness of other supporting devices such as the Apple Watch, as well as other AT benefits and issues with Android.

Recommendations

As a result of the findings of this project we propose the following recommendations:

- Service providers and particularly the DSC must embrace app-based communication, particularly to assist their clients navigate the urban environment. Providers must commit to constantly updating these apps to ensure their effectiveness.
- While web resources such as Access WA are vital to this group and still accessed via smartphones, we recommend the DSC create an app version of this resource for greater ease of use. Preliminary discussions with an app developer suggest this is feasible.
- Local councils need to integrate public access with mobile access. Councils should work towards free public Wi-Fi access modelled on the ACROD parking system for the disabled population.
- Councils should also communicate with local populations regarding access via an app where people can report inaccessibility as they experience it, for example, alerting councils to broken footpaths etc.
- Further training for people with disabilities about what apps are available and how this group can use their smartphones for greater public accessibility is vital. We recommend two approaches – create more specific tip sheets and conduct public training sessions. As discussed throughout this report, people with disabilities who are active smartphone users are the ideal facilitators for this training; however, they must be paid.
- Support workers also increasingly require training and professional development in this area. They would benefit from the unique perspectives of people with disabilities who as mentioned above could facilitate this training.
- There is a clear need for further research in this area. Several important opportunities for further research and evaluation have arisen through this project. The research team received an Australia Research Council Discovery Grant of $187,222 to investigate this issue across both regional and capital cities in three Australian states, taking in a greater number of disabilities. The

researchers are also working closely with local service providers and academics at other Western Australian universities on future grant applications.

Authors

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References

Abbott, C., Brown, D., Evett, L., & Standen, P. (2013). Emerging issues and current trends in assistive technology use 2007–2010: practising, assisting and enabling learning for all. *Disability and Rehabilitation: Assistive Technology, 9*(6), 453-462.

Agar, J. (2013). *Constant touch: A global history of the mobile phone*. London, UK: Icon Books.

AppAdvice. (2016). Apps for blind and visually impaired. Retrieved from http://appadvice.com/applists/show/apps-for-the-visually-impaired

Appcessible. (2014). 11 free iPad and iPhone apps for wheelchair users. Retrieved from http://www.appcessible.org/11-free-ipad-iphone-apps-wheelchair-users/

Apple. (2016). iOS accessibility. Retrieved from http://www.apple.com/au/accessibility/iphone/

Apple. (2017). Use accessibility features on your iPhone. Retrieved from https://support.apple.com/en-au/HT204390

AppleVis. (2016). iOS apps – navigation. Retrieved from http://www.applevis.com/ios-app-directory/navigation

Australian Bureau of Statistics. (2016). Disability, ageing and carers, Australia: Summary of findings 2015. Retrieved from http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/4430.0Main%20Features452015?opendocument&tabname=Summary&prodno=4430.0&issue=2015&num=&view=

Australian Communications Consumer Action Network. (2010). ACCAN grant recipients target Deaf consumers and scams, privacy complaints and culturally diverse consumers. Retrieved from https://accan.org.au/news/media-releases/156-accangrant-recipients-target-deaf-consumers-and-scamsprivacy-complaints-and-culturally-diverse-consumers

Belk, M., Fidas, C., Germanakos, P., & Samaras, G. (2015). Do human cognitive differences in information processing affect preference and performance of CAPTCHA? *International Journal of Human–Computer Studies, 84*, 1-18. http://dx.doi.org/10.1016/j.ijhcs.2015.07.002

Boellstorff, T. (2008). *Coming of age in Second Life: An anthropologist explores the virtually human*. Princeton, NJ: Princeton University Press.

BrailleWorks. (2015). 5 top mobile apps for the bind. Retrieved from https://brailleworks.com/5-top-mobile-apps-for-the-blind/

Brown, J., & Hollier, S. (2015, July 27-30). *Web accessibility and security: an analysis of online security mechanisms and the Web Content Accessibility Guidelines 2.0.* Paper presented at the International Conference of Internet Computing and Big Data, Las Vegas, Nevada.

Budde, P. (2016). Australia – Mobile communications – Smartphones, tablets and handset market. Retrieved from https://www.budde.com.au/Research/Australia-Mobile-Communications-Smartphones-Tablets-and-Handset-Market

Bursztein, E., Martin, M., & Mitchell, J. C. (2011). Text-based CAPTCHA strengths and weaknesses. *ACM Computer and Communication Security.* Retrieved from https://pdfs.semanticscholar.org/aacf/b2cfe450ecceb9d607f982dcd7eb45761748.pdf

City of Bunbury (2014). CBD parking map – ACROD locations. Retrieved from http://www.bunbury.wa.gov.au/pdf/Community/CBD%20Parking%20Map%20-%20ACROD%20locations.pdf

Casas, I. (2007). Social exclusion and the disabled: An accessibility approach. *The Professional Geographer, 59*(4), 463-477. http://dx.doi.org/10.1111/j.1467-9272.2007.00635.x

Cavender, A., Vanam, R., Barney, D. K., Ladner, R. E., & Riskin, E. A. (2008). Mobile ASL: Intelligibility of sign language video over mobile phones. *Disability & Rehabilitation: Assistive Technology, 3*(1-2), 93-105. http://dx.doi.org/10.1080/17483100701343475

Davidson, J. (2008). Autistic culture online: virtual communication and cultural expression on the spectrum. *Social & Cultural Geography, 9*(7), 791-806.

Dobransky, K., & Hargittai, E. (2006). The disability divide in internet access and use. *Information, Communication & Society, 9*(3), 313-334. http://dx.doi.org/10.1080/13691180600751298

Doughty, K. (2011). SPAs (smartphone applications) – a new form of assistive technology. *Journal of Assistive Technologies, 5*(2), 88-94. http://dx.doi.org/10.1108/17549451111149296

Ellis, K. (2015). A Democratization of Access: From Clinical to Consumer models of communication for people with disabilities In J. Hartley & W. Qu (Eds.), *Re-Orientation: Trans-cultural, Trans-lingual, Transmedia Studies in narrative, language, identity and knowledge* (pp. 179-195). Fudan: Fundan University Press.

Ellis, K. (2016). *Disability Media Work: Opportunities and Obstacles*. New York, NY: Palgrave Macmillan.

Ellis, K., & Goggin, G. (2014). Disability and social media. In J. Hunsinger & T. Senft (Eds.), *The Social Media Handbook* (pp. 126-143). New York, NY: Routledge.

Ellis, K., & Goggin, G. (2015a). In U. Ekman, J. D. Bolter, L. Diaz, M. Engberg & M. Søndergaard (Eds.), *Ubiquitous computing, complexity, and culture*. New York, NY: Routledge.

Ellis, K., & Goggin, G. (2015b). Disability media participation: opportunities, obstacles and politics. *Media International Australia* (154), 78-88.

Ellis, K., Goggin, G., & Kent, M. (2015). FCJ-188 disability's digital frictions: Activism, technology, and politics. *The Fibreculture Journal*, 26. Retrieved from http://twentysix.fibreculturejournal.org/fcj-188-disabilitys-digital-frictions-activism-technology-and-politics/

Ellis, K., & Kent, M. (2011). *Disability and New Media*. New York, NY: Routledge.

Ellis, K., & Kent, M. (2015). Accessible television: The new frontier in disability media studies brings together industry innovation, government legislation and online activism. *First Monday*(20), http://firstmonday.org/ojs/index.php/fm/article/view/6170.

Findlay, C. (2015, 24 December). Problems with the Mighty myth. Retrieved from http://carlyfindlay.blogspot.com.au/2015/12/the-problems-with-mighty-and-my.html

Ginsburg, F. (2012). Disability in the digital age. In D. Miller & H. Horst (Eds.), *Digital anthropology* (pp. 101-126). London, UK: Berg.

Goggin, G. (2006). *Cell phone culture: mobile technology in everyday life*. London. UK; New York, NY: Routledge.

Goggin, G. (2011a). Disability, mobiles, and social policy: New modes of communication and governance. In J. Katz (Ed.), *Mobile communication: Dimensions of social policy* (pp. 259-272). New Brunswick: Transaction Publishers.

Goggin, G. (2011b). *Global mobile media*. New York, NY: Routledge.

Goggin, G., & Newell, C. (2003). *Digital disability: The social construction of disability in New Media*. Lanham, MD: Rowman and Littlefield Publishers Inc.

Goggin, G., & Newell, C. (2006). Disabled e-nation: telecommunications, disability, and national policy. *Prometheus, 22*(4), 411-422.

Google. (2016). Android accessibility – Overview. Retrieved from https://support.google.com/accessibility/android/answer/6006564?hl=en

Google. (2017). Google accessibility. Retrieved from https://www.google.com.au/accessibility/

Hollier, S. (2013, 15 July). 10 milestones in the mainstreaming of accessibility. Retrieved from http://www.creativebloq.com/netmag/10-milestones-mainstreaming-accessibility-7135541

Hollier, S. (2014). The accessibility of cloud computing: current and future trends. Retrieved from https://mediaaccess.org.au/research-policy/white-papers/the-accessibility-of-cloud-computing-%E2%80%93-current-and-future-trends

Hsu, L.-T., Gu, Y., Huang, Y., & Kamijo, S. (2016). Urban pedestrian navigation using smartphone-based dead reckoning and 3-D map-aided GNSS. *Sensors Journal, IEEE, 16*(5), 1281-1293. http://dx.doi.org/10.1109/JSEN.2015.2496621

Hustad, K. (2015). 'Be My Eyes' app lets you help the visually impaired see. Boston, MA: The Christian Science Monitor.

Geissbühler, A., Demongeot, J., Mokhtari, M., Abdulrazak, B., & Aloulou, H. (Eds.). (2015). Inclusive smart cities and e-Health: 13th International Conference on Smart Homes and Health Telematics, ICOST 2015, Geneva, Switzerland, June 10-12, 2015. Chamonix: Springer International Publishing.

International Data Corporation. (2016, August 2016). Smartphone OS market share, 2016 Q2. Retrieved from http://www.idc.com/prodserv/smartphone-os-market-share.jsp

Jacquemard, T., Novitzky, P., O'Brolcháin, F., Smeaton, A., & Gordijn, B. (2014). Challenges and opportunities of lifelog technologies: A literature review and critical analysis. *Science and Engineering Ethics, 20*(2), 379-409. http://dx.doi.org/10.1007/s11948-013-9456-1

Kane, S., K, Jayant, C., Wobbrock, J., O, & Ladner, R., E. (2009). *Freedom to roam: A study of mobile device adoption and accessibility for people with visual and motor disabilities.* Paper presented at the ASSETS, Pittsburgh, 25-28 October 2009 .

KNFB Reader Garners AppleVis Golden Apple Award. (2016). Jacksonville: Professional Services Close - Up Le, T. A., Baydin, A. G., & Wood, F. (2016). Inference compilation and universal probabilistic programming. Retrieved from https://arxiv.org/abs/1610.09900

Liebs, A. (2016). Top iPhone apps for the blind & visually impaired. Retrieved from http://assistivetechnology.about.com/od/ATCAT6/tp/Top-10-Iphone-Apps-For-The-Visually-Impaired.htm

Livingstone-Lee, S. A., Skelton, R. W., & Livingston, N. (2014). Transit apps for people with brain injury and other cognitive disabilities: The state of the art. *Assistive Technology* . http://dx.doi.org/10.1080/10400435.2014.930076

Lupton, D., & Seymour, W. (2000). Technology, selfhood and physical disability. *Social Science & Medicine, 50*(12), 1851-1862. http://dx.doi.org/10.1016/S0277-9536(99)00422-0

Matthews, H., Beale, L., Picton, P., & Briggs, D. (2003). Modelling access with GIS in Urban Systems (MAGUS): capturing the experiences of wheelchair users. *Area, 35*(1), 34-45. http://dx.doi.org/10.1111/1475-4762.00108

McNaughton, D., & Light, J. (2013). The iPad and mobile technology revolution: Benefits and challenges for individuals who require augmentative and alternative communication. *Augmentative and Alternative Communication, 29*(2), 107-116. http://dx.doi.org/10.3109/07434618.2013.784930

Montreal In/Accessible. (2014). Montreal in/accessible – Megafone. Retrieved from http://mia.mobilities.ca/megafone/

Morris, J., Mueller, J., Jones, M. L., & Lippincott, B. (2013). Wireless technology use and disability: Results from a national survey. *Journal on Technology and Persons with Disabilities, 1*(23).

Naslund, R., & Gardelli, A. (2013). "I know, I can, I will try": Youths and adults with intellectual disabilities in Sweden using information and communication technology in their everyday life. *Disability & Society, 28*(1), 28-40. http://dx.doi.org/10.1080/09687599.2012.695528

Office for National Statistics GB. (2016). Internet users in the UK: 2016. Retrieved from https://www.ons.gov.uk/businessindustryandtrade/itandinternetindustry/bulletins/internetusers/2016#things-you-need-to-know

Okuyama, Y. (2013). A case study of US deaf teens' text messaging: Their innovations and adoption of textisms. *New Media & Society, 15*(8), 1224-1240. http://dx.doi.org/10.1177/1461444813480014

Raising the Floor. (2017). GPII. Retrieved from http://www.gpii.net/

Ryskamp, D. (2015, 31 December). If you like it then you shoulda put a paycheque on it. Retrieved from https://autisticacademic.com/2015/12/31/if-you-like-it-then-you-shoulda-put-a-paycheck-on-it-my-real-problem-with-the-mighty/

Schmöcker, J.-D., Quddus, M., Noland, R., & Bell, M. (2005). Estimating trip generation of elderly and disabled people: Analysis of London data. *Transportation Research Record:*

Journal of the Transportation Research Board, 1924, 9-18. http://dx.doi.org/10.3141/1924-02

Shen, H., Coughlan, J., Brabyn, J., & Chan, K.-Y. (2008). A mobile phone system to find crosswalks for visually impaired pedestrians. *Technology and Disability, 20*(3), 217-224.

Smith, A. (2015). Mobile mania! Australians spend on average more than an hour a day on their smartphones. Retrieved from http://www.nielsen.com/au/en/insights/news/2015/mobile-mania-australians-spend-on-average-more-than-an-hour-a-day-on-their-smartphones.html

Smith, T. T., Cofield, R., Pierce, D., Rose, C., Gao, S., Nolen, J., & Sherman, A. (2015). Interactive navigation system with auditory and haptic cues in crosswalks, indoors and urban areas for the visually impaired. *IIE Annual Conference. Proceedings*, 1-11.

Söderström, S. (2009). Offline social ties and online use of computers: A study of disabled youth and their use of ICT advances. *New Media & Society*, 11, 709-727.

Söderström, S. (2011). Staying safe while on the move: Exploring differences in disabled and non-disabled young people's perceptions of the mobile phone's significance in daily life. *Young, 19*(1), 91-109. http://dx.doi.org/10.1177/110330881001900106

Söderström, S., & Ytterhus, B. (2010). The use and non-use of assistive technologies from the world of information and communication technology by visually impaired young people: a walk on the tightrope of peer inclusion. *Disability & Society, 25*(3), 303-315. http://dx.doi.org/10.1080/09687591003701215

Spinks, R. (2014, 30 August). The new technologies helping visually impaired people navigate cities. Retrieved from http://www.theguardian.com/sustainable-business/2014/aug/29/new-technologies-visually-impaired-navigate-cities

Taylor, Z., & Józefowicz, I. (2012). Intra-urban daily mobility of disabled people for recreational and leisure purposes. *Journal of Transport Geography, 24*, 155-172. http://dx.doi.org/10.1016/j.jtrangeo.2011.12.008

Volunteering Australia. (2015, 16 April). Key facts and statistics about volunteering in Australia. Retrieved from https://www.volunteeringaustralia.org/wp-content/uploads/VA-Key-statistics-about-Australian-volunteering-16-April-20151.pdf

W3C. (2008, 11 December). Web Content Accessibility Guidelines (WCAG) 2.0. Retrieved from http://www.w3.org/TR/WCAG20/

WA Deaf Society. (2011). Internet scams: How to protect yourself. Retrieved from https://www.youtube.com/user/internetscamsprotect

Web Access In Mnd. (2016). *Screen reader user survey #6 results*. Retrieved from http://webaim.org/projects/screenreadersurvey6/#mobileplatforms

Wersényi, G. (2015). Evaluation of a navigational application using auditory feedback to avoid veering for blind users on Android platform. *Journal of the Acoustical Society of America, 137*(4), 2206-2206. http://dx.doi.org/10.1121/1.4920025

Appendices

Appendices

Appendix 1: Curtin University Urban Spaces Tip Sheet I

Using smartphones to navigate urban spaces:
General tips for people with disability

Is a smartphone necessary for navigating urban spaces?

Curtin University has recently conducted research into how wheelchair users and people who are blind or vision impaired use smartphones to navigate urban spaces. The research findings indicate that smartphones can provide a number of benefits to help people with disability when navigating urban spaces. The research also indicated that many people are not aware of all the benefits smartphones can provide.

As such, tip sheets have been created to provide guidance on how a smartphone can be used to navigate urban spaces. In addition to this tip sheet there are also two additional tip sheets that provide specific guidance to wheelchair users and people who are blind or vision impaired respectively.

What are the benefits that smartphones can provide?

The following list highlights the key benefits that smartphones can provide:

- **Route planning:** you can use your smartphone's GPS and mapping apps to determine your location and find directions to your destination – by foot, by car or by using public transport.
- **Identification of surroundings:** you can also use your smartphone's GPS to provide information on where you are and what facilities are nearby, for example wheelchair-accessible toilets, cafes, parks and shops.
- **Weather:** you can use your smartphone to determine precise weather conditions and plan a day out.

- **Image recognition:** you can use your smartphone to take a photo of an object and then listen to a verbal description of it.
- **Text identification**: you can use your smartphone to scan text on signs and documents and then listen to the words being read out.
- **Web searches:** you can use your smartphone's web browser or digital assistant to help find information quickly while navigating urban spaces.

Which smartphone should people with disability choose?

There are two main operating systems available for smartphones. The first is Apple iOS which runs on the Apple iPhone. The second is Google Android which runs on most other smartphone brands such as Samsung, LG, Sony and Motorola.

While Android is more popular among consumers generally, research conducted by Curtin University suggests that people with disability tend to prefer an iPhone due to its ease of use, regular software upgrades, the Siri digital assistant and an increased number of accessible apps. However, some users favour Android due to the smartphones generally being more affordable while retaining similar accessibility features to the iPhone.

It is recommended that before purchasing a smartphone, people with disability try both an iPhone and an Android-based smartphone to decide which one is best for their needs.

What accessibility features are built into smartphones?

The accessibility features available in current smartphones include:

- **Screen reader:** you can use this feature to access spoken and tactile feedback on information on the screen. Navigation on the phone is achieved by moving your finger around the screen or performing swipe gesture commands. On the iPhone this feature is called Voiceover and in Android it is called Talkback.
- **Magnifier:** you can use this feature to zoom in or out of a determined portion of the screen, making it easier to see.
- **Colour correction and inversion:** you can use this feature to change or invert colours to make it more visually accessible for your needs.

- **Accessible touch:** you can use this feature to complete everyday smartphone tasks with a single touch, for example changing the volume, performing a swipe gesture or locking the smartphone.
- **Switch key control:** you can use this feature to complete multiple tasks at once through the use of switches.
- **Text-to-speech:** you can use this feature to listen to text out loud in circumstances where it is difficult to view the screen due to environmental factors.

For information regarding the accessibility features of smartphones, iPhone users can visit the Apple iOS accessibility resource. Android-related users can visit the Google accessibility resource.

What do people with disability need on their smartphone to navigate urban spaces?

Some helpful features are already built into a smartphone, while others will need to be downloaded. On the iPhone, apps can be downloaded from the App Store. On Android, apps can be downloaded from Google Play. There are four broad categories of app types that maximise support for navigating urban spaces. They are as follows:

- **Digital assistant:** you can use this app to provide convenient hands-free communication to perform basic tasks and web searches on your smartphone. On the iPhone use the Siri feature and on Android devices use OK Google.
- **Transportation apps:** you can use this app to assist with route planning and navigating from one place to another. Apps include Google Maps, Uber, Navigo and Should I Run? Google Maps has the additional benefit of providing some information on whether a location is wheelchair-accessible.
- **Point of interest identification:** you can use this app to find out useful information about facilities nearby such as the closest food outlets, banks and shopping centres. Apps include BlindSquare on the iPhone and Eye-D on Android devices.

- **Text and image analysis:** you can use this app and your smartphone's camera to identify objects and text on signs and documents. Apps include KNFB Reader and TapTapSee.

What issues do people with disability face when using smartphones to navigate urban spaces?

Although smartphones can provide many benefits for navigating urban spaces, there are still some limitations that people with disability should consider. They are as follows:

- **Navigation:** mapping apps are effective in navigating to a location but are not as effective in providing topographical information such as whether there are slopes, steep inclines or hills. Wheelchair users in particular should be mindful that currently such information on smartphones is limited.
- **Real-time calculations:** apps such as Should I Run? are useful in determining public transport options in real time. However, it is important to note that the tying calculations are generally based on walking speed. People with disability will need to convert these times into a suitable equivalent for such apps to be effective.
- **Indoor navigation:** while smartphones provide effective navigation for outdoor environments, the lack of GPS functionality indoors means that the ability to use a smartphone for indoor navigation remains limited.

Where can I get additional help regarding using a smartphone to navigate urban spaces?

For information regarding the research conducted by Curtin University and the creation of this tip sheet, please contact Associate Professor Katie Ellis, Internet Studies, Curtin University katie.ellis@curtin.edu.au. This research was funded by the Disability Services Commission Western Australia.

Appendix 2: Curtin University Urban Spaces Tip Sheet II

Using smartphones to navigate urban spaces:
Guidance for wheelchair users

Why do I need a smartphone when navigating urban spaces?

Smartphones can provide a number of benefits to help wheelchair users when navigating urban spaces. Research conducted by Curtin University has highlighted the following benefits a smartphone can provide:

- **Route planning:** you can use your smartphone's GPS and mapping apps to determine your location and find directions to your destination – by foot, by car or by using public transport.
- **Identification of surroundings:** you can also use your smartphone's GPS to provide information on where you are and what facilities are nearby, for example wheelchair-accessible toilets, cafes, parks and shops.
- **Weather:** you can use your smartphone to determine precise weather conditions and plan a day out.

Which smartphone should I choose?

There are two main operating systems available for smartphones. The first is Apple iOS which runs on the Apple iPhone. The second is Google Android which runs on most other smartphone brands such as Samsung, LG, Sony and Motorola.

While Android is more popular among consumers generally, research conducted by Curtin University suggests that wheelchair users tend to prefer an iPhone due to its ease of use, regular software upgrades and the Siri digital assistant. However, some wheelchair users favour Android due to the smartphones generally being more affordable while retaining similar accessibility features to the iPhone.

It is recommended that before purchasing a smartphone you try both an iPhone and an Android-based smartphone to decide which one is best for your needs.

What accessibility features are built into my smartphone?

The accessibility features available in current smartphones include:

- **Accessible touch:** you can use this feature to complete everyday smartphone tasks with a single touch, for example changing the volume, performing a swipe gesture or locking the smartphone.
- **Switch key control:** you can use this feature to complete multiple tasks at once through the use of switches.
- **Text-to-speech:** you can use this feature to listen to text out loud in circumstances where it is difficult to view the screen due to environmental factors.
- **Accessible touch:** allows for the completion of everyday smartphone tasks – like changing the volume, performing a swipe gesture and locking the smartphone – to be completed with a single touch.
- **Switch key control:** allows you to control a smartphone through the use of switches which can complete multiple tasks at once.
- **Text-to-speech:** allows for text to be read out loud in circumstances where it is difficult to view the screen due to environmental factors.

What apps and websites do I need to use when navigating urban spaces?

There are a number of features, apps and websites specifically recommended by wheelchair users to assist with navigating urban spaces.

- **Digital assistant:** you can use these apps to provide convenient hands-free communication to perform basic tasks and web searches on your smartphone. On the iPhone use the Siri feature and on Android devices use OK Google.
- **Transportation apps:** you can use these apps to assist with route planning and navigating from one place to another. Apps include Google Maps, Uber, Navigo and Should I Run? Google Maps has the additional benefit of providing some information on whether a location is wheelchair-accessible.
- **Digital assistants:** The Siri Digital Assistant on the iPhone and the 'OK Google' digital assistant on Android provide hands-free functionality to perform tasks and web searches.
- **Route planning and navigation:** It is recommended that both iPhone and Android users use in preference to where possible. Google Maps are generally

considered more accurate and it now has the added benefit of being able to determine to some degree if a .

- **Public transport:** apps such as For the iPhone can be helpful in calculating the time required to catch the first available public transport option.
- **Weather:** you can use these apps to find out accurate real-time weather information.
- **Public toilets:** you can use these apps to access the National Accessible Toilet Map – a website that provides guidance on the location of accessible public toilets.
- **Tourism:** you can access websites such as the WA government's Tourism Australia site to find out information about wheelchair-accessible facilities in Western Australia.

To download the apps you will need to use the App Store on the iPhone or the Play Store on Android. The web resources can be viewed in a mobile browser such as Safari on the iPhone or Chrome on Android.

What issues am I likely to face when using a smartphone to assist me?

Wheelchair users have indicated that a smartphone is considered essential for navigating urban spaces. However, there are two issues that need to be kept in mind when using the suggested apps and websites:

- While maps are useful in identifying how far away a location is, it may not be presenting the best wheelchair-accessible path. For example, maps will not reveal if there are steep slopes or inclines between you and your location which may lead to challenging situations or delays. As such it is always recommended to allow extra time to reach your destination if relying on your smartphone for directions.
- Apps such as Should I Run? are useful in determining public transport options in real time. However, it is important to note that the tying calculations are generally based on walking speed. Wheelchair users will need to convert these times into a suitable equivalent for such apps to be effective.

Where can I get additional help regarding using a smartphone to navigate urban spaces?

For information regarding the accessibility features of smartphones, iPhone users can visit the Apple iOS accessibility resource. Android-related users can visit the Google accessibility resource.

For information regarding the research conducted by Curtin University and the creation of this tip sheet, please contact Associate Professor Katie Ellis, Internet Studies, Curtin University katie.ellis@curtin.edu.au. This research was funded by the Disability Services Commission Western Australia.

Appendix 3: Curtin University Urban Spaces Tip Sheet III

Using smartphones to navigate urban spaces:
Guidance for people who are blind or vision impaired

Why do I need a smartphone when navigating urban spaces?

Smartphones can provide a number of benefits to help people who are blind or vision impaired when navigating urban spaces. Research conducted by Curtin University has highlighted the following benefits a smartphone can provide:

- **Route planning:** you can use your smartphone's GPS and mapping apps to determine your location and find directions to your destination – by foot, by car or by using public transport.
- **Identification of surroundings:** you can also use your smartphone's GPS to provide information on where you are and what facilities are nearby, for example wheelchair-accessible toilets, cafes, parks and shops.
- **Weather:** you can use your smartphone to determine precise weather conditions and plan a day out.
- **Image recognition:** you can use your smartphone to take a photo of an object and then listen to a verbal description of it.
- **Text identification**: you can use your smartphone to scan text on signs and documents and then listen to the words being read out.
- **Web searches:** you can use your smartphone's web browser or digital assistant to help find information quickly while navigating urban spaces.
- **Image recognition:** smartphones can read out descriptions of objects nearby by taking a photo of them.
- **Text identification:** smartphones can scan text on signs and documents which can then be read out to you.
- **Web searches:** using the web browser or digital assistant can help to find information quickly while navigating urban spaces.

Which smartphone should I choose?

There are two main operating systems available for smartphones. The first is Apple iOS which runs on the Apple iPhone. The second is Google Android which runs on most other smartphone brands such as Samsung, LG, Sony and Motorola.

While Android is more popular among consumers generally, research conducted by Curtin University suggests that people who are blind or vision impaired tend to prefer an iPhone due to its ease of use, regular software upgrades and an increased number of accessible apps. However, some blind and vision impaired users favour Android due to the smartphones generally being more affordable while retaining similar accessibility features to the iPhone.

It is recommended that before purchasing a smartphone you try both an iPhone and an Android-based smartphone to decide which one is best for your needs.

What accessibility features are built into my smartphone?

The accessibility features available in current smartphones include:

- **Screen reader:** you can use this feature to access spoken and tactile feedback on information on the screen. Navigation on the phone is achieved by moving your finger around the screen or performing swipe gesture commands. On the iPhone this feature is called Voiceover and in Android it is called Talkback.
- **Magnifier:** you can use this feature to zoom in or out of a determined portion of the screen, making it easier to see.
- **Colour correction and inversion:** you can use this feature to change or invert colours to make it more visually accessible for your needs.
- **Screen reader:** an accessibility featured that provides spoken and tactile feedback to the user. Navigation on the phone is achieved by moving the finger around the screen or performing swipe gesture commands. In the iPhone this feature is called Voiceover and in Android it is called Talkback.
- **Magnifier:** an accessibility feature that allows the user to zoom in or out of a portion of the screen, making it easier to see
- **Colour correction and inversion:** accessibility features that allow for the colours to be changed or inverted to assist people that cannot see particular colours.

What apps do I need to navigate urban spaces?

Some helpful features are already built into your smartphone, while others you will need to download. On the iPhone, apps can be downloaded from the App Store. On Android, apps can be downloaded from Google Play. People who are blind or vision impaired specifically recommended the following apps as useful when navigating urban spaces.

Type	**iPhone**	**Android**
Built-in features	Apple Maps Siri Digital Assistant	Google Maps
Transportation apps	Google Maps Uber Transit Navigon Australia Should I Run?	Stop Announcer Uber Navigon Australia
Point of interest identification apps	BlindSquare Guide Dogs NSW/ACT	Eye-D
Text and image identification apps	KNFB Reader TapTapSee	KNFB Reader TapTapSee Eye-D

Where can I get additional help regarding using a smartphone to navigate urban spaces?

For information regarding the accessibility features of smartphones, iPhone users can visit the Apple iOS accessibility resource. Android-related users can visit the Google accessibility resource.

For information regarding the research conducted by Curtin University and the creation of this tip sheet, please contact Associate Professor Katie Ellis, Internet Studies, Curtin University katie.ellis@curtin.edu.au. This research was funded by the Disability Services Commission Western Australia.

Appendix 4: Applications That Can Make Live Easier

This information sheet was created by Visability and made available to the researchers during the course of the study.

[insert info]