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The VI Nav Cards: A Holistic Approach to Supporting the Design of Navigation Aids for the Blind and Visually Impaired

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بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِيْمِ

قُلْ هُوَ الَّذِي أَنشَأَكُمْ وَجَعَلَ لَكُمُ السَّمْعَ وَالْأَبْصَارَ وَالْأَفْئِدَةَ ۖ

قَلِيلًا مَّا تَشْكُرُونَ

Say, “It is He who has produced you and made for you hearing and vision and hearts; little are you grateful.” — The Holy Quran, 67:23

Abstract

The Royal National Institute for Blind People (RNIB) estimates that there are around two million Blind and Visually Impaired (B/VI) people in the UK. Due primarily to the general ageing of the population, this number is expected to increase to four million by 2050. Previous research has highlighted that B/VI people frequently experience problems with their mobility and thus desire improved means for travel and navigation. As a consequence, researchers and industry put much effort into producing a range of navigation aids. Nevertheless, there is considerable evidence that such supporting mechanisms typically fail to satisfy the wide range of needs that B/VI people have for their aids, and thus tend to have low adoption rates.

The aim of this thesis is to curate the various needs that B/VI people have for their navigation aids, and package this design knowledge into a novel set of ideation cards that can be used to better support B/VI navigation aid design. The principal benefit of using ideation cards over other methods of democratising academic design knowledge, such as design guidelines, is the utility of ideation cards in creative design sessions. The intention is that, by using ideation cards, designers will be better positioned to consider at the point of design the wide range of needs that B/VI people have for their navigation aids and thus be better equipped to produce navigation aids that satisfy the full scope of needs.

Although ideation cards may be developed by following a participatory design methodology, this research does not take such an approach.

To collect the needs, I conducted in-depth interviews with nine B/VI people and two employees of Wayfindr, a leading navigation aid design con-

sultancy based in London. The cards were created following Golembewski and Selby's (2010) five-step method for creating ideation decks. The cards were then evaluated in a set of trial studies with seven human factors researchers, three executives of the Guide Dogs charity in the UK , and a VI person. All data was analysed using Braun and Clarke's (2012) Thematic Analysis method.

My thesis makes fives main contributions. Firstly, my research contributes a set of ideation cards , known as the VI Nav cards, that can be used to design and evaluate navigation aids to support the needs of B/VI people. The intention is that these cards can be used to embed a holistic consideration of the needs of B/VI people into future navigation aid design efforts.

Secondly, while the literature typically only discusses the challenges that B/VI people face 'outdoors' and 'indoors', there is little discussion of the types of challenges that occur in specific environments, e.g. Train Stations, Shopping Centres, Airports. An understanding of this is important, as different types of locations under these general headings are far from homogeneous. I outline the navigation challenges that can occur in specific environments mentioned by my participants.

Thirdly, although there is much discussion in the literature about the needs that B/VI people may have for their navigation aids, there is little, if any, discussion of the barriers that can prevent an aid from becoming successful commercially. Understanding these requirements is important if navigation aids are to go on to have a significant impact on the B/VI community and I present and discuss the important commercial factors from the perspectives of B/VI users and of industry.

Fourthly, ideation cards are typically only presented as methods of gener-

ating ideas. Because of the incorporation of an evaluation element in my cards, I demonstrate how ideation cards can be used more widely to evaluate pre-existing ideas, even those of third-parties. This is very useful for organisations such as Guide Dogs or the RNIB who may wish to check for common issues before making recommendations of tools to their service users.

Finally, this thesis defines how ideation cards, and their usage, can be made accessible to B/VI people. This is important not only for the cards in this thesis, but also for the wider HCI design community, as they continue to strive to make their practises and methods participatory and accessible to all.

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Any opinions, findings, conclusions or recommendations expressed in this thesis are the view of the author, and do not necessarily reflect the views of any of the sponsors.

List of Publications

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Overview

Chapter 1

Introduction

1.1 General Introduction

The Royal National Institute for Blind People (RNIB) estimates that there are around two million blind or visually impaired (B/VI) people in the UK. In 2015, the RNIB conducted the “My Voice” survey (Slade & Edwards, 2015), which presents findings from telephone interviews with over 1,200 B/VI people in the UK. The survey asked questions related to a wide variety of life areas such as finances and employment, social life, well-being, and transport, and ultimately aimed to help “better understand the circumstances, views and experiences of registered blind and partially sighted people over time”. The report from the survey reveals that over half of B/VI people need support to get out of the house; 40% are unable to make all the journeys that they want or need to make; 23% are rarely or never able to get out and about how and when they choose; 22% were only “sometimes able”; and nearly two-thirds (61%) of B/VI people identified problems related to sight loss as a barrier to travel.

Perhaps most telling is that, although the My Voice survey asked questions

related to many areas of life and not just navigation, when the 1,223 participants of the My Voice survey were asked “What is the one thing that would make everyday life better for you?”, the most frequently mentioned theme was the desire for easier travel (Slade & Edwards, 2015, pp. 43-44).

In order to address the wide array of navigation challenges that the B/VI community face on a day-to-day basis, researchers and industry put much effort into developing a variety of navigation aids, many of which are technologically very impressive.

Yet, despite these efforts, there is a theme in the literature which has persisted for more than a decade that these navigation aids typically fail to address the complete set of needs that B/VI people have, and thus tend to have low adoption rates (Bernardine Dias, Steinfeld, & Beatrice Dias, 2015; Giudice & Legge, 2008; Gori, Cappagli, Tonelli, Baud-Bovy, & Finocchietti, 2016; Padmanaban & Krukar, 2016; Sanchez & Elias, 2007). Padmanaban and Krukar (2016, p. 135), for example, write that considering the user needs of B/VI navigators is “a neglected research area” and that “creators of navigational aids for the blind are limited in their understanding of the true user needs and wishes”.

Interestingly, however, research already exists on what the functional and non-functional needs of B/VI navigators may be (Beatrice Dias et al., 2015; Golledge, 2004; Williams, Galbraith, Kane, & Hurst, 2014; Williams, Hurst, & Kane, 2013). Therefore, there appears to be a disconnect between the research on the needs of B/VI people, and the prototypes produced by the research community.

I propose that part of the issue may be that designers are lacking a method for integrating into the design process a consideration of the wide range of needs that the B/VI community have, and are thus struggling to design in a user-centred way.

The absence of such a method is a gap that has long been unaddressed, and is one that I hope to contribute to through the work of this thesis. My work has led to the development of a novel set of ideation cards that can be used to support the development of new navigation aids for the B/VI community. I hope that the design tool that this thesis presents can be used to foster a more user-focused approach to navigation aid development, and help to produce a better quality of life for the blind and visually impaired.

This thesis is structured in five parts. Part I presents a review of the existing literature on navigation (chapter 2), the navigation challenges faced by the visually impaired in their daily lives (chapter 3), the different types of navigation aids that are in use and under development (chapter 4), and the literature on ideation cards (chapter 5).

After conducting the literature review, I noticed two gaps. Firstly, I noticed the research gap mentioned above that the navigation aids being developed for B/VI people tend to not take account of their full range of needs.

In part II, I set out to find what these needs were. When curating the needs, I use Hassenzahl (2007)'s pragmatic/hedonic framework of product qualities, which has been widely adopted in the fields of human factors, user experience, and human-computer interaction (Diefenbach, Gerber, & Hassenzahl, 2014). Hassenzahl proposes that users evaluate products based on two types of qualities: pragmatic qualities and hedonic qualities. Pragmatic qualities help the user to achieve what Hassenzahl calls 'do goals', and incorporate qualities related to functionality and usability. Hedonic qualities are typically treated as dichotomous with pragmatic qualities (Diefenbach et al., 2014), and help the user to achieve 'be goals'; Hassenzahl mentions "being competent", "being related to others", and "being special" as examples of 'be goals'.

Taking this framework, I define the term "need" in this thesis as a quality that

a user has expressed as being desirable. Therefore, when I refer to 'pragmatic needs' or 'hedonic needs' in this thesis, I am referring to the pragmatic or hedonic qualities that B/VI users expressed as being desirable for their navigation aids.

To collect the needs, I conducted interviews with nine B/VI participants and an interview with two employees from Wayfindr, a leading indoor navigation aid design and consultancy company, based in London. I analysed the data using Braun and Clarke (2012)'s thematic analysis method (chapter 7). Taken together, these interviews also allowed me to extend the list of pragmatic and hedonic needs that B/VI people have for their navigation aids, as well as gain insight into the commercial barriers to an aid's success that designers may need to overcome.

In part III, I package this learning into a set of ideation cards. Ideation cards are a type of card-based design method that use card-game style mechanics to help designers to generate design ideas (Wetzel, 2017). Unlike other methods of packaging design knowledge gained from academia, such as design guidelines, ideation cards are easily usable in creative design sessions (Wetzel, 2017). By providing structure to the gameplay and repositories of useful concepts at each stage, ideation cards help guide designers through a design process and help to avoid common mistakes along the way (Wetzel, 2017). Part III describes how the cards were created, and also demonstrates their contents and their intended use.

Part IV discusses the findings from a set of four trial studies that were conducted to evaluate the cards. The trials which involved seven human factors researchers, one B/VI person, and three executives from the Guide Dogs charity. After a brief discussion of how each session went (chapter 14), chapter 15 presents the feedback that participants of those studies gave and presents how the cards can be improved. Based on this feedback, chap-

ter 16 presents a discussion of how ideation card sessions can be made accessible to B/VI people, which serves as a novel contribution to the ideation card literature.

Finally, part V concludes the work with a summary of the thesis contents, and demonstrates its main contributions, limitations and future work.

1.2 Research Aims

Aim 1: To confirm the general challenges faced by B/VI people that are reported in the literature, and to investigate the particular navigation challenges that B/VI people face in specific environments.

Approach:

1. To conduct interview studies with B/VI people and compare the findings to the literature on VI navigation challenges. This will provide the opportunity to confirm the literature findings and the opportunity to identify navigation challenges that have not yet been discussed in the literature.

Aim 2: To understand the pragmatic needs that B/VI people have for their navigation aids

Approach:

1. To synthesise data from the interviews with the literature on navigation and on B/VI navigation challenges to produce a descriptive model of B/VI navigation, and use that model to propose the functional needs that B/VI people have for their navigation aids.

2. To use the data from interviews with B/VI people to collect data that can be compared to the literature findings about the usability needs that B/VI people have for their aids, and to identify other ones that may have been missed.

3. To conduct an interview with employees from a leading navigation aid design and consultancy company, Wayfindr, and use the data from it and from the interviews with B/VI people to understand the factors related to a navigation aid's commercial success from both the customer and industrial points of view.

Aim 3: To understand the hedonic needs that B/VI people have for their navigation aids

Approach:

1. To use the data from interviews with B/VI people to confirm the literature findings about the hedonic needs that B/VI people have for their aids, and to potentially identify other ones that have not yet been discussed in the literature.

Aim 4: To condense the findings from the previous three aims into a set of ideation cards, and determine the suitability of the cards for generating and evaluating navigation aid ideas.

Approach:

1. To create a set of ideation cards that packages the findings from the previous stages into a form that is usable in creative design sessions.

2. To conduct trial sessions of the cards with some human factors researchers and some employees from the Guide Dogs charity to de-

termine the appropriateness of using ideation cards as a method for supporting the design and evaluation of B/VI navigation aids.

Aim 5: To understand how ideation cards can be made accessible to B/VI people.

Approach:

1. To use data from the card trials, as well as the data from an additional demonstration interview with a VI participant, to investigate how ideation cards may be made accessible to VI people.

Part I

Literature Review

Chapter 2

Navigation Literature

Navigation is most commonly defined in the literature as the purposeful or goal-directed movement through space (Freundschuh, 2001; Montello, 2005). Successful navigation may be defined as arriving at one's destination in a safe and efficient manner (Giudice & Legge, 2008; Montello, 2005).

Navigation is frequently conceptualised as having two components: wayfinding and locomotion (Darken & Peterson, 2014; Golledge, 1999; Montello & Sas, 2006). Although they are often only truly separable conceptually (Montello, 2005), locomotion refers to the physical component of navigation and to tasks related to moving one's body through space, whereas wayfinding refers to the more cognitive aspects of navigation.

Locomotion, as the physical component of navigation, can only occur within a navigator's immediate environment and sensory horizon (Wiener, Büchner, & Hölscher, 2009). Successful locomotion requires the use of many unconscious processes such as steering, avoiding obstacles, and maintaining one's balance (Freundschuh, 2001; Montello, 2001, 2005). Often, we are unaware of precisely how we locomote; we are just aware that we do.

Wayfinding, on the other hand, is the more cognitive component of naviga-

tion. Wayfinding uses an individual's faculties of spatial cognition (Montello, 2001) to allow movement towards distant locations that are beyond the navigator's current sensory horizon (Freundschuh, 2001). Typical wayfinding tasks include planning trips, selecting routes through an environment and orienting oneself towards a distal non-perceptible landmark (Montello & Sas, 2006).

As an individual moves through space, they are understood to draw upon their abilities of spatial cognition, i.e. their ability to receive, process and act appropriately on spatial knowledge (Golledge, 1999). This spatial knowledge may be acquired in real-time, as in locomotion, or it may be acquired ahead of time and recalled from memory, as in wayfinding.

Humans can either acquire spatial knowledge through direct sensorimotor experience of an environment or through the examination and interpretation of some form of externalised "spatial representation" (Golledge, 1999) or "spatial product" (Liben, 1982) such as maps, images, computational models, and verbal directions from others (Golledge, 1999; Montello, 2001; Tellevik, 1992).

As spatial cognition is a cognitive process and, therefore, occurs within the navigator's mind, all such externalised representations only become useful when a navigator actively uses their senses and mind to interpret the spatial knowledge they contain and encode this information into what is known as a cognitive map (Golledge, 1999).

The term "cognitive map" was first coined by Tolman (1948). The particular wording attached to the term has been criticised in the literature, with some saying that it is misleading and that the wording implies a model (map) of cognition (Eden, 1992). In actuality, cognitive maps are a similar concept to that of a mental model in the human factors literature (Johnson-Laird, 1983): a cognitive map is essentially a navigator's own heuristic mental model of an

environment or route.

As wayfinding is concerned with helping the navigator to arrive at locations beyond their current sensory horizon, navigators engaged in wayfinding tasks, by definition, cannot access all the spatial information/knowledge required to reach their goal using their senses alone. Therefore, wayfinding typically requires the navigator to have access to a sufficiently-developed representation of spatial knowledge that is applicable to their wayfinding task. Therefore, cognitive maps are a critical component of successful wayfinding and navigation.

Although it is accepted that cognitive maps are constructed from spatial knowledge and that one's cognitive map knowledge is being continually updated over time (Golledge, 1999), the actual structure of cognitive maps is still under debate (Chrastil, 2013).

Perhaps the most commonly used model of cognitive map development is Siegel and White's Landmark-Route-Survey (LRS) model (Siegel & White, 1975).

In the LRS model, the development of a cognitive map occurs through a dynamic process known as environment learning, and one's knowledge of a given environment increases in a hierarchical fashion (Siegel and White, 1975). The LRS model is based on the Euclidean view that space can be represented by points, lines, areas, and surfaces. At the lowest level of spatial knowledge, an individual will first identify key points within an environment. These useful points are called landmarks, and thus the navigator is said to have acquired landmark knowledge. As their landmark knowledge increases, an individual will begin to be able to determine spatial relationships between these landmarks and thus be able to identify routes between them, thus acquiring route knowledge. Over time, as more landmarks are discovered and more routes between them are determined, routes begin

to become perceived not as isolated links but as part of an interconnected route network spanning a given area (Golledge, 1999; Siegel & White, 1975), known as survey knowledge. Survey knowledge is analogous to knowledge of Euclidean areas and Euclidean surfaces, and may, therefore, also incorporate three-dimensional properties of an environment, such as elevation (Golledge, 1990).

The LRS model is an established model of spatial knowledge which has the benefits of being intuitive and of being empirically supported in terms of navigation behaviour (Golledge, 1990; Golledge, 1999). Several criticisms of the LRS model do exist, however.

Some criticisms note that, although the LRS model suggests that spatial knowledge develops in a hierarchical fashion, with landmark knowledge being acquired first and survey knowledge being acquired last, people can, and often do, acquire survey knowledge directly. An example of this is when a navigator looks at a map of an environment and directly begins to accumulate survey knowledge of it, or when someone takes a visual scan of an area from an elevated vantage point. Thorndyke and Hayes-Roth (1982), for example, demonstrated that map-based learning is, in fact, a type of learning that is entirely distinct from the environmental learning that occurs from direct experience. In circumstances where the navigator has very little direct experience with a space, this type of learning may even be more effective than experiential learning (Thorndyke & Hayes-Roth, 1982).

Others, such as Chrastil (2013) criticise the LRS model from a neurological standpoint, and note that, due to its simplicity, the LRS model may not be best suited for understanding actual brain functioning during environmental learning. That said, Chrastil does acknowledge the practical utility of the LRS model for understanding and describing navigation behaviour (Chrastil, 2013, p. 208).

Although there are criticisms about the order in which the different types of spatial knowledge are accumulated, as well as disputations about neurological validity of the model, there is not any apparent dispute about the existence of the three types of spatial knowledge represented by the LRS model, nor any dispute about the utility of the LRS model in understanding actual navigation behaviour. As such, the LRS model is still the default model of spatial knowledge development and, as can be seen from the work by Gomez, Langdon, and Clarkson (2016), is still used in navigation research today.

Landmarks are a core part of cognitive maps and represent the most basic element of spatial knowledge: the knowledge of a key point. Landmarks have a range of uses, such as serving as a home-base or as an anchor around which to situate other knowledge in one's cognitive map (Golledge, Gale, Pellegrino, & Doherty, 1992; Golledge, 1999). For such an important concept, it is interesting that there is ongoing discussion around what constitutes a landmark. In her paper, Kaplan defines a landmark as "a known place for which an individual has a well formed representation" (Kaplan, 1976, p. 42).

Kaplan outlines two main qualities that lead to an object/place becoming a landmark: the frequency with which one is in contact with a given object or place, and the distinctiveness of that object or place.

In a relatively unfamiliar environment, Kaplan's writings suggest that it will be the property of distinctiveness that primarily determines whether or not an object or place becomes a landmark as the navigator's frequency of exposure will be relatively low. Distinctiveness was also seen as a critical component of landmarks by Lynch (1960). Lynch writes in his influential book, "The Image of the City", that the use of landmarks "involves the singling out of one element from a host of possibilities" (Lynch, 1960, p.78).

Kaplan hypothesises that there are three types of distinctiveness: visual distinctiveness, inferred distinctiveness, and functional distinctiveness.

Visual distinctiveness is a completely sensory type of distinctiveness, and can be thought to arise from physical properties of a place that are unusual in their surroundings (Burnett, 1998); such properties may include colour, size, shape, luminescence, opacity and others. Burnett (1998) gives the example of a tall tower among small buildings; in this example, the tall tower is a landmark that is highly visually distinct by virtue of its size.

While visual distinctiveness is an objective property based purely on the sense of sight, inferred distinctiveness requires some form of knowledge of the context where the object or place is situated (Kaplan, 1976). As an example, one can consider a large luxurious home in an extremely low-income area. A navigator may deem it unusual to find such a home within the area, and, therefore, infer the distinctiveness of the house using prior knowledge of the area's level of income. In an extremely high income area where such homes may be more abundant, the very same home would have less inferred distinctiveness.

Finally, Kaplan hypothesises functional distinctiveness. Functional distinctiveness arises because of the functional benefit that a place or object has for the navigator. As Burnett (1998) points out, this makes functional distinctiveness a more subjective type of distinctiveness as functionality will be related to a navigator's individual movement patterns and goals.

In addition to Kaplan's (1976) three types of distinctiveness, more recent writings such as those by Balaban, Röser, and Hamburger (2014) and Palmiero and Piccardi (2017) also empirically address the importance of emotion in landmark distinctiveness. The importance of emotions has, until recently, been rather neglected in the wayfinding literature but the empirical data generated by the above studies can be used to argue for a fourth type of

distinctiveness, termed emotional salience by Balaban et al., 2014. Another suitable name for this may perhaps be emotional distinctiveness to follow the nomenclature of Kaplan. Examples of landmarks with emotional salience/distinctiveness may be a graveyard or one's childhood home.

Alongside the concept of distinctiveness, the quality of permanence within an environment has been cited by Burnett (1998) as a fundamental prerequisite of landmarks. Burnett uses empirical data to suggest that navigators assume landmarks to be permanent within the environment and will "physically be there" when they intend to use them. Burnett also cites visibility as another important factor for landmark choice.

In order to reach a destination beyond their sensory horizon, it is necessary for navigators to relate the information that they can access from their senses to the information that they have stored within their cognitive map; this task is known as orientation (Montello, 2005). Orientation can be rather simply defined as 'knowing where you are' (Montello, 2001) or more formally as an awareness of one's 'location relative to their destination and to other places or objects' (Montello, 2005). On a more granular level, orientation is thought to be comprised of one's ability to determine their location within a space, their ability to determine bearings to other locations, their ability to determine distances to other locations, and their ability to determine which way they are facing within the environment (i.e. determining their heading) (Montello, 2005, p. 264, 267).

Orientation is a dynamic process, and a navigator can be oriented to varying degrees. Their degree of orientation depends on how accurate and complete the navigator's cognitive map of the space is, and on the navigator's individual spatial ability (Lawton, 1994; Montello, 2005). If an individual becomes significantly geographically dis-oriented they experience what is commonly known as being/feeling "lost" (Montello, 2005), and unnecessary effort, both

physically and emotionally (Montello & Sas, 2006, p. 4), must be exerted to reach one's destination.

A navigator's degree of orientation is continually being updated as they move through a space and this updating occurs via a combination of two types of processes: landmark-based processes and dead-reckoning (Allen, 1999a; Montello, 2005).

Landmark-based processes, also known as piloting (Allen, 1999a), involve the identification of landmarks, as well as the use of one's own internal cognitive map of the space to understand where those landmarks are positioned within the environment, and to infer one's position in the environment relative to those landmarks (Allen, 1999b).

Dead-reckoning, on the other hand, involves an individual mentally keeping track of internal kinematic cues from their vestibular system such as their velocity, their acceleration, and the time they have been travelling since they were last sure of their location, and using this information to estimate their current position in space (Montello, 2005). Because of the mental calculations involved on the vector quantities of velocity and acceleration to determine a position in space, dead-reckoning is also referred to in the literature as path integration (Gallistel, 1990; Golledge, 1999; Loomis et al., 1993). Dead-reckoning processes are typically less-reliable than landmark-based processes and compound error over time if they are not suitably corrected by landmark-based processes at regular intervals (Montello, 2005).

Although required for everyday life, navigation is a highly complex and multifaceted process. Navigation has physical, cognitive, and emotional components, all of which combine together to form a holistic system.

For B/VI people, the situation is complicated even further, giving rise to a plethora of extra challenges that our field aims to address and alleviate.

Chapter 3

B/VI Navigation Challenges

3.1 An Introduction the Blind and Visually Impaired

There are around 360,000 registered B/VI people in the UK, but it is expected that only a small proportion of B/VI people officially register their condition. The RNIB estimates that there are currently more than two million B/VI people in the UK, and due to the general ageing of the population, this number is expected to double to over four million people by 2050 (RNIB, n.d.-b).

In this section, I shall discuss how blindness and visual impairment are defined, present some example eye conditions, and discuss the impacts that blindness and visual impairment have on an individual's ability to navigate.

3.1.1 Defining Blindness and Visual Impairment

When conducting eye examinations to determine the quality of someone's sight, consultant opthalmologists will measure the quality of vision in a pa-

tient's visual field, and measure their visual acuity (RNIB, n.d.-d). The term 'visual field' refers to a patient's peripheral vision and is measured by a visual field test. The term Visual acuity refers to the quality of the patient's central vision in their better eye, after correction with glasses, contact lenses or surgery. Visual acuity is measured using a Snellen test. A Snellen test involves a patient reading a board which contains rows of letters; the letters get smaller towards the bottom of the board, and the further down the board that patient can correctly read, the better their visual acuity. Results of Snellen tests take the form a/b to represent the ratio of the distance where the patient can see clearly, a, to the distance that a person with normal vision could see those same letters clearly, b. Being able to read the second line from the bottom means that the patient has normal vision, which is represented by a Snellen's score of 6/6. A score of 6/6 means that the patient can see from 6 metres away (the distance the patient is sat from the board during the test) what a person with normal vision can see at 6 metres away. A score of $6/6$ is equivalent to a score of $20/20$, when converted to imperial feet. Being able to only read the top line in a Snellen test would result in a score of $6/60$ (RNIB, n.d.-d).

Based on the results of these visual acuity and visual field tests, a person may be categorised as sight impaired (other terms include partially sighted and visually impaired) or severely sight impaired (blind). There are various ways to be categorised in either group depending on the combination of the patient's visual acuity and visual field. The RNIB (n.d.-d) uses the following criteria to define partial sightedness (visual impairment):

- Visual acuity of 3 / 60 to 6 / 60 with a full field of vision.
- Visual acuity of up to 6 / 24 with a moderate reduction of field of vision or with a central part of vision that is cloudy or blurry.
- Visual acuity of 6 / 18 or even better if a large part of your field of

vision, for example a whole half of your vision, is missing or a lot of your peripheral vision is missing.

and use the following criteria to define blindness (RNIB, n.d.-d):

- Visual acuity of less than 3 / 60 with a full visual field.
- Visual acuity between 3 / 60 and 6 / 60 with a severe reduction of field of vision, such as tunnel vision.
- Visual acuity of 6 / 60 or above but with a very reduced field of vision, especially if a lot of sight is missing in the lower part of the field.

When I refer to B/VI people in this thesis, I am referring to people that fit into one of these categories defined by the RNIB.

Visual impairment and blindness can be caused by a wide variety of conditions, and each condition provides differing visual symptoms. Figure 3.1 presents the most common eye conditions that can result in a visual impairment according to The World Health Organisation's 'World Report on Vision' (WHO, 2019, p.7). According to 2010 US census data, the most common of these conditions are cateract, diabetic retinopathy, glaucoma, and age-related macular degeneration Institute (2019).

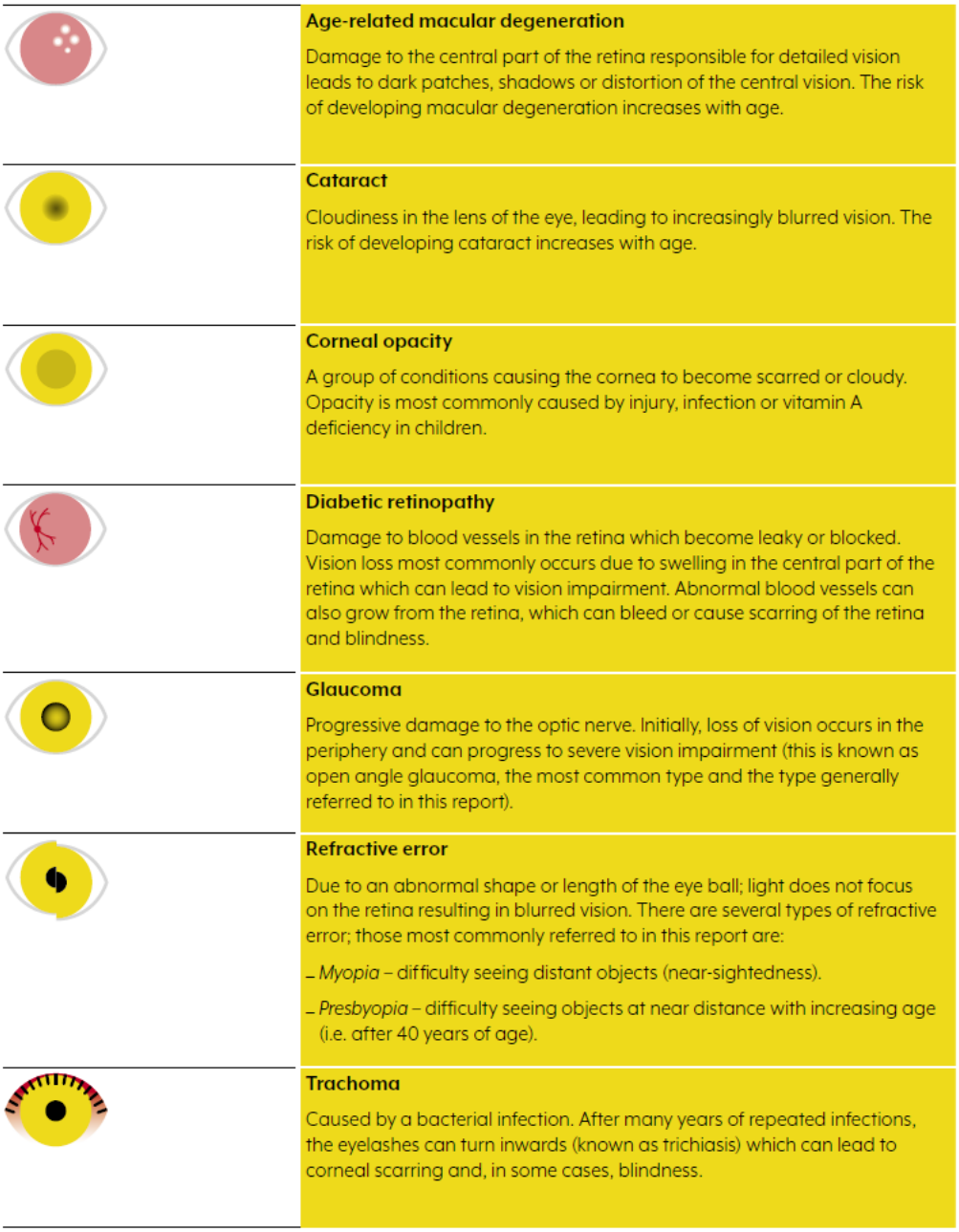


Figure 3.1: *An infographic appropriated from the World Health Organisation's 'World Report on Vision' (WHO, 2019, p.7) demonstrating the most common eye conditions that can cause visual impairment and their symptoms*

3.1.2 The Impacts of Visual Impairment on Mobility and Quality of Life

As mentioned in the thesis introduction, when the RNIB's My Voice survey asked the question "What is the one thing that would make everyday life bet-

ter for you?", the theme most frequently mentioned by the 1,223 participants was the desire for easier travel (Slade & Edwards, 2015, pp. 43-44). According to the report from the survey, over half of blind and partially sighted people need support to get out of the house; 40% of B/VI people are unable to make all the journeys that they want or need to make; 23% were rarely or never able to get out and about how and when they chose; 22% were only "sometimes able"; and nearly two-thirds (61%) of B/VI people identified problems related to sight loss as a barrier to travel.

At the same time, the issues with navigation that B/VI face are not only related to the raw mechanics of navigating; there are also important associated emotional and psychological factors to consider. For example, because of their difficulties navigating and conducting their daily affairs, many B/VI people are dependent upon the support of a caregiver, who may be a close friend or family member. Although this may provide much-needed support to the B/VI person, over time the responsibilities involved can result in feelings of burden and even depression for the care-giver who is typically not offered much, if any, support of their own (Braich et al., 2016; Braich, Lal, Hollands, & Almeida, 2012; Khan et al., 2016; Khare, Rohatgi, Bhatia, & Dhaliwal, 2016). As a result, B/VI people have a tendency to feel like a "liability" or like a "burden" to others (Percival & Hanson, 2005, p. 193), which creates a feeling of dependency and low self-esteem. This dependent situation is not helped by the fact that only 30% of newly registered B/VI people are offered any form of mobility training within the first 12 months after registration (Slade & Edwards, 2015).

The mobility challenges associated with visual impairment also limit the social engagement of B/VI people (Hanson, Johnson, Percival, & Zako, 2002). The social stigma (Goffman, 1963) associated with being a B/VI person reduces these possibilities for interaction even further.

According to Sanders (2000), stigma arises from displaying characteristics that negatively distinguish oneself from the “normal” group in a society, or as Goffman (1963) would say, from displaying a “spoiled social identity”. Individuals with spoiled social identities, such as people with overtly visible impairments, experience what Mik-Meyer (2016) refers to as “othering” from members of “normal” groups. This othering further contributes towards social isolation, and to feelings of low-self esteem (Sanders, 2000; Tuttle & Tuttle, 2004).

A great amount of work has been put into helping B/VI people with their navigation issues by developing navigation aids, yet these aids often have low adoption.

In the following section, I will present a set of navigation aids, their limitations, and possible reasons for their low adoption rates. But first, let’s consider some of the common every-day challenges that VI people experience while attempting to navigate.

3.2 The Navigation Challenges that B/VI people face

The investigation of VI navigation challenges has a long history, spanning around 40 years. For the purposes of this thesis, I shall restrict my discussion to the recent literature from approximately the last decade.

Around 11 years ago, Giudice and Legge (2008) wrote a book chapter entitled “Blind Navigation and the Role of Technology”, which provides an excellent place to begin our review.

A central premise of Giudice and Legge’s work is that although B/VI people

have pretty much the same goals for navigation as sighted people do, i.e to get to their destination safely and efficiently, the environmental information available to B/VI people is quite different to that available to sighted people, and is often less useful.

Depending on their level of visual impairment, B/VI people rely more on their auditory, haptic, and olfactory sensory modalities to get the information they need from their environment. Citing the work of Strelow (1985) and Thinus-Blanc and Gaunet (1997), Giudice and Legge argue that these remaining sensory modalities are less suitable to providing the information required to conduct the tasks necessary for navigation, such as tracking self-motion, learning layouts, or judging distance. Giudice and Legge emphasise the role of technology in providing this information through more convenient mechanisms, but acknowledge that there is no simple solution to this problem.

Giudice and Legge write that reduced access to vision reduces the perception of environmental information, and thus results in difficulties in learning layouts and in developing cognitive maps. Moreover, these difficulties in cognitive map development result in issues with orientation, both with respect to distant landmarks, and even over much shorter distances.

It is a great misfortune that B/VI people have added difficulties in developing cognitive maps, and, at the same time, B/VI people have a greater need to possess such a cognitive map than their sighted colleagues, as they cannot easily access environmental information to discover and follow routes ad hoc. Giudice and Legge discuss the problems related to the lack of accessible signage that B/VI people experience and note that, although Braille signage may be helpful, it is still difficult for B/VI navigators to find these signs, or to know of their existence. In addition, older buildings may not even have Braille signage installed at all. This lack of access to printed environmental information limits the ability for B/VI navigators to explore a location inde-

pendently; B/VI people cannot, for example, read the directory of available stores in a shopping centre, or read “you are here” maps. Giudice and Legge note that, although GPS services can be used to provide some contextual information, such as street names, they are unavailable for use indoors.

Given the fact that the requirements of navigation stay the same, yet B/VI people are required to satisfy these requirements using less suitable modalities, the issue of mental workload (Wickens, Hollands, Banbury, & Parasuraman, 2013b) becomes far more of a central issue for B/VI navigators than for their non-VI colleagues (Giudice & Legge, 2008; Rieser, Guth, & Hill, 1982).

For example, consider how B/VI people detect obstacles in their path. While a sighted person can easily use their vision for such a task, B/VI people have a much harder time navigating everyday obstacles such as stairs, road crossings, crowds, and even just low-hanging signs. Traditional mobility aids such as the cane and guide dog help with this significantly, but require a B/VI person to undergo orientation and mobility (O&M) training (Blasch, Welsh, & Wiener, 2010), and to dedicate significant cognitive resources to executing this training in their journeys. Even with this equipment, obstacle avoidance is still by no means a trivial task for the visually impaired.

Quinones, Greene, Yang, and Newman (2011) interviewed 20 B/VI people, nine of whom were from the US and the remaining eleven were from South Korea. Their goal was to get some first-hand experience of the challenges that B/VI people face so that they could later develop an navigation aid.

The interview structure used by Quinones et al. draws on the work by Darken and Sibert (1996), who hypothesised that there are three kinds of wayfinding behaviours: naive search behaviour, primed search behaviour, and exploration. Naive search behaviour occurs when a navigator has a destination in mind, but has no prior knowledge of where it is; primed search behaviour occurs when a navigator has a destination in mind and has some prior knowl-

edge of where it is; and exploration occurs where the navigator has no particular destination in mind but is still searching the environment. These three situations are mutually-exclusive, which makes for a useful way of dividing the different situations a navigator could possibly be in so that they can be considered individually.

Taking the point from Darken and Sibert that different behaviour occurs in different contexts, Quinones et al. broke their interviews up into three parts. They would ask their participants to explain three recent journeys to them: one they do routinely (primed search), one they do only occasionally (primed search but with less information), and one to a new and unfamiliar environment (naive search). They neglected to consider pure exploration, noting that independent exploration is rare among B/VI navigators due to the difficulties involved.

Quinones et al. found that B/VI people mentioned different challenges when discussing the different types of routes. On the more familiar routes, participants would focus on issues related to their cognitive maps, particularly on issues related to the absence of sensory cues along the route. Participants mentioned that, in some cases, the error would be on their part, and they would simply make mistakes and miss the sensory cues and landmarks, and thus end up being confused or lost. This helps us realise that, even on familiar routes, the detection of landmarks and cues is a challenge for B/VI navigators. At other other times, however, participants would report that sudden changes in the environment, a sidewalk closure for example, would cause the cues that navigators used to no longer be available. Participants also noted how changes in weather across the seasons may make some routes more difficult to traverse, by presenting new obstacles (leaves on the floor, for example), and interfering with expected lighting conditions.

In the unfamiliar routes, participants focused more on the preparation mea-

sures that they are required to undergo to develop a cognitive map. Participants mentioned various methods, such as calling ahead for directions, asking their B/VI friends for route advice, arranging private transportation, and asking friends and family to accompany them. If these preparation methods failed, however, participants also mentioned speaking to strangers when lost, although they couldn't say that this approach was always helpful. Quinones et al. note that, although detailed, the cognitive maps that B/VI people develop tend to be focused around particular routes, and thus any disruption to the routes can also derail the wayfinding process.

The fact that the discussions from the participants in Quinones et al.'s research focused either on the use or the development of a cognitive map demonstrates how much of a central role that cognitive maps play for B/VI navigators.

In 2013, Williams et al. conducted interviews with 30 visually impaired adults and aimed to unpack how B/VI people navigate as individuals, rather than as an aggregate population. Williams et al. also discuss the differences in the challenges that B/VI people are likely to face when navigating outdoors and indoors. They also discuss the role that social interactions play in B/VI navigation by touching on themes of theft and personal safety.

When discussing outdoor navigation, Williams et al. found similar results to Giudice and Legge (2008) and Quinones et al. (2011); participants had issues with crossing streets, avoiding obstacles, or having their routes disrupted by environmental changes. Williams et al's findings also add to Quinones and Yang's findings about the impact of weather; while Quinones and Yang commented on lighting and leaves on the floor, Williams et al. (2013) point out that deep snow can affect cane usage and that severe wind and rain can impede a B/VI person's hearing and potentially damage the electrical devices that participants used to support their navigation.

Indoors, however, B/VI people need not worry about crossing streets or variable weather, but indoor navigation presents its own set of challenges. Williams et al. found, like Giudice and Legge (2008), that navigation technology is typically unavailable indoors, which leaves B/VI navigators without any support for their orientation.

While Quinones et al. discussed the various ways that participants may prepare for a trip, Williams et al. (2013) discuss how a B/VI navigator may familiarise themselves with an environment in real-time. Williams et al note that, when navigating indoors, B/VI people will typically use sighted guides to support their navigation until they can learn an environment. A sighted guide is a sighted person who offers assistance to a B/VI navigator; a sighted guide may be a friend or family member, a member of staff, or a member of the general public. By frequently using a sighted guide in unfamiliar locations, Williams et al's participants would, over time, familiarise themselves with the environment and later be able to navigate on their own. Some environments, however, may be highly variable or not conducive to memorisation by B/VI navigators. Williams et al write that shopping centres are typically perceived as wide open spaces by B/VI navigators, and do not present sufficient landmarks for environment learning. Supermarkets were also mentioned to be highly variable locations, with products often moving from shelf to shelf and disrupting the navigator's learned route. Such difficult-to-learn locations typically require B/VI navigators to be continually reliant on sighted guidance. Although they may be of great utility, sighted guides are not without their drawbacks. In supermarkets, for example, Williams et al's participants were frequently frustrated by the staff's lack of training in understanding their needs, and also expressed difficulties in communicating with their sighted guides. This theme of difficulties in communication between sighted and B/VI people was made the focus of further research by Williams et al. in 2014.

Although typically not an issue when dealing with members of staff, safety concerns were an important issue when dealing with members of the general public. For example, a participant from Williams et al's interviews recounted an experience of asking for directions and being intentionally misled by two young men who intended to isolate her behind a building. Aside from personal safety issues, concerns about theft were raised by participants who used their iPhones for navigation, as they felt that brandishing the expensive item openly was unwise. These sentiments are not exclusive to Williams et al's participants; research by Ahmed, Hoyle, Connelly, Crandall, and Kapadia (2015) presents similar findings.

Not all of Williams et al's participants were concerned about safety, however. In stark contrast, one of Williams et al's participants preferred not to use navigation technology at all, as she enjoyed the social interaction that arises from speaking to strangers whenever possible. Williams et al.'s research reminds us to not neglect the importance of the personal qualities of the individual themselves when constructing the navigation context.

Although an important part of everyday life, indoor navigation is a historically under-considered area in the B/VI navigation literature, though it has seen more interest in recent years.

Beatrice Dias et al. (2015) conducted a needs assessment study that focused on the indoor navigation needs of the visually impaired. The study was constructed in four phases, and involved 20 B/VI individuals, 7 Orientation and Mobility Specialists, and 5 building managers. Beatrice Dias et al. used a mix of methods across the four stages, including passive observation of indoor navigation training sessions, structured interviews, and reviews of relevant online and offline documentation. Beatrice Dias et al. wanted to answer questions regarding: (1) the navigation challenges that B/VI people face indoors; (2) how they familiarise themselves with indoor

environments; (3) the usability requirements that B/VI people have for novel indoor navigation aids and their user interfaces; (4) the potential barriers to adoption for new technologies; and (5) what barriers building managers may have identified that prevent indoor locations from being made accessible. Similar to the research of Quinones et al. (2011), which was focused on outdoor navigation, Beatrice Dias et al. (2015) point out the difficulties that B/VI people face in familiarising themselves with indoor environments, and the importance that B/VI people place on detecting landmarks and environmental clues when learning their environments and remaining oriented. Beatrice Dias et al. give a list of possible landmarks and clues that B/VI navigators use to orient themselves indoors, which is complemented nicely by Padmanaban and Krukar (2016)'s curation of landmarks and clues that B/VI navigators may use when outdoors.

Although sighted navigators may identify landmarks by virtue of their visual properties (Burnett, 1998; Kaplan, 1976), (Beatrice Dias et al., 2015) ask us to broaden our conception of landmarks beyond the visual modality and consider landmarks to be any notable sensory stimulus. Under this conception, a landmark could be a uniquely identifiable sound, smell, or even an uprooted pavement slab. Beatrice Dias et al. (2015) proceed to divide this conception of landmarks into "landmarks" and "clues". In this terminology, a landmark is a sensory stimulus within an environment that is permanent. Doors, elevators and stairwells are typical examples of landmarks. Clues, on the other hand, are more transient. The sounds of people eating and talking may be a clue for a B/VI person that they are in a cafeteria; these sounds would not be landmarks because as soon as the stores close and people leave, so do the sounds. Beatrice Dias et al. (2015) point out that the transient nature of these clues can leave B/VI navigators disoriented when the clues do not materialise when expected (see also the work by Gomez et al. (2016)). Aside from landmarks not materialising when ex-

pected, it is also possible for B/VI people to become disoriented by mistaking one environmental feature for another and thus making incorrect navigation choices (Easley et al., 2016, p. 2038).

When mentioning the explicit methods that B/VI people use to familiarise themselves and build up a knowledge of the landmarks in an indoor environment, Beatrice Dias et al. note that B/VI people use a variety of methods including getting information from websites, using smartphone apps, calling to arrange staff assistance at the destination, or request help from a friend. Aside from the use of websites, these methods are consistent with the findings of Quinones et al. (2011) and Williams et al. (2013). If their preparation efforts did fail them, however, Beatrice Dias et al. also note that B/VI people will also resort to seeking help from sighted strangers indoors, and mention some of the frustrations that B/VI people may experience when seeking sighted help that arise from the tendency of sighted navigators to provide directions from their own perspective and failing to use accessible language (see the work by Williams et al. (2014) and Bradley and Dunlop (2005) for more on this phenomenon). Like Williams et al. (2013), Beatrice Dias et al. (2015) also add that, beyond these points, the individual navigation practices of B/VI people can vary, and encourage us to take into account the individual differences among the B/VI population, rather than treating them as one homogenous group.

One novel navigation challenge that Beatrice Dias et al. mentioned was emergency evacuation. Methods of providing support to B/VI people in emergency evacuation scenarios, such as those related to fire, is a neglected topic in the literature. Beatrice Dias et al. (2015) argue that continual neglect of questions regarding how to provide effective emergency evacuation support to B/VI people may have life-threatening consequences.

Easley et al. (2016) attended four conventions organised by the U.S National

Federation for the Blind (NFB) as passive observers. One was a national convention with over 2,200 B/VI delegates, and the other three were smaller state conferences hosting approximately 100 B/VI delegates each. Easley et al. (2016) were particularly focused on the navigation behaviours that the delegates would exhibit when in environments where B/VI people were the majority, and how these behaviours may have social consequences in predominately sighted contexts.

One issue mentioned was that the delegates would bump into each other on occasion, with both sides offering an apology to the other, regardless of who was actually at fault. Indoor environments are often crowded, and this potential to collide with crowds, or the fear thereof, is an interesting new addition to our list of challenges.

Another point mentioned was that the delegates would struggle with learning the layout of the conventions. To help, the conventions had in place sighted assistants who would shout out to the crowds of B/VI delegates the locations of various landmarks, “Escalators, over here!”, for example. Although no-doubt well-meaning, this approach was deemed distracting by some delegates, and as perpetuating negative stereotypes of B/VI community by others.

Once delegates had found their way to their intended rooms, Easley et al. (2016) point out that the delegates also needed to learn the layout of those particular rooms. Although it is already known that B/VI people need to engage in intensive preparation before navigating to new places (Passini & Proulx, 1988), this finding by Easley et al. (2016) puts in perspective the scale of the familiarisation task that is required of B/VI people. Consider a shopping centre. When venturing to a store for the first time, a sighted person may only need to read the directory of stores in the shopping centre to find out what level a store is on, and then follow signs as appropriate. Once

they have arrived, the sighted person can visually scan the store and quickly locate the products that they need. A B/VI person, on the other hand, would be required to learn the general layout of the shopping centre, learn how to get to their chosen store within that shopping centre, and also be required to learn the layouts of the products within of the stores themselves, all without access to vision.

One issue that Easley et al. (2016) mention is the challenge that the delegates had finding empty seats in the seminar rooms. The uneven spacing between the seats made it difficult for the B/VI people to distinguish between aisles and rows, and made seat counting difficult. To find empty seats, the B/VI delegates would walk up to people at the end of the row and ask if there were any empty seats, a method that Easley et al. note could easily be embarrassing to perform in a predominately sighted context. Easley et al. (2016) point out that this issue of finding an empty seat is an issue that could easily occur in theatres, cinemas, and classrooms. One may also consider adding public transport to this list. It can be seen here, with the introduction of finding seats as a challenge and the corresponding list of locations where this challenge may apply, the need to distinguish between challenges that are specific to certain types of locations, and challenges that are entirely generalisable to all locations, such as familiarisation and obstacle avoidance.

From reviewing the last decade or so of the literature on B/VI navigation challenges, it can be concluded that B/VI people have difficulties related to all fronts of the navigation task, both indoors and outdoors.

From the outset, B/VI people have issues in familiarising themselves with new environments and routes. They typically have to undergo some intensive familiarisation process and learn routes based on landmarks that may not be entirely reliable. This can lead to issues with maintaining orientation, and their difficulties in accessing printed information from the environment

does not make this any easier. B/VI people are also under continual threat of unexpected obstacles and slip hazards. Moreover, B/VI people are required to conduct navigation using senses that are less suitable to the task and thus cognitive load and stress become far more present components of navigation for B/VI people.

Despite the fact that navigation challenges faced by B/VI people are vast and varied, technology can have a significant role in alleviating some of these challenges, as will be discussed in the next chapter.

Chapter 4

Navigation Aids for the Blind and Visually Impaired

Given the wide range of challenges that B/VI people face, it is perhaps unsurprising that, in the recent My Voice survey, the majority of B/VI people (71%) reported using some form of mobility aid (Slade & Edwards, 2015, pp. 31-32).

Although some researchers argue for an increased focus on accessible architecture (Williams et al., 2016), the majority of the efforts within the research community focus on developing specific tools and devices to support the navigational needs of the visually impaired.

Providing a truly comprehensive review of all of the technologies and devices that have been produced to help the the visually impaired with their navigation efforts is a near impossible task due to the sheer number of devices that have been attempted. Instead, most reviews take the approach of dividing the domain using some categorisation scheme, and discussing some interesting examples of each category. Some authors, such as Giudice and Legge (2008), base their categorisation on the types of sensors that the de-

vices use. Others conduct their reviews by breaking down the navigation task into its components, and provide reviews of the devices that support each part. Some of these reviews, such as that by Bernadine Dias and Ravishankar (2015), provide a shallow but broad coverage of the components of navigation; others provide a very deep coverage of just one aspect, such as Fernandes, Costa, Filipe, Paredes, and Barroso's 2019 review of devices that support orientation.

I believe that a balance between these two approaches is most suitable, and intend to break up the navigation task into its components, and then cover some of the different ways that aids support that task, distinguishing by underlying technology where appropriate. I also intend to point out the ways that many of these devices, although technologically very impressive, tend to suffer low adoption rates due to an unsatisfactory consideration of the the wider needs of B/VI users (Giudice & Legge, 2008; Gori et al., 2016; Sanchez & Elias, 2007).

4.1 Aids for Obstacle Avoidance

As mentioned in chapter 7, avoiding obstacles and environmental hazards is key challenge for B/VI people. Arguably, helping B/VI people to avoid obstacles is the core function of the cane and guide dog, which are two of the most common navigation aids in use by B/VI people [Beatrice Dias et al. 2015; Bernadine Dias and Ravishankar 2015; Dutton 2015].

4.1.1 Traditional Aids

The Cane

The cane has been used by B/VI people for as long as is known (Wiener, Welsh, & Blasch, 2010) and is the most common type of navigation aid currently used by B/VI people (Bernadine Dias & Ravishankar, 2015; Slade & Edwards, 2015).

There are three main types of cane: the symbol cane, the guide cane, and the long cane (RNIB, n.d.-a).

Symbol canes, although not for detecting obstacles, are used by B/VI people to signify, or symbolise, their visual impairment to others; it is hoped that, by being made aware of the B/VI person's impairment, the general public will exhibit more more cooperative and understanding behaviour. Symbol canes are white for B/VI people, but are red and white for deaf-blind people.

The guide cane, on the other hand, is for detecting obstacles and is to be held diagonally across the body.

The long cane is the most common type and is what typically comes to mind when thinking of a B/VI person's white cane. As the name would suggest, the long cane is the longest of the three types, and is held out at a distance approximately two steps ahead of the B/VI person and moved from side to side to detect obstacles, steps or drop-offs (Giudice & Legge, 2008). The long cane may also be tapped on the ground to generate a sound that the B/VI person can use to echolocate obstacles (Giudice & Legge, 2008; Schenkman & Jannson, 1986) and can also be placed against a wall to maintain orientation using a technique called shorelining (Wiener et al., 2010). Because the long cane is the most common type of cane, the term "cane" will be used to refer to the long cane in particular, moving forward.

For portability reasons, all of these canes can usually be folded down when not in use, and are typically made of lightweight materials such as aluminium or wood (Bernadine Dias & Ravishankar, 2015; RNIB, n.d.-a).

Although the cane is the most commonly used navigation aid, it does have some significant down sides. Firstly, the cane has a relatively high workload cost associated with using it. One has to focus on the input that the cane is providing, which subtracts away from their limited attentional resources to detect other spatial information (Giudice & Legge, 2008).

Moreover, using the white cane can require the user to undergo several months of orientation and mobility (O&M) training before the cane can be used effectively and safely (Wiener et al., 2010). However, only around 30% of B/VI people are offered such training within the year after registering as blind (Slade & Edwards, 2015); it is typically the responsibility of the B/VI person to seek out this training themselves (Williams et al., 2013).

Because of the need to physically make contact with obstacles in order to avoid them, it is common for cane users to be impacted by obstacles that are not at ground level (Jeamwatthanachai, Wald, & Wills, 2019). Because it relies on making physical contact, the cane is also unable to detect slip hazards, such as a puddle on the floor, which can lead to injury (Jeamwatthanachai et al., 2019, p. 143).

Some canes have their obstacle detection capabilities improved via technological augmentation. An example of an augmented cane is the Ultracane (Hoyle & Waters, 2008), which uses ultrasonic pulses to increase the obstacle detection range of the cane to up to four metres (Ultracane, n.d.). The Ultracane also allows the detection of obstacles up to 1.5 metres away at chest and head level (Ultracane, n.d.), which helps overcome the issue with objects at height. Tactile feedback is given back to the user using vibrating fingerpads in the handle of the device. However, given its sizable price

tag of £635 GBP, the Ultracane may not be a financially accessible option for all B/VI people without the help of third-party support.

A similar device, the WeWALK smart cane (WeWalk, n.d.), has not been previously discussed in the literature as it is a recent development that was only launched in 2019. Like the Ultracane, WeWALK also uses sonar pulses to help B/VI people to discover obstacles at farther distances and at height. Where the WeWALK differs, however, is with its smartphone-integration feature.

When outdoors, B/VI cane users often use a smartphone device to receive navigation directions. This means that B/VI cane-users may have both hands occupied, which is inconvenient. The WeWALK cane, however, is capable of pairing with the B/VI user's smartphone via Bluetooth. The B/VI person is able to control their smartphone via a touchpad on the cane, and can also receive audio feedback from the phone via some speakers on the device. WeWALK has also been integrated with GoogleMaps and Amazon's Alexa voice assistant, with intended future integrations with transport services, such as Uber, and ride-sharing applications. The obstacle detection range is 1.6 metres, which is shorter than the ultracane, and WeWALK also only has a modest battery life of five hours (WeWalk, n.d.), but it is available for a lower cost than the Ultracane at $499 USD.

Finally, cane users may also experience negative side-effects from the stigmatisation that is associated with white canes (Goffman, 1963; Michalko, 1999; Sanders, 2000).

There are two sides to the stigmatisation issue. On the one hand, according to Chevigny (1946, p.88) and Michalko (1999, p. 160), B/VI people are culturally regarded as 'helpless', and holding the cane may elicit undesired support from members of the public which can be frustrating for B/VI people. At the other extreme, the cane acts as a clear symbol of what Goffman (1963)

calls a “spoiled identity” (Sanders, 2000). Visibly associating oneself with a spoiled identity, by using a cane for example, often results in social stigmatisation (Sanders, 2000) and “othering” (Mik-Meyer, 2016). People with physical disabilities can often be made to feel “invisible” as they are avoided by members of the general public who are made to feel uncomfortable by their stigma (Eddy, Hart, & Boltz, 1988, p. 42-43).

The Guide Dog

The guide dog is another well-known navigation aid, but is a far less common one than the white cane (Slade & Edwards, 2015). According to Audrestch et al. (2015), out of the estimated two million B/VI people in the UK (RNIB, n.d.-b), there were around 5,000 guide dog owners in the UK as of 2015, and over 800 new partnerships are trained every year.

There is evidence that suggests that the use of dogs to guide blind people dates back as far as Roman times (Audrestch et al., 2015; Fishman, 2003), but the organised breeding and training of guide dogs is a relatively recent practice (Fishman, 2003). During World War I, the German Shepherd Dog Society proposed in 1916 that dogs be trained to aid the increasing number of Germans being blinded in the war (Fishman, 2003). The ‘Seeing Eye’ was established later in 1927 in the USA to provide guide dogs to US war veterans (Fishman, 2003), and in 1931, Muriel Crooke and Rosamund Bond trained the first four British guide dogs in the UK (Guide Dogs, n.d.-b).

The guide dog is an alternative approach to the obstacle-avoidance challenge. Instead of the owner detecting the obstacle and then moving to avoid it as they would with the cane, it is the guide dog that detects the obstacle and then moves to lead the owner around it without the B/VI person ever needing to know the obstacle existed (Audrestch et al., 2015). The owner

holds a harness in one hand that is connected to the dog's torso and as the dog moves to avoid the obstacle, the owner feels a guiding pull through the harness which indicates which direction the owner should travel in to avoid the obstacle. The harder this pull is, the more the B/VI person needs to move.

This reliable 'just-in-time' input source is reassuring, because the B/VI person knows that they can confidently walk in their current orientation without colliding with anything/anyone and that they only need to adjust their orientation when they are informed to do so. This reduces the cognitive load on the owner and also greatly improves confidence (Michalko, 1999).

Guide dogs have other abilities besides just avoiding obstacles. These abilities include, among others (Audrestch et al., 2015; Giudice & Legge, 2008; Guide Dogs, n.d.-c):

- Finding doorways.
- Helping to navigate up and down sets of stairs.
- Walking in straight lines to help with orientation in open spaces.
- Stopping at every curb/crossing to help with safety and orientation.
- Judging height and width so that the owner doesn't bump their head or shoulder.
- Selectively disobeying the owner's instructions to cross a road if the dog feels it would be unsafe to do so.

Although there is still some debate on the issue (Chur-Hansen, Stern, & Winefield, 2010), the field of occupational therapy has generally recognised the rehabilitative benefits that assistance dogs can provide to the physically

disabled (Winkle, Crowe, & Hendrix, 2012). Unlike the cane, there is a significant body of literature indicating that owning an assistance dog can provide the owner with significant increases in the quality and quantity of one's social interactions with other people (Audrestch et al., 2015; Fairman & Huebner, 2001; Sachs-Ericsson, Hansen, & Fitzgerald, 2002; Sanders, 2000; Siegel, 1993; Whitmarsh, 2005; Winkle et al., 2012). There are also benefits arising from a strong emotional and social bond that can form with the dog itself, with owners sometimes feeling that they and their dog are each working as part of a single "whole" (Michalko, 1999; Sanders, 2000). This unique relationship that forms with the guide dog can make the task of travelling to familiar or unfamiliar new places seem less intimidating than it would otherwise and therefore result in highly increased feelings of independence, confidence, dignity and self-esteem (Lambert, 1990; Michalko, 1999; Sanders, 2000).

Although there are very well-established social, functional, and psychological benefits to using a guide dog as a navigational aid, guide dogs are still living beings. They, therefore require significant financial and time investments in order to breed and train—an average of £63,000 in 2018 according to the Guide Dogs Charity Website (Guide Dogs, n.d.-a)—and the owner must undergo training themselves to learn how to work with the dog properly. There are also demands on the owner to feed, walk, and entertain their guide dog to maintain its wellbeing (Whitmarsh, 2005).

Guide dogs can also get ill, pass away, and are retired after an average of just 5-6 years in service (Guide Dogs, n.d.-c), all of which can be potential sources of significant distress to the owner (Kwong & Bartholomew, 2011; Schneider, 2005). There are also a host of other reasons that may make owning a guide dog unsuitable for a particular B/VI individual, and, as noted by Whitmarsh (2005), providing every individual with the navigation aid that best fits their needs is often a better approach than trying to determining which navigation aid is "best" overall.

To help reduce the issues of cost, scalability and compatibility that are inherent with the supply of living animals, there exists a line of research that aims to develop robotic navigational aids that have similar functionality to living guide dogs (Galatas & McMurrough, 2011; Gomez & Sandnes, 2012; Kou, Wei, & Lee, 2013; Sugimoto, Nakashima, & Kitazono, 2017).

These "robotic guide dogs" if developed, would be much more scalable from a manufacturing perspective, and when not in use for a navigational task they would not place any of the other demands on the owner that a living dog would. However, at present, there is no evidence to suggest that they would be able to reproduce the increases in social interaction that owning a guide dog provides or reproduce the emotional attachment and feelings of companionship, that guide dog owners mention experiencing. Robotic guide dogs may have the reverse effect, and prove to be stigmatising objects in their own right, and thus result in social isolation and lower levels of self-esteem (Sanders, 2000).

4.1.2 Other aids for obstacle avoidance

Other methods of obstacle detection also exist in the literature, such as Leslie Kay's head-mounted sonic glasses (Kay, 2000, 2001) and Kaczmarek and Back-y-Rita's tongue-display unit (Kaczmarek, 2011; Nau, Pintar, Arnoldussen, & Fisher, 2014) that converts images from a spectacle-mounted video camera into electrical signals that are delivered to the tongue. According to Giudice and Legge (2008), the key benefit of these types of approaches is that, there is no need to retrofit the environment to the aid. On the downside, however, there is a significant amount of training involved in order to use them (Nau et al., 2014), they tend to be expensive, and head-mounted devices can be less discreet than B/VI people may be comfortable with (Giudice & Legge, 2008).

More recently, researchers have also been investigating the use of computer vision for obstacle avoidance (Albraheem et al., 2014; Elmannai & Elleithy, 2018; Jafri & Khan, 2016; Zhang, Wang, Zeng, & Chen, 2019).

4.2 Aids for Environment Familiarisation

Familiarising oneself with the environment is usually the first task that many VI navigators engage in (Beatrice Dias et al., 2015). Being able to explore environments is essential for finding new opportunities and resources, and being able to do so independently can contribute significantly towards one's quality of life.

One of the most common methods used by B/VI people, especially indoors, is to recruit a sighted guide for support. As mentioned, a sighted guide may be a friend, family member, mobility instructor, member of staff, or member of the general public. While very useful in many ways, particularly for indoor exploration where GPS is not available (Jeamwatthanachai et al., 2019), repeated use of sighted guides may result in lower levels of self-esteem in some B/VI people (Percival & Hanson, 2005, p. 193), and over-reliance on a particular sighted guide may result in feelings of burden and depression in the sighted guide (Braich et al., 2016; Braich et al., 2012; Khan et al., 2016; Khare et al., 2016).

To help people with visual impairments acquire more independence in their exploration and familiarisation efforts, and lessen the reliance on human support, contemporary research agendas generally focus on two broad goals: improving the quality and effectiveness of map-based tools, such as tactile maps, and exploring the feasibility of using virtual worlds to create familiarisation tools, such as Lahav, Schloerb, Kumar, and Srinivasan's (2008) *Blind Aid* virtual environment.

Tactile maps are a long-established method of familiarising people with visual impairments with new environments (Espinosa, Ungar, Ochaita, Blades, & Spencer, 1998). Tactile maps typically provide static representations of spaces that VI people can explore using their sense of touch to determine points of interest and possible routes to their destination. Papadopoulos et al. (2017) found that audio-tactile maps can even be more effective than verbal directions. Although tactile maps have been around a long time, innovative efforts are still ongoing in the research community to improve their utility for VI people. In general, tactile maps suffer from several shortcomings: they cannot display a large amount of information, and they are not dynamically modifiable. Ducasse, Macé, and Jouffrais (2015) described how the accessibility of tactile maps could be improved for visually impaired users through the use of tangible maps, whereby a person interacts with digital information through engaging with objects attached to the map. Constructing maps with tangible objects that the VI users can move, add, or remove depending on the area that they want to explore provides two major advantages over traditional audio-tactile maps: (1) they allow the VI user to autonomously build a simple map, without having to rely on a professional transcriber; (2) they enable the VI user to zoom or pan and re-position tangible objects to match the digital map that has been moved or zoomed by the user (Ducasse et al., 2015).

Taking a different approach, the use of pin array matrices allows tactile maps to provide refreshable and dynamic information to navigators in real-time. Zeng and Weber (2016) used a pin array matrix to create a tactile you-are-here (TacYAH) map that displayed tactile information about the user's live position, and of their relation to points of interest in their surrounding environment. Various tactile symbols were embedded in the map to allow the user to determine their own location and their own orientation. Key locations such as supermarkets, crossings, and train stations were also given unique

tactile representations. Moreover, users could get audio descriptions of map features by touching them, get live updates about their own position, pan the map, and also zoom in and out. Zeng and Weber found that, even without previous experience with braille or tactile maps, VI users could use their TacYAH system in unfamiliar areas to locate themselves and independently discover the surrounding environment. Ivanchev, Zinke, and Lucke (2014) built on some of Zeng and Weber's earlier work (2010) to investigate how route guidance can be overlaid onto tactile maps. Although they only conducted a trial with an initial prototype, they say that the idea is 'especially well suited' to preparatory familiarisation. Again focusing on preparatory familiarisation, Brayda, Leo, Baccelliere, Ferrari, and Vigini (2018) recently used the BlindPAD pin array matrix to help VI people explore an environment before engaging in the actual navigation task. They found that using such pin array matrices can also be effective for familiarisation prior to navigating. The primary limitations of using pin array-matrices are their high production cost, and the limits on the resolution that are set by the available inter-dot spacing (O'Modhrain, Giudice, Gardner, & Legge, 2015).

Other recent developments in the tactile mapping literature include systems of converting various file types to (semi) automatically create 3D-printable tactile maps (Brown & Hurst, 2012; Götzelmann & Pavkovic, 2014; Kim & Yeh, 2015), as well as integrating 3D-printed tactile maps with interactive components to enhance usability (Götzelmann, 2016, 2018). For example, recent work by Götzelmann (2018) investigates how 3D-printed tactile maps can be used in conjunction with interactive components from a user's smartphone or tablet to leverage the residual vision available to the visually impaired Götzelmann (2018) found that augmenting the maps so that visually impaired people could better utilise their remaining vision resulted in the participants being able to complete map-related tasks more accurately and in less time.

Unfortunately, however, studes such as those by Gomez et al. (2016, p. 572), Padmanaban and Krukar (2016), and Jeamwatthanachai et al. (2019, p. 144), show that tactile maps are still secondary methods of familiarisation, mostly due to difficulties in interpreting the contents of the maps and a lack of standardisation of the symbols they use.

Diverging from the traditional tactile map approach, contemporary researchers are also investigating the potential uses of virtual worlds for familiarisation purposes. Virtual worlds offer the opportunity for people with visual impairments to independently familiarise themselves with a space, without the difficulty of actually travelling to the desired location. Familiarising oneself with an environment in this way has been shown to translate into increased navigation performance in reality (Guerreiro, Ahmetovic, Kitani, & Asakawa, 2017; Lahav & Mioduser, 2008; Lahav, Schloerb, Kumar, & Srinivasan, 2012), even if the virtual worlds are rendered using only acoustic information, as in the case of Picinali, Afonso, Denis, and Katz (2014). For now, however, such efforts are not yet commonplace, and are still undergoing research.

4.3 Aids for Localisation and Path Planning

As has been shown, B/VI people have many issues with localising themselves in space, discovering routes, and following those routes; in other words, they face many issues related to orientation.

The most obvious supporting technology in this regard is satellite navigation (satnav). There are many types of satellite navigation systems, some regional and some global, but perhaps the most well-known satnav system is the Global Positioning System (GPS).

The major benefit that GPS provides is the ability to localise oneself accurately to within five metres, at any point on the globe. By using network-based routing algorithms, it is possible for services layered on top of satnav systems, such as Google Maps, to plot routes and provide directions between any two points on the globe (Swobodzinski & Raubal, 2009). Contrary to popular belief, weather conditions, such as rain, clouds, and fog, do not affect the reception of a satnav signal; however, satnav signals often cannot penetrate the concrete used to construct buildings, which generally prevents systems such as GPS from being used indoors, and in built up urban environments, or so-called 'urban canyons' (Bensky, 2016).

Aside from their unavailability indoors, another downside of GPS-based devices, shown by Burnett and Lee (2005), is that using such tools can inhibit navigators from developing their own cognitive maps of spaces, thus perhaps leading to dependence on GPS device and less navigational independence. This is especially true to B/VI people who already have significant challenges in accessing the spatial information required for environmental learning.

To address this issue, Microsoft's novel "Soundscape" smartphone application notifies B/VI people of interesting features in their surroundings as they follow a GPS-guided route (Microsoft, n.d.).

Microsoft Soundscape users place virtual audio "beacons" on a given destination using the app and then, through audio notifications and pulsating tones, receive guidance to that destination. Through the directionality of the stereo audio feedback, users can know where their virtual beacon is located relative to themselves. For example, if the beacon is placed on a map location to the left of the user's current position, they will hear a pulsating drumbeat-like sound in their left ear. If the destination is on the right of the user, they will hear the drumbeat in their right ear. If the user is directly facing

the beacon, then a high-pitched intermittent beeping sound will be overlaid on top of the drumbeat and played in both ears, thereby making it seem as though the destination is straight ahead. This use of audio directionality removes the need for turn-by-turn directions; users should just focus on using their orientation and mobility skills to move towards the beacon in a safe manner.

A key feature of the Soundscape app is its ”call out” feature. As the user is walking along, Soundscape will automatically call out points of interest to the user. These points of interest may include steps, bus stops, parking lots, buildings, intersections and more. These call out locations are filterable by type, so the user can choose what types of locations they want to be notified about. This feature of calling out points of interest allows users to be informed about what is around them, and to discover places that they may not have done otherwise. While these call outs happen automatically, there are also some options available in the app that allow users to more willfully explore their environment. The ”around me” feature will call out four points of interest in a 360-degree sweep, and the ”ahead of me” feature will call out five points of interest in front of the user (Microsoft, n.d.). Again, all of these call outs are directional. An additional feature called ”locate” helps the user to determine their location.

After having determined their location, navigators may like to receive directions to a chosen destination. Many algorithms exist for achieving this task, and for sighted people, the shortest route is often the best. However, Williams et al. (2014) demonstrated that there are differences between what routes are suitable for a B/VI person and what routes are suitable for sighted people. For example, while a sighted person may opt for the shortest distance, a B/VI person will likely prioritise safety and prefer to stay close to walls and away from open-spaces so that they can more easily maintain their orientation (Jacobson, 2012; Swobodzinski & Raubal, 2009). This in-

troduces research challenges around how to develop route planning algorithms that are designed around the orientation and mobility behaviour and needs of B/VI people, like the one developed by Swobodzinski and Raubal (2009). Rather than only focusing on behaviour, however, the verbal route directions provided should also refer to landmarks that the visually impaired person would naturally use, rather than only relying on the conceptions of landmarks held by a sighted people (Bernadine Dias & Ravishankar, 2015).

In an attempt to drawback of convention route-guidance systems, there exist “narrative maps”, such as the ClickAndGo Wayfinding maps reviewed by (Beatrice Dias et al., 2015, pp. 153-154), which provide access via a smartphone to a library of pre-recorded audio and text-based directions uniquely developed by Orientation and Mobility (O&M) specialists for specific locations. Although not an automated solution, because such maps are produced by O&M specialists, they refer to landmarks and environmental features that are useful and accessible to B/VI navigators which helps prevent confusion. The user is required, however, to determine their own location. Moreover, because of the effort involved to create a map, and because they are produced on a case-by-case basis, narrative maps tend to only be available for a limited set of locations (Beatrice Dias et al., 2015). Because the issues of route planning and familiarisation are so closely related for B/VI people, the ClickAndGo wayfinding maps also have virtual tours that can be accessed via a smartphone that B/VI people can use to familiarise themselves ahead of time (ClickAndGo, n.d.).

4.4 Aids that help provide access to signage

Signage is a ubiquitous form of communication, especially for navigation, and is arguably the default analogue method of communicating route and

landmark information to navigators moving through a space. Signage can be used to provide warning information, to provide directions to a specific landmark, or simply let the navigator know that they have arrived at a specific place.

Signage has been traditionally considered an inaccessible form of communication for people with visual impairments, but devices such as Giudice and Legge's Digital Sign System 2008 or OrCam's MyEye2 aim to address this.

Giudice and Legge's digital sign system (DSS), requires barcode signs to be fitted at key locations within an environment. Infra red beams are emitted from a hand-held device, and when a barcode is detected, the barcode is transmitted to a server which sends back information to the user via synthetic speech about the content of the sign. The downside of this system is that the signs need to be installed, which comes at a cost to the host environment, who may not be willing to cooperate.

OrCam MyEye is the commercial name for a device created by OrCam Technologies Ltd (OrCam, n.d.) which provides the user with an spectacle-mounted camera unit that uses optical character recognition (OCR) technology and a variety of computer vision techniques to read text, read signs, determine the value of monetary notes and detect faces within the environment.

Although there are few studies evaluating the effectiveness of the OrCam (Findlater et al., 2015), researchers have noted the OrCam's potential to improve the quality of life of people with visual impairments (Waisbourd et al., 2015), by allowing them to perform many everyday tasks more easily than they would otherwise be able to do so (Moisseiev & Mannis, 2016). OrCam consists of a small camera, some bone-conducting headphones, and a small pack which houses the OrCam's battery and computational unit. This pack may be put in the user's pocket, clipped onto a belt, or held in their

hand (Moisseiev & Mannis, 2016).

To get the OrCam to read out the content of its visual field, the user must press a small button on the device (Moisseiev & Mannis, 2016, p. 749). This, however, does require that the B/VI person know that the sign is there in the first place, which may not be the case, especially in new environments. The same can also be said of Giudice and Legge's DSS system, and of Braille signage.

4.5 Navigation aids and the needs of their users

A theme exists in the B/VI navigation aid literature that many navigation aids, as technologically impressive as they are, fail to satisfy the usability and emotional needs of the B/VI community. After presenting a review of navigation aids in the literature, Gori et al. (2016) propose that this lack of consideration of the wider needs of B/VI people underlies the typically low adoption rates of navigation aids, and their failure to successfully commercialise into useful products. Gori et al. note that many of the devices are invasive, impart high cognitive loads, and require long training periods in order to be used. Gori et al. also note that the devices often remain in the prototype stage, have poor performance, and are often only validated on a small number of participants.

Gori et al. are not alone in making their criticisms of navigation aids, nor are they the first. Over a decade ago, Sanchez and Elias (2007) noted that, although many navigation aids use top of the line technology, they are not necessarily addressing the needs and interests of their users, and their use may even provide them with additional burden. They note that the devices are often difficult to use, occlude the user's hearing, obstruct their hands, require lots of training, and are bulky, importable, and expensive.

Giudice and Legge (2008) noted similar points and mentioned that designers often don't take into consideration the aesthetic appeal of the devices. Shinohara and Wobbrock (2011) makes a similar case for increased consideration of the aesthetics of accessibility technology in general, and noted how not doing so can result in social stigma issues, low adoption rates, and personal safety concerns. Williams et al. (2013) also focused on this personal safety aspect and discusses how particularly conspicuous devices can put a B/VI at risk of theft.

Similar concerns can still be heard today. Noticing a persistent problem of low-adoption, Bernardine Dias et al. (2015, p.220) conducted research into the potential barriers to adoption of navigation aids, and found that high cost, blocking of senses, lack of standardisation, lack of portability, poor user interfaces, and lack of adaptation to weather conditions as pertinent issues.

Even until very recently, in 2017 Padmanaban and Krukar (2016, p. 135) note that considering the user needs of B/VI navigators is "a neglected research area" and that "creators of navigational aids for the blind are limited in their understanding of the true user needs and wishes".

There appears to be a disconnect between the literature on the usability needs of B/VI people, and the prototypes that become produced by the research community. However, research does already exist on what these these needs may be (Beatrice Dias et al., 2015; Golledge, 2004). Therefore, it is plausible that a potential cause for this disconnect and the resulting low adoption rates of navigation aids is that designers of navigation aids are lacking a method for integrating a consideration of the needs of B/VI people into the design process, and are, therefore, struggling to cater for the full range of needs of B/VI navigators.

Chapter 5

Ideation Card Literature

Research into what are today known as ideation cards (Wetzel, 2017) appears to have begun in the early 1990s, with the research of Tudor, Muller, Dayton, and Root (1993) with their work on the CARD participatory design method. CARD stands for the ”Collaborative Analysis of Requirements of Design”, and their research sought to use cards to create a game-like interaction dynamic between people that could be used to facilitate the participatory analysis of task flows in software systems.

Thereafter, in 1996, Tschudy, Dykstra-Erickson, and Holloway (1996) built on the CARD method from Tudor et al’s research, and developed pictureCARD, a method that was used to gather insights from participants in rural India regarding contextual factors that should be considered when designing technology to be used by rural health care workers as part of Apple’s India health care project.

Although other methods such as ethnography or interviews could have, in theory, been appropriate for the task, Tschudy et al. identified several factors that they felt justified the use of the pictureCARD method instead. For example, project members were unfamiliar with the language and culture of

participants, there were limited resources available in the field, they had a widely distributed design team; and there was a varied and widely distributed user population (Tschudy et al., 1996, p. 181).

Tschudy et al. found the method to be very useful for breaking down communication barriers and found that the cards helped to facilitate a highly collaborative and participative atmosphere. They found that, rather than being constrained by card content, participants were very open to interpreting the cards as they saw fit, and even creating their own cards or requesting that existing cards be corrected. Tschudy et al. noted that all of this enhanced the participative feel of the sessions and thus enhanced the richness of the data.

The authors did mention that, at first, there were almost too many cards for participants to handle, and participants struggled to procss all of the new cards. Some concepts on the cards were also too abstract, so the process was open to modification and simplification throughout the research. Moreover, Tschudy et al. note that the method should be complemented with other methods of data capture, such as recordings, in order to make data analysis a richer and more detailed process. Finally, the authors expressed intentions to make the method more ”compressed” and ”computerised”, but didn’t elaborate upon the specific meaning of these terms.

A few years later, Buur and Soendergaard (2000) investigated the concept of *Video Cards*. They noted that when developing user-centred products, the ability to analyse video footage from user trials is of tremendous value. Buur and Soendergaard write that, at the time, it was an industry norm for video footage from usability sessions to be handed off to a team of expert video analysts and then reports would be fed back to the usability team and engineers. Buur and Soendergaard felt that video should, instead, be an integral part of the design process and the video should be available for interpreta-

tion by engineering teams. This would allow engineering teams to make their own insights from the footage, rather than just receiving them from a report. Their research therefore investigated how video may be turned into a tangible design resource for engineering teams using what they termed *Video Cards*.

Whilst working on the development of a heat pump for a domestic heating system at Danfoss, the Danish component manufacturer, Buur and Soendergaard decided to get the intended users of the pump (installation engineers) as well as design engineers together for a design session with the Video Cards.

The users were asked to install the component and to discuss potential improvements, with both the installation and discussion being recorded. Usability staff then went away and extracted, from the eight hours of footage, 60-70 snippets that they felt were important. They also made key frames (snapshots) of key moments in each snippet that they felt represented the snippet's essence. An example of a video card can be seen in fig. 5.1 below:

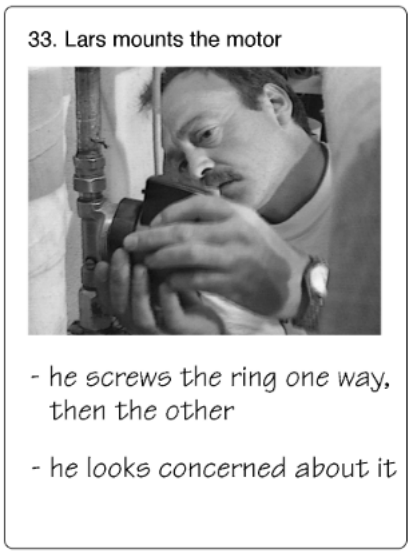
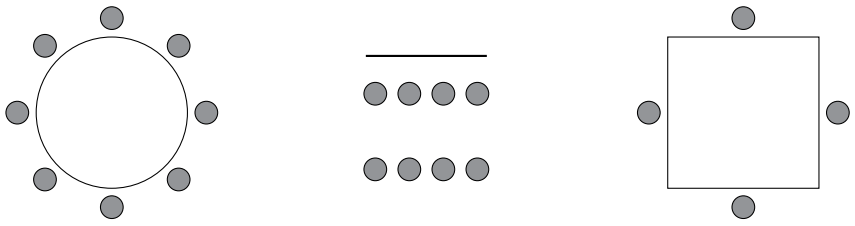


Figure 5.1: *A Video Card. Adapted from Buur and Soendergaard (2000, p. 64)*

Upon the creation of the cards, they got four engineers and two usability staff

to participate in a usability workshop with the video cards. The team of six would be split into three pairs, and each pair would go to watch a certain set of the 60-70 snippets. Each snippet corresponded to a card, and the participants were asked to annotate each card in their own handwriting, and to do so without informing their partner of what they were writing. Buur and Soendergaard write that this was an attempt to instill participants with a sense of *ownership* over the card, a concept that Buur and Soendergaard learned from Mogensen (1994) to be important to successful innovation when using physical artefacts such as cards (Buur & Soendergaard, 2000, p. 64). Participants would then rejoin the main group and go through a series of other stages. They would first arrange their own cards in an organised fashion and describe to the group how they grouped them. Next they would be asked to each choose a certain card ”family”, and then find other cards that fit into that family. Finally, they would discuss each other’s card families and show each other relevant video snippets and demonstrate how each card could be considered as part of that family and why it was important. The overall process from start to finish would take between six and seven hours.

Buur and Soendergaard write that after a dozen such sessions, they found the Video card method to be ”highly successful”, but at the time of writing had not yet finalised the precise parameters for optimum execution of a video card session. They reported that one factor which they had been experimenting with was the room layout, and they found that the room layout had a ”remarkable influence” on how the sessions unfolded. They experimented with the three types of room layout shown fig. 5.2:



(a) *The meeting room* **(b)** *The cinema* **(c)** *The design desk*

Figure 5.2: *Room layouts referred to in (Buur & Soendergaard, 2000). Grey circles refer to participant positions.*

Buur and Soendergaard found that the meeting room layout was well-suited for facilitating communication, but inhibited the ease with which participants could view the video screens. They also found discussion to be more general with this room layout than it was with other layouts. The cinema layout enhanced the role of the monitors, but caused participants to shy away from stepping in-front of the group. Conversation was also referred to as ”uneasy” due to participants having to rotate in their chairs to look at each other. The design desk was found to be rather favourable, as the cards and physical artifacts were placed in the centre of the table and within close proximity of everyone.

From this experimentation, Buur and Soendergaard suggest a few principles for room layouts. Firstly, the participants need to feel comfortable and feel as though they are all on equal terms with one another. Secondly, participants should have minimal distance between themselves, each other, and any physical artifacts that will be used in the session. Thirdly, try to avoid requiring participants to stand up in front of the group, as participants will feel less comfortable to express their views.

Finally, Buur and Soendergaard also made some comments on the practicalities of the card use. They noted that participants assign meaning to cards, and will wave them around to make points. They also noted that the images on the cards can be too small to see for participants seated at a distance, or may be upside down depending upon where the participant is sitting.

Some years later, Halskov and Dalsgård (2006) presented a method which they call the *inspiration card workshop*. The workshops aimed to formalise the inclusion of sources of inspiration in the design process through using what the authors termed *inspiration cards*. Halskov and Dalsgård appear to have been themselves inspired by the work of Ehn (1988), who identifies the balance between working within the contemporary design domain whilst simultaneously attempting to transcend it as one of the key dilemmas of design practice. Halskov and Dalsgård also refer to the work of Schön (1983; 1988), who highlights designs as a type of iterative interaction, or ”conversation” in Schön’s terminology, between the designer and the physical artifacts around them. Thus Halskov and Dalsgård thought that by providing the designer with physical artifacts that facilitate the easier consideration of domain-specific information, as well as physical artifacts which provide sources of inspiration, the design process could be improved. Building upon research by Tschudy et al. (1996), Buur and Soendergaard (2000), as well as more recent work by Brandt and Messeter (2004), Halskov and Dalsgård felt that using cards would be a suitable way of providing designers with these physical artifacts.

As a result, they developed inspiration cards, and divided them into two distinct categories. The first were called *domain cards*, which were the cards that would represent the contemporary design domain. The other type were called *technology cards*, which Halskov and Dalsgård used to provide the designer with sources of inspiration. Halskov and Dalsgård note that there is possibility for further sub-divisions; for example, domain cards may be divided into cards representing specific environments, or specific types of people. However, in interest of simplicity, Halskov and Dalsgård opted for just the division between domain cards and technology cards in their research. Domain cards are intended to be developed from the analysis of domain-specific research studies, and technology cards are likewise intended to be

developed from technology studies. Because of this, Halskov and Dalsgård cite the ability to bring domain research and technology research into the design process as a primary benefit of the inspiration workshop method.

Once the cards have been developed, designers are to conduct an inspiration workshop session, the process of which shall now be explained. The inspiration workshop follows three phases: 1) an introduction to the cards, 2) combination and co-creation with the cards, and 3) presentation of the results.

The method is a participatory method, and involves both designers as well as participants with domain expertise. The participants may be users, or other people with relevant experience. Each workshop begins a presentation of each of the cards, in turn, so that a common understanding of the cards is held by all designers. Designers present the technology cards, and participants usually present the domain cards. Halskov and Dalsgård note that this may take from one to three minutes per card, which hints that, due to time constraints, the quantity of cards is not too numerous in inspiration workshop sessions. Following a similar methodology to Buur and Soendergaard (2000), Halskov and Dalsgård suggest that this introduction phase may be accompanied by video snippets, or by supporting images.

Then participants split up into groups, and use the cards to collaboratively come up with concepts. This phase usually begins with each group discussing the cards, and then picking domains they find interesting, deciding on how they want to improve that domain, and then using the technology cards as inspiration towards that end. Halskov and Dalsgård note that it is possible, although rarer, for participants to start with a particular piece of technology that they find interesting and then find a domain that they can apply it to. The result of this stage is one or more design concepts which are captured on separate posters. These posters are then discussed, in

turn, with the aim of understanding the concepts, rather than to criticise or evaluate them for realism or practicality. These concepts can then be taken forward by design teams, and developed as needed into final products.

Halskov and Dalsgård had performed three inspiration workshops at the time of writing their paper, and noted that, although they kept the setup of the sessions 'almost identical', the sessions would run differently due to variations in the individual participants and group dynamics. They identified three factors that appeared to influence how fruitful the sessions were:

1. Level of familiarity with fellow participants.
2. Level of experience in using creative methods.
3. Insight into the usage domain.

The level of familiarity between participants was found to be conducive towards better overall performance of the sessions; this was believed to be due participants having an increased willingness to express more risky concepts, and thus result in a less-stifled creative process. The level of experience with creative methods had a similar effect for similar reasons. Halskov and Dalsgård note that, if participants are more comfortable using creative methods, they will engage better with the process and it will lead to better results. Insight into the usage domain was also important to the workshops, as a key purpose of the sessions is to help to develop concepts that "transcend" a given domain. This is done most effectively if participants are well-grounded in the realities of the domain, and see how the inspiration may practically fit in.

After explaining the process of the ideation workshop, Halskov and Dalsgård become more general about the value that they think the cards provide to the design sessions. They mentioned that the cards:

- Helped idea generation.
- Assisted in shifting focus during the discussion.
- Helped to bring new ideas into the discussion.
- Helped participants to select from a wide array of options the areas that were most important for them to focus on.

They also mentioned that there was an important value of the cards in how the cards differed in their conceptual proximity to the contemporary design domain. Cards that represented concepts conceptually closer to the domain helped participants to see the value of the cards more easily, but those with concepts that were more conceptually distant had greater potential to bring about innovative ideas. Halskov and Dalsgård write that considering concepts that are both conceptually near and far from what is usual helps to generate concepts that both fit into and expand the design domain.

Halskov and Dalsgård also provide a comparison between the inspiration workshop method and other methods for innovation; namely: *metaphorical design* (Madsen, 1994; Schön, 1979), *future workshops* (Jungk & Müllert, 1987; Kensing & Madsen, 1991), *interaction relabelling* (Djajadiningrat, Gaver, & Frens, 2000), and *lateral thinking* (De Bono, 1993). The comparison was made based upon four different constructs:

1. The conceptual distance between domains of inspiration and domain of use.
2. The number of sources of inspiration that the method provides the participant.
3. The amount of materials and tools that the method requires.
4. The level of structure and the amount of rules that the method has.

Halskov and Dalsgård's comparison presents inspiration workshops as a semi-structured innovation method, that helps provide many sources of inspiration, but one that does require a large number of materials (cards) to be produced ahead of time. A unique factor of the inspiration workshops, is the way that the cards allow a participant to consider concepts that have a range of different conceptual distances from the design domain, whereas the other innovation methods tend to stick at just one level of distance. Halskov and Dalsgård believe that this feature is what results in the higher number of generated concepts.

It appears that around 2008 the topic of using cards for creative purposes became a much more active research area. Kultima, Niemalä, Paavilainen, and Saarenpää (2008) published a paper on their work in developing a set of ”idea generation games”, that could be used to stimulate innovation in the gaming industry. Kultima et al. build their work on a fundamental concept from Mumford and Gustafson (1988), that ”a successful creative process requires a relaxed and playful atmosphere”. Kultima et al. note that the creative process of traditional creativity methods, such as brainstorming, can be stifled by what Kultima et al. call ”busy and oppressive” environments; such as environments where creatives fear criticism and rejection of their ideas.

To counteract this, Kultima et al. developed a set of games as a method of creativity. Kultima et al. draw on Huizinga's (1931) concept of the *magic circle*. A ”magic circle” is an abstract term which refers to a conceptual space experienced by players of a game where the rules and norms of reality are suspended for the purposes of play, and instead are replaced by the rules and reality of the game world. The separation between reality and the magic circle, Kultima et al. write, is what could give power to games as creativity techniques. This idea of separation from the present reality having innovative power is a similar concept to the idea of conceptual distance that is found in the work of Halskov and Dalsgård (2006). However, rather than creating

a general creativity method, they do note that their designs were focused more around the development of casual mobile multiplayer games (Kultima et al., 2008, p. 5).

They developed various different methods, including: computer programs, game-specific brainstorming, user enquiries, pen and paper approaches, toy-boxes, and mobile applications. However, Kultima et al. note that the most successful approaches they found were in the form of card and table-top games. Only three of their prototypes presented, and these three were sent for pilot tests at four Finnish game development companies.

The most popular of the their games was what they called ”VNA”, which is short for ”Verbs, Nouns, Adjectives”. VNA is comprised of three decks; one deck for cards containing verbs, one deck for cards containing nouns and one deck for cards containing adjectives (see fig. 5.3). In the VNA game, players sit down and the first player picks a verb card and uses it to describe to the rest of the group a game mechanic that is related to the verb on the card. The next player will then pick up a noun card and builds on the idea using a concept loosely related to that noun. Finally, the third player will pick up an adjective card and complete the game idea by merging the verb, noun and adjective together (Kultima et al., 2008, p. 6). The players will now have a completed design concept and can then discuss the concept together before creating another one using the same process.

Kultima et al. mention that VNA was the most popular of their three games. Kultima et al. cite three reasons for the games popularity: the fact that the game is based on rapid idea generation; the game’s provision of random input to participants; and the structured turn-taking which ensures that all players are involved and can have their say. One may add to this that the easy-to-learn nature of the game is also welcoming, and the random input removes all fear of criticism as the source of the idea was not within the con-

trol of the player; they merely had to respond to what was ”dealt” to them. There is also an appeal to the rather mechanical process of the game; VNA essentially promises that, if one just follows the ”recipe”, then a new game idea will be produced. In a trade-off for this speed of idea generation however, VNA only produces initial ideas, and is not well suited for producing well-developed concepts; VNA's focus is on quantity over quality (Kultima et al., 2008).



Figure 5.3: *VNA cards. Adapted from (Kultima, Niemalä, Paavilainen, & Saarenpää, 2008, p. 6).*

The second of Kultima et al.'s games was called ”GameSeekers”. Kultima et al. say that GameSeekers is similar to the game UNO®, where players are each dealt a hand of cards and the first one to dispose of their cards wins. When a card is disposed of, the concept that it contains furthers the development of the game idea. There are four types of cards in GameSeekers:

1. Red: Photos of objects, people or abstract themes.
2. Purple: Black and white patterns.
3. Green: Descriptions of casual game genres or social aspects.
4. Blue: Possible in-game operations.

The difference between UNO® and GameSeekers is that, in GameSeekers, no player actually ”wins”. The game is over when all players cannot dispose of another card in a way that would improve the game, or when one player disposes of all of their cards. To add an element of competition to stimulate

creativity, the first player to dispose of all their cards in a given game can become the ”idea dictator”. The ”idea dictator” can finalise the development of the game without input from the other players.

GameSeekers was met with a mixed reception. Some preferred it to VNA, as generally more highly developed game concepts would result after playing Game Seekers. Others found that the game was a little too complicated, and that the structure of the game lead to big but disjointed ideas. Overall, GameSeekers was determined to need further improvement.

The final game was called GameBoard. GameBoard was a game for between two and five players and could be played in ”solo mode”, with each player developing their own idea in a competitive way, or it could be together, with players working as a group in a cooperative way. Kultima et al. note that the cooperative mode of play was slightly more popular, which indicates a preference for collaboration in creative efforts. Presumably the reason for this is that, by collaborating, the risk of personal failure is lowered. Unlike VNA, GameBoard aims to produce developed and applicable game ideas.

GameBoard implements a board containing eleven slots for cards to be placed in (see fig. 5.4). When a card is placed on the board, its concept is included in the game idea, its impact on the game is discussed and the team score a certain number of points. The objective is to score as many points as possible by placing as many cards on the board as possible. GameBoard is rather rule-based; in comparison to the other ideation games, as cards are placed according to a set of rules, and the scoring system also depends upon a set of rules.

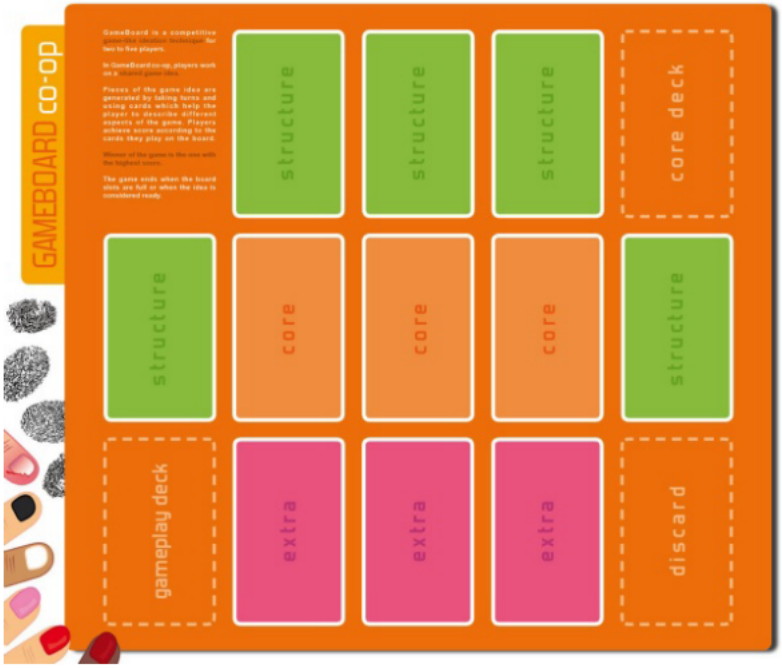


Figure 5.4: *GameBoard board. Adapted from (Kultima, Niemalä, Paavilainen, & Saarenpää, 2008, p. 10).*

There are two decks of cards in GameSeekers: core cards and gameplay cards. Core cards are used at the outset of a GameBoard game to initialise the idea, and include cards for game mechanics and game themes. Gameplay cards are used during the GameBoard session to develop the idea, and include concepts such as: goals, win-conditions, game features and so on. GameBoard's core cards and gameplay cards are similar to Halskov and Dalsgård (2006)'s domain cards and inspiration cards; in Halskov and Dalsgård's terminology, the core cards initialise a design "domain", and the gameplay cards serve as forms of inspiration for that domain.

GameBoard received rather polarised results; participants either liked or disliked it. It appears that the structured nature of the game harmed its reception; the points system was said to be "awkward and unnecessary" and Kultima et al. write that the rules and structure inherent in the game presented barriers to some participants. In fact, Kultima et al. write that some participants would ignore the rules entirely, or customise them as they wished. From comparing the success of relatively unstructured approaches, such as

VNA and Halskov and Dalsgård's inspiration workshops, it appears that an overly structured method actually stifles creativity, rather than helping guide participants through the rather complicate ideation process. It seems that participants want a general direction of which way to go, but they do not want turn-by-turn directions.

In the same year, Beck, Obrist, Bernhaupt, and Tscheligi (2008) developed their *instant card* method to provide a formalised method for involving users in scenario development. While the instant card method is similar to Tudor et al.'s CARD method or Halskov and Dalsgård's inspiration workshops, Beck et al. write that the instant card method goes beyond focusing on only tasks and activities and includes user personas (Cooper, 1999) and contexts of use in the ideation process.

Beck et al. use six types of instant cards which are intended to cover all the aspects of a specific context scenario:

1. User Cards.
2. Location Cards.
3. Time Cards.
4. Technology Cards.
5. Activity Cards.
6. Goal Cards.

User cards act similar to personas, in that they define either real or imaginary users based upon certain features such as demographic information (age, gender, etc), skills and preferences.

Location cards provide information about where a certain interaction takes place, time cards provide temporal information for the interaction, such as

the time, frequency and duration of the interaction. Technology cards show what technology the user is using, activity cards detail the certain activity that the user is engaged in and goal cards detail what the user is trying to achieve (Beck et al., 2008, p. 164). This division of cards is very useful, as it helps to separate out all the different factors that should be considered when defining a context of use, which is a very important factor task to accomplish when hoping to develop a successful design.

Inspiration card workshops are conducted with between six and ten people, and Beck et al. attempt to make the setting up and conducting of an instant card workshop as formalised and as structured as possible by providing a five-step process for preparing for an instant card workshop, as well as another five-step process for conducting an instant card workshop.

How instant card sessions are conducted is the matter most interesting to this discussion at present, so this aspect shall be discussed now. The process is very similar to that of Halskov and Dalsgård's inspiration card workshops (2006), with the sessions beginning with an introduction by the facilitator, and then participants breaking into groups, familiarising themselves with the domain, brainstorming concepts using the cards, and finally presenting their best concept to the group in the form of a poster. Beck et al. additionally added a stage in which participants can give feedback upon the method to the researchers, as well as feedback on the usage of the cards. Beck et al. used this feedback over a course of three sessions to improve the method iteratively, but these sessions are documented in alternative publications.

As part of a trend in the systematisation and specialisation of ideation cards, Golembewski and Selby (2010) wrote about a method for producing what they termed *ideation decks*. Golembewski and Selby write that, whilst card-based methods tend to support the overall design process, ideation decks are more of a method that can be customised to each design project that

a designer faces, rather than a bespoke deck or game intended to be used in multiple situations. Tohidi, Buxton, Baecker, and Sellen (2006) call these different angles 'parallel design' activities.

The idea behind ideation decks is to provide a structured method for designers to generate sub-briefs for a given overarching brief using cards, thereby allowing for a multifaceted consideration of the initial problem space.

In a similar style to Beck et al. (2008), Golembewski and Selby provide a structured five-step method of creating an ideation deck, and another structured five-step method for using one.

With regards to creating an ideation deck, the first step is to define the project domain that one is working in. Thereafter, one attempts to break down this domain into its various distinct features. For example, if one was considering the question of how to creatively present technological information in airports, distinct features of that domain may be: the technology, the user, the airline, the location in the airport, the class of travel and so on. These would form what Golembewski and Selby call the *category suits*. Similar to suits of cards in a standard card game, category suits represent the various different categories that specific examples can fall into. Golembewski and Selby's method requires that there be at least three category suits, for reasons which shall become apparent when discussing how the ideation decks are used.

Once the category suits have been defined, the next step in the ideation deck method is to create what Golembewski and Selby call the *instance cards* for each suit. For example, instance cards for the "location" suit may be: the check-in desk, the gate, the food court, the shopping area and so on. The suits should be a mixture of concrete and abstract concepts; this is to try to strike a balance between concepts that will result in designs that are impracticable due to their abstractness, and those that are not innova-

tive enough due to their concreteness (Golembewski & Selby, 2010, p. 91). Furthermore, Golembewski and Selby note that, for each suit, there should be at least as many instance cards as the total number of suits. So, if there are five suits, then each suit should have at least five instance cards. All the design team may have at this point is a list of concepts on a piece of paper or spreadsheet software; the next step is to ”engage creatively with the instance cards”. What this means in practice is that designers will go and determine what exactly they mean by each of those concepts and attempt to create and gather the required digital assets to create the cards: photographs, descriptions, and so on. This forces the designers to engage critically with the design space from various angles, gain a certain intuition for the nuances of the design space, and prepare for the final stage of development which is to actually create the cards. Golembewski and Selby recommend that cards are made to be visually distinct based upon suit, with the colour of the cards being a suggested method of doing this.

The process of actually designing the cards is intended to be a valuable part of the design process, as the designers become intimately familiar with all the different aspects that they can consider. The development stage is similar to an extended and in-depth familiarisation step that participants were asked to engage in during the works of Buur and Soendergaard (2000), Halskov and Dalsgård (2006), and Beck et al. (2008).

Once the cards are developed, however, a simple method is used to actually generate sub-brief concepts. The first step is to select three suits to include, and to layout instance cards from each suit according to the layout shown in fig. 5.5.

Suit C	Suit B	Suit A
Suit B	Suit A	Suit C
Suit A	Suit C	Suit B

Figure 5.5: *How to layout instance cards. Adapted from (Golembewski & Selby, 2010, p. 90).*

This layout is intentional; by laying out the instance cards in this way, it ensures that the rows and columns each use an instance card from each of the suits. Thus, each row and column can represent a new sub-brief. Golembewski and Selby note that this gives six possible sub-briefs for each layout of cards, but it appears that an additional combination can be made by reading the cards from the top left to the bottom right of the grid, thereby bringing the total up to seven. The choice to use a 3x3 grid is also intentional; Golembewski and Selby note that, from experimenting with the grid size in workshops, a 3x3 grid provided an optimal level of flexibility in the produced sub-briefs. Larger grids produced sub-briefs that were overly prescriptive, and smaller grids produced sub-briefs that were overly vague. Moreover, it is the grid layout that caused the prescriptive minimum amounts of suits and instance cards mentioned earlier.

Whilst designers consciously choose the suits and instance cards to include, the sub-briefs occur with a certain sense of randomness. This sense of randomness was shown to be a favourable characteristic of Kultima et al.'s VNA game as it adds a sense of fun and novelty to the process, and removes any individual burden of blame for the success of the outcome, thereby removing a significant barrier to authentic participation. The layout also provides a similar sense of being quick and structured, which were two other characteristics that were favoured in VNA.

Although the layout is generally fixed, Golembewski and Selby do afford de-

signers the ability to engage in what they call *constructive cheating* (Golembewski & Selby, 2010, p. 92). Constructive cheating is where designers can change the position of cards if they deem it favourable to do so; however, designers must justify their reasoning to the team for this to be allowed.

One insight from Golembewski and Selby's work was noting that by breaking down the design domain into suits, and then furhter breaking the suits down into instances, no matter what arrangement of instances is selected to create a sub-brief, the sub-brief will be applicable to the original domain. This is a useful approach to take when analysing complicated design domains with cards.

While Golembewski and Selby's ideation decks involves designers effectively creating their own models of a domain space, Hornecker (2010) converted existing research into the field of *tangile user interfaces* (TUIs) into a set of cards for designing such interfaces. TUIs are user interfaces where a user interacts with a physical device and a computer processes the input. Then, instead of simply outputting data, the output is perceived by the user as a physical change in some object; perhaps an object's colour changes, or a sound is emitted, or a vibration occurs. The output object may be the same as the input object, or different (Fishkin, 2004; Ishii & Ullmer, 1997). More specifically, Hornecker discussed experiences in using a deck of cards that they created to be compatible with their previous theory on the *Tangible Interaction Framework* (Hornecker & Buur, 2007). Hornecker's research contributes the notion that existing research frameworks can be converted into card-based design games to make abstract concepts from the framework more accessible to non-expert users.

This notion of using cards to make academic work more accessible was also employed in the work of Alves and Roque (2011b), who created a deck of cards to help independent game developers use existing research into sound

pattern languages in their games. The aim of the deck is to help developers to implement sound more consciously into their games, thereby hopefully leading to developers creating games with more immersive experiences for their customers. Alves and Roque didn't run a creative session like previous authors, but their paper instead discusses the design choices they made when designing their cards, as well as a novel methodology for evaluating how ”good” the deck of cards was and identifying areas for improvement. Alves and Roque (2011b) demonstrated that there is a need to iteratively develop ideation decks over time, and, therefore, their method of analysing the performance of a deck is a highly valuable contribution.

In 2012, Friedman and Hendry published a paper on their *envisioning cards*, cards that are intended to facilitate a better inclusion of human values in the design process. By considering Friedman and Hendry's work alongside the applications mentioned previously, one can begin to appreciate the breadth of applications that can benefit from the use of card-based methods in a significant way; Friedman and Hendry even position their work with the cards in support of Bannon's call (2011) to re-envision HCI as a more human-centered practice (Friedman & Hendry, 2012, p. 1145, p. 1148).

There are, as described above, many examples of cards being used as design methods. To try to get a grasp on the activity and potential future directions in the space of card-based design methods, Wölfel and Merritt (2013) analysed 18 card-based methods and categorised them based upon five design parameters, each of which had various sub-categories (see table 5.1).

Table 5.1: Wölfel and Merritt's (2013) card method categorisation scheme

Parameter	Examples
Intended purpose and scope.	1. General purpose/repository 2. Participatory design 3. Context-specific
Duration of use and placement in design process	1. Anywhere/anytime 2. As needed. 3. Beginning of design process. 4. Specific point in design process.
Methodology or system of use.	1. No methodology. 2. Suggestions for use. 3. Specific instructions.
Potential for customisation.	1. No customisation. 2. Trivial customisation. 3. Optional customisation. 4. Requires customisation.
Formal/Material Features	1. Only text/only images. 2. Both text and images. 3. Has categories. 4. Has virtual components.

Based on these parameters, Wölfel and Merritt determined three main classes of card-based design method:

1. General purpose / repository cards.
2. Customisable cards.
3. Context-specific cards.

The general purpose/repository cards essentially present a large body of potentially useful concepts to designers, and they mainly aim to assist and stimulate ideation (Wölfel & Merritt, 2013, p. 483). They don't tend to come with instructions for use and can be used at any point in the design process.

The customisable cards, as defined by Wölfel and Merritt, are 'cards that are inherently customisable to some degree' (Wölfel & Merritt, 2013, p. 483).

These cards tend to have the intended purpose of facilitating participatory design; that is, they are intended to be used in collaboration between designers and end-users. The customisation helps to facilitate discussion, but these types of cards tend to be most useful at a specific point in the design process. Given the challenge of getting end-users and designers to collaborate productively and to understand one another, these cards also attempt to alleviate this issue by providing structure and rules for how the should be used (Wölfel & Merritt, 2013, pp. 483-484).

The context-specific cards are cards that have a specific use or design agenda. Therefore, these types of cards tend to be the most restrictive, and tend to be used at a specific point in the design process and with specific instructions (Wölfel & Merritt, 2013, pp. 484). An example of such from the works already presented would be Alves and Roque's sound cards, and Wölfel and Merritt do indeed classify this deck under this category.

Although Wölfel and Merritt note that their categorisation is not meant to be more than a useful outline of the design space, it appears that a certain amount of circular reasoning has occured, as two out of three final categories are actually potential options for the ”intended purpose and scope” design dimension (see table 5.1). In fact, for the one that is not (customisable cards), Wölfel and Merritt note that the customisable cards consist mainly of cards intended for participatory design (Wölfel & Merritt, 2013, pp. 483-484). Participatory design is the other option of the ”intended use” design dimension. Perhaps the reason for this is that Wölfel and Merritt performed the final categorisation based upon what was the apparent post hoc purpose of the cards, but this essentially reduced the analysis down to that single dimension. Either way, the elaboration of the specific qualties of each deck is still very useful.

Finally, Wölfel and Merritt provide some valuable insights into further av-

enues of development for card-based design methods. From the analysis, Wölfel and Merritt recommended that more decks should offer a customisation component, and they also recommend that more decks should attempt to leverage opportunities to incorporate virtual features into the cards, such as QR codes or augmented reality. The customisation recommendation is reminiscent of the ”ownership” concept that Buur and Soendergaard (2000) built into their design sessions. However, the recommendations for virtual components should be adopted only after consideration of one’s specific use-case. The cards are primarily tools intended to facilitate the design process. Therefore, if adding such features may potentially hinder this process, as was the case in the research of Buur and Soendergaard (2000), then the features shouldn’t be included simply by virtue of their originality or novelty. Indeed, it may be that the relative rarity of these features that Wölfel and Merritt identify is somehow related to a latent recognition of this point.

Prior to the work of Wölfel and Merritt, but also in 2013, Lucero and Arrasvuori developed a deck of cards called the PLEX cards. The PLEX cards would prove in the future to be quite popular, and they are essentially a conversion into cards of earlier work by Korhonen, Montola, and Arrasvuori (2009) on the playful experience (PLEX) framework. Korhonen et al., in turn, built upon prior work by Costello and Edmonds (2007), who developed an in-depth framework of pleasurable experiences. Korhonen et al. expanded Costello and Edmonds’ work and adapted it to the domain of play. Korhonen et al.’s PLEX framework includes 20 concepts, ranging from conventional concepts that one might typically associate with play, such as *challenge* or *competition*, to more unusual concepts such as *sadism* or *suffering*. The PLEX framework was updated in later work by Arrasvuori et al. (2011) to include a total of 22 concepts.

As mentioned, Lucero and Arrasvuori (2013) converted the PLEX framework into a set of cards, known as the PLEX cards. They also developed

two design methods to accompany the cards. Firstly, there was the *PLEX Brainstorming* technique which was inspired by Kultima et al. (2008)'s VNA game. PLEX Brainstorming "aims at rapidly generating a large amount of ideas" (Lucero & Arrasvuori, 2013, p. 37). Secondly, there is the *PLEX Scenario* technique, which is inspired by Kultima et al.'s GameBoard game, and aims to help in generating more developed ideas (Lucero & Arrasvuori, 2013, p. 38).

Although Lucero and Arrasvuori's work is interesting in its own right, what is more relevant to the present work is how the PLEX cards would later be applied in the works of Olsson, Väänänen-Vainio-Mattila, Saari, Lucero, and Arrasvuori (2013), Pakanen, Polli, Lee, Lindley, and Goncalves (2013), Ventä-Olkkonen, Kinnula, Dean, Stockinger, and Zúñiga (2013) and Ojala et al. (2015), as part of an experience-driven design approach to improving the built environment. Briefly, experience driven design is a design approach where a target experience that the designed product or service should provide is first determined, and then designs are generated with the aim of providing that target experience (Ojala et al., 2015, pp. 74-75).

Olsson et al. (2013) employed the PLEX cards in a postgraduate seminar course. Olsson et al. claim that, although the use of the cards was done in an educational setting, their findings will be applicable to real-world design practices (Olsson et al., 2013, p. 167). The students lived in Finland, and were given the design brief of *"How to support moving and navigating in the Finnish winter?"*. This design brief is especially relevant here, as the students were using cards to assist design for a navigational context.

Students were split into five groups of between three and four students, and each group was given a small subset of the 22 total PLEX cards. Each subset consisted of three PLEX cards, and represented a "meta-category". For example, one meta category was the *Adventure* meta-category, which con-

sisted of the *Discovery*, *Exploration* and *Captivation* PLEX cards. By having these meta categories, each group was required to tackle the overall design brief from a different angle, and the categories served as an experience that would serve as an overall goal. Thus, the students had to design in an ”experience-driven” way.

Olsson et al. deemed this approach to be a fruitful one, and identified four areas in which the experience-driven design approach with the PLEX cards was useful: *guiding and framing* the design process; providing *inspiration*; helping with idea *evaluation*; and improving group *communication*.

The *guiding and framing* benefit refers to how having a target experience to design for helped to narrow the design space and helped to keep the students on task throughout the design process. If they got off track, they could refer to their category and regain focus.

Inspiration refers to how having a relatively unconventional experience to design for helped generate more innovative concepts than would have been the case if students were left to choose their own design solution. Olsson et al. write that, although the PLEX categories were concrete enough to guide the design process, they were also flexible enough to assist with inspiration. Due to the use of the different categories, the concepts produced by the different groups varied greatly, even though the initial overall brief was the same. It appears that this imposition of a meta-category to target caused new perspectives to be considered by virtue of the fact that the meta-category wasn’t one that the designers would immediately have opted to aim for.

Evaluation is similar to the guiding and framing benefit, but refers to how the target experience would give grounds to reject concepts that weren’t fitting their overall design goal and to see how their designs could be improved to better provide the target experience.

Communication referred to how the target experience helped students to better know whom the design would be appropriate for, and thus were able to communicate better within their groups, better communicate the benefits of their design, and better produce more marketable ideas.

Ventä-Olkkonen et al. (2013) report on their experience of creating a cardboard interactive display that served as a prototype of a TUI tangible user interface for interacting with people in distant cities. The PLEX cards were used in the brainstorming phase of this project to help incorporate play elements in the display.

The PLEX cards were also used in the work of Pakanen et al. (2013) on developing a *virtual garden*. Pakanen et al. note that, when waiting at bus stops, people tend to avoid interacting with each other, and are 'alone together'. In an attempt to bring people together at bus stops, Pakanen et al. aimed to develop a virtual garden. The intention was that people at the bus stop can use their smartphones and gestures to care for this virtual garden, and doing so would bring people together and improve the experience of waiting at a bus stop. Again, this application has an inherent element of play, and the PLEX cards are again found as a tool that was used in the brainstorming phase of the project.

Once again, the PLEX cards are found in the work of Ojala et al. (2015), who aimed to use an experience-driven design approach to identifying potential improvements to be made during the development of the railway area in the city of Tampere, Finland. They situate their work as part of the smart city agenda (Caragliu, D Bo, Kourtit, & Nijkamp, 2015). Ojala et al. began their work by going to the the Tampere train station and recruiting 31 participants "on the spot" for some short 5-10 minute interviews, in order to gather some preliminary understanding of the needs people had for development in the area. Ten of these participants were recruited to take part in the second

phase of the study, which itself had two phases. The first phase of stage 2 (stage 2.1) was a more in-depth interview, and the second phase of stage 2 (stage 2.2) was a participatory design session with the PLEX cards.

In the phase without the cards (stage 2.1), Ojala et al. note that participants generated concepts mostly related to more pragmatic matters such as: services and events; signage and guidance; and smart traffic. When given the PLEX cards however, participants generated concepts mostly experience-related concepts, such as: experiences in the area; gaming and entertainment; and crowdsourcing or social applications. This shows that using cards can be used to set a frame of a design session and focus creative effort towards a particular area. This is a useful approach for focusing design consideration on a generally under-considered design domain, such as experience-design or accessibility. Moreover, Ojala et al. noted that, in total, participants generated 59 ideas from stage 2.1, but 75 ideas from stage 2.2. This is an increase of 27%, which shows that using cards can also help to increase the number of ideas that are generated.

It is also worth noting an interesting methodological choice made by Ojala et al. They didn't provide the participants with a meta-category to design for like Olsson et al. (2013) did in their postgraduate course; instead, Ojala et al. allowed participants to pick the cards that the participants themselves thought were most important, and allowed them to discard the cards that they thought were unimportant. This allowed Ojala et al. to identify which areas would be key targets for development, and which areas would likely be less fruitful. Ojala et al. cite this as a useful approach to take.

The discrepancy between Ojala et al.'s method and that of Olsson et al. (2013) can be explained by considering the nature of the users in each case. Olsson et al.'s target users were designers, who generally can benefit from being 'forced' to think in novel and unconventional ways. In the case of Ojala

et al., the card users were the actual travellers; that is, the ultimate recipients of the designs, not the generators of them. Therefore, in the case of Ojala et al.'s work, it was beneficial to allow the users to declare what their true needs were, rather than to cause them to think differently for novelty's sake alone. Thus, the recommendation to provide meta-categories or to allow the card users to choose should be based upon whether the card-users are designers or ultimate end-users of a product.

Other more recent examples abound of ideation card usage, such as Luger, Urquhart, Rodden, and Golembewski's 2015 "Privacy deck" which is intended to help designers consider data privacy issues, or Wetzel's (2017) Mixed-Reality Game Cards which help game designers generate new mixed-reality game ideas, or Bedwell's Visitor Box which is a set of ideation cards to support organisations in the cultural heritage sector (www.visitorbox.org).

To summarise, card-based design methods are a vast and varied field of research. Essentially, card-based methods are tools for assisting with the creative process. As Wölfel and Merritt (2013) point out, some are general purpose and serve as stores of information to help provide new ideas to designers, some help to facilitate participatory design sessions between designers and users, and some have their own specific use case. Popular decks of cards, such as Lucero and Arrasvuori's PLEX cards, convert research frameworks into fun games and tools that non-experts can readily access and utilise in their creative projects. These projects may range from somewhere as simple as a classroom design module (Olsson et al., 2013), to providing recommendations for the development of a city's central railway station (Ojala et al., 2015).

The cards work by offering a game-like experience, where the card-users are free to "play", and are shielded from criticism and real-world considerations. Halskov and Dalsgård identify the notion of conceptual distance as

an important benefit of the cards. If cards contain concepts that are readily understandable by a design team, as well as those that are more abstract, then this contrast of conceptual distances is thought to enhance innovation. Kultima et al.'s design games, such as VNA, show the benefits of concepts of randomness in the games, as well as the benefits of a simple repeatable process to the sessions.

Overall, card-based design methods are simple, effective, flexible, and tangible methods that are accessible to experts and non-experts alike. They can be applied to many design domains and are effective for integrating into the design process, right from the beginning, a detailed consideration of areas and concepts that may tend to be neglected. As such, they make an excellent fit for the research agenda of this work. Such an approach does not seem to have been attempted in the B/VI navigation literature at present. Therefore, it is believed that in the development of a card-based design method to be used for the development of B/VI navigation aids lies the opportunity for a novel research contribution.

Summary of Part I

In this part, I have reviewed the literature on navigation, B/VI navigation challenges, B/VI navigation aids, and ideation cards.

Chapter 2 discussed navigation. Navigation is defined as the purposeful or goal-directed movement through space (Freundschuh, 2001; Montello, 2005). I have discussed how navigation is typically conceptualised as being made up of two components: wayfinding and locomotion (Montello, 2005).

Locomotion is the component of navigation concerned with coordinating one's body to the local surroundings, and involves many unconscious processes such as steering, maintaining balance, and avoiding obstacles. Wayfinding is the more cognitive component of navigation and is concerned with how the navigator employs spatial knowledge of an environment to arrive at locations beyond their sensory horizon.

I have discussed how navigators acquire spatial knowledge and encode this knowledge to form cognitive maps. I have also discussed Siegel and White's (1975) LRS model of cognitive map formation, and noted its accepted continued use in research into navigation behaviour despite its criticism from a neurological standpoint (Chrastil, 2013).

I have also discussed how, using their cognitive maps, navigators are continually maintaining their orientation in space via landmark-based and dead-reckoning processes.

Because a desire for easier navigation is the number one factor that would make everyday life easier for B/VI people (Slade & Edwards, 2015), there was a good rationale for discussing the navigation literature in this thesis.

Chapter 3 began with a definition of the terms ‘blind’ and ‘visually impaired’ and presented the most common types of eye conditions according to 2010 US census data and example symptoms according to the World Health Organisation (WHO, 2019). After discussing the impacts that visual impairment can have a person’s quality of life, I moved on to discuss the literature on the various navigation challenges that a B/VI person may face. My review showed that B/VI people experience difficulties with all parts of the navigation task, which include difficulties with developing cognitive maps, maintaining orientation, and avoiding obstacles.

As so many B/VI people desire easier navigation, it is important to understand what the challenges they face are. This was the rationale behind the discussion of challenges in the literature review.

In order to address the challenges faced by B/VI people, various types of navigation aids have been designed. In chapter 4, I reviewed the various types of navigation aids, and categorised them with respect to which part of the navigation task they help with. Following on from the challenges in chapter 3, I discussed aids that help with obstacle avoidance, environment familiarisation, localisation, path planning, and providing access to signage. Understanding the various efforts that have been put forth to address the challenges that B/VI experience is important to see how these efforts may be improved further, and thus a discussion of the different aids was included in this thesis.

My review showed that although there is consistent development of navigation aids in the literature, there is also a persistent thread that points out the low adoption rates of these developments and identifies a lack of considera-

tion of user needs as a key cause of this (Giudice & Legge, 2008; Gori et al., 2016; Padmanaban & Krukar, 2016; Sanchez & Elias, 2007). However, the review also showed that research into the needs of B/VI navigators exists in the literature (Beatrice Dias et al., 2015; Giudice & Legge, 2008; Golledge, 2004; Williams et al., 2013). This lead to me to hypothesise that this long-standing issue with navigation aid design isn't due to a lack of knowledge of the needs in the literature, but rather due to the lack of a method of integrating a holistic consideration of those needs into the design process.

This brought me onto the final chapter of the literature review, chapter 5, which discussed the history and present application of ideation cards. Ideation cards are a design method which use custom-made playing cards to present designers with concepts relevant to a given design domain. My review showed that ideation cards are a highly flexible design method, and that they have applications in a wide variety of domains.

Unlike other methods of disseminating design knowledge such as formal lists of design guidelines and best-practices, ideation cards are well suited for use in the context of creative design sessions (Wetzel, 2017). We have seen from our discussion of the literature on navigation aids (chapter 4) that the needs of B/VI navigators have already been studied to a significant extent in the literature. Although these needs are already known in the literature, Padmanaban and Krukar (2016) write that designers are continuing the perpetuate the long-standing trend of not accounting for all the needs that B/VI navigators have when they are designing aids for them.

This lead me to assume that the reasons for these errors lies not with a lack of knowledge regarding the needs of B/VI navigators, but rather with the lack of a design method that supports designers in holistically considering these needs when designing. In other words, I assumed that designers are lacking a method which presents the design knowledge in a format that is

easily usable in the context of a design session. Therefore, I was looking for a method of encapsulating the design knowledge that would allow for the design knowledge to be considered easily during design sessions in a structured and holistic way. Ideation cards are good for providing designers with inspiration, and at the same time helping them to consider concepts relevant to a given design space that may otherwise be forgotten or under-addressed (Ojala et al., 2015). Therefore, ideation cards appeared to provide a good format for addressing the issues revealed by the literature review.

By taking an ideation card based approach, my intention was to develop a design method that can help designers to produce navigation aid ideas that have a holistic consideration of the needs of B/VI navigators 'built in' from the start of the design process. My intention is that such a method will help designers to produce navigation aid that have higher levels of user acceptance, as they will be better able to detect and root out common issues early in the design process when they are easy, and cheap, to amend.

Although ideation cards can be developed in a participatory way—i.e., in collaboration with end users from the beginning—, it is worth noting that it is not necessary for them to be developed in this way, and due to difficulties in recruiting B/VI participants and navigation aid designers in sufficient quantities, this was not the approach taken in this work. However, many ideation card decks, such as those by Halskov and Dalsgård (2006), Hornecker (2010), Alves and Roque (2011b), and Friedman and Hendry (2012), condense academic research into a form that is easily usable in creative design sessions and then test how well the decks perform, rather than developing the decks in a purely participatory way from the outset. This thesis takes a similar approach by first gathering the needs, then creating the cards, and then evaluating their performance.

It should also be pointed out, however, that, regardless of how they are de-

veloped, ideation cards are a highly visual method of relaying design information. Given that the context of this research being the design of navigation aids for the blind and visually impaired, the reason for using cards to relay information should be discussed a bit, it remains necessary to provide a justification for using such a visual medium of relaying design information. The reason that ideation cards were chosen was that I assumed that the designers who were having difficulties in holistically considering the needs of B/VI people were not B/VI themselves. Therefore, it appeared reasonable that using ideation cards would be suitable for these designers, and the apparent advantages of ideation cards made them attractive as an option to explore. The cards, in their current form, are *not* intended for use as part of a participatory design approach. That said, it is still highly worthy aim, both pragmatically and ethically, to make the cards accessible for use by B/VI people. This is true not only for my cards, but also for ideation card methods in general. Therefore I have also investigated how ideation cards may be made accessible to B/VI participants and a discussion of this is included in chapter 16.

Part II

Curating B/VI Navigation Aid Needs

Introduction

The literature review spanning the last four chapters has shown that B/VI people face a lot of navigation challenges and use navigation aids to support them in overcoming these challenges, but the navigation aids available do not typically satisfy all of their needs. I have proposed ideation cards as a suitable method of addressing this issue because they will allow the needs of B/VI people to be curated and placed in front of designers in a way that is conducive for use in creative design sessions. The intention is that this will lead to a better consideration of the needs of B/VI people, and thus to better navigation aid design.

To curate content for the cards, however, I need to have an understanding of how these needs may be structured. From what has been shown in the literature so far, the needs of B/VI people generally fall into two different categories. On the one hand, there are the needs that are about the functionality of the aid and its usability: Does it work? Is it portable? Does it block the user's hearing? On the other hand, however, there are needs more related to how the aid makes the B/VI person feel about themselves and about their environment: Does it enhance their social stigma and isolation? Does it make them feel more confident? Does it make them feel unsafe?

Hassenzahl (2007) introduced the hedonic/pragmatic framework of user experience, and it is has had a significant impact on the fields of human factors and human-computer interaction (Diefenbach et al., 2014). The framework

proposes that humans evaluate products based on two types of qualities: pragmatic qualities and hedonic qualities, which are typically assumed to be dichotomous (Diefenbach et al., 2014, p. 307). Pragmatic qualities are concerned with the products utility and functionality, i.e its ability to help its user achieve “do goals”. Hedonic qualities, on the other hand, are qualities that the user believes will help them to achieve “be goals”. Hassenzahl mentions “being competent”, “being related to others” and “being special” as examples of “be goals”. Although they do include it, hedonic qualities move beyond simple sensory stimulation. Hedonic qualities can also associate the user with a particular identity (e.g. imply the user is an athletic person, an intelligent person, a disabled person), symbolise certain concepts, and provoke memories (Hassenzahl, 2007).

Hassenzahl’s framework fits nicely with the observations here. The needs that B/VI people mention about not restricting hearing, portability, and functionality would be classified as pragmatic qualities of the navigation aid. The qualities of the aid that help the user be less stigmatised, feel more confident, and feel more secure, would classify as hedonic qualities.

By using this lens of pragmatic and hedonic qualities, where the former contains the qualities pertinent to the aid’s functionality and usability, and the latter contains every other pertinent quality, we have a useful tool for approaching the needs curation required for the cards.

In this part of the thesis, I will cover the pragmatic needs that B/VI people have for their navigation aids, but discussing their functional needs (chapter 8) and usability needs (chapter 9). I will also add commercial needs as a new type of pragmatic need to our consideration, to reflect the commercial factors at play in a navigation aid’s success (chapter 10). I made this addition because it is not enough for navigation aids to function well; if they are to have a positive impact on the lives of B/VI people, they need to translate into

successful products, and the commercial needs will help designers consider the factors important to this from both the perspectives of both the user and of industry. Finally, I will also present the hedonic needs (chapter 11) and some universal and specific challenges that B/VI people experience when they navigate chapter 7.

In each chapter, I will present:

1. How my data confirms the literature findings
2. How I contribute knowledge
3. How the content of that chapter will be taken forward in part 3 to develop the ideation cards

Chapter 6

Methods and Methodology for Part II

6.1 Introduction

The literature covers a wide range of needs, but it is also rather fragmented, with some papers discussing challenges and needs that are not mentioned elsewhere.

At this point in the research, it seemed advantageous to conduct some primary research that would afford an opportunity to (a) confirm the findings reported in the literature (b) ground any understandings from the literature in real-life experience with B/VI people, and (c) to uncover other needs that may not have been mentioned in the literature.

Therefore, a series of interviews were conducted with nine B/VI people. The data from these interviews were used to curate the pragmatic needs that B/VI navigators may have for their navigation aids—which includes their functional, usability, and commercial needs— as their hedonic needs.

When curating the commercial needs, I focus on the other side of the argument. Instead of only speaking to the end-users of the aids (B/VI people), I decided it would be useful to also speak to people involved in the industrial side of navigation aid development.

Therefore, I conducted an interview with two executives from Wayfindr, an award-winning tech non-profit based in London. Wayfindr have developed an open international standard that is recognised by the International Telecommunication Union (ITU). Wayfindr's open standard, ITU-T F.921, provides a standardised way of delivering audio-based indoor navigation support to VI people. By following this standard, developers can ensure that VI navigators have a consistent experience as they move through different environments, and thus empower VI navigators to navigate indoor environments independently.

Wayfindr offer consultancy services to people who want to set up audio indoor navigation systems. Wayfindr will come to a client's site and conduct trials with indoor navigation technology to help their clients explore how audio directions can be used to help make their spaces more accessible to VI navigators. Wayfindr have conducted trials at various high profile locations, such as the Illunion's Las Arenas shopping centre in Barcelona, and Shakespeare's Globe Theatre in London.

Wayfindr's consultancy work, especially when combined with their experience in policy, give them the ability to comment on the commercial factors that might cause industry to reject the installation of navigation aid infrastructure. Perhaps some of these points could also be generalisable to all VI navigation aids and thus be valuable points to consider in the cards as barriers to a design's commercial success.

6.2 Why interviews are an appropriate method of data collection?

Methods texts for qualitative research advise the researcher to pick a research method that aligns well with the philosophical stance they take to the work and to make this stance clear in their writing (Hignett, 2005). My research is conducted from a realist paradigm, where I make, like Mason (1996), the ontological assumption that the views I encounter represent properties of reality and are not simply a bi-product of the engagement, like a more constructionist view would assume. I also make the epistemological assumption that interacting with the sources and views is a legitimate way to learn about them (Mason, 1996).

Table 5 of Hignett's work (2005) draws upon work by Wolcott (1992), Miles and Huberman (1994), Mason (1996), and Dingwall (1997) to suggest appropriate qualitative methods of research for various ontological and epistemological stances a qualitative researcher may take. Hignett suggests that a suitable way to satisfy the philosophical positions adopted for this work is to conduct research interviews. Interviews serve as an excellent method for gathering deep explorations of a particular context, even with a relatively small group of participants. Interviews come in three types: structured, semi-structured, and unstructured. Because, based on my literature reading, I already had some ideas about the topics I wanted to touch on, I opted for semi-structured interviews, as this would allow me to ask particular questions I had in mind, but also allow for serendipitous discussions to take place.

6.3 Interview Methods

6.3.1 B/VI Interview Method

Questions with the B/VI participants aimed to explore the experience that B/VI travellers have when navigating unfamiliar locations. The questions were open-ended to leave room for elaboration, but touched on topics such as what challenges the participant faces when navigating an unfamiliar environment, how they are feeling when in that situation and how they overcome the challenges that they face. There were also questions about how the participant uses various navigation aids for the task, as well as the perceived usefulness of these aids and opinions on how they could be improved.

Due to logistical considerations, participants P1–P5 were interviewed on a one-to-one basis over the telephone, and participants P6–P9 were interviewed at the same time in the form of a focus group. Although, focus groups and interviews are different methods, they are similar enough and the differences are not thought to have any detrimental effect on the results, as no comparison was made between the groups.

A purposive sampling approach was used to restrict the sample to only people with visual impairments, and a total of nine participants were recruited. However, no restrictions were placed on the type of visual impairment the participants had. As a result, three participants reported having no remaining vision, and the remaining six had various forms of visual impairment. Relevant sample demographics can be seen in table 6.1.

Table 6.1: B/VI Participant Demographics

Participant	Gender	Visual impairment	Primary Navigation aid
P1	F	No remaining vision	Guide dog
P2	F	No remaining vision	Guide dog
P3	F	Retinal detachments and glaucoma	Guide dog
P4	M	Retinitis pigmentosa	Guide dog
P5	M	No remaining vision	Guide dog
P6	M	Retinitis pigmentosa	Cane
P7	F	Uveitis	Cane
P8	M	Blind left eye. Congenitally weak right eye.	Cane
P9	F	Bilateral cateracts	Cane

All the participants were sourced from the research participant pool available to the Guide Dogs charity, who are the industrial partner for this research. P1-P5, who attended one-to-one telephone interviews, were sourced by Guide Dog's Nottingham mobility team. The mobility team briefed the participants on the nature of the study and gathered consent from the participants according to the policy of Guide Dogs before passing along the contact details of the participants to me by email in the form of a password-encrypted file attachment.

Upon receiving the participant contact information, I contacted the participants with an introductory phone call where they were informed verbally about the nature of the study and appointments for the interviews were scheduled. At the end of the call, participants were told that they would be sent an information sheet and consent form by email or by post if preferred using desired font-sizes. Four participants (P1, P2, P3, P5) were sent the information sheet and consent form by email and were able to read the documents using screen-reader software and digitally sign the consent form before returning the signed consent form back to the researcher as an email attachment. The remaining one participant (P4) did not have an email address and therefore the information sheet and consent form was sent out to them via post, read

out verbally to them by their sighted spouse and the signed consent form was returned to the researcher using a pre-paid envelope that was enclosed in the initial envelope.

The contact numbers for the participants were dialled using Skype, and recorded using the Evaer Skype-recording software (Evaer Technology, 2017). The audio from the calls was saved in MP3 format to a secure hard-drive and then transcribed for analysis. The one-to-one interviews lasted between 60 and 90 minutes each.

The remaining four B/VI participants (P6-P9) were sourced by the Guide Dogs head office in Reading. A focus group was organised at one of the offices there and I conducted the focus group. The focus group lasted two hours and was audio-recorded and transcribed for analysis.

The interviews were semi-structured, but where focused around some key questions.

As part of some scoping questions, I first asked the participants what eye conditions they had and how long they had had their particular eye condition. I would then ask the participant to walk me through what an average journey would be like for them. I then asked them which types of locations they tend to visit, and how often they tend to visit them. By knowing which locations a participant visited often, I got an idea of which locations I could investigate further to identify challenges, as the participant would have frequent experience of travelling through them.

It is possible, however, that the most important locations to consider are the ones that participants don't travel to, as these locations may be the ones with the most significant challenges. To cater for this possibility, I also asked participants which locations they would like to travel to by don't, and the reasons why they don't travel to those locations. Phrasing the question in

this way would help ensure that the locations that participants mention are not being travelled to due to difficulty rather than due to lack of need or want to travel there.

Note that it is not necessarily the case that all the locations B/VI people travel to are easy to navigate and all the ones they don't travel to are hard to navigate. It may be the case that, even though the locations are difficult to navigate, B/VI people do navigate them regularly due to necessity despite the many challenges they pose. This is why it was useful to ask participants both what locations they travel to regularly and those which they don't travel to but like to.

I also wanted to gather primary data on the challenges that were mentioned in the literature, such as the challenges that B/VI people are reported to have in familiarising themselves with new locations, getting sighted assistance of a suitable quality, maintaining orientation on a route, avoiding obstacles, and so on. To this end, I would ask participants to imagine that they had arrived at an unfamiliar location. I would then ask them how they would be feeling in that situation and what they would do first. I also would ask them what tactics they would be likely to use to orient themselves in that situation. In particular, I focused on unfamiliar indoor locations, as indoor locations are known to be harder to navigate for B/VI people (**Karimi2015_Chapter8**). I also asked participants to explain the challenges that they faced in some commonly-travelled locations, and some locations that they rarely travelled to. In one-to-one interviews, the locations discussed were based on the frequency of the participant's engagement with the location, either locations they travelled very common or very rarely. As I was trying to get a good spread of challenges across multiple locations, I would try to vary the locations discussed across interviews where possible. In the focus group, the choice of locations to discuss was based more on a balance of what the group wanted to discuss and what locations I felt had not been discussed

much in other interviews.

I also investigated the theme of technology and navigation aid use. I would ask my participants what 'base navigation aids' they used (cane, guide dog, etc) and also asked participants to explain the differences that their main base navigation aid (cane or guide dog) has brought to their life. This was helpful in understanding more what it is like to navigate blind without any support whatsoever, as well as the different purposes that these aids may fulfill.

I also asked participants what their opinions were on using technology for navigation, and what pieces of technology they already use to support their navigation. I would ask them what considerations they would make when evaluating whether or not a certain piece of technology would be suitable to help them navigate. If participants expressed a general disaffect towards technology, I would probe to ask what qualities a certain piece of technology would need to have in order for it using it to be desirable for them. My intention in catering for this possibility was to understand whether a given participant's lack of use of technology was just due to a personal preference, or whether it was due to a repeated failing of technology to satisfy their needs.

I also wanted to look at the different usability factors that designers should consider so that a more technological navigation aid could be used alongside a more traditional navigation aid, such as a cane or guide dog. To do this, I would ask participants to discuss whether there were any factors that could result in a navigation aid interfering with their current mobility behaviour.

Next, I asked participants to describe in general terms the qualities that make a navigation aid 'good' or 'bad'. The intention with this was to understand the more general qualities that a navigation aid should try to have, or should try to avoid.

Finally, I asked participants to describe an ideal or 'perfect' navigation aid and how that navigation aid would make them feel and impact their life. The intention behind this was to make it possible to access the deeper needs that B/VI try to satisfy when choosing a navigation aid. My intention was to better understand the deeper hopes and wishes that B/VI people have for their navigation aids beyond functionality to ease of use. My intention was to gain more insight into the deeper hopes and wishes that B/VI people are trying to move closer towards by selecting and using a navigation aid.

A list of questions used in the interviews and focus group with the nine B/VI participants can be seen in appendix A.1.

6.3.2 Wayfindr Interview Method

The Wayfindr interview was conducted in a similar way to how the telephone interviews were conducted with B/VI participants. Two employees from Wayfindr, W1 and W2, were invited for a focus group to be conducted via Skype. The focus group lasted approximately one hour and focused on the commercial factors surrounding B/VI navigation aid design. Evaer Skype recording software was used to record the audio of the conversation, and the audio was transcribed for analysis (**Evaer_Website**).

It is important to bear in mind that Wayfindr is a company with particular expertise in the domain of indoor navigation aid development. For this reason, the interview asked questions surrounding the commercial aspects of primarily indoor navigation aid design. This is appropriate as many of the challenges discussed by the B/VI participants were related to indoor environments.

The interview began with some introductory questions about the current state of the industry for indoor navigation aid development, including what

challenges and opportunity the industry is currently facing.

Wayfindr were then asked for what things they believed were important for designers to consider so that their designs could be successfully implemented in reality. This was intended to unearth some of the commercial needs that navigation aids have.

Some navigation aids require infrastructure to be installed in a third-party environment. To dig deeper into the commercial needs that may be present from an industrial perspective in such a situation, Wayfindr were asked what key challenges may be encountered when trying to install a navigation aid's infrastructure in a third-party environment. They were asked what would need to be in place to satisfy relevant stakeholders and gain their approval of such installations.

As I was also curating functional and usability needs of B/VI navigators, I thought it would be interesting to ask Wayfindr for their thoughts on what the needs of B/VI navigators were for navigation aids. I also asked Wayfindr for what pieces of technology designers may consider using for designing their aids. Seven of these suggestions eventually made their way into the 'tech building blocks' part of the set of ideation cards that this thesis contributes, as discussed in chapter 12.

A full list of questions for this interview can be seen in appendix A.2.

6.3.3 Ethical Approval

All the interviews received ethical approval from the University of Nottingham's School of Engineering's Ethics Committee and all participants provided informed consent to participate in the studies.

6.4 Thematic Analysis

The interviews were analysed using Thematic analysis (TA). Thematic analysis is a method of qualitative analysis that is used to find patterns of meaning or ”themes” across a data set (Braun & Clarke, 2006, 2012). TA is a flexible and accessible method and is also one that can be applied across a range of epistemological and theoretical approaches, unlike more framework-driven methods such as grounded theory or discourse analysis (Braun & Clarke, 2006). Because of the flexibility of its application, however, TA can be sometimes be criticised as being unsystematic.

To improve the rigour of how TA is applied, Braun and Clarke (2006) suggest a set of guidelines for conducting ”good” thematic analysis. One such guideline is that, in the final reporting of a thematic analysis, ”the assumptions about, and specific approach to, thematic analysis are clearly explicated”. To that end, I will begin by noting that the thematic analysis will be a mostly data-driven inductive TA, but will involve some researcher-driven elements. This means that although I will be focusing on particular broad themes (commercial needs, hedonic needs, etc), I will allow the other sub-themes under those broad headings to emerge from the data. Secondly, the analysis will primarily focus on identifying semantic themes rather than latent themes, which means that I will not look beyond what has been said by participants for further meaning. Finally, the analysis sits as part of a realist philosophical paradigm rather than a constructionist one, which means that I assume that there is a straightforward relationship between meaning, language, and experience and that the language used by a participant reflects their external real-world experiences rather than constructs them.

As suggested by Braun and Clarke (2006), once the interview audio recordings were transcribed, I listened to the audio once again to check the accuracy of the transcripts. Thereafter, the interviews were coded sequentially in

the same order that they were conducted. Version 11 of the NVIVO software package (QSR International Pty Ltd, 2018) was used to conduct the coding process. Because of the difference in their content, the analysis for the B/VI interviews and the Wayfindr interviews were kept separate in different NVIVO project files. As is the nature of TA (Braun & Clarke, 2012), coding the interviews was an iterative process and the codes would change focus and merge occasionally as the coding of subsequent interviews enlightened the coding of previous ones. It should be noted that although the codes were evolving as further interviews were processed, no codes were deleted at this stage.

Once all the interviews had been coded, the codes were grouped according to common themes. Again, this was performed with the assistance of version 11 of the NVIVO software package. Being able to see all the codes together necessitated the merging of some codes and the very occasional removal of other codes deemed to be merely incidental.

6.5 Presentation of Themes and of How They Relate to the Thesis Structure

6.5.1 Themes of the B/VI Interviews

The analysis of the interviews with the B/VI participants resulted in the following themes:

1. Navigation Challenges
    (a) Location-specific (chapter 7)
        i. Transport Hubs

A. Bus Stations (9 references)

B. Train Stations (19 references)

C. Airports (7 references)

ii. Shopping Environments

A. Restaurants and Cafes (6 references)

B. Shopping Centres (20 references)

C. Shops and Supermarkets (16 references)

(b) Universal (Chapters 7 and 8)

i. Physical

A. Noise / Echoes (20 references)

B. Crowds (13 references)

C. Unexpected Obstacles (15 references)

D. Lack of Landmarks (7 references)

E. Low Signage Accessibility (11 references)

F. Changes and Disruptions (8 references)

ii. Emotional

A. Anxiety (20 references)

B. Workload (9 references)

C. Stigma (15 references)

(c) Effects of challenges on quality of life (17 references) (chapter 9)

2. Needs for Navigation Aids

(a) Expressions of Pragmatic Needs

i. Expressions of Functional Needs (70 references) (chapter 8)

ii. Expressions of Usability Needs (67 references) (chapter 9)

iii. Expressions of Commercial Needs (15 references) (chapter 10)

(b) Expressions of Hedonic Needs (19 references) (chapter 11)

As can be seen from the list above, the following chapters in this part of the thesis are structured to follow the themes arising from the analysis.

In chapter 7, I begin with a review of the universal challenges that my participants brought up and how they match the challenges mentioned in the literature, which were reviewed in chapter 3. The main focus of chapter 7, however, is on the challenges that B/VI people face in specific environments. This is a new contribution to the literature, and discusses the challenges my B/VI participants reported facing in bus stations, train stations, airports, restaurants, cafes, shopping centres, supermarkets, and small shops. I wrap up chapter 7 with a discussion of the impacts that my participants mentioned these challenges having on the quality of their lives.

In chapter 8, I synthesise the literature on navigation (chapter 2), the literature on B/VI navigation challenges (chapter 3), and the findings from my interviews on universal challenges discussed in chapter 7 to produce a generalisable model of B/VI navigation. Because the issues that arise in all instances of navigation (the universal challenges) are likely to be the issues arising from the navigation task itself and not from some other accidental feature, I use this model to present the functional needs that B/VI people have for their navigation aids.

In the remaining three chapters in this part, chapters 9, 10 and 11, I discuss the usability, commercial and hedonic needs that my B/VI participants expressed having for their navigation aids.

6.5.2 Themes of the Wayfindr Interview

As I mentioned in the introduction to this part of the thesis, because a few commercial needs were raised by the B/VI participants in the interviews, I decided to take a closer look at what the commercial factors related to

navigation aid success may be from an industrial point of view, rather than restricting my investigation to the perspective of the end-users. I did this by interviewing two employees from Wayfindr and the analysis of the interview data resulted in the following themes:

1. Commercial Needs (chapter 10)
    (a) Safety and Liability (1 reference)
    (b) Data Privacy (1 reference)
    (c) Establishing Stable Collaborations (7 references)
2. Usability Needs (chapter 9)

The commercial needs from the Wayfindr interview are discussed alongside the commercial needs raised by the B/VI participants, both being discussed in chapter 10. In that chapter, the points raised by the B/VI participants are written under the heading of “customer-facing” commercial needs, and the points raised by Wayfindr are written under the heading of “non-customer-facing” commercial needs.

The breakdown of themes shows that the Wayfindr participants also mentioned some usability considerations that they recall from their work engaging with B/VI people. These points are interwoven with the discussion of usability needs made by B/VI people in chapter 9.

Now that the themes from the thematic analysis have been listed, and the relation of the upcoming discussion to those themes has been presented, I will now move on to discuss the challenges that my B/VI participants mentioned during our interviews.

Chapter 7

Location-Specific B/VI Navigation Challenges

7.1 Introduction

At the outset of this chapter, it is worth pointing out that participants mentioned many of the more universal challenges that we have already seen in the literature review. Amongst other things, participants reported on crowds, environmental disruptions and changes (such as out-of-order lifts), noise, echoes, and other more generalisable issues.

As an example, P4 mentioned unexpected obstacles, which we have already seen reported in the works by Quinones et al. (2011) and Williams et al. (2013):

> P4: there's things like bollards and, you know, um, probably street furniture which we call, it's billboards and things like that that can become, you know, a bit of a nuisance if you're not aware of them.

In this section, I want to focus on the more location-specific navigation chal-

lenges that my participants brought up.

Before beginning our discussion, there is a distinction that needs to be drawn between a “difficulty” and a “navigation challenge”. My participants reported many difficulties in their everyday lives, inconveniences and bothers that tend to accompany a particular location. An example of a difficulty may be struggling to reading the menu at a restaurant or being able to find a seat in a cinema. Although detrimental to the overall accessibility of the venue, I couldn’t categorise this as a navigation challenge per se. So, although my participants faced many difficulties in the various environments, I will restrict my discussion here to the specific navigation challenges that they faced, the challenges that affected them getting from A to B.

The locations discussed by my participants can be broken into two classes. Firstly, there are “transport-hubs”, which included train stations, bus stations and airports. Secondly, there were shopping-environments, which included shopping centres, supermarkets, individual stores, and restaurants and cafes.

These weren’t the only locations mentioned by participants, however. Participants mentioned a wide range of locations, including: Theatres, Cinemas, Doctor’s offices, Sports Stadiums, Other people’s houses, Offices, Eye hospitals, Community Centres, Banks, and even public toilets.

Although they mentioned navigation challenges within these locations, the challenges mentioned were often specific instances of some of the general points already mentioned in the literature. For example, if a participant mentioned challenges scaling stairs in their local council house, as P8 did, this is a specific instance of the more general issue of scaling stairs.

7.2 Transport Hubs

7.2.1 Train Stations

In train stations, P7 and P9 noted that they couldn't use the self-service ticket machines due to being unable to read the screen display.

> P7: But like P9 said about this morning at the train station, sometimes if there's not a man, there's a ticket machine…you know, a self-service ticket machine…
>
> P9: We can't do it.
>
> P7: …which is obviously no good for any of us because we need to go to a physical counter and a physical person, to buy a ticket. We can't use the machines.

Although not a navigation challenge per se, this difficulty does require B/VI navigators to find the ticket office themselves, which may be a challenge in unfamiliar stations, or at understaffed stations. P9 mentioned that, because of a lack of human staff, they were unable to pay for a train ticket on a recent trip:

> P9: They used to walk along the train as well when you went to Reading, but they don't now, so, therefore, I haven't paid. I do feel odd that I haven't paid, but that's not my problem.

After purchasing tickets, navigating to the correct platform was the next challenge mentioned, which can be a significant challenge in larger stations:

> P2: In a railway station, I would need assistance finding my platform and making sure I get the right train. […] that's difficult navigating through; obviously, some trains stations are bigger than others.

This challenge can be exacerbated even further by unexpected platform changes that can nullify the preparation that a B/VI navigator may have done beforehand:

> P9: What happens is the lady from Guide Dogs here teaches you how to get from A to B, every route you want to learn, and you learn it very well […] she made me get on and off the train about four times to show that I was getting on and off it right. […] [she] taught me [that] my train from where I come from always, apparently, goes into platform 4, 5, and 6 at Reading. […] But, unfortunately, *twice* recently, it's come in at different [platforms]. It came in at platform 9 last week and it came in at platform 14 a few weeks ago.
>
> P6: Which is over about 3 different platforms that is.
>
> P9: Yeah, and its a completely different area so […] the lady from guide dogs is teaching me next week how to do the rest of the station. It will be a big area to learn, but I need to learn it cuz it keeps coming into a wrong platform **laughs**

Notice, here, the size of the extra familiarisation task that P9 needs to undertake with the help of a mobility instructor just to account for these platform changes; learning the layout of an entire train station is not a trivial task.

These platform changes can happen at the departure station, or, perhaps more problematically, can happen at the destination station.

> P7: Well, sometimes you'll come in on another platform and you've lost your bearings.

P7 explained that a major difficulty with these platform changes at the destination station is that the audible train announcements typically don't alert passengers about such platform changes. They are left to figure out that they have pulled in at the wrong station by themselves.

7.2.2 Bus Stations

Bus stations were another mentioned environment. Similar to difficulties in finding platforms at train stations, participants mentioned difficulties in finding the appropriate bus bay at bus stations.

The illuminated signage was helpful for participants with residual vision, but for those without residual vision, they aren't much use:

> P7: There's also signs illuminated, but that's OK if you can read them; if you can't read them, you can't read them.

When speaking about their local bus station, P9 reported that there are typically no staff around to provide assistance.

> P9: But, there's no ticket office, there's no help; […] in the past, there would always be an office for the bus station; there's nothing there [now].

When at the bus bay, because multiple buses can come at a given bay, participants mentioned difficulties knowing whether a certain bus was theirs or not. This issue can also occur at bus stops.

P7 mentioned that, to solve this issue, they simply memorised the timetable:

> P7: I have to learn what time my buses are going because I can't read the timetable. There's no announcements at the bus station, so it's down to me to know that I'm there at that time and I'm in the right bay number to get that bus. So you've gotta just remember it.

This is, in a sense, similar to familiarisation, but involved the B/VI person familiarising themselves with the route in a temporal sense, rather than a spatial one.

Just like at train stations, unexpected bay changes can happen at bus stations, with the bus pulling in at an unexpected bay; for example:

> P9: Well again…as long as the bus is going to the same place every time, you're all right.
>
> P7: Yeah
>
> P9: But if they don't you're stuck.

7.2.3 Airports

A similar set of challenges was mentioned for airports. A non-trivial task even for sighted people, the first challenge mentioned was finding the appropriate check-in desk. P9 mentioned that they would necessarily require assistance to be checked in at the counter:

> P9: […] I'd have to be checked in at the counter

After checking in, the next challenge is to determine one's gate. Airports do not provide audial announcements of gate numbers, and therefore passengers are required to view the electronics boards to determine their gate number and whether the gate is open or not.

P9 noted that, due to their visual impairment, they cannot read the monitors themselves.

> P9: I can't read any of the monitors; you've got to remember that you can't read.

P8, who also recalls experiencing similar issues, mentioned receiving some dismissive and unpleasant treatment from a member of airport staff when they notified them of this difficulty:

> P8: They say "You have to look at the screen". And I remember, I once went there years ago and they said "If you have visual impairment, get someone else to look for you".

P9 mentioned that airports are far too large and fast-paced to navigate alone, and that they would require assistance from the point of checking in until boarding the plane:

> P9: I could never walk, do an airport on my own now, without assistance. I'd have to be checked in at the counter and then assistance from then on, I would have to have. But, because it's just too big, too fast, you know?

7.3 Shopping Environments

7.3.1 Restaurants and Cafes

The major difficulty that was particular to restaurants and cafes is finding the counter to place orders and pay for one's meal:

> P9: Again, often its perhaps an effort to find out where's the counter.

If the counter location was known, tables and chairs still provide an abundant source of obstacles to the B/VI navigator:

> P9: Too many tables and chairs in your way to get to the counter.

> P6: Yeah

P7 reported getting around this issue by asking staff to bring things to their table

> P7: There's always staff in there, so I will just ask for what I want and they'll bring it over to me.

Although effective, this approach requires the B/VI person to wait until the staff are available, which may be difficult to detect with reduced vision.

7.3.2 Shopping Centres

Shopping centres had a wide array of challenges and were commonly reported as very difficult places to navigate.

P1 mentioned that they have difficulties in discovering what stores a shopping centre contains, even over extended periods of familiarity with the centre itself:

> P1: You know there's lots of places that, you know, somebody will say "oh have you not been to so and so in Victoria [shopping] Centre?" I'll say "well, I didn't even know it was there." You know?

Although they could go for more formalised familiarisation trips, P1 expressed their desire for the possibility of serendipitous and real-time discovery of new places, and indicated the new opportunities that this would open up:

> P1: I would love to just be able to walk along and know what I'm passing you know? Because there's probably all sorts of places that I don't even know are there.

Once the presence of a given store have been discovered, B/VI people may still have difficulties in actually navigating to it.

A lack of physical landmarks was a notable challenge in shopping centres:

> P5: It's the layout. There's no structure to the layout. There's nothing we can use to indicate where we are. If I was on me own, I would be totally stuck in Meadowhall [shopping centre]. I wouldn't be able to walk anywhere 'cause there's no indication as to what shop you're in, what shop you're near, or what shop you're at, or what department you're near, or anything like that. Or stairs, or lifts, there's just nothing at all, it's just like a, …just a big space.

P2 also reported that shopping centres contain a lack of audial landmarks, as each of the individual stores sound very similar:

> P2: It's very difficult to tell where one shops ends and the next begins when you're just listening. […] it's very difficult to sort of orientate yourself to navigate […] it's very difficult to work out which one's which.

Because of the lack of physical and audial landmarks, some participants reported being forced to rely on olfactory landmarks, such as perfume shops:

> P6: You'd do well to differentiate anything in there, that's... well that, in itself, is a good pointer to help us through when we're in the Oracle [shopping centre], cuz to get to our cafe, we always have to pop past a Lush [perfume] shop.
>
> P7: Yeah.
>
> P6: And we can pick up that smell true, and that makes it so easy for us.
>
> P7 & P9: *agreeing crosstalk*

Shopping centres are also typically very crowded, resulting in added obstacles and noise.

Because discovering changes in their environment can be a challenge for B/VI people, some may have the rather disheartening experience of going through the difficulty of navigating a shopping centre, arriving at the store, only to find out that it has closed down without them knowing:

> P3: […] like I went there the other day and the pound shop what used to be upstairs is not there anymore.

When asked what they would do in such a situation, P3 replied that they would “leave it” and go home, adding that these experiences were just “part of being VI”.

7.3.3 Shops and Supermarkets

After successfully finding the store they wanted, however, there is still an issue of navigating within the individual stores themselves.

In supermarkets, for example, an important challenge is finding the products. Although participants mentioned going to smaller stores and memorising the layouts of the products on the shelves, they were often plagued by frequent product layout changes and unhelpful staff:

> P8: Well the most common places I go are the supermarkets or community centres. Supermarkets, Asda, they keep changing things around. You can ask people, but they don’t know where it is because one day’s staff has moved something and the following day’s staff don’t know where they’ve put it.

Having gone through the process of finding products, B/VI navigators still have the challenge of finding the checkout

> P7: If you’re in the supermarket as well, just like knowing where to go to pay, because a lot of the tills are now these ones where you do it yourself.

> P9: No chance!

P8, who has some residual vision, mentioned that locating the tills can be made easier by placing flashing lights above them:

> P8: At least Asda have got flashing lights above the tills, which is a good idea.

These checkouts, however, may not necessarily be near the entrance of the store. P1 mentioned her experience in a department store where, after returning an item, she didn't know how to get back out of the department store and wasn't provided any support from the staff. Fortunately, P1 was able to use her guide dog for this purpose, as the dog was able to determine a route out from its experience on the way in:

> P1: I had to return something, and somebody said to me, "oh, you need to go to customer services". So somebody took me up to customer services, which was on the fourth floor, and then just sort of left me at the counter. I thought "alright, well I'll have to ask somebody here to show me the way back down". I did my transaction at the counter, and then, immediately, the person started serving the next person in the queue. I realised I was on my own, so I just thought "well, I'll try it". And the dog was just brilliant. She took me, you know, found the flights of stairs; down and out we went.

For cane users, however, issues such as this could be far more problematic.

7.4 Effects of Navigation Challenges on Quality of Life

As a result of experiencing all these challenges participants expressed an aversion to indoor navigation in general.

P1, for example, felt that, often times, a major reason for navigating indoors was being compelled to do so, not for their own choice or for enjoyment:

> P1: Often it's a case of *having* to go to places. You know, I live with my husband. We're both totally blind, so you know, sometimes there are times when you just …There aren't necessarily people available to go anytime you want to go somewhere. So a lot of the time it's a case of *having* to go places, *having* to make it work

P3 mentioned that they generally didn't explore new places. To them, sticking to known routes was preferable to the challenges of becoming lost:

> Researcher: Do you tend to explore new places, or do you tend to just go for what you came for without much deviation?
>
> P3: I normally just go for what I go in for; you know, unless I'm with somebody, I just go for what I go for.
>
> Researcher: And why is that?
>
> P3: Because I might end up getting lost **laughs**

P5 also was averse to exploration due to fears about their own safety:

> P5: I think it's the same again because it's that difficult to orientate where you are anyway and to get around and to navigate where you are anyway, it's just easier to get a certain task in your head that you need to do. Do that task; get out. Safety, it's all about safety. If I was wandering about and deviated, I don't know where

> I'm going to be wandering around to, I don't know what's in the area. So, I tend to go to where I need to go, and back again. That's it.

P1 mentioned that, although it can be easier, this approach can be quite limiting and they would love to be facilitated opportunities to explore more:

> P1: It's good in one way, but it's actually quite limiting you know, going back to my, my shopping list of you know, announcements for everywhere I go. I'd like to you know, I would love to just be able to walk along and know what I'm passing you know, because there's probably all sorts of places that I don't even know are there.

P4 mentioned that it had been around three years since he travelled to somewhere new, and even then, that was a mostly outdoors environment:

> P4: the last time that I can honestly think that we actually went to somewhere strange really was …We had a date in York, uh, about three year ago, just myself and me wife. Even though me wife were with me, we did tend to rely on people directing us to where we needed to be. That were more outdoors than indoors.

7.5 Summary

This chapter has discussed the various navigation challenges that B/VI people can face. The interviews confirmed the findings from the literature, and also offered new challenges to consider for specific environments.

We learn from this that there is unlikely to be one cure-all navigation aid at the present time. Navigation aid designers would be advised to consider individual contexts when conducting their designs.

We can also see that the navigation challenges that B/VI people face can be significantly detrimental to their quality of life. Navigation aids can play a part in alleviating these difficulties, but only if they satisfy the pragmatic (functional and usability) and hedonic needs of B/VI people. The purpose of the next few chapters is to shed some light on what these needs may be.

Chapter 8

Functional Needs for Navigation Aids

8.1 Introduction

Based on Hassenzahl's (2007) framework of pragmatic and hedonic needs, this chapter aims to understand the various functional needs that B/VI people may have for their navigation aids. The objective of this chapter will be to use the literature and interview data to derive a model of B/VI navigation, using a casual loop diagram, and distill from that model the various ways that navigation aids could possibly support the navigation task. Each of these ways will represent a potential functional need that a B/VI person may have for their navigation aid.

8.2 Model Development

8.2.1 An Introduction to Causal Loop Diagrams (CLDs)

The model is presented as a causal loop diagram (CLD). CLDs find their origin in the system dynamics literature, which began development in the 1960s (Forrester, 1961) as a practical application of the systems thinking methodology (Checkland, 2009; Kim, 1999; Meadows, 2015). CLDs are used today in a wide variety of domains, from business management applications (Williams & Hummelbrunner, 2010), to waste management (Arnfalk, Erdmann, Goodman, Lehmann, & Wäger, 2006; Chaerul, Tanaka, & Shekdar, 2008) and food logistics (Georgiadis, Vlachos, & Iakovou, 2005), and are generally used to provide holistic perspectives on complex and interconnected systems, so that action can be taken to improve the system in some way.

CLDs have three primary strengths relevant to this work.

Firstly, rather than presenting a static “as is” situation, CLDs allow us to more easily represent dynamic phenomena (Georgiadis et al., 2005). As navigation is a highly dynamic process, this property of CLDs makes them a useful tool for modelling it.

Secondly, by incorporating feedback loops, CLDs allow us to capture the interrelations of the various components of the situation under study. This helps us to consider how these components work together to form a complete whole (Williams & Hummelbrunner, 2010). Just as the value of a car does not lie solely in its wheels, its engine, or its steering wheel, navigation doesn’t arise solely from perception of the environment, the construction of a cognitive map, or the avoidance of obstacles. It is only when the various different parts work together, as a system, that navigation is precipitated, and

feedback loops help us to model these interactions (Kim, 1999; Meadows, 2015).

Thirdly, CLDs allow us to find what are known as “leverage points” in the system that can be used for positive intervention. This property is what will allow us to understand the various different ways that navigation aids can be used to improve navigation as a whole, and thus to determine the possible functional needs that a B/VI navigator may have for their navigation aids.

In terms of how CLDs are constructed, CLDs use nodes, arrows and polarity symbols to represent the relationships between the various parameters incorporated into the model. For example, consider fig. 8.1 which presents a re-enforcing feedback loop between two parameters, A and B.

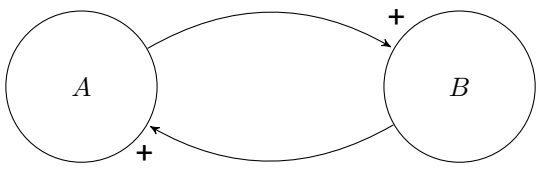


Figure 8.1: *A re-enforcing feedback loop*

As indicated by the ”+” symbol at the end of the arrow, fig. 8.1 shows that if A increases, then B increases too. Furthermore, it shows that if B increases, then A will also increase. This is an example of a re-enforcing feedback loop, which represent exponential growth or decay.

The other type of feedback loops in CLDs are balancing feedback loops. Balancing feedback loops typically involve the system settling to some form of steady state over time. fig. 8.2 shows a simple example of a balancing feedback loop.

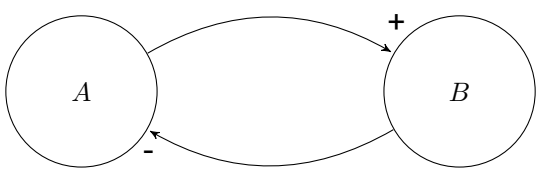


Figure 8.2: *A balancing feedback loop*

According to fig. 8.2, as the amount of A increases, so does the amount of B. However, as B increases, A decreases. The result is that, over time, A and B will settle down at some respective steady state values (Kim, 1999; Meadows, 2015).

8.2.2 An overview of how the model was constructed and used

The model was developed in two stages. First, the general knowledge of navigation from chapter 2 was modelled to give a view of how navigation works as a system for sighted people (fig. 8.3). Thereafter, the findings from the thematic analysis and literature on B/VI navigation challenges were incorporated into that model to show how being B/VI affects navigation (fig. 8.4). From comparing the two models, it was possible to determine a set of approaches by which navigation aids can improve the functioning of B/VI navigation. Each of these approaches is one possible functional need that a B/VI person would have for their navigation aid. A full list of the possible needs is found in table 8.2.

To clarify precisely how the interview data was used to create the model, consider the link between unexpected obstacles and number of accidents. P3, P4, and P8 each reported an incident of an unexpected obstacle either causing, or almost causing, them to have an accident when navigating. Because multiple participants reported experiencing this phenomenon, I concluded that it was sufficiently generalisable issue, therefore included it in the model. Consider, for example P8's statement:

> P8: "The other thing about Reading town council offices [is that] their seats in the waiting area are all cream on a cream floor. I cannot see those at all. I've literally fallen …I don't know how

many times I've fallen over them."

This comment shows a positive relationship between unexpected obstacles and number of accidents. Therefore, a node representing "unexpected obstacles" and a node representing "number of accidents" were included in the model, with a positive relationship between them.

The reasoning behind each of the links in fig. 8.4 will be discussed in detail in the next two sections, with table 8.1 showing a tabulation of the various evidence sources used to construct each link.

8.3 Modelling the Navigation Literature

To develop the model of sighted navigation (fig. 8.3), the first step was to make a dichotomous division between the navigator and everything that is not the navigator, i.e., the navigator's environment. Successful navigation necessarily requires the navigator to employ their faculties of perception to pick up on the stimuli relevant to the navigation task. Therefore, to navigate successfully, the navigator must either perceive their own movements, or perceive their environment. The "ability to perceive surroundings" node and "ability to perceive own movement" nodes in fig. 8.3 represent this division of perception, and they are both core parts of the model.

The attention that one pays to their own movements and to the environment is essential to the development of a cognitive map of the space (Golledge, 1999). Once developed, navigators also use their cognitive maps to maintain orientation (Montello, 2005). In order to incorporate into the model the process of environment learning but also allow the model to represent references to an existing cognitive map for orientation, a further conceptual division was made between the learning processes and the respective bod-

ies of knowledge that these learnings amount to, i.e., landmark knowledge, route knowledge, and, ultimately, survey knowledge (Siegel & White, 1975). I pragmatically assumed that there is an upper limit to the amount of spatial knowledge that the navigator will acquire for a given environment, and, therefore, a balancing loop was constructed between each type of learning and it's respective body of knowledge. For example, landmark learning was modelled as increasing the navigator's store of landmark knowledge, but landmark knowledge was modelled as causing a decrease in future landmark learning. It is important to note that, although reasonable, these particular links are based on assumptions from my personal subjective experience and not that of empirical evidence.

Recall from chapter 2 that Thorndyke and Hayes-Roth (1982) showed that there are two distinct methods of environment learning: direct experience, and studying maps.

Consider first learning by direct experience. Because landmarks are an external property of the environment, when learning from direct experience, knowledge of landmarks can only be acquired through perceiving one's surroundings. One cannot learn about external landmarks by perceiving their own motion. Therefore, only the "perception of surroundings node" was modelled as increasing landmark learning when using direct experience. However, both the perception of surroundings and perception of own movement nodes were modelled as facilitating route learning. This is because, unlike landmark learning, route learning can be acquired through reference to internal kinesthetic cues, such as an estimation of distance travelled, and memory of turns taken (Siegel & White, 1975).

In terms of studying maps, the model includes a "map examination" node. Map examination was modelled as increasing landmark learning and route learning. Map examination was also modelled as contributing directly to

survey knowledge, because survey knowledge can be acquired directly from studying maps (Siegel & White, 1975; Thorndyke & Hayes-Roth, 1982).

In accordance with Siegel and White's LRS model an increase in landmark knowledge was modelled as enhancing route learning, both landmark and route knowledge were modelled as increasing survey knowledge, and all three types of knowledge were modelled as individually contributing to the maturity of one's cognitive map.

Because cognitive maps are stored in the navigator's memory, they are, like all memories, subject to decay over time (Bennett & Giudice, 2017). Therefore, the time away from the environment was modelled as decreasing the maturity of the navigator's cognitive map.

At this point, the reader should now be familiar with all the orange and green nodes in fig. 8.3, which represent perception and cognitive map formation, respectively. What follows is an explanation of the blue nodes which represent orientation. According to Montello (2005, p. 264 and p. 267), orientation requires knowledge of: a) one's own location within an environment, b) knowledge of the distance from one's location to places in the environment, c) knowledge of one's heading, and d) knowledge of the bearings from one's position to places in the environment. Each of these were modelled as individually contributing to the navigator's overall level of orientation.

However, knowledge of one's own location arises from perception of one's own movement, perception of one's surroundings, and cross-referencing that sensory information with one's cognitive map [Montello 2005, p. 267-268]. Knowledge of one's location combined with sufficient knowledge of a space gives, knowledge of the distance to other locations relative to one's own location, at least with a qualitative level of precision. Moreover, once the navigator knows their own location, they can complement this with perception of their surroundings and reference to their cognitive map to determine

their heading, i.e., the direction that they are facing in the environment relative to some reference frame (Gallistel, 1990; Loomis, Klatzky, Golledge, & Philbeck, 1999).

Knowledge of one's heading may, once again, be combined with one's knowledge of the environment to provide knowledge of bearings to places within the environment relative to one's heading. The term bearing may be defined as "the direction to a landmark relative to some reference direction" (Gallistel, 1990; Loomis et al., 1999). The reference direction for determining bearings is assumed in the model to be the navigator's heading, which is a reasonable assumption for pedestrian navigation.

Considering all of these factors together, orientation is modelled as a phenomenon that stems, with the support of a pre-existing cognitive map, from the navigator's perception of their surroundings (landmark-based orientation) and from their perception of their own movcement (dead-reckoning).

Next, the model turns to the purple set of nodes, which are related to the definition of success of navigation. The definition of successful navigation adopted for this research is the same as that adopted by Montello (2005) and Giudice and Legge (2008): *successful navigation is reaching one's destination in an efficient and accident-free manner*. From this definition, the factors of navigation efficiency and number of accidents were related to the success of navigation. Moreover, navigation efficiency was modelled as increasing the success of navigation, and number of accidents was modelled as reducing it. If one is disoriented (lost), then unnecessary effort, both physically and emotionally, is exerted to reach the goal (Montello, 2005). Therefore, a positive relationship was modelled between orientation and navigation efficiency. Finally, distraction of attention is well known to increase the risk of accidents in pedestrian navigation (Lopresti-Goodman, Rivera, & Dressel, 2012; Nasar, Hecht, & Wener, 2008; Stavrinos, Byington, & Schwebel,

2009, 2011). As attention is a necessary component of perception (Wickens, Hollands, Banbury, & Parasuraman, 2013a), perception of one's surroundings and of one's own movement were both modelled as decreasing the number of accidents as well.

Taking the steps above results in the model shown in fig. 8.3.

8.4 Incorporating the Interview Findings with Support from the Literature

At this point, the model largely reflects the general sighted-navigation literature. In this section, I will incorporate into the model my findings from the interviews. I will make reference to the B/VI navigation literature where appropriate to show agreement between my interview data and the literature.

The first concept that will be brought in from the interviews is the issue of mental workload. Although workload is not inherently "bad", participants would often report feeling overwhelmed when navigating, and would report that they often have too many things to focus on: sounds, obstacles, crowds, the emotional state of their guide dog (if applicable), and so on.

> P2: For example, railway stations, then. That can be very echoey. And if you're trying to, to find your way around—because I sense things like walls and stuff— it's difficult sometimes to do that. And also understand and hear announcements in the station because they're so echoey.

> P2: Sometimes you get things, obstacles, things like put outside shops and stuff that can get in the way a bit.

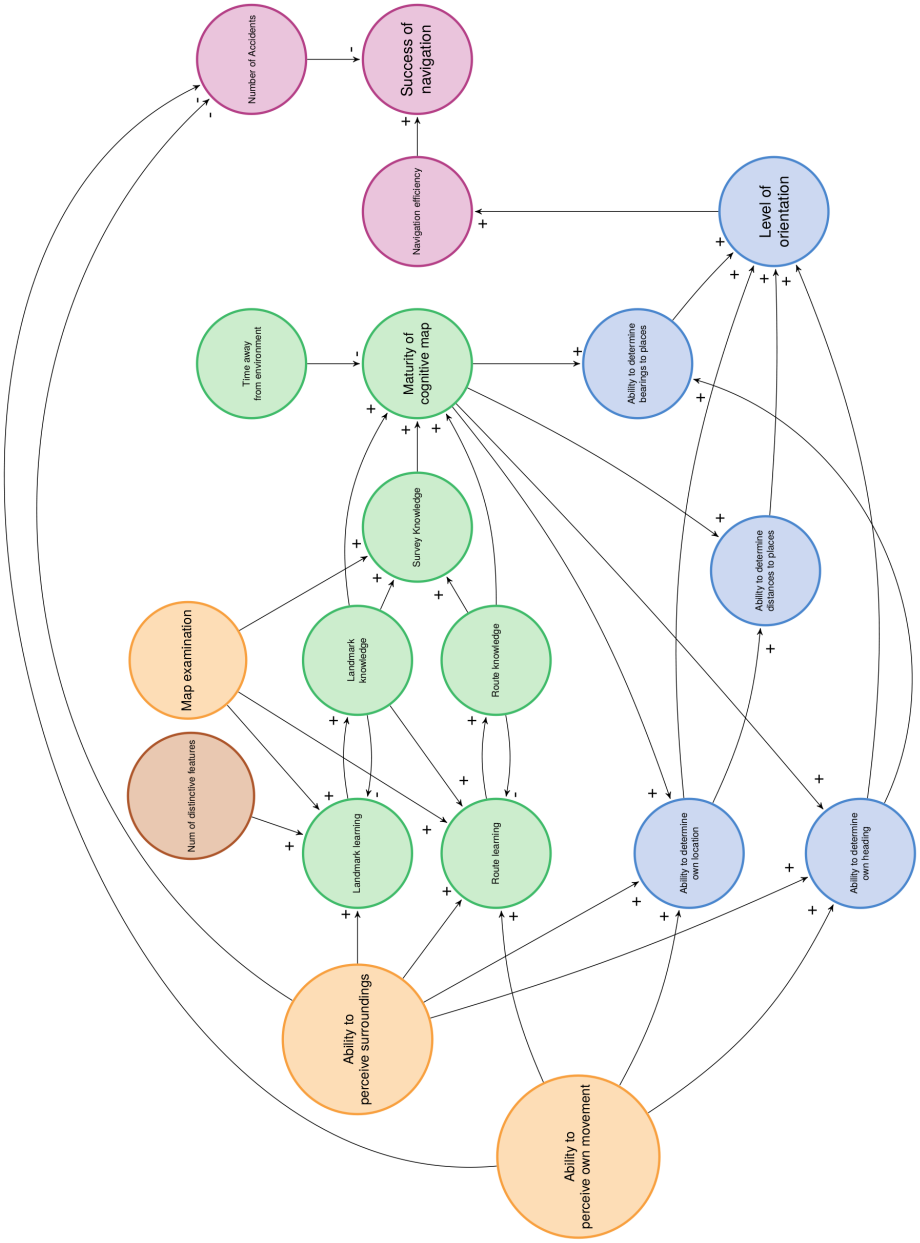


Figure 8.3: *Causal loop diagram modelling navigation of sighted people*

> P3: Uh, and sometimes, if it gets too much crowds and the noises and everything around me, then they can just take me straight outside.

> P4: We've got to keep us, you know, us concentration on the dog whether the dog's getting distracted.

Similar experiences have also been reported by others in the literature, such as Quinones et al. (2011) and Beatrice Dias et al. (2015). To capture this effect, a workload node was added to the model; however, this requires us to now consider how it should be integrated with other parts of the model.

Wickens et al. (2013b) write that, just like the physical muscles, the brain can also become burdened by tasks, and mental workload is the term often used to refer to this type of burden. The established model of workload in human factors literature is that the mind has a finite amount of attentional resources that can be supplied at one time, and that each task places a certain demand on this resource pool. When the supply of attentional resources exceeds demand, task performance is stable. However, when the demand for attentional resources exceeds their supply, task performance drops off sharply (Wickens et al., 2013b). As workload is proportional to the amount of attentional resources that are occupied, and given that attentional resources are necessary for successful perception, balancing loops were modelled between the perception nodes and workload: perception increases workload, but workload decreases perception through tying up resources.

Montello and Sas (2006, p.5) write that "wayfinding during familiar trips, such as driving between home and work, becomes automatized over time, leaving attention for other activities […] In contrast, maintaining orientation in unfamiliar environments over more than short distances demands attention." Therefore, a higher maturity of a cognitive map was modelled as decreasing

workload.

Map examination was also modelled as contributing to workload, because examining a map is a cognitively effortful process. Navigation aid use was also modelled as contributing to workload, because, like any tool, navigation aids will require attentional resources to operate successfully. However, each navigation aid will place differing demands on the attentional resources of the navigator; for example, guide dogs were often reported by participants who were former cane users as providing significant cognitive relief when compared to the cane, as obstacle detection can be offloaded to the dog.

> P3: I can be walking down the street with Zola, and I can be listening to music and still concentrate on what she's doing [. . .] it's so exhausting using the cane.

Anxiety was another common theme reported in the interviews. Participants reported experiencing feelings of anxiety both when entering an indoor environment, and when navigating around them. Anxiety has been defined as a "response to prolonged unpredictable threat" (Robinson, Vytal, Cornwell, & Grillon, 2013). In line with this definition, participants attributed the cause for their anxiety to unfamiliarity with the environment or "fear of the unknown".

> P5: If it were somewhere I don't know, I can sometimes turn into a quivering wreck, and I'm a really confident person. But, it's …it's just the fear, total fear of the unknown. That's all it is.

To model this effect, a well-developed cognitive map was modelled as reducing anxiety. Montello and Sas (2006, p.4) also write that, disorientation, even in small amounts, can also generate anxiety. To capture this effect, orientation was modelled as decreasing anxiety.

Anxiety is also known to have effects on cognitive processing (Derakshan & Eysenck, 2009; Duffy, 1957; Eysenck & Derakshan, 2011; Eysenck, Derakshan, Santos, & Calvo, 2007; Selye, 1976). Anxiety is known to cause an attentional bias for threat (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007), with the anxious individual showing a preference to detect and process threat-related information (Robinson et al., 2013, pp. 4-5). As attentional resources are finite, this attentional bias for threat, and the ”intrusive thoughts” that it gives rise to (Robinson et al., 2013), can be thought of as reducing the pool of available attentional resources that could possibly be used for the core task of navigation. Therefore, anxiety may be conceptualised as contributing to workload.

The last node category from fig. 8.4 is represented by the brown nodes. The brown nodes represent general environmental factors that participants mentioned as affecting their wayfinding process.

Given the dependency of people with visual impairments on audial input, the effect of *noise* was something important to include in the model. I define the term ‘noise’ here as ‘any auditory input received by the navigator that does not assist the wayfinding process’. This definition allows us to distinguish between useful auditory input which is contained in the “perception of surroundings” node, and background auditory distractions or obstructions to hearing.

Just like useful audio input (Wickens et al., 2013b), noise also contributes towards workload, and was modelled as such. The difference is that cognitively processing noise does not provide any benefit to the navigator, and simply consumes attentional resources which may be put to better use. Participants mentioned several sources of noise, including crowds, echoes, and navigation aid use. Auditory information from a navigation aid may also prove to be “noise”, depending on the context. Several participants ex-

pressed apprehension at the notion of using headphones to receive audial directions, noting that it would interfere with their ability to pick up other audial cues:

> P8: I'd also worry about something that interfered too much with my natural hearing, sort of like one of those audio aids, because I rely on my ears a lot.

Audio-directions may be useful in their own right, and conducive to navigation, but only at the will of the navigator; if the navigator wishes to use other audial cues as navigational information, then, despite their technical sophistication, audio directions may be relegated to background noise.

Crowds were another commonly recurring theme. It is also a common theme in the literature (Easley et al., 2016). Other than contributing to noise, crowds were modelled as directly contributing to anxiety. This is because, like Easley et al. (2016)'s participants, my participants reported feeling anxious about bumping into other people.

> P1: Um, shopping centers not very often. Um, not very often alone. That's somewhere that I would go more with other people. Um, because I find it very difficult and, you know, it's not an enjoyable experience to go there because they're so, um, so busy and it's very difficult to orient around them.

If the threat of colliding with others causes anxiety, it was assumed that actually being involved in accidents will also increase anxiety; therefore, *number of accidents* was modelled as increasing anxiety as well.

In a similar vein, the *pace of the environment* was another factor included in the model. Pace of environment refers to how quickly one is expected to

move through the space. For example, a major central train station would likely have a fast pace, and a cinema would have a relatively slow pace. A higher pace of the environment was reported to stress the participants, as they could not move as quickly as other people.

> P9: Well, obviously travelling in rush hour can be a bit more difficult than it would when it's not rush hour, cuz you're gonna go slower, and you're gonna be in someone's way, and they're in a hurry

Therefore, *pace of environment* was modelled as increasing anxiety.

For participants with residual vision, the visual properties of the environment were very important for navigation. Although they may not have much vision, "they need to make use of what they've got", as P6 put it.

There were three main visual properties of the environment that were mentioned by participants: colour contrast, level of light, and lack of access to signage.

P8 noted that high contrast helps VI people with residual vision to detect environmental features that may otherwise go unnoticed, and this may, in turn, help to avoid accidents. Key areas mentioned for implementing contrast were low hanging ceilings and the edges of steps

> P8: There's always somewhere I'll find it: where the stairs aren't clearly marked. That's one of my worst ones, cuz I always worry. It's one of the easiest places to fall, and if the individual steps aren't marked so that they have a completely contrasting colour at the end, like a little strip, I am going to be *really* stuck.

The *level of light* in the environment was either seen as a benefit or a detri-

ment, depending upon which type of visual impairment the participant had. Quinones et al. (2011) also mentioned how changes in light level across the seasons can affect B/VI people navigation. Some eye conditions cause a sensitivity to glare and light, known as *photophobia* (RNIB, n.d.-e), and people with photophobia may find that their vision actually *improves* when navigating in lower levels of light. An example of this discrepancy was mentioned in context of trips to the cinema. Some participants mentioned that they could never visit the cinema on their own due to the low light levels:

> P6: Well, that brings me onto cinemas; I would avoid that like the plague if I were going to meet [friend name], or somebody else who couldn't see, cuz it's too dark!

However, P8 mentioned that they have no problems in the cinema, and actually find the low light levels rather relieving and conducive to their vision.

> P8: No, Cinema I don't have a problem with, because I can actually take off my dark glasses.

Due to the variable nature of the effect of lighting levels on perception of surroundings, it was modelled with a "+/-" polarity.

Lack of access to signage was another common complaint of participants. As noted by Giudice and Legge (2008), signs are a ubiquitous method of communicating directions and location information, and being unable to access such information is a large hindrance to people with visual impairments.

Because signage is such an important environmental feature, being unable to access it can be understood as a reduction in perception of the environment, and it was modelled as such.

While the above environmental features were modelled as affecting environment *perception*, other environmental features were modelled as having effects on environment *learning*. For example, when discussing eye-hospitals, participants would complain that the uniform nature of the corridor design and lack of distinct landmarks made it difficult to learn the space. Kaplan (1976) noted that distinctiveness is an important property of landmarks, as did Burnett (1998). Therefore, the *number of distinctive features* in the space was modelled as improving landmark learning.

When discussing supermarkets, the regularity of the layout was also revealed as another property that is conducive to environmental learning, specifically route learning. P7 mentioned that the regular row-column layout of supermarkets makes supermarkets easier to learn. As such, *layout regularity* was modelled as contributing to route learning.

Changes and disruptions to the space were also cited as a significant cause of distress by interview participants.

> P7: Well, sometimes you'll come in on another platform and you've lost your bearings. It's okay if you know where you're coming in, and, therefore, if you know where you're coming in you would know where the steps or the lifts were, but if you're coming in on another platform …

> P3: Yeah. Exactly, like I went there the other day and the pound shop used to be upstairs is not there anymore. Interviewer: So what happens then? P3: Probably just leave it [and go home] …that's part of being VI.

Although both the terms *change* and *disruption* refer to alterations in an environment, the terms are used here to refer to alterations that have differing

time durations. The term *change* refers to a permanent alteration of the space, such as a shop in a shopping centre closing down. The term *disruption* refers to a temporary alteration to how the navigator would usually interact with the space, such as a train pulling into an unexpected platform, or a corridor closing due to routine maintenance. Both types of alteration introduce a mismatch between the reality of the space, and the past reality which the navigator has encoded in their cognitive map.

As shown by P3's statement above about needing to go home after a shop changed location, changes and disruptions to the environment can result in significant inconvenience for B/VI people. To model this effect, the *environment changes/disruptions* node was modelled as reducing the maturity of the cognitive map. This is because, when an environment is changed or disrupted, it is as though the B/VI person holds an immature cognitive map with respect to the present reality of the environment.

The final node in the model is the *unexpected obstacles* node. This node could refer to environmental features such as wet-floor signs, trolleys in shopping centre aisles, tables and chairs in cafes, etc. Participants reported that the presence of these obstacles increases the chance of accidents occurring:

> P8: The other thing about Reading town council offices, their seats in the waiting area are all cream on a cream floor. I cannot see those at all. I've literally fallen.. I don't know how many times I've fallen over them.

> P4: There's things like bollards and, you know, um, probably street furniture which we call, it's billboards and things like that that can become, you know, a bit of a nuisance if you're not aware of them.

> P3: The dog's normally fantastic, but sometimes you get people who go around and those, those baskets where you got handles on them and they pull them along. They're a nightmare. Sometimes people just don't look where they are going and then put that in front you. A couple of times, I've been with people, like my husband, and he stopped me from falling over it.

Therefore, the *unexpected obstacles* node was modelled as increasing the number of accidents. Crowds also present obstacles to people with visual impairments:

> P3: If you're indoors, it's more cramped and then you getting people who's going past you with uh, just scooters and pushchairs and you just feel so claustrophobic inside.

> P3: Uh, some people, when you're in supermarkets with their trolley, they don't see your dog and they knock your dog

> P6: Even just walking here on the train, there's a few just…seen the cane, I can see she's seen the cane and she walked within about six inches of me, so I have to make sure I pull her out the way.

so the *crowds* node was also modelled as increasing the number of unexpected obstacles.

The above discussion constitutes the complete derivation of the model, with every node and link explained. The final model can be see in fig. 8.4. The associated references and sources for each link can be found tabulated in table 8.1.

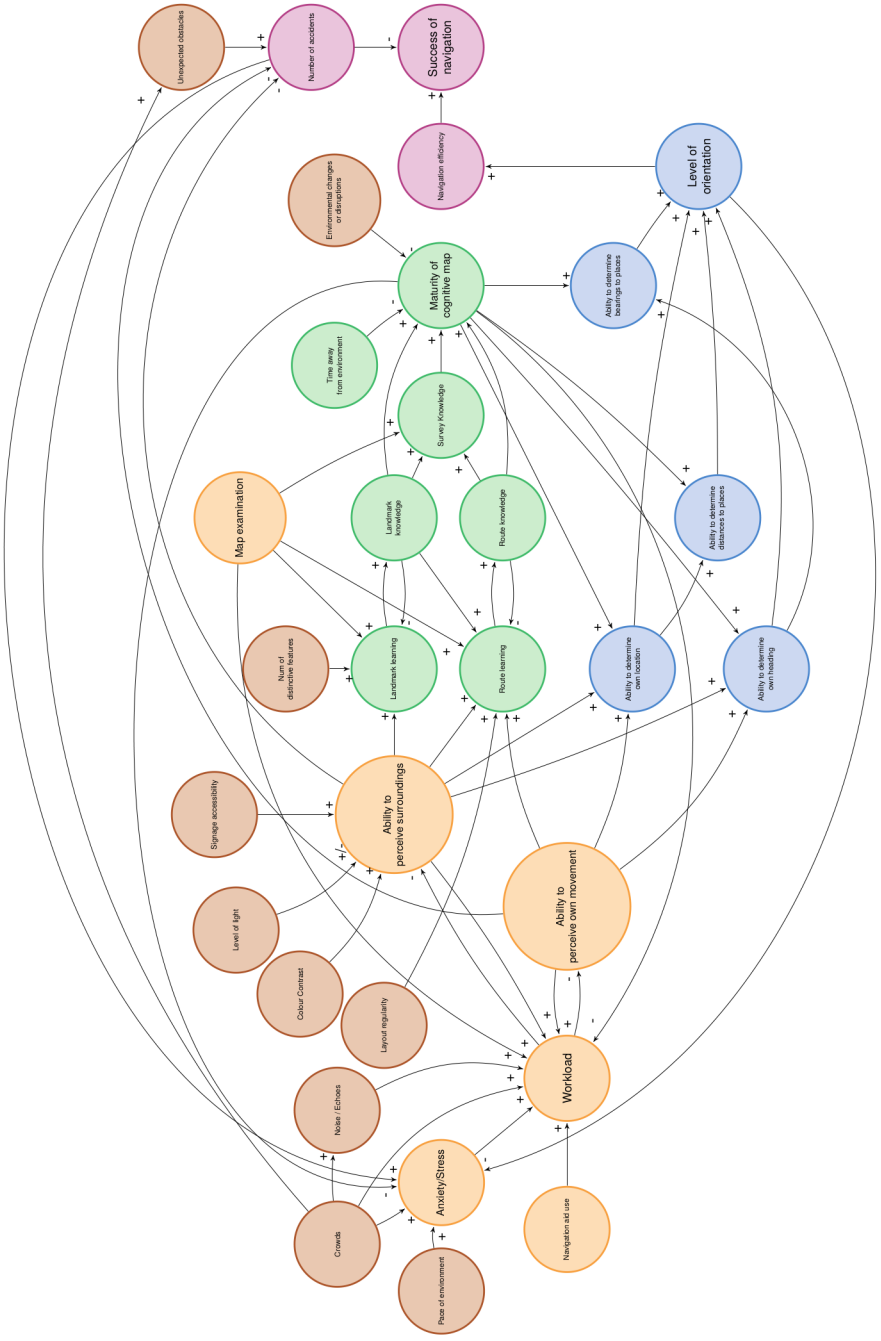


Figure 8.4: *Causal loop diagram modelling navigation of B/VI people*

Table 8.1: Evidence base for each link in CLD. ATD="Ability to determine"

Source node	Sink node	Sources
Ability to perceive own movement	ATD knowledge of heading	(Montello, 2005, pp. 267-268, (Dead-reckoning processes))
Ability to perceive own movement	ATD knowledge of own location	(Montello, 2005, pp. 267-268, (Dead-reckoning processes))
Ability to perceive own movement	Number of accidents	(Nasar et al., 2008; Stavrinos et al., 2009, 2011)
Ability to perceive own movement	Route learning	(Montello, 2005, p. 259)
Ability to perceive own movement	Workload	(Wickens et al., 2013b)
Ability to perceive surroundings	ATD knowledge of heading	(Montello, 2005, p. 267, Landmark-based processes)
Ability to perceive surroundings	ATD knowledge of own location	(Montello, 2005, p. 267, Landmark-based processes)
Ability to perceive surroundings	Landmark learning	(Montello, 2005, p. 259)
Ability to perceive surroundings	Number of accidents	(Nasar et al., 2008; Stavrinos et al., 2009, 2011)
Ability to perceive surroundings	Route learning	(Montello, 2005, p. 259)
Ability to perceive surroundings	Workload	(Wickens et al., 2013b)
Anxiety/Stress	Workload	(Bar-Haim et al., 2007; Eysenck et al., 2007; Wickens et al., 2013b)

Source node	Sink node	Sources
ATD knowledge of bearings	Level of orientation	(Montello, 2005, p. 264)
ATD knowledge of distance to places	Level of orientation	(Montello, 2005, p. 264)
ATD knowledge of heading	ATD knowledge of bearings	Pre-requiste by definition
ATD knowledge of heading	Level of orientation	(Montello, 2005, p. 267, Landmark-based processes)
ATD knowledge of own location	ATD knowledge of distance to places	Pre-requisite by definition
ATD knowledge of own location	Level of orientation	(Montello, 2005, p. 264, p. 267)
Colour contrast	Ability to perceive surroundings	Interviews (see section 8.4)
Crowds	Anxiety/Stress	Interviews (see section 8.4)
Crowds	Noise/Echoes	Interviews (see section 8.4)
Crowds	Unexpected obstacles	Interviews (see section 8.4)
Crowds	Workload	Interviews (see section 8.4)
Environment changes/disruptions	Maturity of cognitive map	Interviews (see section 8.4)
Landmark knowledge	Landmark learning	Assumption
Landmark knowledge	Maturity of cognitive map	(Siegel & White, 1975)
Landmark knowledge	Route learning	(Golledge, 1999; Siegel & White, 1975)
Landmark knowledge	Survey knowledge	(Siegel & White, 1975)
Landmark learning	Landmark knowledge	(Siegel & White, 1975)
Layout regularity	Route learning	Interviews (see section 8.4)

Source node	Sink node	Sources
Level of light	Ability to perceive surroundings	Interviews (see section 8.4) and (RNIB, n.d.-e)
Level of orientation	Anxiety/Stress	(Montello & Sas, 2006, p. 4)
Level of orientation	Navigation efficiency	(Montello, 2005, p. 264)
Map examination	Landmark learning	(Siegel & White, 1975; Thorndyke & Hayes-Roth, 1982)
Map examination	Route learning	(Siegel & White, 1975; Thorndyke & Hayes-Roth, 1982)
Map examination	Survey knowledge	(Siegel & White, 1975; Thorndyke & Hayes-Roth, 1982)
Map examination	Workload	Self-evident
Maturity of cognitive map	Anxiety/Stress	Interviews (see section 8.4)
Maturity of cognitive map	ATD knowledge of bearings	Pre-requiste by definition
Maturity of cognitive map	ATD knowledge of heading	(Montello, 2005, p. 267, Landmark-based processes)
Maturity of cognitive map	Knowledge distance to places	Pre-requiste by definition
Maturity of cognitive map	Knowledge own location	(Montello, 2005, p. 267, Landmark-based processes)
Maturity of cognitive map	Workload	(Montello & Sas, 2006, p. 5)

Source node	Sink node	Sources
Navigation aid use	Workload	(Wickens et al., 2013b) and Interviews (see section 8.4)
Navigation efficiency	Success of navigation	(Giudice & Legge, 2008; Montello, 2005, p. 264) (Definitions)
Noise/Echoes	Workload	Interviews (see section 8.4) and (Wickens et al., 2013b)
Number of accidents	Anxiety/Stress	Interviews (see section 8.4)
Number of accidents	Success of navigation	(Giudice & Legge, 2008; Montello, 2005, p. 264) (Definitions)
Number of distinctive features	Landmark learning	Interviews (see section 8.4) and (Burnett, 1998; Kaplan, 1976; Lynch, 1960)
Pace of environment	Anxiety/Stress	Interviews (see section 8.4) and (Zakay, 1993)
Route knowledge	Maturity of cognitive map	(Siegel & White, 1975)
Route knowledge	Route learning	Assumption
Route knowledge	Survey knowledge	(Siegel & White, 1975)
Route learning	Route knowledge	(Siegel & White, 1975)
Signage accessibility	Ability to perceive surroundings	Interviews (see section 8.4)

Source node	Sink node	Sources
Survey knowledge	Maturity of cognitive map	(Siegel & White, 1975)
Time away from environment	Maturity of cognitive map	(Bennett & Giudice, 2017)
Unexpected obstacles	Number of accidents	Interviews (see section 8.4)
Workload	Ability to perceive own movement	(Wickens et al., 2013b)
Workload	Ability to perceive surroundings	(Wickens et al., 2013b)

8.5 Functional Needs

From viewing the model and the literature on B/VI navigation challenges, it is possible to identify three areas where B/VI people face issues navigating:

1. Familiarisation
2. Environmental perception and obstacle avoidance
3. Orientation and Wayfinding

In essence, B/VI people face difficulties with all parts of the navigation task.

The benefit of the model is that we can see how each of these different parts are composed and inter-related. From this, it is possible to point out precisely how navigation aids can help improve navigation. For example, rather than just saying “the aid could help with familiarisation”, we can suggest that an aid help specifically with landmark learning, with route learning or with survey learning. Rather than just saying that an aid could help with orientation, we can suggest that, among other things, the aid could help provide bearings, provide distance information, or help with localisation. The inter-relations between the different areas also yielded other functions; for example, the inter-relation between the green cognitive map nodes and the blue orientation nodes indicated the need for providing route guidance. Table 8.2 below shows how each category can be broken down into functional needs like this based on the model, and the nodes in the model that are associated with each need are also tabulated.

Although it is not part of navigation per se, many B/VI people complete their navigation tasks by seeking human assistance (Easley et al., 2016; Quinones et al., 2011; Williams et al., 2014). My interviewees also reported seeking help as the first thing they would do in an unfamiliar environment.

Table 8.2: Table of Functional needs derived from the model and their associated nodes

Category	Functional Requirement	Relevant nodes in model
Familiarisation	Support Landmark Learning	landmark learning, landmark knowledge, Number of distinctive features, ability to perceive surroundings
	Support Route Learning	Landmark knowledge (because turn points, and start and end points are essentially landmarks), route learning, route knowledge
	Support Direct Survey Learning	Map examination, Survey learning, Survey knowledge
Environmental Perception & Obstacle avoidance	Assist Obstacle Detection	Crowds, unexpected obstacles, number of accidents
	Assists Obstacle Avoidance	Crowds, unexpected obstacles, number of accidents
	Increases access to Textual Information	Signage accessibility
Orientation and Wayfinding	Provide Location Information	Ability to determine own location
	Provide Heading Information	Ability to determine own heading
	Provide Bearing Information	Ability to determine bearings to places
	Provide Distance Information	Ability to determine distances to places
	Assist Route Planning	Route knowledge, Route learning, Maturity of cognitive map (pre-req.) Navigation efficiency
	Provide Route Guidance	Ability to determine location, Ability to determine bearings, Ability to determine heading, Ability to determine distance to places, Orientation, Ability to perceive own movement (Essentially route guidance maintains orientation along a route)

Although not without their drawbacks (Percival & Hanson, 2005; Williams et al., 2014), sighted guides are a very valuable kind of support for B/VI people and are an integral part of how many B/VI people currently navigate unfamiliar environments. Beatrice Dias et al. (2015) note that it is actually the most commonly used method of support for B/VI indoor navigation. Getting this kind of support, however, can be difficult, even when it is arranged ahead of time.

> P1: If I'm going somewhere like a big concert venue, so the Nottingham Arena or something like that, or the [train] station, you'll often ring up and book assistance, you know. And I'm quite happy to do that, but […] I'll say "well, how will I find you?" And they'll say "well, just find somebody. Just make yourself known to a member of staff". And that is really difficult. That's something that venues haven't really thought about.

Some tools help to overcome these difficulties by providing functionality that makes getting access to sighted assistance easier, such as the Neatebox Welcome (Neatebox, 2019) or the BeMyEyes smartphone application (Be My Eyes, n.d.). For example, by using a sensor installed above store entrances, the Neatebox Welcome helps VI people to acquire sighted assistance when entering shops. It does this by transmitting information—stored in the Neatebox Welcome's companion smartphone app—about the VI person's needs and goals for the store visit to the store-staff (e.g. "I want to buy a blue blouse"), along with information about their sight condition and other contextual information related to the individual (e.g. "I'm deaf in my left ear"). I argue that the cards should also support the development of such technologies that help users access sighted assistance.

Based on this, although it is not in the model, we can also add "Supports assistance attraction" to the possible functionalities that B/VI people may

find beneficial in their navigation aid. Each of the potentially beneficial functionalities above in table 8.2, as well as the “supports assistance attraction” functionality, constitute the functional needs that a B/VI person may have for their navigation aids, and were taken forward to the cards.

Chapter 9

Usability Needs for Navigation Aids

9.1 Confirming Findings from the Literature

The discussions with the participants were very rich and detailed. However, although there were some interesting findings, which I shall discuss shortly, many of the points that participants brought up have already been mentioned in the literature.

It is worth briefly presenting the statements of my participants that confirm the literature findings, before moving on to discuss the more novel content that stemmed from the interviews.

Beatrice Dias et al. (2015) provide an excellent discussion of the preferred interaction modality for B/VI people. They note that the preferred modalities for B/VI people are either purely audial, or a combination of audial and haptic vibrations.

My participants mentioned similar preferences saying that they preferred

audial interfaces, but also liked the ability to have haptic information as a backup.

> P7: Yeah, it all needs to be audio, no buttons.

> P9: You know, setting it up, whatever you need it to do, it all needs to be audio.

—

> P3: I like the vibration. My Garmin [smart watch] has a vibration, so I know I've done every mile. […] It bleeps and vibrates at the same time. So quite like that, because sometimes you miss a bleep, but you don't miss a vibration.

Gori et al. (2016) notes that many navigation aids can place too much of a cognitive workload on their users, and that this leads to the aids being unused. A percipient from Wayfinder, W1, also noted a similar point and mentioned that the instructions provided by the aid should be as simple as possible:

> W1: If the instructions are delivered to the users in a very complex long way—the cognitive mode, if it's too much,—they will probably misunderstand, they will stop, they will get confused, and then they will probably not try to use it again.

Beatrice Dias et al. (2015) write that the workload can be reduced by ensuring that the information provided to the user uses accessible language, rather than language that a sighted person would use. W1 also made this point:

> W1: When we gave the instructions to some totally blind people in Barcelona, that in three meters you need to turn left, they asked me "what is three meters?" So, they don't understand meters, they understand steps.
>
> Researcher: So, it's about making the information you provide in accessible language? Is that what you mean?
>
> W1: Yes.

Beatrice Dias et al. (2015) also note that B/VI people need different information at different times and would like to have control over the interface, and have control over the detail of the information that is provided to them. Our participants gave similar findings, noting that they would want their device to provide the minimal possible information when in a more task-oriented mode, where the extra information may be overwhelming and distracting:

> P1: I like to keep the audible feedback to a minimum, you know, to the absolute necessities of what you need to know. Um, if there's something that I need to listen to a lot of information I would probably be looking to stopping, standing aside, and listening. You know, if I need to find out a lot of information so that my concentration isn't taken away from the work with my dog.
>
> P2: So you wouldn't want it to be …You wouldn't want any intermittent interactions, some frequent interactions. You want to set it and forget it basically.

At the same time, participants also wanted their devices to be capable of providing information about their surroundings to facilitate opportunities for exploration:

> P2: I'd like to know what's on my left and what's on my right as I walk along so I could tell whether I wanted to go to that particular shop, if I was approaching steps or escalators or stuff like that. Um …and then, obviously, if there was any food places around me or that sort of thing really.

> P5: [I'd be able to] go to more places on my own that I've never been to before. Because the technology would be there telling me what to do, and well not telling me, but telling me what's around me. Uh, so I wouldn't be unaware of my surroundings.

As these are contrary desires, P3 pointed out, like Beatrice Dias et al. (2015), that providing B/VI people with the ability to control the level of information that their device provide them is a good course to take, as it will allow them to cater the functionality of their devices to their own personal contexts.

> P3: I'd like to have a choice. It depends on the day, if you're in a hurry, you don't want to know everything, do you? So, it'd be nice to have a choice.

After noting that navigators may be subject to time pressure, W2 also suggested that it is a good idea to put the navigator in control of the amount of information they receive:

> W2: Ideally you would give the user that choice [of information detail]. But as I said, kind of make it very clear to the [user] what the implications of that choice are for the information they are going to receive.

Note that W2 makes an additional suggestion that users should be informed

about the effects of the various options when controlling the level of information they receive.

Other more general points were made by my participants about user interfaces. The literature reports that user interfaces for B/VI people should be sure not to obstruct the user's hearing, or utilise both of their hands (Beatrice Dias et al., 2015; Gori et al., 2016; Sanchez & Elias, 2007). My participants reported similar preferences:

> P2: I personally would need just an ear-piece to listen to it through; I only use one ear-piece because I like to keep my other ear free to listen to what's about me.

> P4: It'd probably be hands-free, obviously, because we're actually trained to work using both hands. Us left hand to hold the harness [of the guide dog], and there is times where we do have to correct the dog using the lead as well, so it would have to probably be hands free.

Participants from the Wayfindr study also noted this point:

> W2: If it takes more than one hand to operate, it's probably going to be useless because it's very likely that a person will have a cane or a dog or just want to keep a hand free for something else.

This point to keep a user's hands and ears free could be considered as a subset of the wider need to consider the user's pre-existing orientation and mobility behaviour when designing. Swobodzinski and Raubal (2009) placed great emphasis on this point when developing their algorithm for indoor route guidance for B/VI people. W2 also noted this point:

> W2: Very often, visually impaired people would prefer to walk around the walls instead of just walking straight across the concourse even though it takes longer. So if you had an aid that didn't take those types of specifics into account, it would probably be much less usable.

The literature also reports that navigation aids should be made as portable as possible (Beatrice Dias et al., 2015; Sanchez & Elias, 2007). This was also confirmed by my participants:

> P3: Well you don't want it to be too bulky, so you want it to be easy to handle. You don't want it to be too big.

> P2: [I'd want] Something that you can put in your pocket or your handbag or just something small that you can tuck away. You know, you don't want to be lumbered with loads of big stuff to have to carry around.

9.2 New Usability Needs

9.2.1 Usability Needs for the Device

Having confirmed the literature findings, let us now transition to the needs that were brought up by my participants that I feel have not been discussed in the literature so far. These were spread across three areas: the general usability of the device, the usability of the user interface, and the commercial aspects of the device. The usability needs for the device and user interface will be covered in the remainder of this chapter, but the discussion commercial aspects will be covered in chapter 10.

Before considering the usability of the aid when it is deployed, designers must consider whether the setup procedure is easy for their users. For example, P7 brought up the difficulties they face in installing apps onto their smartphones:

> P7: So if it's an app or something, even like downloading that, I struggle to do that, I need someone else to do that. And then how do I make it work? How do I turn it on? […] It's really hard; It's really hard.

Arguably, for sighted users, installing an app on a smartphone is a relatively simple procedure. However, as we have seen often throughout this thesis, it is often these seemingly simple tasks—climbing stairs, determining the correct train platform, discovering new shops—that can pose the most difficulty for B/VI people. Although there is very little that navigation aid developers can do about this issue in particular, because the app stores are typically under the control of third-party companies like Google and Apple, this point made by P7 highlights to us the importance of focusing intensely on the details and threading a user story throughout the entire usage cycle of a given device. Although of crucial importance, it is not enough to only consider the usability of the deployed state; in fact, without considering whether or not the user can actually set up the device, the efforts made on the functionality of the deployed state may be compromised.

For example, P9 mentioned that, although they had succeeded in downloading several navigation apps, they couldn't benefit from them due to difficulties in learning how they actually work.

> P9: But the trouble is that even when I've got it though, I haven't learned …I've got two [apps] I've been told about by [name] and

> I can't use them. I said to her "I can't use them, I don't know how to use them."

As such, designers should ensure that it is easy for their B/VI users to learn how to use their products, and ensure that the methods for doing so are accessible, and made easily and readily available.

A final set of needs were bundled in the form of an anecdote told by W1:

> W1: But, I'll throw in one more which is the devices that people are actually willing to have on their hands and the capabilities of these devices. Because a few days ago I passed our technology expert […] I asked him what types of mobile phones do [VI] people have that are capable to [run the algorithms], for example bigger iPhone 6, 7, now 8? What is popular?
>
> Researcher: Mm-hmm (affirmative)
>
> W1: Surprisingly he came back and said "the iPhone SE". I said, "Oh, that's an old model". He said "Yes, but it has a very small screen. You don't need to read it, you only need to touch it
>
> Researcher: Mm-hmm (affirmative)
>
> W1: "And it's light. And the battery is fine because you're not using any of the lighting on the screen because it's black all the time and you don't need the larger one". So if the application that people are designing requires a hardware that's not available for the users, then there may be a problem.

This anecdote points out some highly relevant points to bear in mind if designers are aiming to leverage mainstream technology in their designs. It points out that some VI people have specific requirements when they shop for their devices and may not be using the most up to date model of a given piece of technology. We know from the RNIB's My Voice survey that a lack of finances is a common issue for many VI people (Slade & Edwards, 2015), and many VI people may, therefore, not have the financial resources required to purchase the latest technology. If the design team is mostly composed of non-VI members, then this point to design for older models of a given technology may go unnoticed, and W1's story points out that they may, therefore, end up creating an aid that is too complex to be run on the devices that their users are actually using.

Of course, it is not always the case that B/VI people use older models of technology. For example, in my interviews, P1 mentioned that in the past purchasing expensive technology was not an option for her, but she had recently purchased a then top of the range iPhone simply because she wanted to:

> P1: I mean, the Trekker is something I coveted for a long time. I really wanted one. And they were so expensive, and actually quite bulky as well, but the, the real thing that stopped me from having the Trekker was its expense. Um, okay, now I have you know, I've got an iPhone 8, so I have made that financial outlay for an iPhone 8. Um, because I'm a bit of a technology geek and I wanted the latest one. But that was my choice.

The point here is not so much about designing for old technology, but rather it is about designing for the pieces of technology that are commonly used amongst the B/VI population.

9.2.2 Usability Needs for the User Interface

While software for sighted users may be recommended based on its number of features, the B/VI participants I spoke to encouraged designers taking a minimalist approach to their functionality.

> P3: You don't want it to be too many buttons. You want it to be simplistic.

While such minimalism may be an aesthetic preference for sighted users, for B/VI users, the preference was purely pragmatic and stems from the difficulties associated with learning user interfaces.

> P9: Even when they design things *for* the visually impaired, there's been one or two cases [I've got something, and] you think "oh that's really good", but actually it's not that good cuz you've still got to see what you're doing.
>
> P7: Yeah, you've got to work out where the buttons are.
>
> P9: Yeah, everything, you know?

This desire for simplicity also carried over to the information that the aid would provide too.

> P3: Do you know what I mean? So, it's got to be accurate. And it's got to be simple. You don't want too much details.

While P3 points out here that, although they still need the information to be valuable (in the context they were referring to, value was determined

by accuracy), they place a high importance on simplicity of the information. Extraneous details can be counterproductive.

As we have seen, however, this is not always the case. When on a more leisurely route, navigators may welcome the idea of serendipitous explanations of their environment to allow for opportunities for exploration. We see here, again, that giving users the ability to control the level of information would likely be a welcomed feature (Bernadine Dias & Ravishankar, 2015).

P9 mentioned the need to have a spacious user interface.

> P9: Yeah it is hard, it is. But I tend to do it on my mini iPad and it will go to my phone. I've got it set up so that any apps I've got on my iPad got to my phone, but if I don't want it on my phone I can then delete it. But at least it's there to start with, cuz I can't do it via the phone, cuz it's too small an area.

Here P9 is pointing out how they used a device with a larger screen (iPad) that would synchronise with the device with the smaller screen (iPhone) in order to accomplish tasks that they, ultimately, wanted accomplished on the smaller device. The reason for this is that the larger device provided them with more space to complete the task, which they found to be too difficult on the smaller device.

Note that, although increasing screen size does come with trade-offs in terms of portability and cost, it may be possible for designers to include a lot of redundant space in their designs to cater to this need.

P9 pointed out the need for high colour contrast in the interface features.

> P9: bright, reasonably bright, on the whole. Not that it really matters if you can't see at all or you can only see badly.

Although P9 uses the term “bright” here, a clarfication from a member of the Guide Dogs charity informed me that brightness, such as that in a luminous pink, can actually be difficult for B/VI people to see, and a high colour contrast is what P9 meant.

Making use of contrast checking websites, such as webaim.org, may be useful for designers in this regard.

Finally, W2 introduced the concept of making the user interface consistent:

> W2: Because travelling can be stressful for a lot of vision impaired people, it’s very important that any mobility aids doesn’t add to that stress by malfunctioning or acting in a strange way or acting in a different way in different places. Because all of that acts as a disincentive to users. So I think predictability is a big thing.

There are a few different concepts bundled in that statement. In one sense, by referring to the word “malfunctioning”, W2 is referring to the reliability of the aid. Reliability is a very important quality for all tools to have, but it is especially important for those which that users will *rely* on every day, such as a navigation aid.

For the most part, however, W2 is referring to a consistent interaction protocol with the aid. W2 followed up that statement immediately with an analogy between the consistency of a navigation aid and the consistency of telephone conversations:

> W2: When they do surveys on people with disabilities in general on travel services, so people with disabilities and older people, they all really like the idea of there being an actual person to talk to because they kind of know how to talk to a person, and if the person works for the rail or the bus company, they should act in

> a kind of reasonably consistent way every time. So, you would need to replicate that with any type of technology for people to kind of to use it at scale.

Although W2 didn't provide a reference for the survey he was referring to, his point is clear. When developing services that need to be used in many use cases, designers should try to ensure that the various different use cases can be covered with reference to an overarching consistent method. Each particular phone conversation (i.e each use case of the telephone technology) may be different, but the overall protocol for every phone call is the same. In the same way, when designing a device that has multiple possible use cases, each use case should be a slight variation of an overarching general protocol of use for the device. As a further example, consider the Google Maps service. Whether the user is walking, taking public transport, or driving (different use cases) doesn't greatly alter the interaction method with the aid. Users will always enter their location and desired destination, and the different use case is simply a minor variation of that approach, i.e, pushing a different button.

W2 is drawing on Wayfindr's particular focus on developing generalisable indoor navigation systems as a basis for his point. Not all navigation aid designs need to follow this advice, as they may be solving one particular problem. When an aid is solving one problem, consistency becomes irrelevant. The generalisable point here, however, is that users should be clear on what they can expect from their aids and if any variation in purpose is possible, it should only require a minor shift in user behaviour, which is consistent with the first rule of Shneiderman's eight golden rules for interface design (Shneiderman et al., 2016). W2 notes that:

> W2: So, I think, obviously acting in a consistent way and being very clear to the intended users what type of information the nav-

igation aid is going to give to you, and kind of from that, what type of information that navigation aid isn't going to be able to give to you [is important]. That's why canes and guide dogs have been around for so long because it's very obvious what you can learn with a cane and, from that, what you can't.

Chapter 10

Commercial Needs for Navigation Aids

10.1 Customer-Facing Commercial Needs

In terms of the commercial needs, P7 and P9 pointed out an important issue that may be contributing to low navigation aid adoption: they found it difficult to discover new aids that may be useful to them.

> P7: But it's knowing what is out there that can help you. Unless you know what's out there how do you know? How do you know that that app's there? Only by talking to other people you realise that that's there; otherwise, you wouldn't know.
>
> P9: Yeah, the blind society here and even here [Guide dogs] and RNIB aren't really that good at getting that it out there, and yet you come across someone and they've got an app that does something really good and you think "Well, I don't know about *that*"
>
> P7: See I didn't know about your glasses thing [ORCAM] until

> you told me, so how would you know in the first place? You don't get a magazine…
>
> P9: Well I didn't know until the window cleaner told me *laughs* Seriously, the window cleaner told me that she'd trialled it in Scotland or something, she trialled it…
>
> P7: But how would you know that?

We learn from this exchange that designers cannot necessarily rely on organisations such as Guide Dogs and the RNIB to disseminate news about their new tools. Taking a considered approach to precisely how they will market their aids to their users is very important not only for the commercial success of the design company, but also to ensure that the new products get into the hands of the people that need them.

Support does not stop at the point of sale, however. Designers need to ensure that their devices remain up-to-date so that their users continue to receive useful information. P7 recalled a time they were trialling the Microsoft Soundscape application mentioned in chapter 4 (Microsoft, n.d.), but the maps that the device was using were out-of-date, which undermined the entire functionality of the app.

> P7: I went to use it [Microsoft Soundscape app] a while ago around the new bit in Bracknell and it's still designed as if it's the old bit in Bracknell, so it's not 100%.
>
> P9: Oh really?! Well that was stupid then.
>
> P7: I walked through with someone else with a guide dog and it was like "this is not the new layout" […] It needs to be up to date.

We learn from this that functionality is only part of the solution. Even the most sophisticated technology can only be helpful if it is provided with valid data, and designers must, therefore, put in place methods of keeping their aids up-to-date and determine how they will allocate resources to make this happen.

10.2 Non-Customer-Facing Commercial Needs

10.2.1 Stable Collaborations

Some navigation aids, such as indoor positioning systems, are impossible to deploy without the collaboration of a third party. Often times, that third party needs to install beacons or perform some form of preparatory mapping of the space, and also to maintain that infrastructure over time.

As Wayfindr works in the indoor positioning space, they had a lot to say about what makes these kinds of collaborations work. Not all navigation aids are indoor positioning aids, but much of the advice is generalisable to aids that require collaboration with a third party for the installation and maintenance of some form of infrastructure, so I felt that it was useful to include these suggestions in the cards.

The points made by Wayfindr about stable collaborations may be gathered under three principles: (1) Make it clear, (2) Make it easy, and (3) Make it beneficial, Where “it” refers to the collaboration itself.

Make it Clear

By “make it clear”, I mean that how the collaboration is to work, and what is expected of both parties, should be clearly defined.

In particular, W2 mentioned that designers and/or product makers should be clear on how the required infrastructure should be set up and configured, and also how it should be maintained:

> W2: And there’s going to be some mapping exercise. Someone needs to do the configuration and the set-up. Who’s going to do that? Is it the venue themselves? Do they need to spend time and money or is it the software supply that is going to do this? Beyond that, […] one needs to understand about maintenance. How is the digital mapping going to be maintained and by whom? Who has the responsibility of updating the systems and how these systems will disseminate the updated information back into the user’s devices?

Make it Easy

W1 highlighted that potential collaborators may flee at the sight of extra responsibilities if they feel that they are too complicated for them to handle:

> Researcher: And what might cause them to say no?
>
> W1: Eh, I think it’s maybe a lack of understanding of kind of the capabilities of the system em, or what would be actually involved in setting it up. Sometimes people think it’s super complicated. Some people have had bad experiences with very early ordinary

> navigation systems because particularly some Vision Impaired organisations in the US installed them back, maybe as far back as the kind of the late 90s. And, eh they hadn't really thought about this maintenance point. So, say they had this office layout and they had a bunch of beacons which would guide you around the office and then they changed the layout of the office for whatever reason and then realised they had no way to update the audio guidance, so it made the entire system redundant

Prior bad experiences with former collaborators may make third parties harder to persuade, and thus designers who are designing aids which require third party collaboration should place a focus on ensuring that the aid is not only easy to use for the end user, but also easy to set up and maintain from an infrastructure perspective as well.

Make it Mutually Beneficial

Finally, designers need to make the collaboration a mutually beneficial endeavour to engage in. The proposition must have a clearly-articulated return on investment for the third party.

One way that Wayfindr mentioned this could be done within the indoor positioning space, was to point out that the indoor positioning architecture could be re-purposed to provide other benefits:

> W2: The other thing would be the kind of the alternative usage of the system. Either, as I said, using the indoor positioning system for different things, or using the indoor navigation to meet the needs of people that are Vision Impaired but people might have other mobility needs, so someone who wants statutory access for

> example. Or just for people without permanent disability, as W1 said, help them move through the space more efficiently. Em, I think those are all valid considerations for someone who was thinking about installing it.

W2 gave a further example of a hospital in the United States that installed an indoor positioning system, and found added value in that it could also be used for asset tracking:

> W2: But, you can also use that technology for other things. So, one of the reasons that more and more hospitals in the US provide indoor navigation is because they use indoor positioning for asset tracking. So if you have mobile, very valuable pieces of medical equipment, it's obviously a massive benefit to you if you can see where they are in the hospital at anytime, and kind of see if they're moving when they shouldn't be because that's the sign that someone's going to steal it. And obviously if you're doing all those other stuff with the indoor positioning system, the cost comes way down.

If nothing else, this serves to reminds us that responsibility to install and maintain infrastructure will likely not be adopted purely out of good will. There will need to be a compelling business case for why third parties should adopt and maintain the infrastructure behind the aid, and designers need to have thought through what third parties will be getting out of the partnership if they want it to succeed. As Adam Smith wrote in his *The Wealth of Nations*, "It is not from the benevolence of the brewer, or the baker, that we expect our dinner, but from their regard to their own interest" (Smith, 1776).

10.2.2 Legal Issues

In terms of legal issues, Wayfindr mentioned two important areas: safety and data privacy.

In terms of safety, designers need to have considered where the liability will fall if something does unfortunately go wrong and Wayfindr suggested considering this aspect of the design deeply:

> W1: Oh the legal brick wall. That is the very interesting part, […] for example if you use the word “safe”, then you have declared a lot of liability on what you are going to do.
>
> Researcher: How do you mean?
>
> W1: Safety is very important example. Someone could guide through to the platform of a rail station and tell you that it is “safe”. Follow my instructions, go there and then suddenly you find yourself electrocuted from the railways. Then where is the liability and how does the application itself claim that? Um, so the word “safety” and legal implications are very, very important. One again, needs to understand that these types of applications, currently, they’re probably not designed to replace the primary mobility aids.

As is commonplace in technological design today, W1 also reminded that designers need to also be aware of the data privacy issues that may be relevant to their aid.

> W1: Some of the countries may be more freer, but the UK and the EU with the GDPR, there has to be some explicit authorisation

> from the users to share their personal data […] [that's] something that the designers need to put into their application design.

W1 reminds us that designers should consider what data, if any, their aid requires from their user, and ensure that they are gathering informed consent from their users for collecting that data.

Chapter 11

Hedonic Needs

Transitioning now to the hedonic needs, the literature states that the B/VI navigation aids should be non-stigmatising, discreet when being used, concealable when not in use, as well as conducive to personal confidence and independence (Giudice & Legge, 2008; Shinohara & Wobbrock, 2011; Slade & Edwards, 2015; Williams et al., 2013).

My participants confirmed all of these needs, but didn't provide any further hedonic needs. It is worth, however, briefly presenting the data that confirmed these needs in the literature.

I will begin with the needs for the aids to provide confidence and independence. Towards the end of the interviews, the participants were asked to describe an ideal navigation aid, and were then asked to describe what impact that owning such an aid would have on their lives.

After they had described their ideal navigation aid, here are some examples of responses to the question "how do you think that would impact your life?"

> P1: I think it's how I would feel. I just think I'd feel a lot more confident, you know, approaching new places because I'd know

that there was information.

P2: I …I …Shoot. I probably …I may go to somewhere I've never been to before on my own for the first time rather than go with somebody. And feel perhaps a little bit more confident about doing so.

P3: Oh god. I could go anywhere. **laughter** I mean, I, uh, vastly. Yeah. Just to think, "Oh, I fancy going to such and such and then I go" […] Oh, freedom and independence. To get out and about. [I'd feel] confidence, happiness, self-esteem, sky high

The participants repeatedly mentioned that having their ideal navigation aid would mean an increase in confidence in their own navigational abilities, and an increase in independence. The term "confidence", here, refers to an inner belief in one's own abilities to carry out a task; the term carries with it feelings of safety, reassurance, and an absence of fear. The term "independence", on the other hand, refers to actual ability one has to navigate without directly relying on other people; the term carries with it feelings of empowerment, self-esteem, and freedom.

Because the participants were asked to describe the ideal navigation aid, and then asked to describe how having such an aid would impact their lives, they provided a window of insight into what the ultimate value that B/VI people are looking to gain from in their aids may be. As we can see, B/VI navigators hope to gain more than just functional assistance; they are after a certain state of being, one categorised by an increased sense of confidence and by more independence.

In search for this independence and confidence, the literature has pointed out that B/VI people do not like to use tools that attach to them a "spoiled

identity" (Goffman, 1963), and thus make them vulnerable to social stigmatisation and isolation (Goffman, 1963; Mik-Meyer, 2016; Sanders, 2000; Shinohara & Wobbrock, 2011). Similar sentiments were expressed by my participants who preferred to use discreet, concealable and mainstream technology whenever possible:

> P1: I don't want to be wearing quote "special" things. You know what i mean? I want, I want my technology …You know, all the things I've talked about there are mainstream with perhaps, you know, specific or even specialist apps. But it's all mainstream stuff that anybody else might be wearing or using.

> P2: I wouldn't want to have something that people are going to say, "Oh, what's that that she's got on?" I like to have something that's discreet, if you know what I mean. […] you're sort of a bit of a show when you've got a dog anyway without this thing stuck around you and people are thinking, "What's that?" You know what I mean? I'd rather have something that's not too noticeable, really. Or even something that I could just use with, in conjunction, say, with my iPhone, that I can then just keep it safely in my bag or my pocket.

Williams et al. (2013) write that devices should not make their users more vulnerable to theft. One of my participants had been a victim of theft on two occasions, and said that the fact that they were clearly visual impaired made them an ideal target of such a crime.

> P3: And they know I've got a guide dog. I mean when they tried to snatch me bag, I didn't let go of it, but they, they could obviously seeing me guide dog, because the guide dog was in a harness. So.

Navigation aids should try not to exacerbate this problem if at all possible.

Even with these needs met, the aids still need to be affordable to B/VI people (Bernardine Dias et al., 2015; Sanchez & Elias, 2007), who typically struggle financially (Slade & Edwards, 2015).

> P9: It's also gotta be really cost effective. It doesn't want to be frickn' nine hundred thousand pounds or whatever the number you want to say.
>
> Researcher: Some of them are really expensive aren't they?
>
> P9: Everything is really expensive for visually impaired people.

—

> P6: You must get confidence in it, it must be easy to use, and it must be cheap.

Summary of Part 2

In this part of this thesis, I have used my interviews to curate and present a wide variety of navigation challenges that B/VI people face, as well as their pragmatic and hedonic needs for their navigation aids. Where appropriate, I have also tied the findings from my interviews back to the literature.

In the next part, I will take these needs and challenges, and use them to construct a set of ideation cards that will take this information and make it accessible for use by designers in creative settings.

Part III

Designing and Producing the Ideation Cards

Introduction to Part III

This part of the thesis discusses how I converted the findings from part I and part II into a set of ideation cards. The cards take the form of a card 'game'. I discuss how I used Golembewski and Selby's (2010) five-step method for creating ideation decks, and discuss the steps I took at each stage to produce the cards. I discuss how the game is made up of eight decks, spread across three stages of the game and explain the purpose of each deck and how the game is played. I also situate the game within Wölfel and Merritt's (2013) taxonomy of ideation cards. A copy of each of the cards can be seen in appendix B.

Chapter 12

Card Game Design

12.1 Golembewski and Selby's five-step method

As part of their 2010 paper, Golembewski and Selby published a five-step method for creating ideation decks. Because of its intention to serve as a general method for creating decks of ideation cards, this method was also followed for the production of the cards for this project.

The five steps are as follows:

1. Define the project domain.
2. Define the category suits.
3. Define instance cards within the category suits.
4. Creatively engage with the instance cards.
5. Produce the cards.

Golembewski and Selby's ideation decks are primarly used to help players to explore a design domain. In contrast, rather than exploring the domain, the

deck that I wanted to create was to help players to leverage the prior exploration from my work and from the literature to generate new ideas. My cards, then, distill academic research in an easy-to-use form for creative practioners. This effective use of ideation cards already has precedence in the literature in the works of Lucero and Arrasvuori (2013), Alves and Roque (2011a), and Hornecker (2010). Because of this difference in purpose, Golembewski and Selby's method needed to be adapted somewhat for this project, but the essential process is the same. I will explain the modifications during the following discussion.

12.2 Step 1: Defining the Project Domain

In step 1, Golembewski and Selby explain that the deck designer is to decide what particular domain that they are going to try to explore with their ideation deck. They present the example domain of using 'technology to explore emotion in the home'. In step 1, the authors are essentially asking us to define a clear purpose of our ideation deck before we begin designing. The goal for our ideation game may thus be written as "to help players generate navigation aid ideas that can be used to support the navigation of the visually impaired".

In a similar way to how Lucero and Arrasvuori (2013) converted Korhonen et al.'s (2009) PLEX framework into the the PLEX cards, and how Alves and Roque (2011a) converted their research into sound into their Sound Cards, my game aims to make the academic knowledge presented in part I and part II accessible to creative practitioners in the field of B/VI navigation aid design.

12.3 Step 2: Defining the Category Suits

In step 2, deck designers are to decide on the decks "category suits". Category suits are a set of high-level areas that designers determine to be "salient to the given project domain" (p.90). Category suits essentially serve as category headings that can be used to group similar cards together. In essence, this step asks designers to determine what players will need to consider to generate an idea that will fall within the project domain. In their paper, for example, Golembewski and Selby break up the project domain of 'use a technology to explore emotion in the home', into "rooms in the house", "technology" and "emotions". This example shows that the category suits stem from the aims and purpose of the game. My game has two main purposes:

1. To help designers to generate navigation aid design ideas
2. To help designers ensure that their ideas avoid common pitfalls and satisfy the broad range of needs that B/VI people have for their aids

To do this, I broke the card game up into three stages, and embedded various suits into each stage. The three stages are scenario generation, ideation, and evaluation. The suits for each stage will be discussed now in turn.

12.3.1 Suits that Support Scenario Creation

The need for scenario generation arises from considering the breadth of challenges that B/VI participants reported facing in the interviews and in the literature. From scaling steps (P8), to finding train platforms (P1, P9), to finding a blue blouse in the store (P3), the everyday challenges that the participants mentioned were highly diverse, and thus require different types of

support. Finding a single device that can provide a solution to all the challenges mentioned is therefore unlikely, if not impossible. If a given solution cannot be universal and thus apply in all scenarios, it becomes necessary to define which scenarios a given solution can be expected to apply in.

The scenarios that we are intending to create are similar to vignettes (Hughes, 2008). Vignettes are a qualitative research method that, according to Hughes, aim "to selectively portray aspects of reality to which participants are asked to respond". In vignette studies, a set of vignettes is typically created by a researcher about a particular topic and then these vignettes are presented to participants to investigate how those participants may respond differently if specific variables in a scenario are varied. Instead of creating a fixed set of scenarios and then providing them to the players, which would be restrictive, I have designed the game so that scenarios are to be created by the players themselves using a structured method with the cards. Players will then use those scenarios to provide the contextual information necessary for their design.

Beck et al. (2008) created the Instant Card Technique for a very similar purpose. Beck et al. created six types of cards that can be used to generate scenarios, as shown in table 12.1 below:

Instant Card Type	What they represent (Beck et al. (2008)
User Cards	The user(s) and their attributes
Location Cards	The spatial setting in which the interaction takes place.
Time Cards	Time, duration and frequency of the Interaction
Technology Cards	Devices and tools which are used for the interaction
Activity Cards	Primary activities of users
Goal Cards	Results/goals of the interaction

Table 12.1: Beck et al.'s Categories of Instant Cards and Their Definitions

Beck et al. intended for the instant cards to be used in a participatory design context to allow participants to express possible scenarios for designers to

design for. In our case, however, given the difficulty of recruiting B/VI participants, we will be aiming to provide a method that designers can use to generate scenarios of their own. By allowing designers to generate scenarios of their own, I was aiming to mimic how Kultima et al's (2008) VNA game provides a certain sense of novelty to every session with the cards. Kultima et al. cited this novelty in every session as a key reason for why their VNA game was so popular with players, and I wanted to incorporate this mechanism into this game as well.

Some of the Beck et al's card categories above are directly applicable to the purposes of this work. Others are also relevant, but at slightly different points in the process and from slightly different perspectives. Others are not relevant and were excluded.

The user cards, for example, were immediately applicable. Beck et al's user cards essentially serve as a way of generating user 'personas' (Cooper, 1999), which can help designers to consider the diversity within the user population without becoming overwhelmed. Since the B/VI population is a highly diverse population, the inclusion of user cards appeared to be a reasonable choice.

The location cards were also immediately applicable. In chapter 7, participants provided rich data on the variety of locations that they travelled to, and it became readily apparent that the challenges that the B/VI participants expressed experiencing could be impacted by the location that they were in. Although some challenges were generalisable to all locations, there were many challenges that were specific to a certain type of location.

The "activity" and "challenge" cards are an example of a type of card that were modified. When asked what types of activities that they get up to in the various locations, the answers were unsurprising. When in a shopping centre, VI people want to find stores or products. When at a train station,

they want to catch a train; when at a bus station, they want to catch a bus; when at a cinema, they want to find their seat; and so on. There were no surprising details to be had in my interviews regarding this point. Therefore, I concluded that the activity and goal could be reasonably assumed from the location that the user was in.

However, from realising that the goals and activities that B/VI people have in a given location are exactly the same as sighted people, it became very clear that the main issue with VI navigation isn't that B/VI people live completely different lives that sighted people cannot understand and thus cannot design for. The issue is that B/VI people struggle to perform the everyday tasks for reasons that sighted people may not expect or anticipate. When wanting to find a store, one may neglect to realise that B/VI people can't see the store banners and may not realise that the store even exists. When wanting to catch a train, sighted people may neglect to consider that B/VI people cannot read the signs and the tannoy announcements are interrupting their ability to keep their bearings. When wanting to catch a bus at a bus station, sighted people may neglect to consider that B/VI people cannot be made aware that a bus has pulled in on a different bay, and even if they were made aware, they haven't rehearsed the route to that bay.

Therefore, what is overwhelmingly interesting for the purposes of my cards is the challenges that B/VI people face when trying to carry out those regular activities. Therefore, I decided to replace the "Activity" and "Goal" cards from Beck et al's formulation with a set of "Challenge" cards that would express the challenges that B/VI people face on a day to day basis, and categorise these challenges by the type of location that they apply to.

Beck et al.'s technology cards are an interesting category. The purpose of our game is to help designers to generate new ideas for technological devices, yet at the same time, as mentioned earlier, I also provide the designers

with ideas of technology "building blocks" that they can use when designing their aid. However, although technology is a central point of my game, it is not considered as part of the scenario generation phase. The technology comes in during the ideation phase, which will I will discuss in the next section.

The final category of Beck et al.'s instant cards are the "time" cards. Participants mentioned that time of day only had an effect in two cases. Firstly, at the two ends of the day (early morning and sunset). These times could introduce issues for people suffering from light-sensitivity, and P8 mentioned that they found it more difficult to see at these times. However, because light-sensitivity only affects certain eye conditions, such as photophobia, it didn't seem appropriate to include time of day as a fixed component of every scenario phase.

The second way that time of day affected the participants was at rush hour, when they typically felt more rushed by other people when travelling in transport hubs. This was modelled as the pace of environment node in the model in chapter 8. As rush hour was only relevant to transport-type locations, it would not be particularly relevant to all the other types of locations that the participants mentioned. Including rush hour as a fixed part of the scenario development would likely just be confusing to players who chose to design for a non-transport-related location.

Time of year has also been mentioned in the literature to introduce further obstacles and slip hazards, such as wet leaves during autumn (Quinones et al., 2011), or slush on the floor during winter (P5), but both of these could just be bundled under an "unexpected obstacles" card — it would not be within the scope of the game to begin listing all the different challenges that may occur at each point of the year and in different weather conditions.

Because there was no pressingly strong reason to include time in the sce-

nario, and because of the potential it had to over-complicate the sessions, and the potential it had to be an irrelevant factor when designing for some locations or eye conditions, I opted against including time cards in the scenario generation phase.

At this point, from going through Beck et al's six instant cards, I could identify three card suits that were relevant for establishing a design scenario:

1. User cards
2. Location cards
3. Challenge cards

As mentioned, the activity and goal cards were bundled into the challenge cards, and the idea of technology cards effectively served as the foundation for the "technology building blocks" in the ideation phase.

However, I noticed the need to define one more deck of cards — the "base aid" cards. It is well known that the mobility aid that a B/VI person uses, whether that be a cane, guide dog, or sighted guide, will significantly impact their orientation and mobility behaviour (Jacobson, 2012). Therefore, it is important for players to be clear on the particular base aid that their user is using, and I thought that providing a specific deck of base aid cards will allow players to clearly express this parameter. Moreover, some navigation aid developments come from augmenting a base aid with new capabilities, such as the Ultracane (Hoyle and Walters, 2008) or robotic guide dog (Sugimoto, 2017). Being able to express clearly the user's base aid so that it can itself become the target of development is, therefore, also desirable.

In summary, four suits were defined for the scenario phase of the game:

1. User cards

2. Base Aid Cards
3. Location cards
4. Challenge cards

The first thing that players will do in a session is use these suits of cards to create a scenario to design for. These suits are intended to provide the players with the context they need to pick an appropriate navigation function, and also to evaluate their design idea.

The next step after choosing a scenario will be to actually generate ideas for navigation aids that are suitable for addressing the scenario. This will be the topic of the next section.

12.3.2 Suits that Support Ideation

With a problem to solve, we now need to guide and support players in their ideation efforts. This part of the process is what is typically associated with ideation card methods.

This stage is where our model of navigation becomes highly relevant. The model of navigation, in its diagrammatic form, is a very complex visual representation of the functional process of navigation, and of how sight loss affects that functioning. As we saw earlier, it is possible to distill from the model a set of functional requirements (table 8.2). In the cards, I call these 'navigation functions'. The navigation functions are the different ways in which the problem of B/VI navigation can be tackled from a purely functional perspective. In essence, if a navigation aid provides one or more of these navigation functions, then it will make the task of navigation for B/VI impaired people easier in some way.

These navigation functions will be contained within their own suit of cards, the navigation functions deck. The navigation functions deck, therefore, provides the integration between the model and the cards.

Players will pick from this deck a navigation function that is most appropriate to addressing the scenario they defined earlier. There may be more than one solution to a given problem, but, generally, no one navigation function is applicable to all possible challenges, hence the need for the scenario to be developed first.

To demonstrate this point, consider a user who is experiencing the challenge of "unexpected obstacles". Providing this user with an aid that fulfils the "obstacle avoidance" navigation function, such as the cane or guide dog, would be highly appropriate in this case. Consider now another user who wants help locating Platform 3B in an unfamiliar train station. In this case, an aid that provides the obstacle avoidance navigation function is not a good match, and an aid that provides the "route guidance" function may be a better choice.

The navigation functions, however, only give a general design direction. There are generally many ways of satisfying each given navigation function; for example, a cane, guide dog, and sighted guide can all provide the "obstacle avoidance" function. As we can see, the different "ways" of providing a navigation function constitute the different navigation aids.

To help players to create different aid ideas for a given navigation function, it is necessary for them to consider a wide array of technologies that they could use. This is where the "technology (tech) building blocks" card suit comes in. The tech building blocks category holds a non-exhaustive, yet sizable (28 technologies), curation of individual pieces of technology that can be combined to create a device. Players will combine together the tech building blocks to create a device idea that provides the desired navigation

function, which in turn will address the chosen design scenario. The specific aid idea that is produced, however, will be a product of the group's creativity.

There are thus two suits for this ideation phase:

1. Navigation function cards
2. Tech building block cards

At this stage, players will have generated one or more navigation aid ideas that address their chosen scenario. It is still possible, however, for the aid idea to fail to satisfy the needs mentioned in part II.

To address this, in the next section, I will discuss the final core category of cards: the evaluation cards.

12.3.3 Suits that Support the Evaluation of Ideas

Let's quickly recap the process that players will have followed so far. Firstly, players will have generated a user persona and create a vignette that represents a realistic everyday challenge that the user is facing. Next, they will have used the navigation functions to select a suitable way of addressing that challenge. Finally, they will have combined together pieces of technology to represent a particular solution to that challenge.

Besides the actual production of a prototype and the subsequent user testing, these steps are essentially what have occurred "behind the scenes" of the academic publications regarding new navigation aids. Academics identify a challenge, spot a way of addressing it, and then produce a technological solution that they believe will help.

However, after surveying 22 such publications, Gori et al. (2016) discuss how

these publications typically exhibit “high technology devices with low user acceptance”, and note that the aids typically fail to satisfy the needs that B/VI people have. Others have noted similar points (Giudice & Legge, 2008; Padmanaban & Krukar, 2016; Sanchez & Elias, 2007). Alerting designers of the presence of these needs and providing them with the opportunity to check their aid against a set of common pitfalls and best practises is the purpose of the evaluation cards. In a similar way to how the navigation functions ensure that the aid is meeting the functional requirements that B/VI users express having, the evaluation cards help ensure that the aid is meeting their other requirements, i.e their hedonic needs, their needs regarding usability, and their commercial needs.

This is a point of novelty in my set of ideation cards. Many ideation card methods focus on producing a high quantity of ideas, such as Kultima et al’s (2008) VNA game, or Ojala et al’s (2015) application of the PLEX cards to the development of the railway area of Tampere, Finland. Sometimes, ideation card methods allow players to evaluate the ideas and to improve their quality, such as Kultima et al’s (2008) GameSeeker’s and the work by Olsson et al. (2013). But the evaluation process is often made without any research backing to guide it; evaluation is often left to the subjective appraisal of the idea by the players. This can be acceptable in some spheres, such as game design, where players have their own personal experience with the domain, and can thus more easily evaluate how “good” the idea is. However, because of the differences in needs between B/VI and sighted people, and because the designers may not have visual impairments themselves, designers may struggle to fully grasp the scope of needs that are present and thus make important omissions. My cards are novel in that they not only provide a feedback mechanism for evaluating ideas, but they also guide players in their evaluation, by presenting them with evaluation points that are themselves distilled from primary research into the needs of B/VI navigators.

There is only one suit of cards that is used for this evaluation step, the evaluation cards: the evaluation cards.

12.3.4 Section Summary

As a conservative measure, one final card suit was included in the game: the blank cards. The use of blank cards in ideation decks has precedence in the literature, such as in the works of Halskov and Dalsgard (2006) and Wetzel (2017). Blank cards allow players to add concepts of their own to the discussions, rather than being restricted only to the contents that the deck designer provided. Because it is almost impossible to be absolutely exhaustive in curating every possible concept relevant to a given design domain, it was deemed prudent to create a category of blank cards that players could use to add concepts of their own to the discussion as they saw fit. These blank cards formed the eighth and final card suit.

Conclusion

In total, eight suits of cards were defined for the game, across four broad categories.

Stage 1: Scenario Suits

1. User cards
2. Base aid cards
3. Location cards
4. Challenge cards

Stage 2: Ideation Suits

5. Navigation function cards

6. Tech building block cards

Stage 3: Evaluation Suits

7. Evaluation cards

Optional: Blank Suits

8. Blank cards

These categories, however, only form the broad headings under which the various instance cards need to be placed. Defining the instance cards for each step is the third step of Golembewski and Selby's (2010) method, and is the topic of the next section.

12.4 Step 3: Defining the Instance Cards

Step 3 of Golembewski and Selby's method is to define all the instance cards that will go into the category suits. For example. under their category of "rooms in the house", Golembewski and Selby provide three instance cards: "Lounge", "Kitchen" and "Attic".

Because of the different types of concepts that the game includes, different data sources and different methods were required to curate them. Furthermore, it was only when collecting and curating the different concepts under the categories mentioned in the last section that the need for some of the category suits to be broken down into subcategories was recognised. The sub-categorised decks were the challenge cards (broken into two subcategories), the tech building blocks (broken into four subcategories), and the evaluation cards (broken into four subcategories).

To give as complete a picture as possible of the contents of the cards, this section will begin with a discussion of the different methods used to curate the instance cards, and then give a closer look at the different subcategories that were within the three sub-categorised decks.

Table 12.2 presents the different methods used to curate the instance cards for each category suit, along with the total number of cards in each suit. In total, there are 145 cards across the eight decks.

Table 12.2 includes five methods of curating concepts:

1. Analysing and filtering the interview data
2. Searching the academic literature
3. Deriving from the model of navigation
4. Identification of differences between B/VI interview participants
5. Brainstorming from personal experience

Table 12.2: The methods used to curate the content for card suit and total number of cards within each suit

Category Suit	Method(s) of Curating Instance Cards	Total Number of Instance Cards
User Cards	Identification of differences between B/VI interview participants	4
Base aid cards	Searching literature for presentations of the most prevalent mobility aids (See Bernadine Dias and Ravishankar (2015, p.177), and Dutton (2015))	4
Location cards	Analysis and filtering of data from Interviews with B/VI participants	23
Challenge cards	Analysis and filtering of data from Interviews with B/VI participants and searching the literature	30
Navigation function cards	Derivation from model of navigation	13
Tech building block cards	Analysis and filtering of data from Wayfindr Interview + Brainstorm of technologies from personal life experience	28
Evaluation cards	Analysis and filtering of data from Wayfindr Interview and Interviews with B/VI participants + Searching the academic literature	33
Blank Cards	N/A	10

Some of these methods are more systematic and of higher epistemic quality than others. I have attempted to rank the methods in terms of quality above, with what I believe to be the highest quality methods at the top and what I believe to be the lowest quality methods at the bottom.

I will now provide some examples of how the various methods were used to create the cards in the various decks.

12.4.1 Method 1: Use of Interviews

Perhaps the highest quality method used was the filtering of the thematically analysed interview data. The term "filtering" here means manually extracting from the resulting analysis the topics relevant to each card category.

As an example of how this filtering was used to curate card concepts, consider the locations deck. Throughout the interviews with B/VI participants, the participants would mention the locations that they travelled to. Each of these mentions was converted into a location card.

For example, consider the "train station" location. P1 said that they visit train stations on a regular basis:

> P1: Yeah, I do [visit indoor environments] on quite a regular basis, particularly train stations.

Because at least one participant mentioned that they visit train stations, it was made into a card, as shown in fig. 12.1 so:

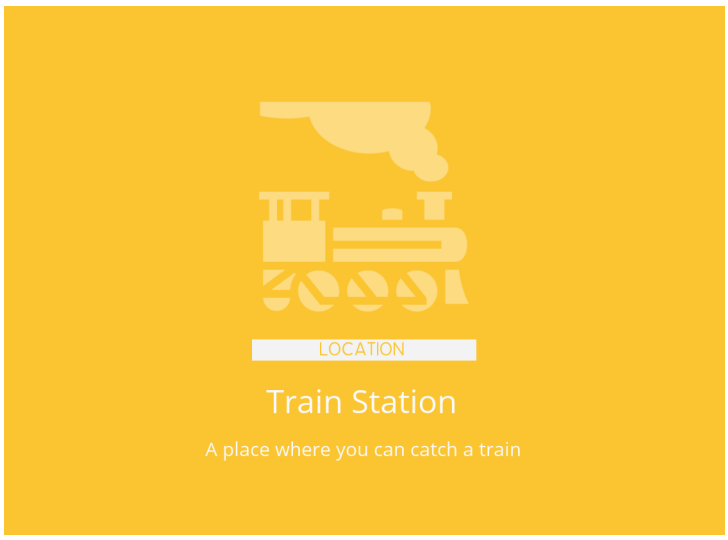


Figure 12.1: *A location card representing a train station*

A similar approach was taken to create the challenge and evaluation cards. In the case of the challenge cards, if a participant mentioned experiencing a particular challenge, then it was made into a card.

If that challenge was not restricted to any location, then it would be categorised as a “universal challenge”; but, if it was specific to a particular location, then it would be tagged as a “specific challenge”.

For example, stairs were a universal challenge:

> P8: One I always seem to have problems with [is] where the stairs aren’t clearly marked. That’s one of my worst ones, cuz I always worry. It’s one of the easiest places to fall.

And they were made into the “stairs” challenge card, with a “universal challenge” tag applied (fig. 12.2).



Figure 12.2: *A challenge card with a 'universal challenge' tag*

P9 mentioned a challenge that is more specific to shop-like environments, finding the checkout.

> P9: I suppose, actually, you could say that what would be useful [when] going in any shop, especially a clothes shop, is to be able to find the till.

This was converted into the "Finding the checkout" card, and given a "specific challenge" tag (fig. 12.3).

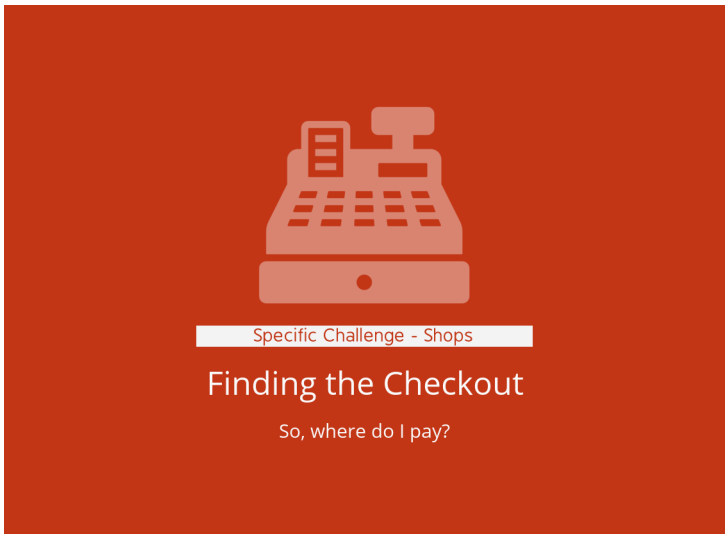


Figure 12.3: *A challenge card with a 'specific challenge' tag*

The evaluation cards were curated in the same way, by using data from the interviews with the B/VI participants, and also data from the interviews with Wayfindr. As we have seen, Wayfindr presented many points to do with the commercialisation of a navigation aid. One such example was the need to consider the user's data privacy:

> W1: Some of the countries may be more freer, but the UK and the EU with the GDPR, there has to be some explicit authorisation from the users to share their personal data […] [that's] something that the designers need to put into their application design.

This point was converted into the "Data Privacy" evaluation card:

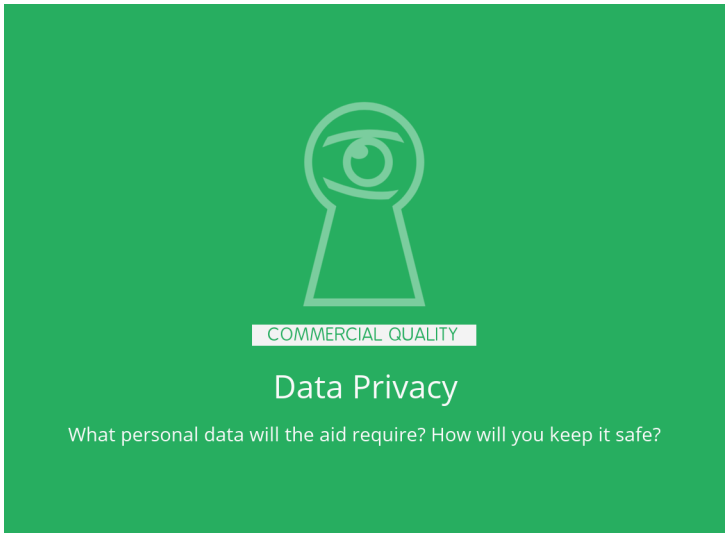


Figure 12.4: *An evaluation card representing data privacy*

12.4.2 Method 2: Use of Literature

Reading the academic literature was another method of curating the cards likely to yield reliable information. It was used to create the base aids deck and to curate some of the evaluation points.

Bernadine Dias and Ravishankar (2015, p.177), and Dutton (2015) both list

canes, guide dogs, sighted aids, and GPS-based devices as the four most common types of navigation aids.

Because GPS-based devices are presently only functional outdoors, and because the base aid cards aim to help produce a general purpose persona, the use of GPS-based devices as a “base aid” was ruled out. This left canes, guide dogs, and sighted aids, as shown in fig. 12.5.



Figure 12.5: *Cards for three base aids: the white cane, the guide dog, and the sighted guide*

The RNIB’s My Voice survey (Slade & Edwards, 2015) reports that 71% of B/VI people use some form of navigation aid. Therefore, some B/VI navigators may go out without the use any navigation aid at all, particularly if they have a relatively high level of residual vision. “No aid” was, therefore, also included as an option.



Figure 12.6: *The ‘no aid’ base aid card*

12.4.3 Method 3: Use of Model

In chapter 8 of part 2, I derived from the model a list of functional needs that B/VI people have for their navigation aids (table 8.2). Each of these functional requirements was simply converted into a “navigation functions” card.

For example, table 8.2 suggests that providing the user with information of bearings to other locations would be one potentially useful function of a navigation aid. This was converted into the “Provides Bearing Information” card:

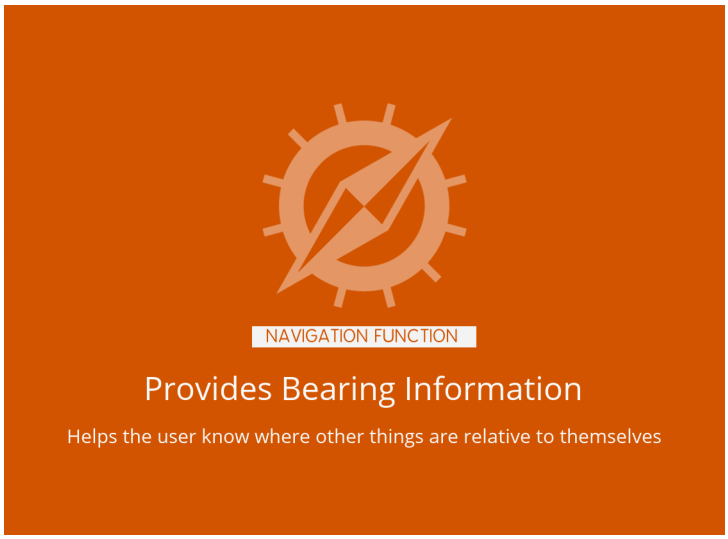


Figure 12.7: *A card representing the ‘Provides bearing information’ functional need*

12.4.4 Method 4: Identifying differences between participants

The fourth method was identifying differences between the VI interview participants. This method was used to create the user cards. The first step that I took when attempting to create the user cards was to search the academic literature for accurate personas representing the diversity in navigation behaviours and attitudes among the B/VI population. Unfortunately, I couldn’t find such a resource. I wanted the user cards to represent the important fac-

tors that distinguish VI people from one another in terms of navigation, but in absence of an external set of comprehensive research-backed personas, I resorted to relying on the primary data I had available from the interviews with the B/VI participants to create my own.

Although my participants shared similarities regarding the challenges they faced every day, I could identify four qualities that distinguished one participant from another:

Table 12.3: The different user cards in the game and the different options for each card

Quality	Different Options
Age	Child, Teenager, Adult, Senior
Gender	Male, Female
Level of visual impairment	Completely Blind, Partially Sighted
Specific personal concerns	Fear of Theft, Sensitivity to Social Stigma, Anxiety around Crowds

My participants could be distinguished in terms of age, and were either adults or elderly seniors. However, since congenital blindness exists, i.e blindness from birth, B/VI people can be of any age. Gori et al. (2016), for example, points out the lack of navigation aid design tailored towards B/VI children. To not neglect consideration for other ages, I decided to open up the consideration of ages in the cards from the adults and seniors in my sample, to include children and teenagers as well. The age card was made to allow players to consider their user's age (fig. 12.8).

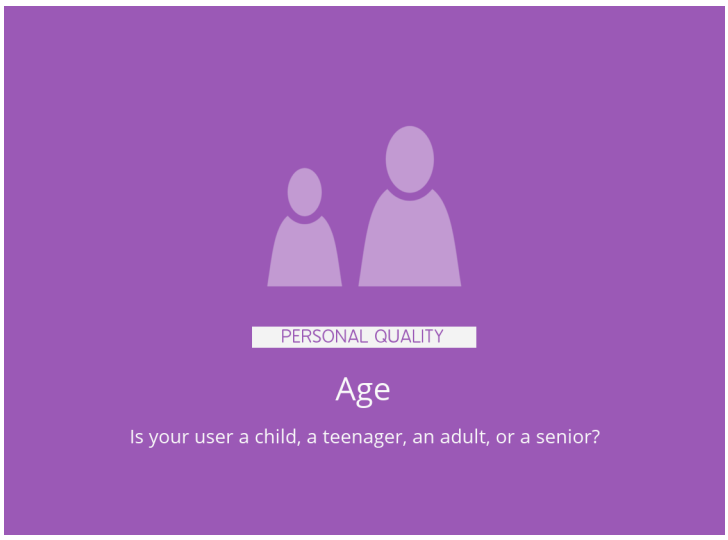


Figure 12.8: *A user card representing the user's age*

Gender was another factor that distinguished my participants from one another in terms of navigation. Gender has been shown in the literature to affect navigational behaviours and abilities (Lawton, 1994; Lawton & Kallai, 2002), so it was included as another user card (fig. 12.9).



Figure 12.9: *A user card representing the user's gender*

The user's level of visual impairment, or "sight quality" was another factor. Some participants were totally blind, while others had varying levels of remaining vision. As mentioned, the user cards offer the opportunity to create user personas, and one purpose of personas is to represent diversity in a

population of users without overwhelming the designers. Because of this, I was wary of including all the different types of impairment at once. I thought that it would be better to take an incremental approach and start with a simple delineation, and add more complexity later as feedback from the players arose in the trials. I thought that the simplest way to represent the diversity in visual impairment was to divide the participants into two broad categories: blind and partially sighted. The "sight quality" card was created to represent this (fig. 12.10).

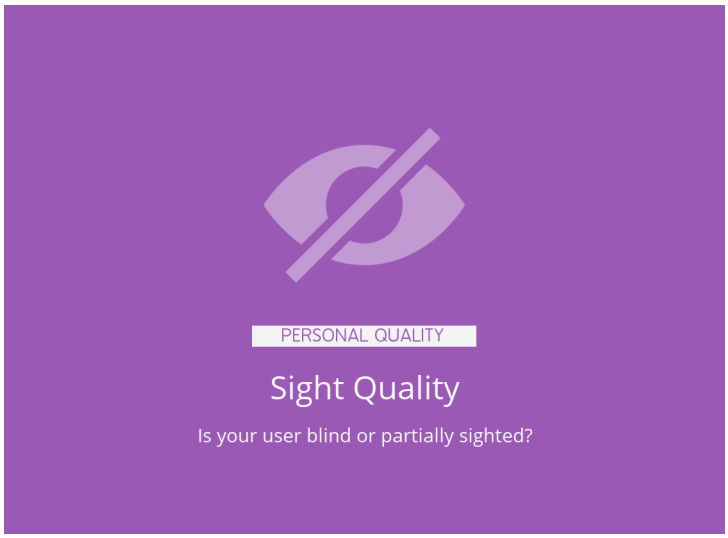


Figure 12.10: *A user card representing the user's quality of sight*

The final way of distinguishing participants was on the level of "specific personal concerns". P3, for example, had been a victim of theft in the past, and expressed that the experienced affected their navigation behaviour.

> P3: I wouldn't go to a new place on me own, I'll always make sure I'm with somebody. […] I've had somebody who's tried to snatch me bag […] You don't know what's happening around you.

Others, such as P2, were sensitive to social stigma:

> P2: I wouldn't want to have something that people are going to say, 'Oh, what's that that she's got on?' I like to have something

> that's discreet, […] you're sort of a bit of a show when you've got a dog anyway without this thing stuck around you and people are thinking, "What's that?" You know what I mean?

These concerns did not affect all participants, but they did have a significant impact on the navigation behaviour of the participants who were affected by them, and on the needs they had for their navigation aids. These specific personal concerns, then, can be considered a way of adding extra contextual information and individuality to the personas than would be created available by only considering the other three factors of age, gender, and level of visual impairment.

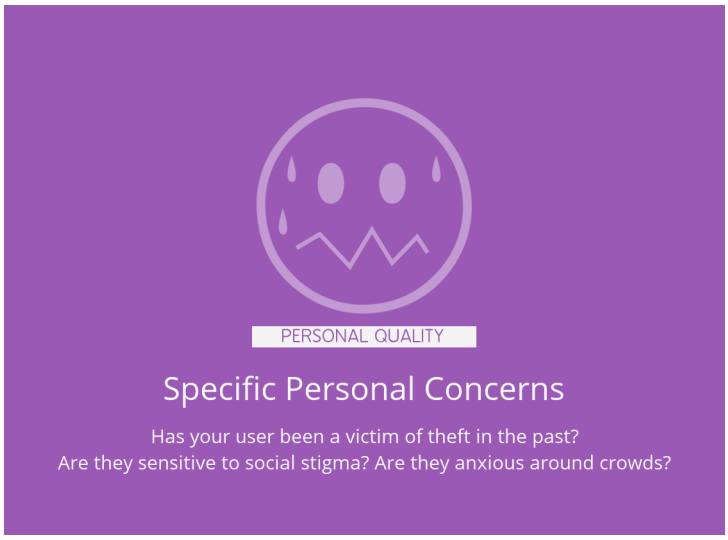


Figure 12.11: *A user card representing the user's specific personal concerns*

Although these differentiating factors are useful in forming personas in the minds of designers, there are questions about how detailed they are, and about how representative they are of the B/VI population at large, especially given my relatively small sample size. Unfortunately the academic literature does not presently hold any generalised personas that represent the B/VI community as a whole. At the same time, providing personas was deemed a necessary step for the game; it would not be sufficient to ask players to design for an amorphous general VI navigator. These four qualities were

the best that I could produce given my limited exposure to my participants and the lack of availability of other personas in the literature. As shall be discussed in chapter 14, the personas served their function, but could be made richer to provide extra context.

12.4.5 Method 5: Brainstorming

Perhaps the least rigorous method used was brainstorming. Brainstorming was primarily used to ideate example technologies for inclusion in the technology building blocks deck.

Once again, the first approach I took in creating the technology building blocks was to search the academic literature for a pre-existing taxonomy of technologies, with the aim of using that taxonomy to guide the creation of the technology cards. Unfortunately, I couldn't find such a resource. With no other apparent approaches at the time, the most expedient method available was to brainstorm all the technological components that I could think of to be included in the game. This approach resulted in a deck of usable concepts, and it was expedient, but it may not have been the best one objectively. Although no component included is technically an incorrect suggestion, generating the concepts for this deck in this way did rely on my limited knowledge of technological components, my limited design experience, and on my limited ability, as an individual, to ideate a representative body of technological concepts that could be used in a generalisable way.

For example, if during my brainstorm the idea of including "smartphone" as a technology seemed reasonable, then that idea would have been converted into a "smartphone" technology card:

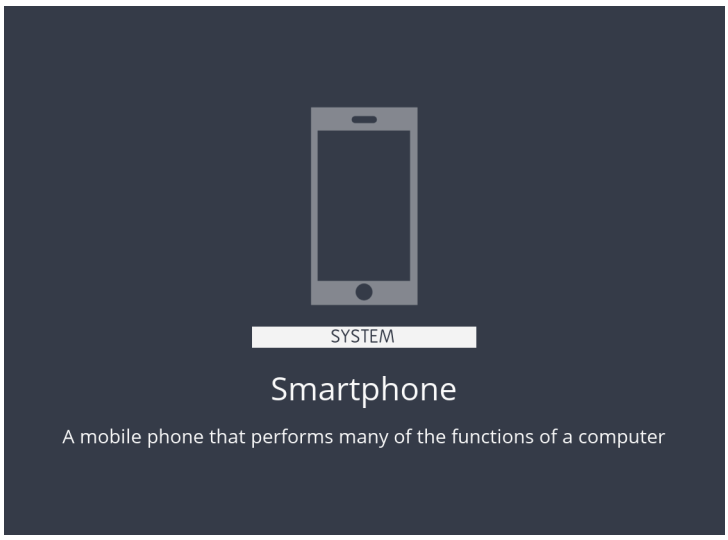


Figure 12.12: *A tech card representing a smartphone*

Because of their role as a navigation aid design consultancy, participants from Wayfindr were also asked for their suggestions of technologies that other navigation aid designers could consider using. The suggestions by Wayfindr account for 25% (7/28) of the contents of the tech building blocks deck and are listed below:

- Bone conduction headphones
- Tactile maps
- Microsoft Soundscape
- Braille
- Medium-range communication protocols (WiFi, Bluetooth)
- Short-range communication protocols (NFC, RFID)
- Announcement system

This concludes the discussion of the different methods for curating the card contents.

As mentioned, it was only after curating the card contents that the need to subcategorise some of the decks became apparent. Following this workflow, I will now round off the discussion of step 3 of Golembewski and Selby's method, by taking a look at the different subcategories that are included in the challenge deck, the tech building blocks, and the evaluation cards.

12.4.6 Subcategorising the Decks

This section will discuss the different subcategories that are present in the challenge deck, the tech building blocks, and the evaluation cards.

Subcategorisation of the Challenge Cards

I noticed while curating the challenges the difference between universal challenges and location-specific challenges.

Some challenges can occur in any location whatsoever; for example, the presence of background noise is a ubiquitous hindrance for VI navigators, as are layout changes, unfavourable lighting levels, and unexpected obstacles, among other things.

On the other hand, some challenges are particular to certain types of locations. For example, a train pulling in on the wrong platform is particular to train stations only. Out of the 30 challenge cards, 18 are specific to certain locations (60%) and 12 are universal (40%). By distinguishing between universal and specific challenges, we give players an extra choice. After having selected a location, players can, on one hand, proceed to tackle a universal challenge, and use the location as added contextual information. On the other hand, players can narrow their challenge selection to focus only on challenges that occur in that specific location.

Subcategorisation of the Tech Building Block Cards

The tech building blocks are divided into four subcategories: inputs, outputs, communication technologies, and systems. In the absence of a taxonomy of technology in the literature, this categorisation of technology into inputs, outputs, communication and systems represents a "best effort" method of categorising the pieces of technology that came out of my brainstorms and the Wayfindr interview. I do not claim that this categorisation is the best one possible, only that this is how the technology cards are categorised in the game.

Inputs and outputs essentially represent data input and output technologies for the device players are designing. Typical examples of inputs include microphones, cameras, and touch screens. Examples of outputs include bone-conduction headphones, vibrating motors, and heatpads.

Communication technologies refer to ways that the navigation aid can communicate with other devices. The Wayfindr interview and the indoor positioning literature (e.g. (Bensky, 2016; Krishnamurthy, 2015)) suggest many different protocols and methods for communicating between devices. Examples include Bluetooth, Zigbee, WiFi, Near-field communication (NFC), Radio frequency identification (RFID), Visible light communication (VLC), Ultra-Wide Band (UWB), Ultraviolet (UV), Infra-red (IR), 4G, 5G, and so on. All of these methods and more are used for communication purposes, and have uses both in localisation and in interaction between devices. However, providing this much resolution between the various communication protocols is likely to be overwhelming to players, and unlikely to provide much value to the game. Instead, the game brackets the communication technologies into three "ranges": Short-range communication, which serve personal area network (PAN) technologies (NFC, RFID, etc); Medium-range communication, which contains local area network (LAN) technologies (WiFi, Bluetooth, Zig-

bee, Ultra-Wideband, UV, Infrared, VLC); and long-range communication, which includes wide area network (WAN) technologies (4G, 5G, etc). The descriptive text on these cards presents examples of the protocols that are included in the "range" that it covers.

Systems are the final category of the tech buildings blocks. In the terminology of the cards "systems", are pre-existing devices that may possibly be leveraged by a navigation aid to perform its function. Systems are essentially miscellaneous pieces of technology that exist and could possibly be useful for players to consider, but cannot be placed into the above three categories. The system cards also allow players to look at some example aids that do/may already exist, and use them as starting points for design.

Examples of system cards include smartphones, tactile maps, and satellite navigation devices.

Subcategorisation of the Evaluation Cards

Based on the curation of usability needs, commercial needs and hedonic needs in part II, the evaluation cards are divided into three categories: usability qualities, commercial qualities, and hedonic qualities.

Each of these categories contains the curation of needs that were found from the respective needs-gathering chapter in part II. Recall that a *need* was defined as a desirable quality. Therefore, the research in part II into user needs maps well here to the qualities in these various decks.

The usability qualities, for example, are based on the research presented in chapter 9, and include qualities related to the usability of a navigation aid and its user interface. Examples include whether the aid is portable, and whether it is likely obstruct the user's hearing.

The commercial qualities are based on the research presented in chapter 10 and represent the qualities that are important to the commercial success of the aid, from the perspectives of both the user and of industry. Examples include whether or not the aid is well-priced, has a good marketing strategy, and has a plan for establishing stable industrial collaborations.

The hedonic qualities are based on the research presented in chapter 11 and represent the important non-pragmatic qualities, such as whether the aid will attract stigma to the user or whether it will enhance their sense of independence.

Taken alongside the functional needs embodied in the navigation functions cards, the evaluation cards enable players to take a holistic consideration of the needs of B/VI users when generating their aid ideas.

12.4.7 Section Summary

Step 3 of Golembewski and Selby's method is about defining the instance cards that go into each of the category suits.

In this section, I have discussed the various methods used for curating the card contents for the different decks, and have also discussed the various subcategorisations that became necessary whilst performing this curation. I have also shown how these subcategorisations relate to the research conducted in part II.

Below is the final summary of the various categories and subcategories of cards in the game.

Stage 1: Scenario Suits

1. User cards

2. Base aid cards
3. Location cards
4. Challenge cards
    (a) Universal
    (b) Specific

Stage 2: Ideation Suits

5. Navigation function cards
6. Tech Building block cards
    (a) Inputs
    (b) Outputs
    (c) Communication
    (d) Systems

Stage 3: Evaluation Suits

7. Evaluation cards
    (a) Usability Qualities
    (b) Commercial Qualities
    (c) Hedonic Qualities

Optional: Blank Suits

8. Blank cards

Step 4 of Golembewsi and Selby's method is discussed in the next section.

12.5 Step 4: Engaging Creatively with the Instance Cards

Step 4, creatively engaging with the cards, involves deck designers deciding exactly how to represent each concept uniquely on the cards. Because each concept is considered on its own, this process, gives designers the opportunity to "explore and consider the nature of each available design parameter. For example, in order to draw 'boredom' a designer must think hard about exactly what they think boredom is." (Golembewski and Selby, 2010, p.91). In my case, this involved me creating a spreadsheet containing each of the concepts to be included. I would then decide on an appropriate title, description, and image that I felt would best capture the essence of each of the concepts and clearly communicate their meaning to players in an unambiguous way.

12.6 Step 5: Producing the Cards

Step 5, producing the cards, is the final step of Golembewski and Selby's method. Because of the continued engagement with the concepts throughout the process, card production also enriches the designer's understanding of concepts in the project space:

"While physically manipulating the cards and their content, the designers are also spending time with the underlying concepts, turning them over in their hands and heads, discussing them with each other, and debating the relevance of each. Thus, the physical assembly of the cards afford a more passive form of reflection engendered by a more process driven, reflective mode of working." (Golembewski and Selby, 2010, p.91)

The difference between step 4 and step 5 is that, while step 4 decides the content of each of the cards, step 5 involves taking that logical content from step 4 and providing it with a physical form.

Rather than opting for a manual method of card creation, I was fortunate to be referred by colleagues in the University of Nottingham's Mixed Reality Lab (Dr Benjamin Bedwell and Dr Dmitri Darzentas) to a website called TheGameCrafter.com. TheGameCrafter.com (Game Crafter) is a website that can be used to create custom card and board games.

Game Crafter also has a companion web application called Component Studio (www.component.studio). Component Studio provides designers with a data-driven way of designing and populating the decks of cards for their games. Component Studio is directly integrated with Game Crafter's online store, which is in turn integrated with Game Crafter's manufacturing facilities.

Because the cards in Component Studio are pre-sized, designing the cards in Component Studio ensured that my designs would be compatible with Game Crafter's manufacturing services, and that the cards would arrive as designed.

Figure 12.13 below shows the process of working with Game Crafter and Component Studio:

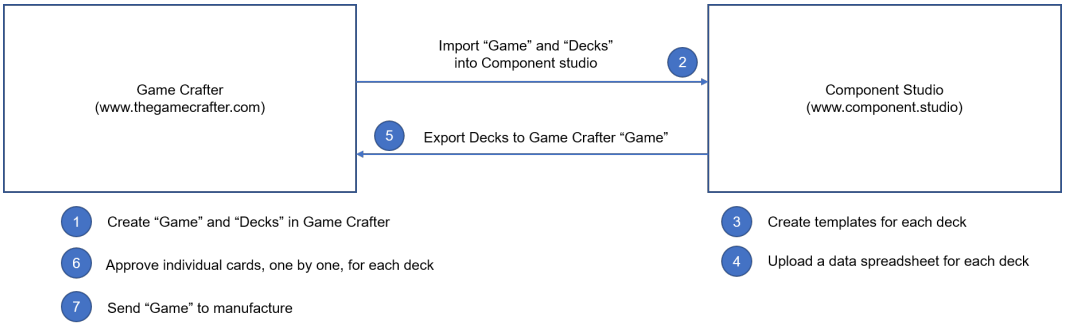


Figure 12.13: *The process of using Game Crafter and Component Studio to create a custom card game.*

Another major benefit of using Component Studio is that it provides data-

driven and dynamic templates, and a user interface which can be used to create the designs. All editing of the designs is done via the web application and only requires that the designer know how to use a web browser.

As mentioned, Component Studio is data-driven. A given “game” is created in the Game Crafter website, and is composed of individual “decks”. These games and decks are then imported into Component Studio. Thereafter, the user uses Component Studio to give each deck a template design that will be shared by all cards in that deck. Each deck’s template can be easily customised by the user at any point in the process, and changes will apply to each card in the deck. Users can also choose to have a different template for the front and back of the cards in a given deck.

Each template design has fields, and these fields are given identifying field names. Field names might include “title”, “description”, “image”, “colour” and so on, and are specified by the user. These fields may have fixed values, which apply across the whole deck, or variable values, which are determined on a card by card basis. By uploading a spreadsheet to Component Studio, where each row in the spreadsheet represents a card, and the columns in that row represent the values for each variable field, a deck of cards can be produced automatically according to the decks template for the deck.

After being designed, the deck is then exported back into the Game Crafter website, where users are required to approve every card one by one to make sure they are satisfied. Once all cards are approved in the deck, the deck is approved, and waits to be sent as part of the whole “game” for manufacturing via Game Crafter’s online store.

Card Design

The cards are rather simple, comprising of an image, a title, a descriptive piece of text, and a white “tag” that could be used to distinguish the card category, and sub-category as necessary. The card suit was denoted by the card background colour. Distinguishing card suits in this way is a technique recommended by Golembewski and Selby (2010).

Table 12.4: Table of Colours used for each of the card suits

Suit	Colour	RGB	#HEX
User Cards	Purple	155,89, 182	#9c59b6
Base aids cards	Grey	127,140,141	#7f8c8d
Locations	Yellow	251, 197, 49	#fbc531
Challenges	Red	194, 54, 22	#c23616
Navigation functions	Orange	211, 84, 0	#d35400
Tech building blocks	Black	53,59,72	#353b48
Evaluation cards	Green	39, 174, 96	#27ae5f
Blank cards	White	249, 249, 243	#f9f9f3

It is worth noting that all the images on the cards were either images available with a creative commons license, or had appropriate non-commercial licenses purchased for use in this project.

Apart from some of the tech building blocks cards, all the cards were the same on the front and on the back. Some of the tech building blocks, however, also featured a QR code that could be scanned to open up a video that would provide more information about the concept represented by that card. Consider the following images of the ‘Braille Reader’ card (figures 12.14 and 12.15):

QR codes were added to the back of some of the tech cards as a response to Wolfel and Merritt’s (2013) recommendation for new ideation decks to incorporate some form of virtual component. I thought that adding the QR codes would be a beneficial component to the game, as it would help players

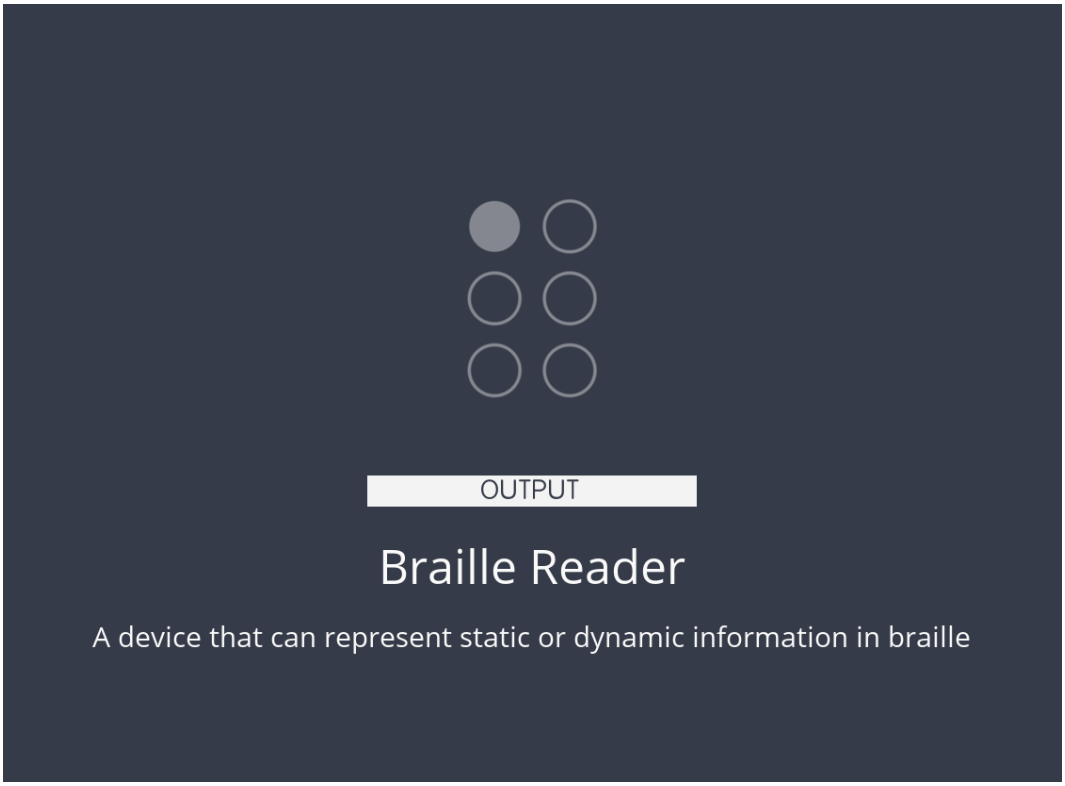


Figure 12.14: *Front of the 'Braille Reader' tech card*

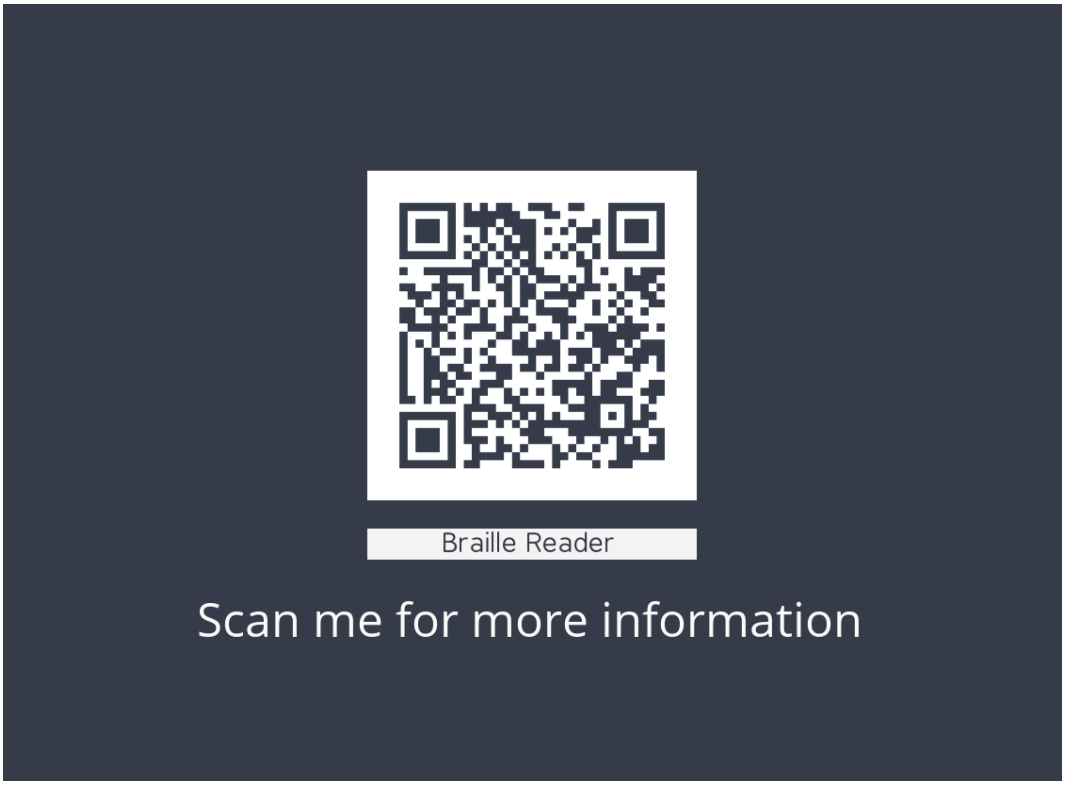


Figure 12.15: *Front of the 'Braille Reader' tech card*

who were not familiar with the technology that the cards contained to become familiar, and thus be able to consider each of the technologies incorporated into the game.

Buur and Soendergard (2000) incorporated virtual components in their video cards game to facilitate discussions. Buur and Soendergard, too, allowed players to trigger video playback using the cards, but using different technology than QR codes. What Burr and Soendergard found, however, was that incorporating a virtual component into the discussions was distracting; players couldn't keep track of each others body gestures and facial expressions, and discussions "did not seem to flow easily" (Buur & Soendergaard, 2000).

The difference between Buur and Soendergard's application and mine is that Buur and Soendergard used the virtual component to facilitate discussion. Players in Buur and Soendergard's game would use the virtual components as evidence in discussions to make their points. In contrast, my QR codes only facilitate players understanding the card content. The virtual component is there to re-enforce and elaborate on the card content and to provide more information. The discussion component of the gameplay still very much occurs between players in a regular fashion.

Because of this difference in usage of virtual components between Buur and Soendergard's work and mine, I thought that it was safe to proceed with the use of QR codes and that the QR codes could provide a beneficial addition to the gameplay. The result of this will be discussed in chapter 15.

One final note to make is that the cards were produced with a UV-coating. Although typically used to provide the cards with a glossy finish, the UV-coating makes the cards dry-erase capable. If players write on the cards using a dry-erase marker, then the cards can easily be wiped clean between sessions. This extra coating was used to make the blank cards re-usable

between sessions. Because of the requirements of the Game Crafter system, the UV-coating was applied to all card decks, and not just to the blank cards.

12.7 Situating the Game in Wolfel & Merritt's Taxonomy

Having presented the process used to design the cards, it will be useful to finish off this chapter by situating the game within Wolfel and Merritt's (2013) taxonomy of ideation card decks. As mentioned in the literature review on ideation cards (chapter 5), Wolfel and Merritt identified three broad types of ideation card methods:

1. Repository
2. Customisable
3. Context-specific

The game provides many repositories of concepts that can be referred to for inspiration. The challenges deck, the locations deck, the tech building blocks deck, the navigation function deck, and the evaluation deck are all individual repositories within the game.

Moreover, with the exception of the locations deck and the tech building blocks deck, I can say that each of the decks in the game is context-specific; they aiming at supporting the ideation of visually impaired navigation aids, and nothing else. The tech building blocks and location cards could, theoretically, be extracted out of the game and placed into another, and are, therefore, contextually neutral.

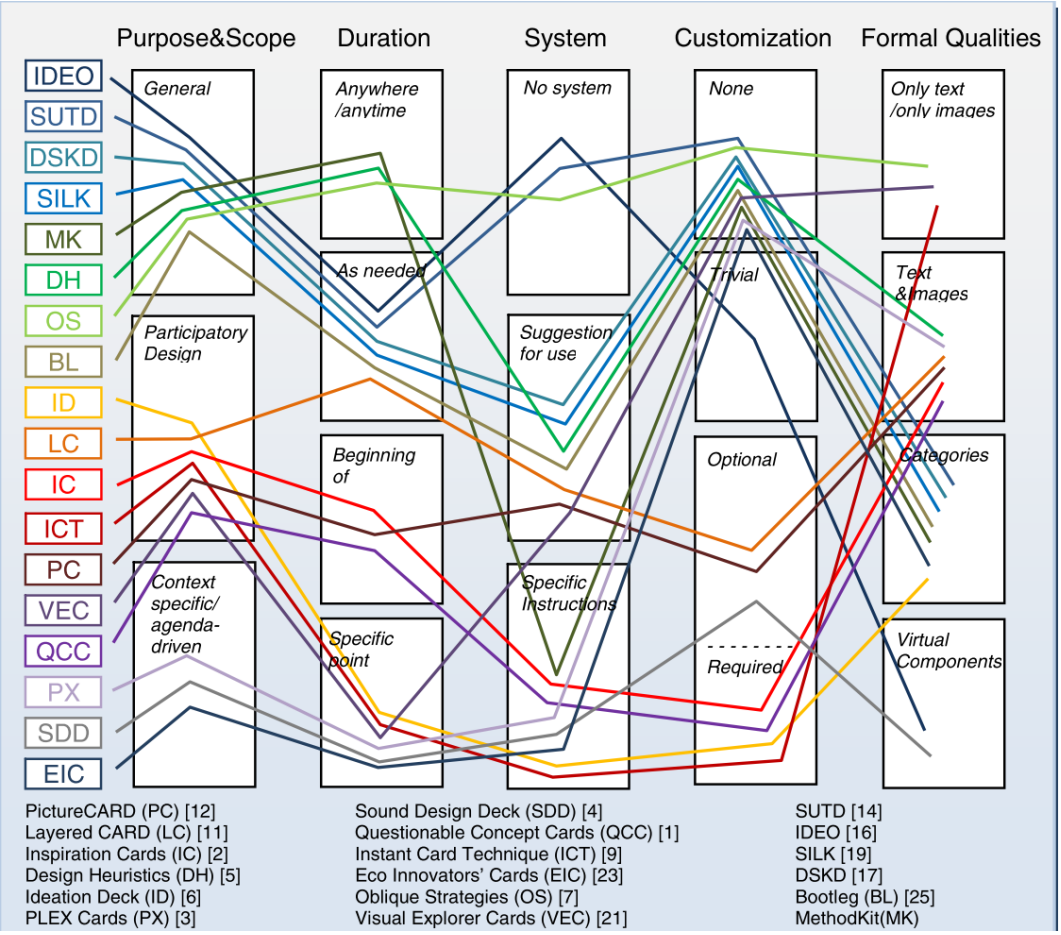


Figure 12.16: *Wolfel and Merritt's (2013) taxonomy of ideation card methods*

The game is also customisable, as it includes blank cards that players can use to add new concepts as they desire.

Since the game does not fit into an obvious archetype, I needed to take a closer look at how the game may fit.

Figure 12.16 shows the categorisation scheme that Wolfel and Merritt used, alongside their categorisation of 18 decks of cards.

Most of the parameters in fig. 12.16 are self-explanatory. The meanings of the "duration" parameter and the "system" parameter, however, may not be immediately obvious. The duration parameter refers to when in the design process the cards are intended to be used, and the system parameter refers to how systematised and structured the game is.

With the parameters understood, table 12.5 presents the values that I would assign the game for each parameter in Wolfel and Merritt's taxonomy.

Table 12.5: Categorising the VI Nav Cards in terms of Wolfel and Merrit's (2013) Taxonomy

Parameter	Value	Reason
Purpose and Scope	Context-Specific	At present, the cards are intended for use by navigation aid design teams, and are highly specific to the context of B/VI navigation aid design. Although it is desirable for the cards to be used as part of a participatory design methodology with B/VI participants, they are presently not fit for this purpose. See chapter 16 for some potential future work to make them accessible to B/VI people.
Duration (and when they are used)	As needed	Although players will likely use the cards at the ideation stage of the design process (a specific point), the cards can also be used to evaluate more developed design ideas, and even those of third-parties (see chapter 14).
System	Specific Instructions	The game comes with an instruction booklet which provides guidance through each stage.
Customisation	Trivial	The cards come with a deck of blank cards, which allow players to add new concepts. I would say that, although useful, this would categorise as trivial customisation.
Formal Qualities	Categories, Text and Images, and Virtual Components	The cards are categorised into suits, each card has text and images, and some card have QR codes which link to virtual components.

With regards to the purpose and scope of the cards, our game is to be used within a specific context: B/VI navigation aid design. Although it would be desirable to have the cards usable in participatory design sessions with B/VI people, they are not fit for this purpose in their current form. At present, they are intended to be used solely by navigation aid design teams. chapter 16, however, discusses various methods for how the cards can be made accessible for use by B/VI people in future work.

Table 12.5 shows that the the "Formal Qualities" parameter does not hold only one value. This is possible because the taxonomy values provided by Wölfel and Merritt are not mutually exclusive. In terms of formal qualities, the cards are categorised, have text and images, and also have links to virtual components via the use of QR codes.

Conclusion

In this chapter, I have discussed how the game was designed by following Golembewski and Selby's (2010) five-step process for creating ideation decks.

The game is composed of eight different decks:

Stage 1: Scenario Suits

1. User cards
2. Base aid cards
3. Location cards
4. Challenge cards
    (a) Universal

(b) Specific

Stage 2: Ideation Suits

5. Navigation function cards
6. Tech Building block cards
   (a) Inputs
   (b) Outputs
   (c) Communication
   (d) Systems

Stage 3: Evaluation Suits

7. Evaluation cards
   (a) Usability Qualities
   (b) Commercial Qualities
   (c) Hedonic Qualities

Optional: Blank Suits

8. Blank cards

The first category, the scenario suits, draw on the concept of using Vignettes (Hughes, 2008) to provide the players of the game with a small scenario and context to design for. Beck et al's (2008) Instant Card technique presented six types of cards that could be used to create personas. I have discussed how I modified Beck et al's work to make it more applicable to B/VI navigation aid design and to determine the scenario suits above.

Having created a vignette or scenario to design for, players will need to decide how to address the given navigation challenge. To help them with this, the functional requirements from the model of navigation (chapter 8) have been converted into the deck of navigation functions. The navigation function cards, then, serve as the link between the model and the cards.

After selecting a navigation function that is appropriate to tackling the design challenge, players will move on to the tech building blocks. The tech building blocks deck is a non-exhaustive, yet sizable, repository of technology components that can be combined together to produce a navigation aid. Taking Wolfel and Merritt's (2013) suggestion that future ideation decks should incorporate virtual components, and taking due caution from the writings of Buur and Soendergard (2000), some of these tech building block cards include QR codes that link to video resources that players can use to better understand the technologies represented on the cards. By combining the technologies in different ways to provide the desired navigation function, players will generate different navigation aid ideas that could address their generated design challenge.

Noting the observations of Sanchez and Elias (2007), Giudice and Legge (2008), Gori et al. (2016), and Padmanaban and Krukar (2016) that many navigation aids in the literature fail to satisfy the needs of their user and typically exhibit low user acceptance, I propose that this issue may be addressed by making designers aware of common pitfalls at the point of design. The evaluation cards, therefore, act as a form of safety net against common issues, and provide a way for designers to root out these issues at an early, and thus effectively cost-free, stage of the design process. It is hoped that this consideration of common issues at early stages of design will help fuel the faster development of higher quality navigation aids.

Unlike ideation card methods that provide no evaluation stage—such as

Ojala et al's (2015) application of the PLEX cards—and unlike other methods which incorporate an evaluation stage, but leave the players unaided in this evaluation—such as Kultima et al's (2008) GameSeeker's—my game presents a research-backed set of evaluation points for players to consider, and this is one of its unique features. This is especially important for the domain of B/VI navigation aid design, because the differences in needs between B/VI and sighted navigators are so different. Because they may not have visual impairments themselves, designers may struggle to fully grasp the scope of needs that are present for VI navigators and thus make important omissions, leading to lower user adoption. My cards are unique in that they not only provide a feedback mechanism for evaluating ideas, but they also guide players in their evaluation, by presenting them with evaluation points that are distilled from primary research into the needs of B/VI navigatons.

The game also includes a set of ten blank cards. The use of blank cards in ideation decks has precedence in the literature, such as in the works of Halskov and Dalsgard (2006) and Wetzel (2017), and allows players to add concepts of their own to the discussions, rather than being restricted only to the contents that the deck designer provided. Because it is almost impossible to be absolutely exhaustive in curating every possible concept relevant to a given design domain, the deck of blank cards was included as a conservative measure. Because of the UV-coating applied to the cards, the blank cards are dry-erase capable, and thus re-usable between sessions.

Finally, I have discussed how the cards were designed using Game Crafter and Component Studio, given a demonstration of what the cards look like, and situated the game among Wolfel and Merritt's (2013) taxonomy of ideation card methods.

What follows is to discuss how the different cards are intended to be used

to conduct an ideation session. This is the topic of the next section.

12.8 How the Game is Played

12.8.1 Stage 1: The Scenario Stage

Players begin a session by defining their user persona. Developing a user persona provides the contextual information that is necessary for making decisions at later points in the game.

The user cards deck contains four cards, and present players with the opportunity to choose the users age, gender, sight quality, and add further context by choosing some specific personal concerns. Players are to go through, as a team, each of the four cards. Each card provides questions and some possible answers to those questions (see fig. 12.17). One player will read out the question, the team will debate their preferences, and an answer will be chosen. By going though each card one by one, and providing answers as a team to the questions each card poses, players gradually develop an idea of the individual they are designing for.

Two of the user qualities that players are asked to consider, age and gender, are qualities that are generally applicable to all human personas in the field of human factors, whereas the other two categories, sight quality and specific personal concerns, are more specific to personas of B/VI individuals.

The method mentioned above allows the user cards to serve as a form of “persona generator”. This is appropriate, as the entire scenario stage of the game acts as a form of vignette or design scenario generator. It is possible, however, for players to come to a session with a predetermined user and environment that they want to target, and thus players may choose to forsake

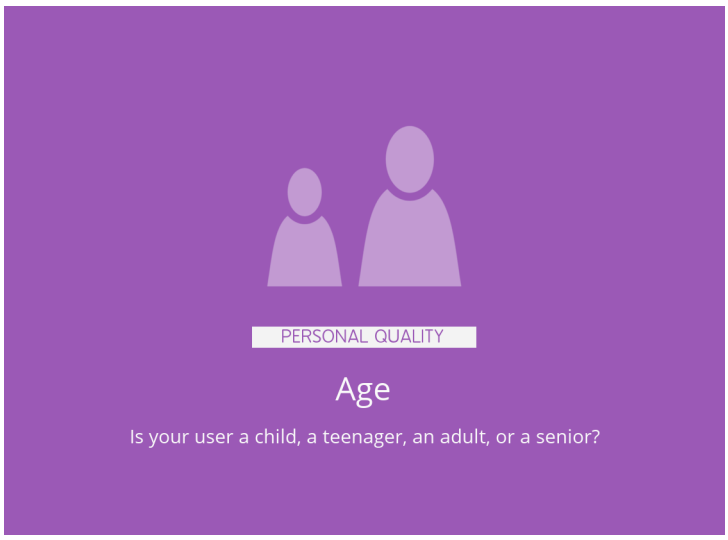


Figure 12.17: *The 'age' user card asks players what the age of their user is and provides several options to choose from*

this stage entirely.

12.8.2 Stage 2: The Ideation Stage

The ideation phase is where the interaction dynamics that we typically associate with ideation card methods come to the fore.

The first part of the ideation phase is to identify a navigation function that their aid should provide to tackle the challenge established in the first stage of the game.

Derived from the model of navigation, the navigation functions deck provides 13 possible ways of approaching navigation aid design challenges. No navigation function is applicable to every challenge, however. As mentioned previously, the requirements of an aid to get a navigator to platform 3B in an urban train station differ from an aid that needs to alert the navigator to unexpected obstacles. As such, it is important for players to have a clear idea of the challenge they hope to address before they can select an appropriate navigation function.

Again, with the hopes of preventing overwhelm, players will flick through the deck and choose one navigation function that they feel as a group represents the most appropriate way of addressing their chosen challenge.

Once players have decided their navigation function, the core ideation part of the game comes into play. Players move on to the tech building blocks cards, where they will combine together pieces of technology to construct an aid idea. Players can use any number of tech cards to create their idea, and may use the blank cards to add new technologies that they feel are relevant.

By combining the various pieces of technology, players will be able to ideate concepts that provide the navigation function selected in the previous step. Because the navigation function has been tailored to addressing the challenge in the scenario, players can rest assured that, by producing an aid idea that provides that navigation function, they will have addressed their chosen challenge.

It remains to be seen, however, to what extent they have done so. The final step of the game is to evaluate the idea for its quality by checking their aid idea against a “safety net” of common issues. By evaluating their idea using the evaluation cards, players can detect potential weaknesses in their idea, and suggest ways to improve it.

12.8.3 Stage 3: The Evaluation Stage

There are two ways in which players can use the evaluation cards. Firstly, players may take a brute-force approach. With this approach, players go through each of the evaluation cards one by one. With each card, they determine if it is relevant to their aid, and if it is, provide answers to the questions it poses. If players discover that their aid idea is lacking in some way, they can either modify the aid idea right there, or write down the point as some-

thing to consider later on. Although this approach is the default and most rigorous it is also the most time consuming. Borrowing from Kultima et al's (2008) GameSeekers game, the second approach is to play a variation of the popular household card-game "UNO". With this approach, each player will take at random a set of, say, five evaluation cards. The aim of the game is to dispose of all the cards in one's hand. Players can discard a card by "attacking" the aid idea using a card in their hand. If the attack is deemed fair by the team, then the card is discarded. The game is over when a player discards all of their cards, or when the aid can no longer be attacked.

The intention is that the competitive spirit behind this variation will cause players to stretch their imaginations to discover the weaknesses of their idea, and to put forth their best arguments as to why that weakness is valid. Having these arguments on the table is likely to be fruitful to a highly critical evaluation of the idea, and thus fruitful to effective development.

Regardless of which route is taken, players should try to be as exhaustive in their evaluation of their aid as possible, and try to consider as many evaluation cards as possible in doing this.

Because it is such an important stage, it is worth spending a bit more time understanding how each of the evaluation cards is used. Instead of framing each concept as a question, such as "Is the aid compliant with all the relevant regulations?", the title of each evaluation card simply states the ideal scenario for that concept, i.e. "legally compliant" "Easy to set up", "Established infrastructure", etc. The general rule of using the evaluation cards is that if their aid cannot be said to have the quality represented in the card title, then their aid idea has a weakness in the area represented by that particular card. In other words, if players cannot say their aid is "well-marketed", then they likely need to investigate further what the "well-marketed" evaluation card is asking them to consider. This approach makes it easier for players

to detect, at a glance, where the weaknesses in their aid idea may lie.

The descriptive text on the bottom of each card poses questions that help players to explore their aid idea from a particular perspective. For example, on the “Well-marketed” card, the descriptive text reads “How will your users hear about the aid? Where will they get it from? Is that place accessible?”.

The descriptive text for the evaluation cards contains a mixture of open and closed questions. The open questions are free to be discussed by players, and have no particular expected answer; possible ways of addressing the question should be discussed and ideated by team members. The closed questions, however, are generally leading questions; the ideal answer is usually, but not always, “yes”. If players cannot say “yes” to a leading question, then they should consider how they can modify their aid idea so that they can say “yes”. For example, the “well-marketed” card asks players to consider whether or not the intended medium of selling the navigation aid is accessible to VI people. If the answer to this question is “no”, or “I don’t know”, then there is an issue to be addressed by the team. If the answer is “no”, then players should modify their idea so that they can reply with a “yes”. If the answer is “I don’t know”, “maybe”, “perhaps”, or “I’m not sure”, then players should have a discussion about this particular point, either now or later in the design pipeline to clarify their position on the issue. By figuring out how they can answer the leading questions with a “yes”, players will have successfully addressed a concern that was raised by interview participants and will have improved the implementation of their navigation aid idea; this is because a “yes” means the idea agrees with the ideal state of affairs recommended by the interview data and the literature.

Not all closed questions require a “yes”, however. An example of this is on the “stable collaborations” card. The card asks “Does the aid require the collaboration of a third party?”. This is not a leading question, as a “yes” is not

necessarily desirable; this is a question used to stimulate discussion from a perspective that players may not have considered. If players answered this particular question with “I don’t know”, then they should discuss the point and explore what might happen if they did bring a third-party collaborator on board, and how that might be done. The context will inform the difference between a leading question, and a question that is intended to spark discussion.

If players take all of the steps outlined above, then they will have formed a navigation aid idea for a particular context, and evaluated it across a holistic set of user needs in the process.

12.8.4 Gameplay Summary

In this section, I have discussed how to conduct a gameplay session with the cards. Table 12.6 summarises the different suits used in each stage, how many cards are to be used from each suits in a given playthrough, and the recommended usage for each suit.

Table 12.6: A summary of recommended usage of the cards

Stage	Suit	Num. cards to use	Recommended Usage
Scenario Stage	User Cards	4	Go through each of the four user cards and pick a value from the options provided.
	Base Aid cards	1	Pass through the deck and pick one base aid for your user.
	Location cards	1	Pass through the deck and pick the location where your user will be situated.
	Challenge cards	1	Pass through the deck and pick one challenge that your user is encountering
Ideation Stage	Navigation Functions	1	Flick through the deck and pick one navigation function that is appropriate to addressing your chosen scenario
	Tech building blocks	As Required	Spread the cards out on the table and try to combine them to generate ideas that will provide the navigation function you selected
Evaluation Stage	Evaluation cards	As many as possible	Go through each card, one by one, and reflect on its applicability to the idea and how it may be incorporated, making adjustments to the idea as necessary.

Summary of Part III

In this part of the thesis, I have discussed the process I took to convert the learnings from part II into a set of ideation cards. I have demonstrated how I followed Golembewski and Selby's (2010) five-step method to create the cards, and I have also demonstrated how the cards are to be used to conduct an ideation session. I have also situated the game amongst Wölfel and Merritt's (2013) taxonomy of ideation card methods.

In part IV, I will discuss the outcomes of a set of card-usage trials conducted with seven human factors researchers, three executives of the Guide Dogs charity, and a visually impaired person. I will present the feedback from the trials, and discuss the positive aspects of the cards, how they can be improved, and how the cards can be made accessible for B/VI people.

Part IV

Card Testing and Evaluation

Introduction to Part IV

Once the cards had been produced, the next step was to determine how well the cards performed, and how they could be improved.

In this part of the thesis, I discuss how the cards were evaluated via a set of trial sessions involving human factors researchers, executives from the Guide Dogs charity, and a visually impaired person. I will present the findings from the trials regarding the positive and negative aspects of the game, and will also present how the cards may be improved. Finally, I will present a novel discussion of how the cards and gameplay can be made accessible to B/VI people.

Chapter 13

Methods and Methodology for Card Testing and Evaluation

13.1 Methodology

13.1.1 Method Selection and Study Structure

This chapter discusses the methods and methodology used to evaluate the cards. When evaluating the cards, there were three main research questions:

1. How useful are the cards for supporting B/VI navigation aid design?
2. What are the strengths and weaknesses of the cards, and how can the weaknesses be mitigated or removed?
3. How can the cards be made accessible to B/VI players?

Because this study aimed to lay the foundation for future development of the cards, it was important get rich and detailed answers to these questions.

Therefore, qualitative methods were selected as the most appropriate approach to addressing the research questions for this study.

Qualitative methods can be divided into interview-based methods, observation-based methods, and documentation-based methods (Hignett, 2005). Because the cards are a new research output, no external documentation exists about them and thus documentation-based methods could be immediately ruled out. As I was looking for feedback on how the game could be improved, I would need to engage with human participants. In order to provide fuel for the discussions, participants would need to have had experience with using cards; a demonstration alone would not be wholly satisfactory. Moreover, because I could not be sure what the feedback on the cards was, it was deemed most appropriate to take an exploratory approach and use the above questions as key talking points, yet allow the discussions to unfold as the opinions of the participants were revealed. This combination of general talking points along with an aversion to strictly fixing the conversation made semi-structured interviews an ideal method for this study.

Therefore, the study sessions were structured to run in two stages each. In stage one, players would be asked to complete a full session with the cards, guided by the researcher. In stage two of a given trial, players would be involved in a semi-structured focus group, and asked questions about their experience and how the game could be improved.

13.1.2 Participant Selection

The next step was to decide which participants would be most appropriate for the study.

The first two questions could be addressed to some degree by anyone who has experience playing with the cards. However, it is important to recall that

the cards are intended for use by navigation aid designers. Therefore, recruiting participants that are similar to navigation aid designers as possible is desirable. Navigation aid designers can be defined as design and engineering professionals that apply their skills towards the production of navigation aids. This population can be well represented by sourcing participants who have sufficient experience of the design process and in working with user needs. It is not strictly necessary that they have had experience designing navigation aids per se.

The most convenient and abundant source of such individuals available to the researcher was The University of Nottingham's Human Factors Research Group. The human factors profession is typified by individuals with solid and diverse experience in design, technology, and user experience, and therefore these participants were deemed to serve as close approximations to navigation aid designers. The compromise in representativeness was deemed an acceptable sacrifice to make the recruitment process easier. The sampling method chosen was, therefore, an example of convenience sampling, which is appropriate for exploratory trials such as these. In total, seven such participants were recruited.

Although the first two questions do not strictly require participants to have any particular expertise in order to provide a satisfactory response (except for experience using the cards), the final question on accessibility would benefit from being answered by individuals with a suitable level of experience with the topic of B/VI accessibility. Examples of such individuals would include people actually living with visual impairments, and people who have a lot of experience working within the accessibility domain. Therefore, both of these types of participants were recruited for the study: one VI participant was recruited, and three executives of the Guide Dogs charity were too.

In total, then, 11 participants were recruited for this study. The 11 participants

were spread across three different trials and one evaluative demonstration. Trial 1 was composed of three human factors professionals (P1-P3), trial two was composed of a further four human factors professionals (P4-P7), one VI person in trial three (P8), trial three was composed of three executives from the Guide Dogs charity (P9-11), and an evaluative demonstration was held with one B/VI person (P8). Each of the sessions were held on different days. It is important to note that, although the participant numbering has started from one again here, the participants mentioned are entirely different to those referred to in the previous sections of the thesis.

Except for the demonstration with the VI participant, all of the studies followed the process mentioned above: a game play phase with the cards, followed by a semi-structured focus group. Each of these trials lasted two hours in total. Participants were remunerated for their time with a £20 amazon voucher each (£10 per hour). Although they were offered remuneration, the Guide Dogs participants declined remuneration, and cited the ethical policy of the Guide Dogs organisation as their reason for doing so.

In the focus-group component of these trials, participants were asked question related to their experiences of the cards, the card categories, the gameplay, and participants were also asked how they game could be made accessible to B/VI players. Specifically, participants were asked how the gameplay, cards, and the game's companion instruction booklet could be made accessible. A full list of questions for the trials with sighted players can be found in appendix A.3.

Because only one VI participant was recruited and no information was known about their level of visual impairment before the session, it was not deemed appropriate to expect the VI participant to be able to play a session of the cards on their own. Instead, a demonstration of the game was given by the researcher, followed by a semi-structured interview with the participant. The

participant was also allowed to try out some of the game sections ad-hoc, as they desired. Fortunately, the residual vision that the VI participant (P8) had remaining was, in their words, “relatively good”, which allowed them to fully engage with the demonstration. P8 described their vision like so:

> P8: My right eye is completely blank, just completely greyed out. My left eye is cut off around the outside, rather, the left edge and underneath. So, its the inner and upper part of my left eye that works.

After the demonstration, P8 was asked for their thoughts on the game. Aside from being asked for general opinions, P8 was asked for their thoughts on the validity of the issues presented by the cards, and for their thoughts on the comprehensiveness of the card categories. They were also asked for comments on how the various parts of the game could be made accessible, and for their thoughts on the accessibility suggestions made by the fully sighted participants. A full list of questions that P8 was asked can be found in appendix A.4.

Because a detailed play session with P8 was not required, the session time was restricted to one hour. P8 was remunerated with a £10 amazon voucher for the one hour session.

13.1.3 Ethical Approval

All of the trials received ethical approval from the University of Nottingham’s School of Engineering’s Ethics Committee and all participants provided informed consent to participate in the studies.

13.1.4 Thematic Analysis

As was the case for the studies in part II, thematic analysis was deemed the most appropriate method of analysis for this study, as the detailed coding and categorising process that thematic analysis involves would ensure that all points of view for a given topic could be curated and contrasted at a later stage. To facilitate the comparison of views across the four trials, all of the data from the four trials were analysed as part of one analysis, rather than four individual ones. All of the studies were audio recorded, transcribed, and then analysed using thematic analysis, supported by version 11 of QSR International's NVIVO software.

13.1.5 The Themes

The thematic analysis conducted for all the trials, which included the interview with the VI person, resulted in the following themes:

1. Impressions of the game (chapter 15):
    (a) Positive
        i. Structure of the Categories (24 references)
        ii. Clarity of Communication (7 references)
    (b) Negative
        i. Limited nature of solutions (6 references)
        ii. The Tech Cards (7 references)
        iii. The Personas (8 references)
        iv. Inconveniences in Use (8 references)
2. Methods of Improving Accessibility (chapter 16)
    (a) Cards

i. Audial Modality Methods (23 references)
   A. Develop Software (1 reference)
   B. Screen-read Word Document (9 references)
ii. Haptic Modality Methods
   A. Braille (7 references)
   B. Props (4 references)
   C. Embossing (3 references)
iii. Visual Modality Methods
   A. Larger Font (8 references)
   B. Improved Contrast (6 references)

(b) Gameplay
   i. Serialising gameplay (15 references)
   ii. Facilitating Preparation (5 references)

(c) Instruction Booklet
   i. Font Changes (1 reference)
   ii. Screen-readable file formats (1 reference)
   iii. Recorded or live instructions (7 references)

It is worth noting that, when discussing the methods of improving accessibility, the number of references for a given theme does not necessarily reflect the worth of the idea contained by that theme.

Using a similar method to part II, the structure of the remaining chapters in this part follow these branches of the analysis. Each of the critiques of the game will also be accompanied with a method of addressing the critique in future work.

Before discussing the results, however, I will begin with a discussion of how each of the trials unfolded and the insights that observing the sessions provided.

Chapter 14

Card Testing

14.1 Introduction

In this chapter, I shall discuss how each of the actual play trials unfolded and the navigation aid ideas that the trial participants generated. I will also discuss some of the insights that observing the sessions provided.

I won't discuss the interview with the VI participant (P8) here, because P8 didn't conduct a full play session with the cards; he simply responded to a demonstration. That said, the comments from P8 will be interwoven with the discussions over the next few chapters.

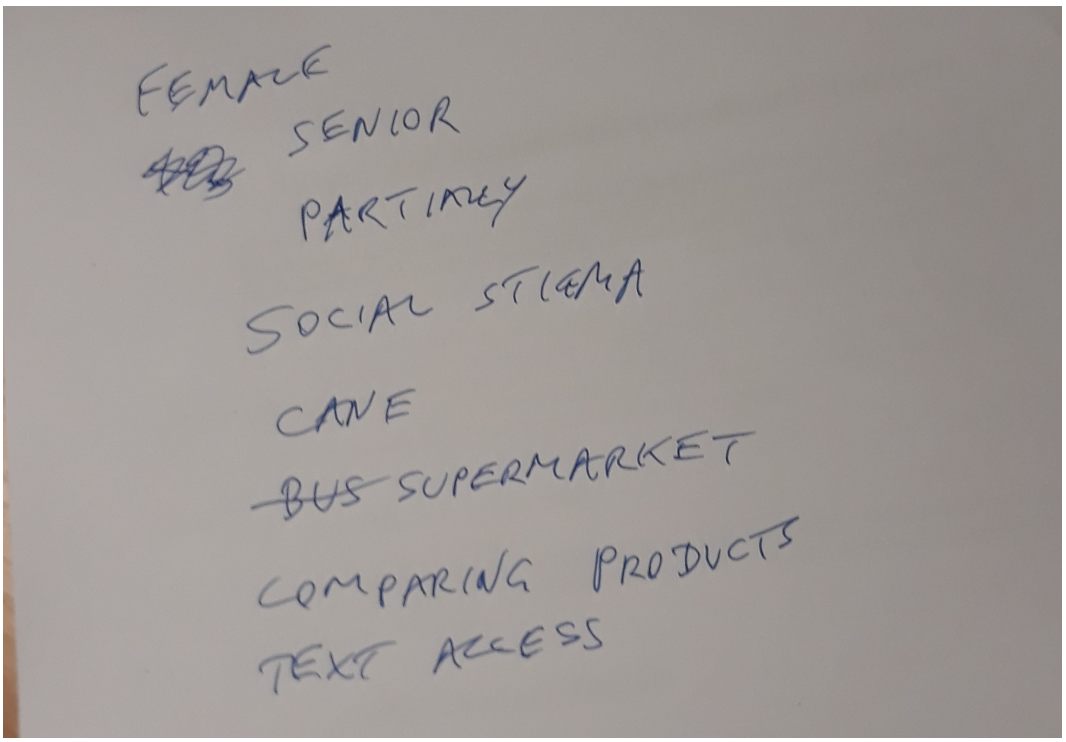


Figure 14.1: *Notes made by participants during the scenario generation of trial 1 (P1-P3)*

14.2 How the Sessions Unfolded

14.2.1 Trial 1

Part 1

In the first run through of trial 1 (P1-P3), players devised a scenario comprising a partially-sighted, female, senior, cane user. This user suffers from social stigma concerns, is presently in a supermarket, and has issues comparing products on shelves (fig. 14.1).

To address this scenario, players decided that the “text access” navigation function would be a suitable one to choose, and used the technology cards to come up with the idea of a camera that would be mounted on the spectacles of a user to help them to read signs and product labels when shopping in the supermarket. Players felt that this aid would not only solve the challenge of

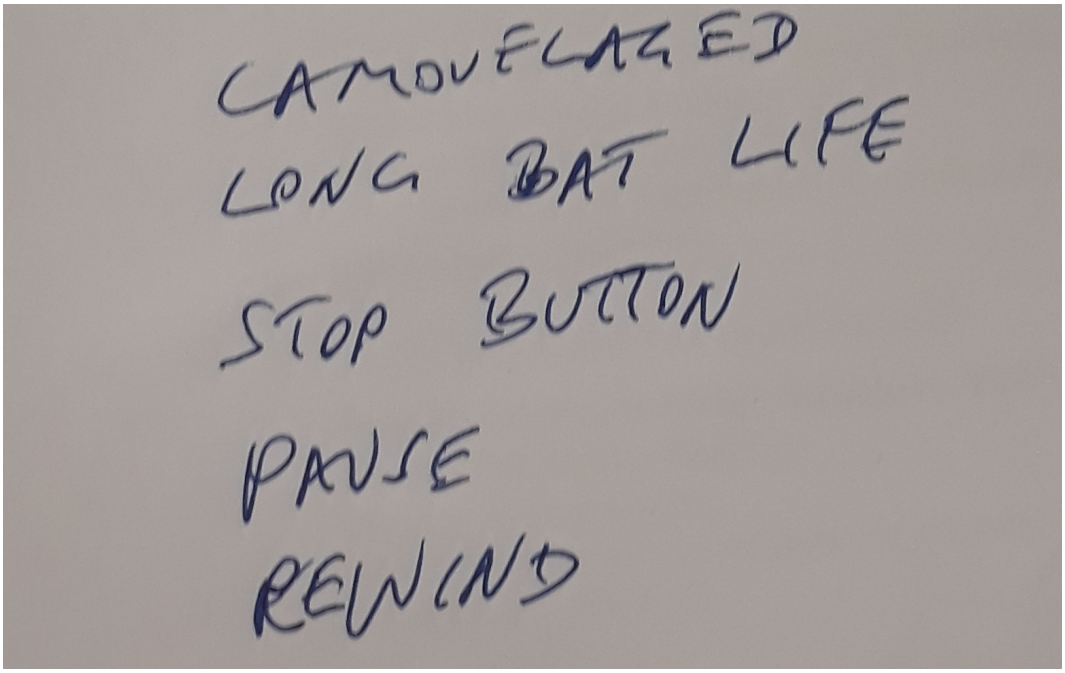


Figure 14.2: *Notes made by participants when selecting challenges during the scenario generation of trial 1 (P1-P3)*

comparing products, but would also help its users to read textual information on signs in new environments.

To help avoid the user's social stigma issues, players felt that the design should also be discreet and "camouflaged" with varying styles to blend into the user's glasses. Players felt that this design should also have long battery life, and other usability functions such as stop, pause, and rewind buttons to stop the user's hearing from being engulfed by randomly detected text (fig. 14.2).

This appears to be a suitable way of addressing the challenge, and was also potentially generalisable to other contexts.

The players found when attempting to instantiate their idea using the tech cards, that, interestingly, their idea was already a successful product: The ORCAM (OrCam, n.d.). While using the tech cards, players noted the similarity between their idea and the ORCAM tech card. Intrigued, players used their smartphones to open the QR code and watched an introductory video



Figure 14.3: *The evaluation cards used during the evaluation stage of trial 1 (P1-P3)*

about the ORCAM. Players concluded that the ORCAM did what they had intended their aid to do.

Players were offered the choice of starting again, or moving forward with the evaluation stage. Players decided to move on with the evaluation of the ORCAM, and discussed the evaluation cards that they thought were relevant to the idea. As fig. 14.3 shows, players considered a wide-array of points and checked that the ORCAM was in line with them. They noted that, going forward, design teams would be wise to make sure the aid was discreet, had methods in place to respond to technical failures, and so on. We can also see that the players used a blank card to identify the potential issue of users becoming over-reliant on the aid.

This interesting but unexpected feature of trial 1 brought to my attention the ability for the cards to be used to evaluate navigation aid ideas that were not generated by the players; I call these ‘third-party’ ideas. This has important implications for the utility of the cards for large organisations such as Guide

Dogs or the RNIB who may wish to make navigation aid recommendations to their service users. The cards provide a way to evaluate third-party ideas for common issues, which can help such organisations become more confident when making recommendations.

It is also a novel use of the ideation card method. In the literature, Ideation cards are typically only used at the start of the design process (Wölfel & Merritt, 2013). This experience, in contrast, demonstrates that ideation cards can also be useful for evaluating finished products. What is interesting about my cards then, is that they are capable of doing both at once. The features of the cards that makes this possible are (1) they integrate design and evaluation into one package and (2) the evaluation stage can standalone. By incorporating these features, other ideation card games could experience the same benefits.

Part 2

Having become confident using the cards following the success on the first try, P1-3 decided to try another run through of the game, but this time tried to tackle multiple challenges at once.

This time, players decided to design for a blind adult male guide dog user, who is visiting a new university for a meeting.

Instead of using the recommended method of picking one challenge to design for, P1-3 started identifying *all* the challenges that could occur in this situation. As this was the first trial and because I wasn't sure whether my recommendation to only use one challenge was too restrictive, I stayed quiet and let the situation unfold.

Participants quickly realised that designing one aid that could solve all of

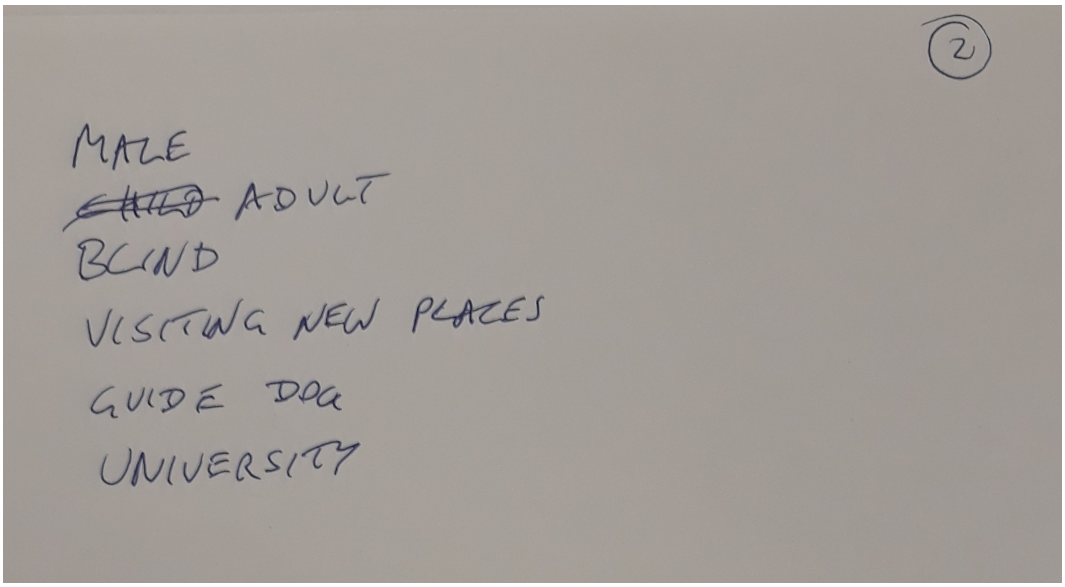


Figure 14.4: *Notes made by participants during the scenario phase of the second card run through of trial 1 (P1-P3)*



Figure 14.5: *The large array of challenges that P1-3 initially tried to design for on their second run through*

these challenges was not viable. Players then tailored back their consideration of challenges, and focused only on three: getting sighted help, dealing with disruptions in the environment, and finding the meeting room (fig. 14.6). This was still more than the recommended focus on one challenge, but better than the previous case.

P1-3 then proceeded to identify the different navigation functions that could be used to solve these challenges. They ended up identifying four navigation functions, which included text-access, localisation, and providing bearing information, and assistance attraction (fig. 14.7).

The gameplay then ground to a halt.

> Researcher: So where have we got to?
>
> P3: I'm not sure.
>
> P1: It's not very good really, is it? I think the problem with this is maybe it's a bit too general.
>
> P2: 'Cause we just said, in university, right, he can do some things in university. He can go to lectures, come up to meetings, he can …<pause>
>
> Researcher: So is it kind of a bit hard to come up with a solution?
>
> P2: [Yes,] Because we don't know what we're solving.

This example highlights the importance of not over-complicating a design brief too quickly. P2 expresses a lack of clarity with the goals of the design session. The scenario cards are intended to provide a clear design goal, and

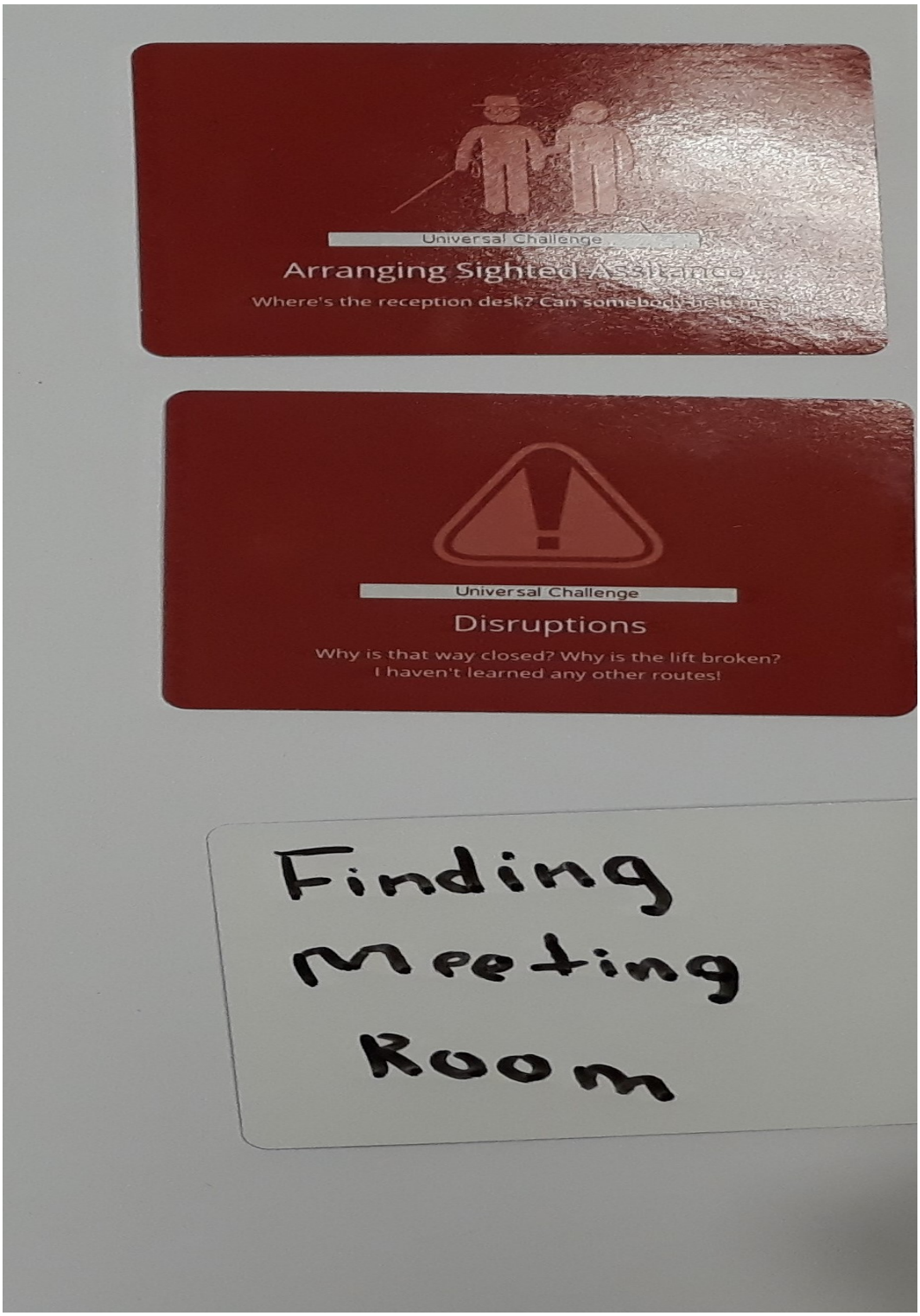


Figure 14.6: *The reduced set of challenges that P1-3 tried to design for on their second run through, after realising that they had previously attempted to design for too many challenges*



Figure 14.7: *The navigation functions chosen in the second run through of trial 1 (P1-P3)*

the navigation functions are intended to point a clear way towards reaching the goal. If many challenges are selected alongside many navigation functions, clarity is lost and the ability of the players to ideate becomes inhibited.

Based on this experience, it is recommended that players only try to tackle one new challenge per run-through of the game. As we will see later, players can tackle more than one challenge, but I make the recommendation that they should only try to tackle one new challenge at a time. Moreover, I can recommend that players should just pick one navigation function to focus on, so that their method of tackling the challenge remains clear and in focus.

It is worth noting that there is nothing particularly special about the number one, however. It is just that focusing on less challenges/navigation functions appears to facilitate clearer design objectives focus and presents players from becoming overwhelmed; focusing only on one challenge or navigation function is the best case of this.

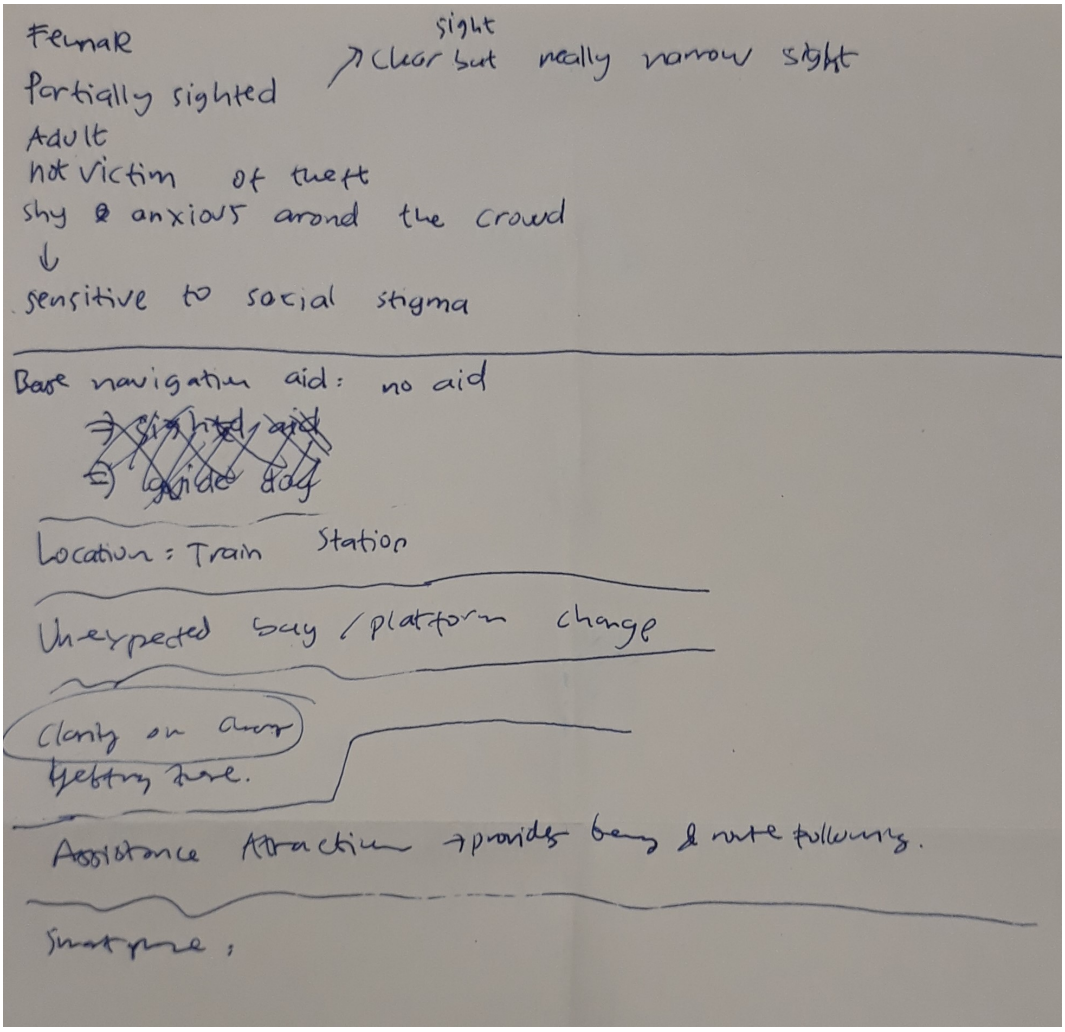


Figure 14.8: *Handwritten notes made by P6 during trial 2 (P4-P7)*

14.2.2 Trial 2

In the second trial (P4-P7), players generated a scenario of a female partially sighted (tunnel vision) adult, with social stigma concerns. This time, the user is in a train station, travelling without any other navigation aid (i.e. no cane or guide dog), and while waiting at the platform for her train, a platform change is announced unexpectedly over the tannoy. She now has to find her way to another platform before the train leaves (fig. 14.8).

Players decided that they wanted to provide this user with clarity on the change, and help her to get to the new platform. They decided that, based on the complexity of the situation, human assistance attraction was the best

navigation function to choose here. Players specifically noted that, to get the B/VI person to the new platform, the sighted guide would need to provide the user with bearings to the new platform and help them to follow a route to get there (fig. 14.9).

The players then used the technology cards to create their navigation aid idea. Their idea was a smart phone app that would allow B/VI people to call for help from station staff. Staff would be alerted of the location of the B/VI person either by satellite navigation, or by a photo taken of the environment where the VI person was standing via the smart-phone camera. A phone conversation could also be had between the station staff and the B/VI user, with bone-conduction headphones being the audio-relay medium. Bone conduction headphones were chosen because of the socially-conscious nature of the selected persona. To protect the B/VI user against malicious intentions, the designated station staff member will need to present a smart card that will communicate the players smart phone via short-range communication technologies, (such as NFC or RFID) to validate that they are official station staff and thus safe to go with. A motor in the smart-phone will vibrate and a sound will play through the headphones to allow the user to know that the card has been validated. The staff member will then guide the user to the new platform, holding up the train if necessary through the stations internal communication/announcement system to get the user onto their train on time.

This idea seems like a sophisticated, appropriate, and viable solution to the challenge scenario. Players used the cards to successfully produce a design idea that was suitable for the chosen scenario, without prior experience in the B/VI navigation domain. This idea was produced on the first attempt using the cards by this focus group.

After generating the idea, players conducted an in-depth evaluation of the

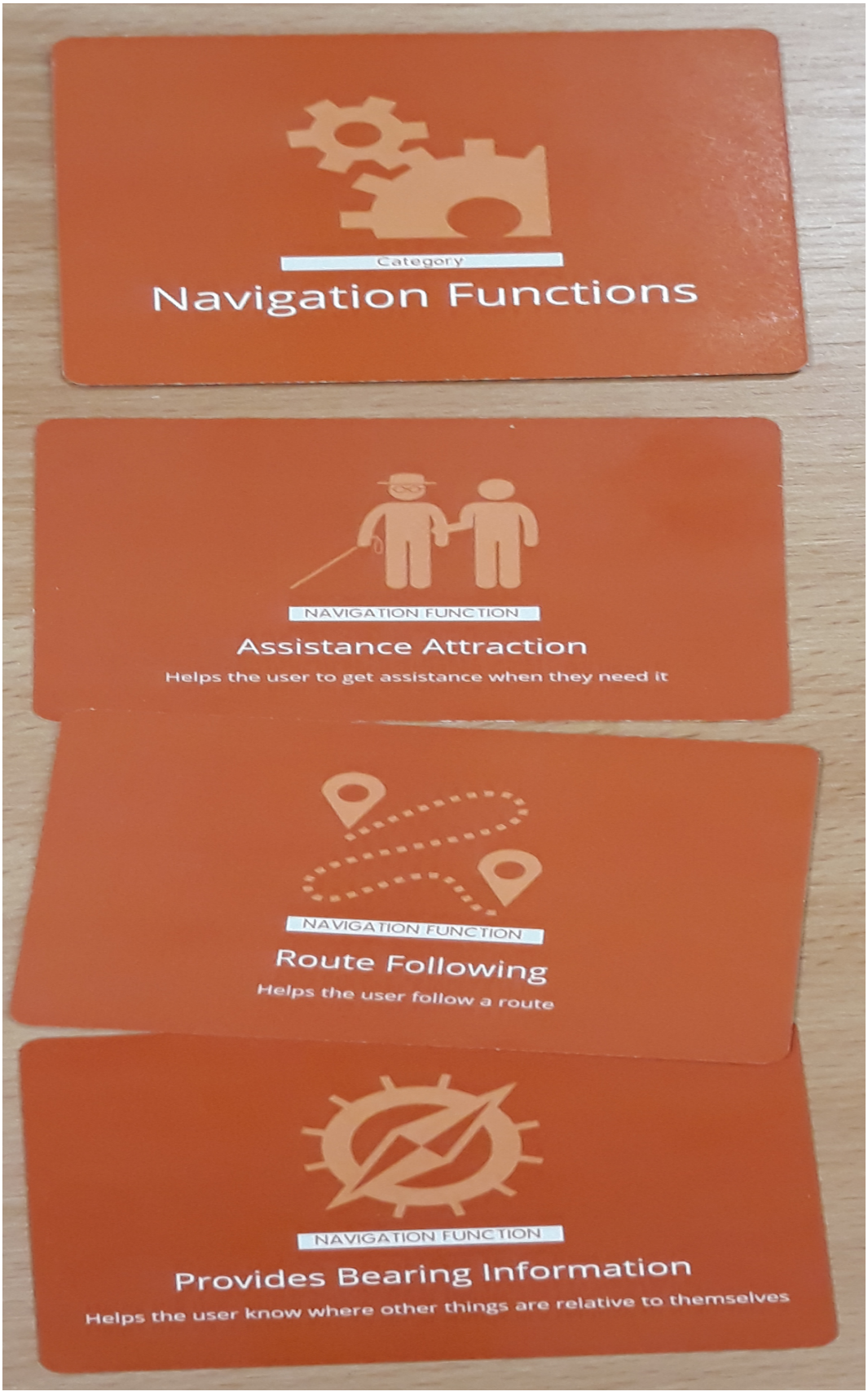


Figure 14.9: *Navigation functions chosen during trial 2 (P4-P7)*



Figure 14.10: *Tech cards used during trial 2 (P4-P7)*

aid, highlighting necessary factors that should be ensured later on in the design (fig. 14.11). Players placed a lot of effort on the consistency of the use of the app, and ensuring that it was easy to learn and simple enough to be used in a rush with very little training. Players expressed the need for data privacy (especially if photographs were to be sent to identify the user's location indoors), and also stressed the needs for established infrastructure with the station staff and for legal coverage in case the user missed their train while receiving help or was harmed in some way when using the service.

P7 felt that this aid idea would also be useful in their life as a non-VI person:

> P7: I think the train station is a very complex environment. Sometimes I can't even find my own way there. So I'm just imagining if I'm the person with kind of access I need to get. And also I think if this system is working, I think it's not only can benefit the half-sighted [*sic*] people, it can also benefit people like me that are not familiar with the environment.

Producing ideas that are potentially useful to both B/VI and sighted users won't always happen, when using the cards, but, given what W1 from Wayfindr



Figure 14.11: *Evaluation cards used during trial 2 (P4-P7)*

was saying about the increased chance of adoption if an aid is useful to both the B/VI and sighted communities, it is interesting to see that this kind of ideas are possible from a session with the cards.

14.2.3 Trial 3

In the trial with the Guide Dogs executives (P9-11), participants decided to design for a teenage female cane user, who was trying to find a lecture theatre at her university.

The Guide Dogs group followed a similar procedure to the others, but became very waylaid at the technology stage, stating that the technology stage was “limiting their thinking”:

> P11: This is limiting. For us in this situation, these [tech cards] are limiting us.

The Guide Dogs participants opted instead to take a more “results-oriented” approach. They tried to see what would happen if, instead of using the tech cards to create an aid idea and then evaluating it, they reversed the process and picked out a few ‘key’ qualities from the evaluation deck to aim for and then used the tech cards to meet those chosen ‘targets’. They found that they weren’t able to prioritise some evaluation cards over others, as all evaluation cards were potentially relevant to their scenario:

> P11: Okay, so now [we’ve] not ruled out hardly any cards, no cards, they’re all important.

When asked for their opinion on the evaluation cards, participants from the other trials noted that, although some evaluation cards may be irrelevant for

a particular design, no point included in the evaluation cards would always be irrelevant.

> P3: I think obviously within the context of your specific use case, a lot of them are irrelevant, but I didn't notice any that I thought would always be irrelevant.

> P2: Yes, I agree. I think they will always come in useful in some way.

It is, therefore, the actual design idea that gives importance to specific evaluation cards; the evaluation cards cannot be used to set design targets.

The guide dogs participants ultimately failed to produce an idea in the session. It is interesting, therefore, to consider why the Guide Dogs participants found the ideation step so difficult.

It is important to note that it is not only the design idea that can affect the importance placed on some of the evaluation points. The backgrounds and interests of the members of the design team can also affect this.

P1 mentioned that the commercial qualities were less of a concern for her, as someone who would be primarily focused on satisfying user needs:

> P1: […] there was something about cost: "well-priced". For us [as designers], we don't really care about that […] we don't care if it can even be achieved; it's just what we want.

> P1: I think my point was that in an organisation, these would be done by different people perhaps. That [evaluation stage] particularly. Things like JLR (Jaguar Landrover), you would have these [tech cards] as the HMI (Human-Machine Interface) team,

> maybe, and then it would go off to someone who would say, ”no sorry, we can’t fit it in because of the airbags”. Or ”it’s too expensive”. But that wouldn’t’ be done by the HMI team. I think it’s still useful to have those in, ‘cause you [can then] have that sense of that.

P2 echoed this feeling:

> P2: They [designers] don’t have to worry about that. They just need to be as creative as they can.

On the other hand, the managerial team felt more comfortable using the evaluation cards, and as mentioned sought to use them instead of using the tech cards. The randomness and chaos involved in picking technologies appeared to be uncomfortable for them, yet that randomness and chaos is an inherent part of ideation, because ideation is not a deductive process:

> P9: For example, push buttons. When are we gonna go, “do you know what we really want this to do? We want this to have push buttons’’. Why would we go push buttons over touchscreen? Why would we say, “actually we want this put out to have a push button, not a touchscreen’’?

The managerial team also expressed the desire to have tech people in the room to help them to overcome the tech phase, and asked whether there was a prescribed skill composition for the teams who would use the cards:

> P10: What kind of team has to, what roles…

> P11: Do you need a tech, do you need an engineer, do you need …

> P10: Cause I was sitting here, when we were doing that [tech phase], and I was thinking ”I could really do with a developer sat here to tell me what that means or what could be the limitations of this, or explain that”.

> P10: And that might add value to into the conversation, and in the ideation session ultimately.

From these discussions, I propose that the ideal team composition should embody different skillsets and these skillsets should be tailored to each part of the game. The skillsets that I recommend as being appropriate to each stage are shown in table 14.1.

Stage of Gameplay	Skills Required
Scenario Building	Experience in understanding and empathising with user needs
Ideation	Engineering and technological skills
Evaluation	Managerial and business skills + Experience in understanding and empathising with user needs

Table 14.1: Recommended skills for each stage of the game

Participants in trial 1 and trial 2 were comprised entirely of human factors professionals, whose profession requires them to have both experience in human needs as well as engineering and technological skills. By coincidence rather than by design, there were members in each group, such as P3 from trial 1 and P4 from trial 2, who were also either in more senior positions or had been in former job roles which were highly business-oriented. This gave both teams the necessary third component of business skills and the teams functioned really well at all stages of the game and produced some good ideas. The managerial group, however, had a wealth of managerial and business skills, and also a rich understanding of the needs of the VI population, but their tech skills as a group were, self-admittedly, less developed, thus leading to the difficulties in using the tech cards above and

different approach to the game. After re-explaining the intended way of using the cards, P11 from the managerial group mentioned that the reason they would have preferred to start with the challenge cards, or skip the tech phase and jump to the evaluation cards and work backwards was because of their background:

> P11: If it was techy guys, they might prefer it this way. Then we would validate it with, "well, it's not easy to use…what would you do then?" So they [tech team] might do it that way. It's just because of our [background].

Regardless of whether players felt that their strengths leaned towards tech or evaluation, all groups could see the value of the evaluation cards:

> P2: I like these ones.

—

> P7: The evaluating card is the best thing because it helps you to consider so many things that otherwise you might forget. Because obviously there is so many things that you consider and that's really good I think.

—

> P9: I can genuinely see that this is a very useful reminder of the critical points from the service users perspective. And I think this as a deck could be used with service development as well as product development very well, for reminding of the really important bits. Totally see its value.

14.3 Summary

In this chapter, I have discussed the key observations that I made during the three trials, which I will summarise below.

I observed that, in general, players were able to use the cards successfully to generate appropriate navigation aid ideas for their chosen scenarios, even without prior experience in the B/VI navigation domain.

When using the evaluation cards, I observed that, aside from evaluating their own ideas, players were able to apply the evaluation component of the cards to pre-existing third-party navigation aids. This is a novel application of the ideation card method, and also offers value to organisations such as Guide Dogs who may wish to have a quick method of evaluating navigation aids for common issues as part of their processes for making navigation aid recommendations to their service users.

I observed that, if players tried to focus on too many challenges or navigation functions at once, they would become overwhelmed and the game play would stall. When asked why, players cited a lack of clarity regarding their design goals. Therefore, to maintain clarity, I recommend that players focus on as few challenges and navigation as possible at any one time. As a heuristic, I recommend just focusing on one of each.

I also observed group composition to be important. In trial 3, which was composed entirely of participants in management roles, the tech stage proved to be uncomfortable and 'limiting'. In the trials with human factors professionals, the tech stage went fine, as did the evaluation stage, but some of the more business-oriented evaluation points were deemed of lesser concern. I draw from these observations that the skillsets that the group embodies can influence how the content of each stage of the game is perceived, and if the necessary skill sets are absent, group composition can with the cor-

rect functioning of a session. Based on my observations in the trials, I have made some recommendations of the skillsets that teams should collectively embody for each stage of the game (table 14.1).

One potential critique of the methodology taken in this stage of the research is whether, knowing that I was the creator of the cards, participants may be more likely to speak positively of the cards so as to not upset me, and thus the results of this study suffer from participant bias. As the feedback provided was well mixed between positive and negative feedback, and the feedback provided was relatively consistent across the trials (except for trial 3 which was, in fact, more critical), I do not believe that participant bias significantly affected the results. Nonetheless, from a methodological standpoint, perhaps a better approach may have been to ask someone else to conduct the study, or to otherwise hide who the card creator was.

In the next chapter, I will discuss the outcomes of the semi-structured focus groups that followed the final play-through of each trial.

Chapter 15

Card Feedback

15.1 Introduction

In this chapter, I will discuss the positive and negative impressions that participants had of the game as a whole.

Following the themes of the thematic analysis, shown in section 13.1.5, I will break the discussion into four parts. The first part will discuss positive impressions that participants had of the cards. The second will discuss the negative impressions, and discuss methods for how the game can be improved. The third section will provide a discussion of how the cards and gameplay may be made accessible to VI players, which is a novel contribution to the field of ideation card research. Finally, I will summarise the chapter and present the key findings.

To increase the richness of the discussion, the impressions of the VI participant (P8) and the other non-VI participants will be interwoven into the same discussion rather than discussed separately.

15.2 Positive Impressions

15.2.1 Game Structure and Contents

Card Categories are Comprehensive

At the outset, let us recall the main purpose of creating the ideation game. The cards aimed to serve as a design tool that condenses the academic research on B/VI navigation aid design into a form that can be used in creative design sessions to generate innovative navigation aid ideas. The cards aim to do this not only by supporting designers in considering their aids from a functional perspective, but they also aim to support designers in considering their aids from a non-functional perspective as well. The cards, therefore, aim to provide a holistic method for generating navigation aid ideas that is usable in a creative setting.

It is significant, therefore, that players generally felt that the card categories presented a comprehensive coverage of the stages someone would need to go through when designing a VI navigation aid.

> P2: I think the categories were comprehensive. You captured everything you need to design

> P3: I can't think of anything missing. Certainly, if it is missing, it's missing so much that we haven't thought of it at all during this session.

> P4: I liked it and it didn't feel like there was anything really obvious that was missing.

P4 mentioned that the card categories presented an array of perspectives that they may have forgotten to consider during design without the cards:

> P4: I like the cards because they contain things that I would've thought about; but, as well, they put things in terms or categories which I may have otherwise forgot.

This general sentiment that the card categories are comprehensive is very positive, because it means that the cards present players with the opportunity to consider all necessary angles for design.

At the same time as providing a comprehensive coverage, however, the categories avoided overwhelming players. P2, for example, believes that the card categories provide a satisfactory range of perspectives from which to consider the design, but at the same time keep the game usable:

> P2: I think the categories are enough, if you add any more categories people will start getting lost.

P2 also felt that the cards were "very focused" and felt as though they were being guided through a process as they went from deck to deck.

> P2: I felt it was very focused on navigation, I didn't feel I was going all over the place with it.

Card Categories Provide a Guiding Framework

Players generally felt as though the various categories were providing a logical and step-by-step way of "guiding them through the process" (P2) of generating a navigation aid idea. P3 said that the gameplay provided them with a framework for decision making:

> P3: It's certainly thought provoking, and it gives you a framework on which to base your decision making process.

P2 liked the guidance that the framework provided and felt that they wouldn't have been able to approach the task in such a structured way without the cards:

> P2: Yeah, I felt that they were very good at guiding you, actually, through the process; you wouldn't be able to come up with this yourself.

At the outset of any design process, it is very easy to become overwhelmed by the possibilities. This framework helps players to focus on one part of the problem at a time. Instead of focusing on the whole task of producing a navigation aid idea and wondering where to start, players need only focus all their attention on just the next step ahead of them:

> P4: I liked the staged approach so that it helped focus your attention on one bit at a time of the problem.

Moreover, the purpose of each stage was easy to understand, and players felt that the order of stages was logical:

> Researcher: Was the purpose of each card category clear? So each colour.
>
> P4: Yes, I think so.
>
> P7: Yes, I think so.

P6: Yeah.

—

Researcher: Okay. So, speaking of the overall structure then. Did the overall game play structure make sense and did you understand the purpose of the different steps in the game plan?

P3: Yes.

P1: Yeah, definitely.

P2: Yes

—

Researcher: And what do you think about these different stages of the game?

P8: That's really logical

—

Because of its clarity and logical structure, players felt that the framework was easy to follow:

Researcher: Did you get lost at any point?

P3: Not particularly.

P2: Um, no.

> P3: I think I tried to skip stages a couple of times. I was like, oh let's get in there (laughter) but wouldn't say that was because I was lost, it was because I was running when I should have been walking!
>
> P1: Yeah, I think it was really clear what each step is supposed to do.

—

After just one guided attempt of running through the game, all groups were confident conducting sessions on their own. This shows that, similar to Kultima et al's (2008) VNA game, players found the gameplay easy to learn:

> P1: Yeah, it wouldn't take long to really learn it as well. The second time around we knew what we were doing, didn't we?
>
> P2: Yeah.

P8 also shared this view:

> P8: But from a visual impaired perspective, it's a very simple system to understand

My game shares the stage-by-stage structure of VNA, and each stage of that process is clear. Perhaps, then, this shared quality of a clear and easy-to-follow structure is what makes ideation card games easy to learn.

Although the game was structured in a step-by-step manner, players didn't feel that they were cut off from previous stages of the game after they progressed. Players felt that they could draw on the decisions and discussions

they had in the previous stages if they needed to, and use that information to inform the decisions they were making at their present stage.

> P4: And it was okay to refer back to other things. You didn't have to change your mind, but just remember different parts that you discussed already.

Category Content Deemed Comprehensive

At each stage of the game, players are presented with decks of cards that contain concepts that players can draw on for inspiration for that particular stage.

The content covered by each of the categories was generally deemed comprehensive. P7 particularly liked the evaluation cards in this regard, and noted that they helped her to consider issues that she may otherwise forget:

> P7: Yeah, the evaluating card is the best thing because it helps you to consider so many things that otherwise you might forget. Because obviously there is so many things that you consider and that's really good I think.

P6 found value in the repository of technology cards:

> P6: It helps us build a mental image of all the processes and technologies you know. It sort of keeps everything in mind.

This is the intended purpose of what Wolfel and Merritt (2013) would refer to as repository decks. Repository decks should collate together related concepts that players can refer to and use as prompts and reminders without

getting overwhelmed. The fact that players didn't feel overwhelmed shows that the academic research has been condensed successfully into an accessible form that is usable by non-domain experts.

P8, the VI participant, also felt that the content of the decks were comprehensive:

> P8: I get the sense that there's a very comprehensive list of options for each possible scenario. What else you could add, I can't imagine.

> P8: It's really comprehensive, it's a great idea.

It is important that P8 felt that the content of the game was comprehensive, as it indicates that the game has not been obviously neglectful in capturing factors that VI people feel are important to consider.

Although the deck contents were deemed to be comprehensive, some players did use the blank cards to capture ideas that fell outside the provided set of concepts. While players could have taken this as a limitation of the cards, they didn't take this view. Instead, they were pleased with the option to add things themselves. P2, for example, found the addition of blank cards reassuring as they felt that their creativity wouldn't be unnecessarily stifled by their restriction to only using the cards in the game.

> P2: I like the blank card that we added […] it feels like you couldn't miss anything, 'cause the categories are well defined but then you just add a few cards if you need to.

Although players could think of more information that could be added to some decks, they felt that adding any more default content would have over-

complicated the game. P3, for example, was satisfied with the depth of the game as it is:

> P3: We added a couple of things, so yes, we did notice gaps, but I can see why you didn't put every single thing in there. The deck would be this big! So I didn't think, "oh this isn't good enough" or anything like that.

The ability for the game to provide useful repositories of concepts at each stage of the framework yet manage to avoid overwhelming players with too much content positions the game at a "sweet spot" between being too simple and being overly complex. Striking this balance of capturing useful content yet still making that content usable in a creative setting is very important for a successful set of ideation cards, so it is good to see that the cards succeeded in this way.

Category Contents Deemed Valid

Another significant point is that the contents of some decks were also directly mentioned as valid and generalisable to the wider VI population. P8, for example, indicated that he had also experienced some of the situations referred to in the game.

> Researcher: This [challenge card] is where there's problems where you might hit your head at height and that kind of stuff.
>
> P8: *Oh* yes. […] Them bike racks at university. I've face-planted one of those a couple of times.

P8 also expressed his experience with some of the points in the evaluation cards:

> Researcher: So another one of the holistic qualities is “Leaving a hand free.” […]
>
> P8: This is really true *laughs*

Because P8 was not part of the initial sets of interviewees, the fact that he could identify with the concepts in the deck is significant, because it means that the challenges captured in the deck are, to some extent, generalisable to the VI population at large.

Furthermore, P9 and P10, two of the Guide Dogs executives, also made similar statements about the validity of the challenges in cards. Consider these comments made about the “layout changes” universal challenge card:

> P9: I know I should stop doing this but I can’t help but think every time it represents someone who I’ve known come through, I think, yeah that’s a really valid one. Because we did a load of work with a teenager in uni who, when they did some building work, suddenly the whole layout of the university changed and even though she’d been there like a couple of years, suddenly she had to learn new routes for everything.

P8 has direct experience being VI himself, and the Guide Dogs executives deal with the needs of many B/VI people on a daily basis as part of their roles. The fact that both P8 and the Guide Dogs executives directly attested to the validity of some of the challenges and evaluation points, and didn’t rule out any of them as invalid, provides support for the notion that the content of the decks validly represents the experiences of B/VI navigators beyond just my sample of interview participants.

When combined with the general perception of the participants that the categories are comprehensive, the deck contents are comprehensive, and the

game provides a useful guiding framework for focusing design efforts, this extra notion of validity begins to build a strong case for establishing the cards as a useful VI navigation aid design tool.

15.2.2 Clarity of Communication

In terms of the clarity of communication of the cards, players generally felt that the individual cards were easy to understand, and the text on the cards was generally deemed as sufficient to convey meaning. P2, for example, didn't feel that any more details were necessary on the cards:

> P2: I think the amount of text is good enough, you don't want to add any more details.

In the instances where the card text title wasn't entirely clear on the first glance, players felt that the subtitle text was helpful in providing clarification

> P4: I think the smaller text helped explain them actually. So there were some we misunderstood at first but the small text helped us.

Players also felt that the cards presented the information in an aesthetically pleasing way:

> P6: Well, it [the design] is lovely. […] It's really cute

—

> P4: I like the graphics.

—

P9: I think the images are nice.

P3 felt that, in the instance that players did want more information on a particular concept or technology, then the cards provided them with enough information to search for more information by themselves.

P3: I mean there was enough information on the card to point me in the right direction to understanding it even if I didn't completely understand it.

Researcher: You could get the gist of it?

P3: I could get the gist and I knew, I'd know what words to put into Google in order to get the rest of the information.

Players in the first focus group did make good use of the QR codes to explore the tech cards, and they were well-received:

P3: I think that's perfectly good.

P1: Yeah, I think that's definitely a good addition.

P2 felt that the QR codes gave direct access to appropriate explanatory resources, and was more efficient than conducting a web search

P2: But that QR code is important for us to have access straight away and know exactly that product that you're mentioning, not just us Googling around.

Moreover, P3 thought that using the resource videos pointed to by the QR codes didn't interrupt the gameplay, because players could just skip to the parts of the video resources that they were interested in:

> P3: I didn't need to watch the whole of the video but I'm capable of pressing pause, and stop, and things, so yeah.

P3 also felt that the resources were generally good at explaining the concepts on their respective cards.

> P3: Also the videos as well were helpful for some of the cards, you know, you just hear of a technology and you think "oh that could be useful", but when you watch it then you're like, "okay that's good", or "no that's actually not relevant". That's what we did with the braille reader: we thought it was useful, but we watched it and then it wasn't.

P1 and P2 thought that the game took the correct approach by only using the QR codes sparingly to explain the unusual concepts, rather than placing them on every tech card.

> P2: I think really, the QR codes, they were positioned on certain technologies that we needed to know more about, so I feel like you don't need a QR code for each one of these [technology cards].

> P1: No, definitely not.

> P2: It's only for these technologies that we really needed to know actually how they work.

Finally, and most importantly, players generally felt that the game was useful for tackling real-world problems:

> P2: I think the categories were comprehensive, you captured everything you need to design, the card within it was sufficient to deal with real world problems.

15.3 Negative Impressions

Although the feedback on the cards was generally positive, some valuable criticisms of the cards also came out of the trials.

15.3.1 Limited nature of solutions

Cards only produce solutions for one context

The criticism that the cards promote isolated thinking about a problem is perhaps the most significant. When players play the game, their first step is to create a scenario. This scenario generation phase was designed to create a really clear and defined scenario for players to work on. I felt that, given the breadth of the design domain, it would be very difficult for players, especially inexperienced ones, to just attempt designing without guidance. They would need some focus, a goal to aim for, and the clearer the better.

However, this lead to the criticism that the cards cause people to design for highly specific scenarios:

> P9: What we're likely to create out of this is something that literally solves the layout issues at university. Rather than going, well if she got layout issues at university then she could well have that at the local shopping centre. She could have it when she goes

> to the cinema. She could have it when she does this and, therefore, rather than coming up with a solution for one very limited problem, we would want to answer that area.

> P10: It's very much task focused and it's solving a handful of tasks within that challenge. Whereas you'd want to do that challenge. You'd want to find a solution for that challenge holistically. You'd really want to explore it.

P9 and P10 here are expressing their desire for the opportunity to consider how their solution to a particular challenge would be applicable across different contexts and locations, rather than accepting the one they created in the scenario generation stage. P9 feels that, if this is not done, the cards encourage the creation of highly specific aids for each possible challenge, rather than the creation of more generalisable and universal tools:

> P9: Putting yourself in the shoes of the customer, would you want a different tool for navigating Uni, as for as doing the shopping centre as for – do you want to have a backpack of different types of cane or things for every different person? Realistically, you're a human being and you want a solution in one area to work semi-universally.

Behind this contention lies the assumption that an idea that is generated using the cards is final and won't be developed further by reconsidering its applicability to contexts other than the one it originated from. I draw this from P9's earlier statement:

> P9: What we're likely to create out of this is something that literally solves the layout issues at university.

P9 is implying that the cards are restricting her to design for one location or context and that the resulting design idea will not consider other contexts. This assumption is true in one sense, as players do indeed define a specific context to design for when playing the game for the first time. This restriction was primarily placed as a practical measure to ensure that players can actually succeed in coming up with ideas, and is based on the experience from the first focus group where designing for a wide general context was found to be counterproductive and stifling to creativity (section 14.2.1). However, this practical restriction does not mean that the idea should not be reconsidered in a variety of contexts *after* it has been generated. P9's statement, therefore, points out the need to clearly incorporate this scenario-variation mechanic into the game, and make it explicit in the game instructions that players should use the cards to create a variety of scenarios and see how their idea can be adapted to be applicable to those new scenarios.

There is a subtlety to when this approach would be necessary, however, which I would like to point out. Recall that each of the challenge cards is labelled as either a universal challenge or as a specific challenge. Universal challenges are challenges that apply to pretty much any location, whereas specific challenges only apply to specific locations. I would argue that, when addressing a universal challenge, it is wise to consider your aid idea in as many different contexts as possible. Layout issues was a universal challenge, so this point raised by P9 is well placed. However, when addressing a specific challenge, this desire to abstract and generalise the solution is likely to be less necessary, and perhaps even counterproductive, as the challenge itself likely only occurs in a specific context, or set of contexts.

So the important lesson here is that the cards should not completely restrict players to designing for one context. They should only restrict players to one context on the first play through, to make it easier to actually generate an idea. After the idea has been generated, however, players should then

be advised to expand the idea by using the cards to create new scenarios. Players should explore how their aid would work in those scenarios and what modifications may be necessary given the new context. All the while, teams should bear in mind that, in doing this, they may be at a risk of over-generalising their solution, because the challenge they are are solving may only actually occur in a specific set of contexts.

While the above discussion was about the issues related to designing for one location, another major criticism of the cards is that they cause players to only design for one challenge.

> P10: That's a really important thing I think. Because, I'm thinking of the application here, because I can't stop doing that, when we get customer insight back, we'll get loads of themes that are coming through about pain points, tackling one of them seems a little bit odd, I guess?

To overcome this issue, players can take a similar approach to the one above by keeping the scenario the same, but incrementally adding challenges and modifying the idea as they go. This approach may be best suited to situations where designers want to target a particular location type—shopping centres, say—in a deep way.

Cards don't solve hard problems

Another major contention against the cards was that the cards don't solve hard problems. In the trial with the Guide Dogs executives (trial 3), the participants that they wanted to create a map-guidance system to guide B/VI users around university campuses. The system was supposed to work both indoors and outdoors.

Participants succeeded in generating an idea of what they wanted to make, but encountered difficulties when trying to deal with the technical issues of creating an indoor positioning system, such as a lack of availability of indoor maps. The participants got a bit frustrated, so I told them that they had picked a hard problem to solve, because, from my experience in the first focus group who tackled a similar problem, and from the insights gleaned from the interview with Wayfindr, indoor navigation for VI people is presently not a problem that has been solved completely.

> P11: It's fixing hard solutions that get products on the market, isn't it? […] You can't just pick an easy problem because this is hard to solve. This *is* the problem.

I can understand the frustration behind this point. Solving indoor navigation for B/VI people would have an immensely positive impact on the lives of many people. That said, I think this issue arises from a misunderstanding that the cards generate solutions to problems. It is important to remember that the cards are ideation cards, not solution cards. The cards only hope to help players to generate ideas and to guide their thinking along the right lines. Those players will also necessarily be limited by their time, the technology available to them, their social context, and also by their own inherent creativity as individuals or as a group. This may mean that some problems turn out to be unsolvable by the present group at the present time.

This is not a problem for the cards though, as their purpose is not to generate solutions. The purpose of the cards is to help facilitate the exploration of these challenges by players, and facilitate the generation of ideas, some of which may be solutions. Although the cards provide a framework for guiding the thinking of the players, we must not make the mistake of assuming that the cards provide a deterministic mechanical system that, if used correctly, is guaranteed to crank out viable solutions. Because of the inherently non-

mechanistic nature of creativity, such a thing does not, and perhaps cannot, exist.

P3 and P8, for example took the perspective that the cards would give them some general ideas, but could not provide final solutions, and were satisfied with their sessions.

> P3: If this was a real design process, it would take days rather than half an hour or what we've had on each one. And we would be drilling down to specific technologies, even bits of code that we would have to incorporate in the app in order to get it to perform the function that we wanted. So, we didn't get that far, so I think we got some ideas…

—

> P8: Nothing can come to a final conclusion but it gives enough hints as to what is necessary to be included in a final design.

Interpreting the cards as an ideal starting point for the design process and as a support to one's inherent ideation capacity, rather than as a source of solutions in and of themselves, is, therefore, likely to be a more appropriate perspective and more likely to help players avoid disappointment.

15.3.2 Critiques of The Tech Cards

Let's draw our attention to the tech cards. The major critique for the tech cards was that there was no clear reason why one would pick a certain piece of technology over another. For P9, this left the tech cards section of the game feeling like a bit of an arbitrary exercise.

For example, in some instances, P9 argued that the cards didn't make it clear whether or not a piece of technology was relevant to the design task:

> P9: But what is it that would make me say "it's got to be a microphone?!" Because, so far, we've used like logic and reasoning with threading a story. Now we're just kind of picking at random. "We'll address it with a microphone or we'll address it with a touch screen". It doesn't, it doesn't feel like I'm following a path anymore.

In other instances, P9 argued that players weren't provided with clear reasons for choosing between similar alternatives.

> P9: For example, push buttons. When are we gonna go, "do you know what we really want this to do? We want this to have push buttons" Why would we go push buttons over touchscreen? Why would we say, "actually we want this to have a push button, not a touchscreen"?

Due to the non-deductive nature of creativity, there likely cannot be the logical and reasoned flow that P9 is looking for in at this more creative part of the game. That said, P9's points are asking us to consider questions such as "how do players know when ideating whether a piece of technology is relevant to their design?", "What does make one piece of technology more applicable to a challenge than another?" and "Is the game suggesting that players combine technologies together randomly, or is there an underlying method to follow?"

Although a certain level of randomness will necessarily be involved, a more complete answer to these questions would include a consideration of the

technical experience of the group, and also a consideration of the design context.

As mentioned before, each of the players in trial 3 was in a managerial role in the Guide Dogs organisation and each of them had very rich managerial skill sets and knowledge of the needs of the VI community. Self-admittedly, however, they didn't have much design or technical experience. P10, for example, expressed that she would have liked to have someone with such a skill set next to her in the session to support them at the tech phase:

> P10: I was sitting here, when we were doing that [tech phase], and I was thinking "I could really do with a developer sat here to tell me what that means or what could be the limitations of this, or explain that"

This need for different group compositions has already been discussed in chapter 14. The point I want to expand on here is the point about the role of contextual information in the game.

I mentioned in chapter 14 that P9-11 struggled with the technology phase, and discussed how their background as managers affected their experience of the tech stage. Their background wasn't the only factor that made the tech stage more problematic, and P9-11 raised some other important issues.

P9 pointed out that the scenario development stage at the start of the game doesn't provide a sufficient level of contextual information to allow players to choose between alternative technologies:

> P9: […] Whereas to have chosen microphone here. Why? Why? Because she wants to find a room, and she's a girl, and she's teenager, and at university? None of those things tell you it needs to be microphone.

As mentioned in chapter 14, P9-11 then P9-P11 began to attempt to use the evaluation cards to provide design 'targets', but found that the evaluation cards were contextually neutral. The evaluation cards themselves need the context provided by a specific design idea to be useful.

By process of elimination, this leaves only the scenario stage as being capable of providing the required contextual information. But, as mentioned, P9 claims that the scenario stage doesn't provide enough context to choose appropriate technologies or to distinguish between them. What can be done?

P10 and P11 appear to have offered a solution to this issue by pointing out that the personas cards, in particular, were very coarse and don't contain many personal qualities that could be used to provide context. They made their point by comparing them to sets of in-house personas available at Guide Dogs:

> P11: I guess this one [user cards] we would have from our personas that we've developed; there'll be more within here [then], wouldn't there? […] although gender and the specific concerns [are relevant], there is more than three [specific concerns] that we will be addressing, one hundred percent.

—

> P10: If I'm being completely honest, I would probably replace that whole section with our personas, if we were using it, because we would be properly representing our users. […] And what that would do is give us a more holistic view of that consumer group when you get to here [the technology cards], especially because you're saying things like, "oh, sliders and knobs". [Having a richer persona would allow us to say] "Well we've got [persona name]

> who's got chronic arthritis, so actually she's probably not gonna use a slider".

P10 provided an overview of the contents of the Guide Dog's in-house personas that are being referred to:

> P10: For the sake of the recording, I'm just reading out from the presentation from my laptop and we've got the personas that are sectioned up so they have their goals, their frustrations and who they are. So they've got a name that represents that consumer group; a mantra or a quote that basically sums up their life and character; words and descriptors; things like "extrovert, friendly, leader" ; motivations. Things like social network, and getting out and about; visually impaired specific activities; We've got mainstream activities; achievements; and then a bit of demographical data; and then a bio. So it's almost like a day in the life of one of them and then a bit about their coping strategies. Are they task focused, emotionally focused, or friend focused and then whether are registered as vision impaired or not.

> P10: You see what I mean? It gives a massive profile, way more qualitative information so that when you get to this stage [tech cards], you really start considering. It's almost like tapping into this card deck here and it makes it relevant to your consumer groups, which is the whole point about personas.

These personas contain a far richer set of qualitative information than the user cards that are presently in the game. I completely agree that allowing players to select from richly-detailed personas, such as the ones that P10 and P11 were referring to, would be a significant improvement to the game

and I believe that it would help overcome the issues with the tech phase pointed out by P9. Unfortunately, however, I was not given permission to publish the personas as part of this thesis.

The only work that I am personally aware of inside the academic literature regarding developing B/VI personas is that by Williams et al. (2013). Williams et al. (2013) interviewed 30 VI participants and produced a set of three "preliminary" personas that represent their participant data. I'd argue that a larger set than three personas is necessary to cover the diversity of the entirety of the B/VI population, and would encourage either (a) Guide Dogs to make their personas available to the academic community, which would be the preferable option, or (b) the academic community to collaborate in building on the work by Williams et al. to provide a more comprehensive set of personas.

15.3.3 Further Critiques of the User Cards

The user cards themselves were a focus of critique beyond their utility for the tech cards. These critiques provided a lot of insight into why the user cards are presently unsatisfactory, and also provide insight into how the richer personas that I recommend should be presented to players of the cards. I will begin with a more general critique of the persona cards, and then transition into how the future personas should be represented.

Why use personas at all?

P9 questioned the value of using personas at all, noting that using personas is an inherently inferior method to directly involving real B/VI people in the design process:

> P9: I don't know what the benefit of creating fictional characters are when we have thousands upon thousands of real genuine people with real genuine needs that we could ask.

I would agree with this point in one sense. The persona cards are built from my efforts to convert my personal experience with B/VI interviewees into cards. There is, therefore, four layers of abstraction between the users of the persona cards and the real human beings they were built from. The first layer is between the real human being and the concept that I got in my mind when talking to them. The second layer is between the concept in my mind and the content that was actually embodied in the cards. The third layer is between the content embodied in the cards and the understanding that gets transmitted to the mind of the players. Because of these three layers of abstraction, even though the cards were themselves were built from real empirical data, players will be referring to a refracted form of my participants and this will thus impact their designs. Moreover, the parameters I used to create the persona cards were drawn from my impressions of the differences between a very limited sample size. Far more data would be needed to provide rich personas that are representative of complete classes of VI people.

I would disagree, however, that B/VI people are an easily accessible population for recruitment by anyone. Guide Dogs has access to thousands of such B/VI individuals for research purposes, yet during my studies I still found recruitment to be a major challenge for my work. A recruitment timescale of approximately three months was typical for a study involving around five people. If this was my experience with Guide Dogs as the industrial partner for my research, what then of people without such a network?

The user cards were initially intended to provide a useful "middle way" between designing in a silo without any participant engagement at all, and ex-

pending a lot of effort and time trying to recruit participants.

This potential use case for the persona cards was picked up by P10:

> P10: I guess you could look at this as a tool that you could use if you didn't have access to people.

That said, if the personas that Guide Dogs has available were built into the cards, it could be argued that using those personas could actually be preferable to working alongside real people. The reason for this is that users of the cards will, due to pragmatic reasons, likely only involve a small sample of B/VI people in their design process small sample sizes. This is a known issue with navigation aid design field in general (Gori et al., 2016).

On the other hand, large organisation like Guide Dogs are able to draw on data from thousands of B/VI people to generate their personas:

> P9: So we use personas to walk through our journeys, but we use huge amounts of data and information to carve out those personas.

Therefore, it is likely that their personas may give a more representative picture than a small sample of real-world participants.

Providing a Homogeneous Understanding of Symptoms

As a further critique of the user cards, P5 and P6 mentioned during trial 2 that they had difficulties in getting a homogeneous understanding of precisely how their persona was viewing the world.

Although they went through the game and designed for a user who has tunnel vision, P5 and P6 mentioned that they found it quite difficult to conceptualise what it would be like to have tunnel vision themselves:

> P5: I think the difficulty is that none of us are actually visually impaired. And then when we said that it's tunnel vision. Tunnel vision - [there's] lots of them; it could be really tiny, it could be bigger tunnel, different sizes of tunnel. It's a bit difficult to actually just use that terminology of tunnel vision to see what the challenges [are] and then what technology actually helps. So I think that's the bit where the problem is that's really fundamental for the next process, the next stages.

> P6: I think for me though, one of the factors that are missing is [that] I didn't have enough information about what it's like to have that specific condition, or any condition of this sort.

As was shown in section 3.1 in part I, visually impaired people can suffer from many different types of eye conditions. One could list cateract, glaucoma, diabetic retinopathy, retinitis pigmentosa, and age-related macular degeneration under the term "partially sighted", yet these conditions each give rise to different symptoms in the patient's field of view; Cateract produces issues with opacity, glaucoma produces tunnelling, diabetic retinopathy produces patching, and so on (fig. 3.1). Moreover, each of these different types of symptoms are not homogeneous. It is quite possible for two cateract patients to experience different levels of opacity; two diabetic retinopathy patients could have different types of patches, etc.

Moreover, this issue would not necessarily be solved by providing better personas, as two people matching the same persona profile could easily have different eye conditions in reality. P4, P5 and P6 suggested various ways of

overcoming this challenge. P5, supported by P6, suggested providing props that players could use to understand VI symptoms. Consider glaucoma for example, which typically results in tunnel vision. P5 would suggest that a tool be provided that players could use to simulate the experience of having tunnel vision, such as a set of goggles.

> P5: So if we had some kind of props for example to help us […] So this is tunnel vision that we can have so that everyone got the same idea

> P6: Yeah, that's a really good idea.

During my research, I achieved certification for level 1 and 2 of the My Guide training course offered by Guide Dogs, that trains people to become sighted guides. During the training, we were asked to wear such props to get an understanding of the experience of VI people with different impairments, so I can attest to the effectiveness and existence of such props. The downsides of such an approach are related to practicality. This approach would require that a large set of props to be provided with the cards and this would make the game both less portable and more expensive.

P8 mentioned that such an approach may be well-suited to community consultants. P8 went on to explain that community consultants are professionals that consult members of communities for their views and ideas regarding upcoming community development projects:

> P8: I think it would be more something you would speak to community consultants. When I did my landscape post grad, there was a community consultation process that you work with the primary school. And came up with various ways to gather new information about designing a playground. And we had all sorts

> of things, posters that they could clamber over, games they could play to show where they like to do things in the playground, and all sorts of things like that. So I think it's more about how you engage with people who are experts in consultation process to incorporate these things into their tool kit.

It would seem viable for such professionals to carry such equipment, in a similar way to the training staff at Guide Dogs carried the equipment for the training session I attended. However, as part of a general distribution to regular design teams, the inclusion of an array of such props may be excessive.

P6 also mentioned the idea of using video to demonstrate what navigating with a particular visual impairment would be like:

> P6: Or video or something […]

Creating such videos would likely involve conducting some case study research. Creating videos for each type of visual impairment would like provide a rich visual description of what navigating with different visual impairments would be like. Using videos would also be far more portable than the prop approach. However, creating such videos would be relatively time intensive to research and create, but they could be of great value to the research community as a general resource.

Perhaps creating such resources is not necessary. Versant Health[1] have created a simulator of various types of visual impairments, that can be experienced using virtual reality. Essentially, by using a set of virtual reality goggles, rather than multiple props, players can experience what it would be like to have different visual impairments. This approach would be more portable than using the props, as only one set of VR goggles would be required; how-

[1] https://versanthealth.com/visionloss/

ever, gaining access to these goggles may be expensive for some users of the cards.

P4 suggested that using pictures may be useful way of demonstrating visual impairments:

> P4: We can get pictures that replicate how someone with their impairments would see certain situations.

For example, consider fig. 15.1 which compares vision with and without glaucoma:



Figure 15.1: *A pictorial representation of the symptoms of glaucoma. Source: https://www.vincett.com/glaucoma.html*

Using images such as these would be a simple and low cost approach, yet it would still provide a clear understanding of the type of symptoms that the user is experiencing.

These images could be added as a feature of the new stock personas mentioned previously. This would, however, bind the impairment type to the rest of the contextual information in the persona, preventing players from experimenting with how changing the eye condition would affect how the same user persona would use their aid design. If the entire user persona needs to change every time players want to consider a new eye condition, it will

be hard for players to get a sense of how changing *only* the eye condition would affect their design.

It may be interesting, therefore, to make the visual impairment choice a more free-form parameter, by creating another deck of cards that each clearly provides an image of what it is like to see with a particular visual impairment. The cards could perhaps provide other information too, such as prevalence data for the eye condition, or a representation of how the impairment progresses over time.

Players could pick the stock persona, and then choose a specific eye condition. This would, perhaps, again feel arbitrary to players who have no particular preference, but the flexibility here is likely to be important. Providing demographic information would perhaps help provide reasons for decision making for the truly indifferent.

A similar argument could be made for the base aids. Whether the persona is a cane user and a guide dog user, for example, will considerably affect the orientation and mobility skills used. Because of this, players may like the flexibility to consider how the user's choice of base navigation aid would affect how they would use the navigation aid under design. Perhaps, then, the base aids deck should be kept as a distinct deck as it currently is, and after choosing the stock persona and the eye condition, players would pick a base aid, but with one exception.

P7 pointed out that, if players choose to have the "sighted aid" as a base aid for their personas, then the game essentially falls apart:

> P7: It seems like if the person has someone go with them, then everything will not need the next process [i.e next stages of the game]. Everything will be solved […]

As was shown in chapter 8 on the model of B/VI navigation, the reason for this is that the sighted aid can, by virtue of their own sight, essentially perform all of the navigation functions that a navigation aid would be required to perform. This is why acquiring sighted assistance is the most common method used by B/VI navigators in unfamiliar indoor environments, although it does come at a cost to their independence (Beatrice Dias et al., 2015). The sighted aid could help them to avoid obstacles, describe the environment to them, point out areas of interest, find routes to the destination, and so on. Arguably, if a B/VI person is navigating with a sighted person who is well-informed about the space, it may not be necessary for them to have another navigation aid. As such, I would argue that the sighted aid be removed as a base aid.

That said, it is still a common approach for B/VI people to seek out assistance when navigating. It is highly likely that, even if more independent methods of performing their tasks were available, some B/VI people would still continue to look for human assistance, perhaps due to the desire for social interaction, or simply out of a personal distrust of technology. As was mentioned in chapter 8, there are recent navigation aid developments, such as the Neatebox Welcome Neatebox (2019), that support those who want to continue taking this approach.

Therefore, although I propose that “sighted aid” should be removed from the base aids deck, I still think that “Acquiring sighted assistance” should be included in the navigation functions deck as a useful function of a navigation aid. Its utility has also been demonstrated in trial 2, where it was used to develop the idea of an aid to attract staff help at a train station during an unexpected platform change.

In summary, here are the changes I propose making to the scenario stage to address the critiques.

Presently the scenario stage has the following categories:

- Age
- Gender
- Sight Quality
- Base aid
- Personal Qualities

I am proposing that the scenario stage be comprised of both fixed, and flexible components:

- Fixed Components
  - Research-backed Stock Personas [Age, Gender, etc.]
- Flexible Components
  - Sight Condition (with photos)
  - Base Aids

The fixed elements would be a set of research-backed stock personas that represent the diversity among the B/VI population. Each of these personas would include contextual information about that subcategory of user, such as the information in the personas mentioned by the Guide Dogs participants. Developing such personas that accurately represent the different subcategories within the wider B/VI population would be a significant body of future work to be performed, but would be highly valuable.

The flexible elements would include a new deck of sight conditions, and the base aids deck. The base aids deck would be essentially the same, but

with the “sighted aid” card removed. The sight conditions deck would be new and, for simplicity, would use photographic images to show representative examples of the visual symptoms for different sight conditions. It would also provide other contextual information about the eye condition. This information could perhaps include some demographic information about how prevalent the condition actually is to make it easier for players to make a decision if they have no pre-formed preference.

Together, I believe that these changes will help to provide far more contextual information to players, which will help them to inform their technology selection and comparison choices. By also varying the other contextual components of the design scenario using the methods mentioned earlier, such as varying the location, or incrementally adding challenges, players will be equipped to address all the contentions made so far.

Moreover, this approach will still allow players to retain the flexibility of being able to change the base aids and sight condition of the user, which will be useful for evaluating the performance of an aid idea in different scenarios later on. The locations deck and challenge deck would still stay the same and still be included as part of the scenario generation phase.

In conclusion, I propose a new scenario generation phase of the game that looks like this:

1. User Cards:
    - Fixed Components
        - Research-backed Stock Personas [Age, Gender, etc.]
    - Flexible Components
        - Sight Condition (with photos)
        - Base Aids

2. Location Cards

3. Challenge Cards

15.3.4 Inconveniences in Use

Turning now to far more minor issues, there were also some criticisms of some design features of the cards.

The QR Codes

Firstly, in contrast to P1 and P3 who felt the QR codes were a good addition to the tech cards, some users felt that the QR codes were burdensome to use:

> P10: Some of these techie ones I would have to look up and even though they've got a QR code on the back, if I'm a technophobe I don't want to scan that. I'll just go on my phone and look up on Google what they are, if I could be bothered.

> P5: Just another thing in there you did mention that we have the QR codes to actually check. The problem with that is that with short space amount of time, we not gonna do that. You have to use the QR code, open your phone, blah blah blah blah.

P10 cites that people who are less interested in technology would not want to use QR codes. They would likely be more inclined to use more commonplace methods of looking for information, such as search engines, if they were inclined to invest any extra effort at this stage of the game at all.

P5 cites the lack of time as a reason for not wanting to use the QR codes. P6 responded to her in the session and demonstrated how the Google Photos mobile application can be used to scan QR codes in an easy-to-use fashion, but P5 remained unconvinced.

P5 mentions that despite her perceived difficulties in using the QR codes ”it is actually really crucial to understand what each technology is”. P5 seems to view the QR codes almost as a necessary evil to be overcome to gain the information required to play the game.

It is worth pointing out at this stage that not all technology cards have a QR code, and thus using them is not necessary at all. The initial purpose behind implementing the QR codes was to provide a link to some informative videos that could explain less common technologies to players. The QR codes were primarily used on the system cards.

P10 pointed out that one way of overcoming the need for the QR codes would be to add some more descriptive text on the back of each of the technology cards:

> P10: I think a more comprehensive definition of them [would be useful]. Like web API, a way to access live data from an online database or service. I still don’t know what that means cause I still don’t know how you access it. So although you’re saying I can access it... How?

P10 said that these definitions would be useful to add, even if the team had team members with more technical skills:

> P10: Yeah. I still think to include it in here because there might not be that person. You can’t always guarantee that your team will be who you want them to be.

At present, because there is a lot of redundant space on the back of cards, and because some players successfully used the QR codes (P1-P3), I propose a middle solution. I propose that the QR code remain on the back of the card, but the tech cards be given more detailed descriptions on the back as well. This would require the QR codes to be reduced in size, but, as long as they are still readable, this should not be a problem.

Difficulties Seeing Subcategory Information

Finally, some categories of cards include subcategories; for example, the challenge cards include "universal challenges" and "specific challenges". At present, the subcategory is represented by some text in a small white rectangle on the front of the card, as shown in fig. 12.3 in chapter 12.

P4 noted that, because the white rectangle is rather small, it can be hard to see which subcategory a card belongs to:

> P4: The sub categories, the little white bit. And this is being very petty. It was quite small, so working as a team, I could only really see the bigger text and the icon.

Multiple players made recommendations for how to make subcategories easier to identify. All of the approaches mentioned suggested using colour as the means of distinguishing categories.

P1 pointed out that it is useful to have a consistent background colour across the different categories, and noted that using a completely different background colour for each subcategory would likely lead to confusion:

> P1: You could just color code that bit, the actual category. 'Cause I think its nice that they're all green 'cause I think if you go into

> too many different colors, it's gonna be confusing. So just have that as a different …yeah marked out somewhere.

P2 followed up this point and suggested that, if the background colours are to be kept the same, then perhaps a different colour could be placed around the white rectangle to delineate the subcategory:

> P2: So a box around the white, like red for all this category but then, just use the four primary colours [to colour the box around the white zone].

While P2 referred to a border around the white tag, P8 suggested having a border around the card itself:

> P8: Maybe you need a base color and a border. So you've got a better variety of colors. […] If you have this dark blue with a yellow outline, that's an audio response. If you have the same color with a light blue outline, that's a visual or textual response. You could have those kind of mixtures.

P8 suggested that this method would be better than having a border around just the white tag, as there would be more surface area covered by the sub-category colour, thus making it easier to see:

> P8: There's more colour to spot that way.

P8's approach also has the benefit of allowing subcategories to be seen when the cards are on top of one-another. If only a border around the white tag is provided, it will be harder for players to see subcategories when cards are on top of one another.

P3 and P4 suggested that a coloured corner would be another method of distinguishing subcategories:

> P3: In a corner is easier to find in the deck when you're shuffling through them. Something in the corner is easier to find.

—

> P4: Well possibly the sub category could maybe a better corner colour.

Taking these together, there are three proposals:

1. Provide a coloured border around the white tag (P1)
2. Provide a coloured border around the whole card (P8)
3. Colour the corner of the cards (P3, P4)

Two main factors to consider when choosing the way forward will be visibility of the distinction, and aesthetics. The chosen method would ideally be easily visible both during gameplay and when stacked behind one another while being sorted. The chosen method would, ideally, also not make the cards look unpleasant.

Because the white tags are no longer easily visible when the cards are stacked behind one I would argue that option 1 of adding a coloured border around the white tag is not an ideal solution. Options 2 and 3, however, are both more easily visible. Thus, we have three options: to choose option 2, to choose option 3, or to choose both. Determining which of these approaches is best received would be a topic of future work.

15.4 Summary

The cards were generally very well received, with the deck categories and category contents being deemed comprehensive and representative of real navigation challenges facing B/VI people. The gameplay provides a logical framework that leads players through the process of generating a navigation aid idea. The framework allows players to focus their thinking on one part of the problem at a time, and is itself easy to understand and learn. The content of the cards was presented in an aesthetically-pleasing manner, and the content was deemed to be clear and easy to understand, with the descriptive text successfully providing clarification where necessary.

Although the cards demonstrated their potential to support players in generating relevant ideas for challenges posed, disappointment could be had if players expected the decks to deterministically result in a solution in all cases. This chapter has argued that the best way to view the cards is as a support to the intrinsic creative capacity of the players, which may itself be constrained by the player's time period, the technology available to them, their social context, and also by their own inherent creativity as individuals or as a group. Sometimes, solutions may not be forthcoming, and this is not necessarily a failure of the cards, or a failure at all; it may just be a reflection of what is possible at the given time.

At other times, players may feel that the cards limited their creativity by focusing on just one challenge or context. It is true that the cards did limit the scope of design, but this was done to make it easier for players to generate ideas. Recall that, in chapter 14, I observed that if players tried to tackle too many new challenges at once, then they found it more difficult to generate ideas and the gameplay would stall. I observed that participants found more success when they targeted fewer challenges, as the design scenario was far clearer in their minds and they had less new problems to solve. I, there-

fore, made the recommendation that players should try to focus on only one challenge.

This chapter demonstrated, however, that having focused scenarios has its own issues. For one thing, it has the potential to produce highly specialised ideas, which would be impractical in reality; B/VI navigators would like their aids to be applicable to multiple scenarios, rather than needing one aid for each problem or location they face, and thus being required to carry many aids to conduct their daily affairs. As a solution to this, I recommend that players take an incremental approach. If they wish to see their aid work in multiple locations, then I recommend they focus on one challenge to generate an idea, and then go back to the beginning to create different scenarios and see how their aid would work in those scenarios, making adjustments as necessary. If players wish to focus on multiple challenges, then I recommend that players keep the rest of the scenario fixed, but introduce one new challenge in each playthrough and see how their aid would need to be modified to meet it. I hypothesise that this incremental approach will be more conducive to producing general solutions without overwhelming players, and also provide guidelines for when this incremental approach is necessary.

Other criticisms were made about how, when using the tech cards, selecting some cards over others felt relatively arbitrary. This discussion pointed out the importance of providing contextual information through richly-detailed and representative stock personas.

P9-11 pointed out that, in their present form, the user cards produced coarse personas, and moreover, there was no guarantee that the users produced were representative of the wider B/VI population. What is required is a representative segmentation of the B/VI population that players can use when selecting personas. Guide Dogs have such personas, based on their data arising from their pool of thousands of participants, but I was not given per-

mission to publish these as part of the thesis.

Although it may be possible, if it turns out that Guide Dogs are unfortunately unable to make these personas available to the academic community, I propose that a significant, but important, body of future work would be to develop a set of personas that accurately represent the B/VI population, and to make these personas available with the cards and also to the academic community at large. These personas would provide far more contextual information to players, and thus improve their ability to select one technological building block over another, and also improve their ability to evaluate the applicability of their aid ideas to different segments of the B/VI population.

Also critiquing the persona phase, P5 and P6 said that they had difficulty in getting a clear understanding of the visual symptoms that their persona was experiencing and noted that this made it more difficult to design for them. I have proposed that a new deck of cards representing various sighted qualities should be created, and have suggested that photos depicting representative visual symptoms and prevalence information would be useful content on the cards.

P7 also pointed out an issue related to including the 'sighted guide' base aid, pointing out that if a persona was using a sighted guide, then the game may fall apart due to the ability for the sighted guide to provide all the listed navigation functions. I proposed, based on this, that the sighted guide base aid be removed from the base aids deck.

Furthermore, I used these critiques of the personas to propose a new structure to the scenario stage that is comprised of both fixed components and flexible components. The fixed components include the research-backed personas, and the flexible components include the new sight-condition cards, and the base aids. Testing the efficacy of this new stage is an avenue for future work.

Other more general comments were made regarding the QR codes and possible methods of better distinguishing the subcategories of the cards.

Regarding the QR codes, although P1-P3 had success using the QR codes, other players felt (P5,P10) that using the QR codes was burdensome and would have preferred to have information printed on the cards. I have proposed a middle solution whereby the QR codes are reduced in size while still maintaining readability, and extra descriptive text is also provided on the back of the cards as well.

With regards to distinguishing the subcategories, three possible methods were proposed by participants: providing a coloured border around the white tag (P1), providing a coloured border around the whole card (P8), and colouring the corner of the cards (P3, P4). Testing which of these approaches provides the best results is an avenue for future work, and I propose that the visibility of the distinction and the aesthetic appeal of the final design are two important parameters to consider when doing this.

The above summarises the positive and negative impressions of the cards made by the participants, ways to address the shortcomings of the cards, and some routes for future work.

In the next chapter, I will discuss the findings from the trials that suggest how the cards and gameplay may be made accessible to B/VI players.

Chapter 16

Accessibility

As shown in chapter 13, one of the key questions I wanted to answer with the card trials was how the cards and game could be made accessible to B/VI people. No former research exists on how an ideation card session could be made accessible to people with visual impairments, so this chapter presents a novel contribution of the thesis.

Various suggestions were made by participants, which can be divided into (1) ways to make the cards accessible, (2) ways to make the gameplay accessible, and (3) ways to make the booklet accessible. These will be discussed now, in turn.

16.1 Ways to Make Cards Accessible

16.1.1 Audial Modality

P8 the VI participant, pointed out that the audial modality is likely to be the best modality for relaying information to B/VI players:

> P8: anything that would come through an audible system is enormously beneficial. Because if you've got a sight problem, everyone, or most people in that group are going to have their hearing senses. So you can pick up on it that way.

Or, put as a more general rule:

> P8: anything audible is helpful.

Moreover, P8 suggested that the audial modality is likely to be the only option for the totally blind:

> P8: For the people with no sight at all, it's going to have to be audible or nothing, think.

P3 suggested that the card contents could be digitised, and then relayed to users by text-to-speech.

> P3: Have it relayed by head phones... something that would actually... like a pager on a browser that reads all the stuff in sequence. But then you've got the same problem that they have to have every single card read to them and they can't easily flip from card to card and go …yeah

By digitising the card content, we make it possible for text-to-speech services and screen-reader software to read out the content to players. This effectively converts the content on the cards from a visual medium to an audial one, and thus makes the card content accessible. P3 points out that, although straightforward, this method does come with downsides in terms of usability. Players will be limited in the ways that they can interact with the

cards; for example, they won't be able to move from card to card as easily as would be possible with physical interaction.

P9, one of the Guide Dogs executives, also suggested that digitising the card contents would be the best way forward.

P9: Digitalise the whole thing […] These days the largest proportion of our service users are using screen readers and certain technology. […] And so actually, these days, the way to tick every box is digitalising it.

P9 revealed that such approaches are rather common, and that there is precedent for using screen-readers to play digital card games:

> P9: And to be honest there's a basis of lots of screen reader game based things. So whether it be playing solitaire cards, or whether it be a more complex game, there's quite a lot of technology around screen readers and games already existing. So you just need to utilise that.

P8, the VI participant, also thought that text-to-speech would be a viable way forward:

> P8: I think it [text-to-speech] would be enormously useful. A friend of mine uses it for his text messages. And his text message comes through and it just reads the messages to him. That kind of tool seems to me incredibly useful to people with more significant sight loss than myself.

It appears, therefore, that digitising the card content and making it available to text-to-speech services is a rather unanimous suggestion.

However, developing an application is a rather costly endeavour, both in

terms of time and effort. P11, another Guide Dogs executive, suggested an alternative way to create the desired functionality – a word document:

> P11: Or the lowest validity that you could do for that is a word document.

P11 noted that this is exactly what happens internally at Guide Dogs; B/VI members of staff are given word documents that contain the important information,

> P11: If we do a process map, we would have the map, which isn't accessible, and we would have a word version that just says what everything is [and distribute that to our B/VI staff].

P11 pointed out that B/VI staff often pre-read information with the help of a screen reader to prepare for meetings. Thereafter, they can more easily follow the discussion and have their memories prompted by the flow of the discussion:

> P11: So for a lot of our guidances, we would share for everyone before a session so they could pre-read and lots of our VI staff are fab at that, so then actually in the session they wouldn't need the document. They would be prompted by listening.

P9 noted optimistically that, if B/VI people were allowed to pre-read the cards in this way, then that would be sufficient to allow them to partake in the gameplay "like anybody else":

> P9: For a VI member of staff, I think if they can pre-read it, then there's no reason why they couldn't partake like anybody else.

Creating a word document is much more expedient than developing a software application, and also avoids converting the cards from a physical card game to a digital one. By pre-reading using text-to-speech, B/VI players would be equipped to engage in the game just like everyone else.

P9-11 also suggested various best practises that would make the word document easier to use.

P10 mentioned adding unique numbers to the cards so that they could be discussed in order:

> P10: I would love there to be like a one, two, three, four, five, six. You know, so it's just really clear [which card is which].

P11 advised that it would be helpful to structure the word document in such a way that the cards were read out in a logical order and grouped by category:

> P11: So you'd have page one: "personal qualities", and then you would list what they were.

P11 further advised that each card entry in the word document should consist of the card number, the category code, the title, and the descriptive text:

> P11: If this was [category] four, you'd have four and within that you'd have four A, for the first set of categories, four B and then they could follow that.

> P11: So you'd have the title to have a definition of what you mean by that, and then you'd say cards one to 20, section A, and list what they actually are. Literally say "simple interface is a simple interface, easy to use."

Overall, I propose that this is a highly promising method of making the card content accessible to players, and I would highly recommend developing such a word document and testing its usefulness as part of some future work.

16.1.2 Haptic Modality

Braille

In terms of using the haptic modality to make the cards accessible, braille was immediately referred to:

> P2: Have braille and have it bigger.

But P8 mentioned that braille is a "dying" technology:

> P8: It has occurred but I don't know that many people in the blind community who actually use Braille. It's not …it seems to be dying away from what I've …from my present experience. I've had no offers to teach me it, through any of the sight support groups. It seems in an increasingly technological world there's other ways around it. So it's not as …it doesn't seem to be as vital. I think it's more important perhaps [to have] some kind of audio method of [communicating information].

P9 also indicated that making the cards available in braille would not be satisfactory:

> P9: Turn it into something that is on an app or something. Because as soon as you actually try and make that accessible, you

> braille it, okay. That knocks out about 4% [of the total VI population]. You then need to large print that will knock out another load. You still got something that loads of people can't read.

P9 says that only 4% of the VI population uses braille. A report by the National Federation for the Blind in the US places the figure at around 10% for the US population (NFIB, 2009). In either case, the figure does not represent a major section of the B/VI population.

Moreover, P9 and P10 pointed out that adding braille would be an expensive method to use—presumably due to the special equipment required to add braille features to the cards—-and would also make the cards far more bulky:

> P10: Braille's super expensive anyway.
>
> P9: And Bulky. As soon as you put braille on this, you're box of cards -
>
> P10: They won't be cards anymore will they? They'll be this [thick] with large print as well.

Given its reduced popularity, high cost, and the need it imposes to make thicker cards, perhaps using braille is not the ideal solution.

Embossing

Some players suggested embossing the cards so that tactile versions of the images could be felt by the VI players to distinguish the cards:

> P2: But actually, I think you could let them pop up, like these images they're very useful for a sighted person to kind of conceptualize what's been written. You know, sometimes a card can have

this popping up, like birthday cards and stuff when you touch them

P1: Embossed?

P2: Yeah that's it! So you can actually feel them and they kind of …That's even better than braille because braille you have to have the text and people need to know braille, but at least they can think of a hand and then they can also think of a concept. [This method would be] mainly for pictures, I think.

P8 pointed out that this idea would potentially be useful if the cards were made larger and fine details were avoided. However, P8 did note that it would be hard to distinguish between many cards with this method:

Researcher: There's another one [idea] about having the icons on the cards relatively indented. So you can imagine that being an indented kind of feeling, you'd be able to sense the icon. What do you think of that idea?

P8: At a larger scale I think that could be really helpful.

Researcher: When you say "Larger scale", do you mean bigger cards?

P8: Bigger cards yeah. Even if ... like we said having different content on two sides of the card. If the whole card was one indented thing. When it gets into a fine scale detail, it's very, very difficult to differentiate unless it's a very clear, one straight arrow, a circle. Very obvious

> Researcher: It could be hard to keep this up for many cards, perhaps.
>
> P8: Absolutely, yeah.

As there are many cards in the game, perhaps this method is not ideal either.

Props

Similar to how P5 and P6 suggested using props to simulate different eye conditions for sighted players, P1 suggested that props could be used to haptically represent different technologies for B/VI players:

> P1: Or a camera that somebody actually picks up …you could have it match with those objects. […] Maybe have a rotary knob that they actually feel […] I mean, maybe having actual artifacts that people can touch and pick up

When asked for his thoughts on this method, P8 pointed out that, because of the number of technology cards, using this method could require players to store a large set of equipment to play with the cards:

> P8: That's going to make the kit you'd turn up for a consultation with enormously complicated

Aside from the portability issues, producing props would also add extra cost to the game. This cost could be mitigated if the items were made as mock props, rather than real functioning items, but it would still be a complicated method to enact.

Having reviewed these suggested options, perhaps the haptic modality does not offer the best source of support for making the game accessible.

16.1.3 Visual Modality

Larger Font

Increasing the font size of text on the cards was repeatedly mentioned as a possible improvement by players:

> P2: Have braille and have it bigger.

—

> P1: You could make the icon bigger, and the word bigger, then have the description on the other side. And that may possibly help partially sighted people to use them as well.

—

> P5: I think the packs need to be much bigger, […] a bit more size for the text

—

> P4: And just text size, so for people who've got limited vision, they may benefit from something where if it would normally fit on A5, then double size it to A4 so, it would make the cards work quite difficult but I think, potentially just for people who've got visual limits rather than blind. A5 cards are a possible option.

—

> P8: The size of the cards, if there was A4 card each, then it's probably more …a lot accessible way of doing it.

In order to increase the font-size, we can (1) increase the size of the cards themselves and simply scale up the design, (2) change the layout of the card content to allow more space for the text, (3) do both.

For (1), the trade-offs are that as the cards get larger towards A4 size, they become less like cards and more like sheets of paper, which will exacerbate space constraints and interfere with the ability to play the game as a card game. Moreover, for teams with no B/VI players, it may be deemed a strange design choice.

For (2), the trade-offs are that, as the card design is made to optimise certain pieces of text, like the title for example, then less space is left for other elements of the design. Fortunately, there is a lot of redundant space in the current design, with the reverse side of each card simply being a repeat of the front. As P1 pointed out, this leaves the opportunity to increase the size of the title text on the front side of each card, and move the descriptive text to the reverse side of the card. However, based on the utility that players mentioned receiving from being able to easily read the descriptive text to clarify concepts, I think that moving the descriptive text to the reverse side of each card, and thus hiding that information, would increase the likelihood of misinterpreting concepts and thus make the game less successful.

A good place to start addressing this problem is to identify a suitable font size. The UK Association for Accessible Formats (UKAAF) published in 2012 a set of guidelines on the accessibility standards for clear print text (UKAFF, 2012). The UKAAF document, which is referred to by the RNIB website, states relevant requirements such as:

- "Minimum text size of 12 point for clear print, ideally 14 point"

- “Minimum text size of 16 point for large print, ideally minimum of 18 point”
- “Legible typeface such as Arial” (on p.19, they also include Verdana, Trebuchet, and Times New Roman.) “Good [colour] contrast between text and background”
- “Paper is non-glossy”

The RNIB website also states that some VI people may require access to “large” or “giant” print (RNIB, n.d.-c). The RNIB explains that, while regular font is usually between 10 and 12 point font, large font is usually between 16 and 18 points, and giant font is anything larger than 18 point font.

From these two sources we can produce a scale of font-size bands:

- Regular font: 10 - 12 pt
- Clear font: 12 - 16 pt (ideally 14 point)
- Large font: 16pt - 18 pt (ideally 18 point)
- Giant font: > 18 pt

However, P8 pointed out that, due to the differences in sight conditions amongst the VI population, it is hard to guarantee that any improvement to font-size will be accessible to all VI people:

> P8: The size of the cards, if there was A4 card each, then it’s probably more ... a lot accessible way of doing it. The text on here, I can read it, I’m saying the patch of sight I’ve got is pretty good. But, I know friends who would have no clue, even in the larger text, as to how to do it.

> Researcher: What do you think would be the smallest card you could get away with? Because I think there's A4, A5, A6...
>
> P8: It's different for different people.

Naturally, as larger font-sizes are selected, the proportion of VI players that cannot read the text diminishes and the cards become more accessible. However, there is an obvious trade-off here between font-size selected and the amount of textual content that can actually be fit onto the card. Larger fonts are to be preferred, but probably not at the loss of important content, in which case the content becomes totally inaccessible to everyone. Some experimentation while designing will be required to see, firstly, to what extent content is lost at larger a larger font-size and card size, and secondly to see how well-received the chosen design is among a sample of the VI population.

Improved Contrast

The colour contrast of the cards was pointed out by P1 and P3 as an important factor to consider:

> P1: And make that image more high contrast as well.
>
> P3: Yeah, the contrast is critical for a partially sighted [person]

.

P4 also did the same:

> P4: For example, the green and white; I don't know, but my guess would be that some people would find that difficult to read.

P8 perhaps gave the most in-depth insights regarding where particularly the colour contrast could be improved:

> Researcher: And you were saying about the colour?
>
> P8: Yes, white and yellow, these are terrible things to try to read, even if you've got perfect sight. You need a very high contrast mix of colours, even between the cards. That and that can be quite similar to some people. The dark blue on the grey …
>
> Researcher: Also these two, obviously as well, the red and the orange.
>
> P8: That is probably worse than the blue and the grey, yeah.

From P8's comments we can learn that is not only important to ensure a high contrast between the background and font colour on each card, but there also needs to be a high contrast between the background colours of each card category.

P4 pointed out that there are online colour-contrast checking tools that are used for these purposes:

> P4: You would need to check all your color texts against backgrounds. There are websites you could use to check that they are very high in contrast, so easy to read.

Examples of such tools include: WebAIM.org, contrastchecker.com, and accessible-colors.com, which are all tools based on the Web Content Accessibility Guidelines[1] (WCAG). Developed as part of the World Wide Web

[1] https://www.w3.org/WAI/standards-guidelines/wcag/

Consortium's (W3C) Web accessibility Initiative (WAI), the WCAG are the official standard for ensuring accessibility of web content internationally. By using tools based on this standard to check colour accessibility when designing, we can give the best possible chance that the colours we use in the card design will be suitable for VI players.

Considering Colour Blindness

This discussion of accessible presentation also brings up the tangential issue of colour blindness. Although not mentioned by participants, colour blindness is still a form of visual impairment that is sensitive by design choices, and thus relevant to this part of the discussion. Page 23 of the UKAFF document also gives some guidance on avoiding issues related to colour blindness:

> There are no set rules to ensure that anyone with colour vision deficiency will be able to distinguish the full range of colour in any publications, but following some simple guidelines can minimise the difficulties: ensure there is a good contrast between text and background avoid combining red and green avoid combining yellow and blue avoid combining colours of similar tone such as dark blue and black.

Although the document states that there is no particular guidance for ruling out all possible issues that colour blind people may face, the above guidance should be adhered to when selecting the improved colour palette for the cards requested in the last section, so as to put for the best efforts possible to avoid any issues.

With these points in mind it is possible to begin experimenting with optimal

card layouts and designs. Perhaps a strand of future work could be to conduct these experiments and convert the findings not only into an improved card design for this set of cards, but also into a set of generalised recommendations for accessible ideation card design. Aside from some older work by Sepchat, Monmarché, and Slimane (2007) and a more recent two-page conference paper by Miyakawa, Kuratomo, Salih, and Zempo (2019), there appears to be little work done in the area of accessible card games. However, both of these take a more technological approach, relying on computer vision technology, rather than identifying how to make the most a human player's residual vision. This could, therefore, be an exciting and novel avenue for future work.

16.1.4 The need for balance

While discussing these design choices to enhance the accessibility of the cards, it is important to remember the importance of maintaining a balance between improving the accessibility of the cards for VI players, and maintaining the usability and features of the cards that provide value for non-VI players to ensure inclusivity.

P9–11 unanimously agreed on this point during our interview:

> P11: But again, we have this big debate with some of our VI staff of you've got to have a balance between what's accessible and losing the value of the tool. Digital dashboards like ClickView aren't accessible, doesn't mean we shouldn't use them; [digital dashboards are still valuable] because they display data. It's then what we do [to make that data accessible] -, someone would provide a summary of that data [in an accessible format]. So don't take the pictures off because -

> P11: Both VI and non VI people are gonna use it [the cards]. So you don't want to make it just black and white, you know?

When making the suggested changes to the design, it is important to bear this guiding principle in mind. The challenge is not to make the cards the most accessible cards for VI people; the challenge is to take into account the diverse needs of all the possible players of the cards, and produce a design that satisfies the most important of those needs across as diverse a set of users as possible.

If, in the end, this approach proves to provide suboptimal designs, there is always the option of designing distinct decks specifically for VI and non-VI players, respectively:

> P8: I think they would have to have a completely different sets of cards depending on the group of people that I'm going to see in this consultation process. You'd have a Braille set and a normal set.

As P8 points out at the end of their statement, this approach is possible, but it may introduce the need to harmonise the different gameplay styles that may be necessitated by the different deck designs.

> P8: How you would do it in a group session where everyone's trying to reach in for the cards all at once, it could end up risking damaging the cards and just causing general confusion.

Having differences in the content of the cards on top of the differences in preferred gameplay styles may make sessions with both VI and non-VI players more chaotic than is necessary.

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This point brings us on to the next part of our discussion regarding how to make the gameplay of each session accessible.

16.2 Making the gameplay accessible

Aside from the cards, the way that the game is played is an important factor for ensuring that the game is as accessible as possible. The term "accessibility of gameplay" refers to how easily VI players can engage with and

contribute to a given session. Participants suggested various ways for making the gameplay more accessible, which will now be discussed.

16.2.1 Serialising the Gameplay

The primary issue that was brought up by players was that much of the card game is non-serial. By the term “non-serial”, I mean dynamic gameplay where the cards can be used in any order. Although the stages of the game proceed forward in a step-by-step (serial) manner, some stages, such as picking a challenge or using the tech cards to generate ideas, have no strict order to them and can get quite chaotic.

P5 expressed the problem like this:

> P5: The process that might be problematic for the blind person will be the orange [red, i.e. challenge cards] and the black ones [i.e technology cards]. Because with the orange [red i.e. challenge cards], there’s so many cards, and I don’t know how that’s gonna work, and every card will have like an explanation and I just cannot imagine how the person has to hold that much information because with me, I keep on glancing on the card now and then to recheck my memory.

It is conceivable that this issue may leave a B/VI person feeling confused and left out of the discussion, as they find it difficult to see the cards that other players are referring to, and to track the changes in position of the cards as they are spread out around the table, and held up as talking pieces during debates.

P8, the VI participant, pointed out that this likely would be the case for B/VI players, as they will be less able to visually scan the tabletop for the cards

they want to discuss:

> Researcher: Do you think a vision impaired person would be able to feel confident chipping in even if they couldn't see which cards are being moved around?

> P8: Yeah, that's maybe more of a problem. If there was a bit of a group discussion and a card they've been expecting to be here, was all of the sudden moved over to the other side and something else ended up in it's place. You'd end up with a very confusing discussion where they're talking about radar while waving around the heat pad card.

P6 mentioned that they, as a non-VI player, were able to visually pan the cards on the table top and transfer those concepts into their short-term memory, thus gaining a rough familiarity with the contents of the individual decks. P6 was then able to draw on their memory of the concepts in the decks to support their efforts in latter stages of the game and in the discussions that unfolded. This familiarisation process occurred passively as P6 was exposed to the content; no specific learning time was required, and thus the familiarisation was unobtrusive to the gameplay.

> P6: It helps us build a mental image of all the processes and technologies you know. It sort of keeps everything in mind, so obviously vision is important in this case but would visually impaired people have other means of achieving this step? Maybe it doesn't require cards. I don't know what they will use.

Moreover, having this cognitive material "loaded" into the short-term memory of the players is important for the ability of the players to make unexpected

connections between the concepts, and thus important for the creative output of a session. As P6 pointed out, however, this familiarisation was made possible by P6's sense of sight. With reduced access to this sense of sight, as in the case of a B/VI person, familiarisation with the card content becomes far more difficult.

An analogy may be made, then, between the issues that B/VI navigators have in familiarising themselves with their environments, and the issues that B/VI players will have in familiarising themselves with the contents of the decks. While sighted people can simply walk into a new environment and use their vision to build up relatively passively a cognitive map of the space and use it to orient themselves, B/VI people find this much more difficult. Likewise, as sighted players of the game can use their sight to build a form of "cognitive map" of the concepts in the game and use that to "orient" themselves through future stages, B/VI players find this more difficult.

To overcome this challenge, P8 mentioned a few ways of fixing the position of cards during the game. One such way was to use a frame or board to structure each session:

> P8: So it may be that you have to have ... a much larger bit of kit. Maybe some kind of frame that has a permanently fixed content to it. So you have one bit of grid that's this response, and you find the next grid and check the next response. So there's no physical cards to pick up and scrapple over. If you see what I mean — more of a fixed, one person at a time [method of gameplay].
>
> Researcher: What would that frame [do]? You're talking about a metal frame that would-
>
> P8: Maybe some kind of thing, some kind of overlay you would have some kind of frame you could put on the table. And then

> just put different sets of panels on. So you'd say, "We're now looking at inputs." And you put the input frame on.
>
> Researcher: Oh, I see.
>
> P8: It might be the only way in doing it for groups where people are completely blind and are Braille users, that may be a more appropriate way of doing it. Probably won't promote as much debates, but you'll get individual responses from everyone who's had a chance to check the panel.

P1-3 also suggested including a board for the game, but their suggestion was slightly different to P8's. In their formulation, P1-P3 suggest that the grid would just provide clearly delineated places for the cards for the various stages to go, and thus prevent them from being spread out across the tabletop:

> Researcher: In general, how could the game play have been improved?
>
> P1: I wonder if you could provide, I don't know, an area, you know, a board?
>
> P3: Yeah, I was just thinking the same thing.
>
> P1: You know, with the things in the different places …
>
> P2: Yeah, yeah, I noted that already cause I thought..
>
> P3: Because you could have a yellow zone and a green zone and a 'da da da' and then you could have a building area.

The idea behind this approach is to prevent the cards from being pushed around the table so much, and constrain particular suits of cards to particular areas. By creating these “bounding boxes” on the possible search area, the task of searching for a card becomes much simpler.

This of course presumes that the B/VI players understand the layout of the grid. In this sense of requiring the B/VI players to learn a layout, the grid idea is analogous to an allocentric tactile map. When B/VI navigators learn tactile maps, they learn the layout of an area (i.e. gain survey knowledge) and then use that layout to navigate to “points of interest” as desired. In a similar way, by understanding the layout of the grid, B/VI players can understand where “cards of interest” may be situated, and thus access them far easier when the time comes.

Discussions continued about the best way to ensure that the cards stayed within their designated areas. P3 suggested that each of the areas of the grid be a particular “tray”:

> P3: Your board itself could have trays instead of lines so that the cards from one category sit in a tray so that when one person does that they don’t just scatter them all across the place, they actually stay within the tray.

P3 also suggested adding magnetic strips to the back of the cards to keep the cards in place on the board:

> P3: They could be embedded magnets, like you can get, like those scrabble pieces?

> P2: Oh yeah, that’s a good point.

The methods of using magnets physically modifies the cards, whereas they idea of having “trays” on the board, i.e. distinct physical boxes rather than easily-transgressed painted lines, does not. Moreover, the use of magnets would inhibit, partially or completely, the reverse of the card from being used to hold extra information.

Recall from our earlier discussion that the ability to use the reverse of the cards is useful both in terms of simply providing a richer description of each of the concepts, and also in allowing the extra space required when working with larger fonts. It would be unfortunate to sacrifice the utility of this extra space for the ability to more easily locate the cards when other methods are available that do not require this sacrifice. As such, I propose that out of these methods, producing a grid that uses physical delineation between the regions (or trays) is the preferred route.

It may not be necessary to produce the trays themselves, however. The benefit of using the trays, which were introduced as an alternative to only using painted lines, is that cards cannot easily transgress beyond their boundaries of the trays into different areas as the game progresses. This benefit can be replaced by replacing the painted lines with protruding railings that are sufficiently high to stop the cards from transgressing their intended area. The railings would also be easily distinguishable from the cards by touch. The use of metallic materials here would be advisable, as the coolness of metals at room temperature, and their hardness versus the paper cards, would provide easily distinguishable cues to allow VI players to navigate the board. Perhaps these railings could also be augmented with braille markings to allow braille users to detect which areas they are currently in. The areas within the railings could be coloured to match the cards, so that those with residual vision could identify the areas at a glance. The designs presently on the divider cards could also be added as backgrounds to the various areas, which would benefit both fully-sighted and partially-sighted players alike. Learning

the layout of the grid would be an additional challenge, but with the help of a facilitator or another sighted player, this should not be too much of a challenge. Developing such a grid and determining the optimal layout would be an exciting avenue for future work.

16.2.2 Provide Content Familiarisation

A rather elegant solution, initially suggested by P4, is to provide a way for VI players to prepare for the session ahead of time by familiarising themselves with the card content.

> P4: A suggestion on that is if you be prepared to, you contact participants before an event and if they have read out loud software or technology that assists them, but it takes time. Then you provide all of the card content up front. […] But then, at that point when they take part in the actual activity, they're only having to recognise cards, not actively, like you're saying, having to keep it all in your head.

In a similar way to how VI people familiarise themselves with new environments before navigating the environment "for real", this method would allow VI players to familiarise themselves with a decks contents, load that information into the memory, and then draw on that preparation during a session. Instead of going into a session "cold", players will be better equipped to adapt as the discussion flows.

Recall here the statements of P9-11 about the technique used at Guide Dogs to familiarise VI staff with documents prior to meetings.

> P11: So for a lot of our guidances, we would share for everyone before a session so they could pre-read and lots of our VI staff

> are fab at that, so then actually in the session they wouldn't need the document. They would be prompted by listening.

This shows that there is precedent in successfully using this method to keep B/VI people engaged with dynamic discussions. Guide Dogs didn't need to implement a new flow for meetings; they just make it easier for their B/VI staff to follow along by providing methods for them to familiarise themselves with the meeting's talking points and relevant documents ahead of time.

When this idea was suggested to P8, he expressed a high level of approval for it:

> P8: Yeah, it could be very useful. Anything that's sort of prep people for what they're going to be experiencing is enormously useful.

P8 continued to point out that the goal here should not be memorisation of deck contents, but just a degree of familiarity with the content to stop players coming in "cold":

> Researcher: I doubt someone could hold all of this in their head. Or do you think they could?

> P8: No, I certainly couldn't. […] not without an awful lot of preparation [laughs]. But I'd say it's just a degree of familiarity [that is required]. Better than coming in cold.

Recall from the previous section that converting the card contents into a Word document so that they could be read out to players audially via text-to-speech software was determined as a preferred method of making the card

content accessible, alongside improvements in font-size and colour contrast. A major benefit of taking this word document approach is that the benefits of the familiarisation with card contents carries over to making the gameplay accessible. By adopting the word document method, the challenges of making the card content and gameplay accessible are both addressed at once.

P8 was asked for any possible downsides for this approach:

> Researcher: What about some downsides of that one?
>
> P8: I can't see there'd be any drawbacks unless you add the topic of the design brief to it. Then you'll get a lot of preformed ideas.

Since the design brief that P8 is referring to would be generated within the session itself and not provided to B/VI players ahead of time, we can avoid the potential issue of players creating pre-formed opinions. As such, no drawbacks to this approach are immediately apparent at this stage. Testing the approach would be necessary to see whether unexpected issues do arise, but as for now, it is a highly promising route to take.

Another way of helping B/VI players to enhance their involvement in a session, would be to give them a clear understanding of how a session is played. At present, this type of information is currently stored in the gameplay booklet. Although the making the gameplay booklet accessible would certainly help make the gameplay itself more accessible, because the booklet is a distinct part of the game in its own right, I have chosen to discuss the methods of making the booklet accessible in its own section. These methods will be discussed next.

16.3 Making the Booklet Accessible

Aside from the cards and the gameplay, the final component to make accessible would be the instruction booklet. Making the intruction booklet more accessible will allow VI players to better understand how the game is played, what roles each of the card categories perform, and how a given session is structured in general. Naturally, knowing this information will make VI players more effective at engaging with a session, and thus making the booklet accessible will have positive impacts on making the gameplay accessible. However, because the booklet is a distinct part of the game, it deserves its own treatment, which this section aims to provide.

16.3.1 Increase Font Size

As it is a physical document, P8 recommended using large font to make the text accessible:

> P8: Probably large .. large text, or Braille I would have thought, because this kind of information is ... an audio file would be pretty daunting. To have the set of rules one after the other, and trying to recall what the first rule was and everything else. Some kind of ... even it was just a fold out to A4, or something with large, large text on it. I see some of the information I've had through sent from RNIB it's got about five words per A4 sheet. Enormous text.

Presumably, P8 is referring here to the large and giant standards defined by the UKAFF mentioned in section 16.1.3. Printing the document in large or giant font would be a potentially viable route forward. According to P8, this

method of transmitting textual information already in practise by the RNIB. However, although this method will support players with residual vision, it doesn't provide any assistance for fully blind players. P8 does mention braille as an option, but as mentioned previously, braille literacy is only at approximately 10% today (NFIB, 2009).

16.3.2 Text-to-Speech

P4 suggested making the booklet available in PDF or text-file format so that players could have the booklet content read out to them audially:

> P4: PDF or text file. Because they would be able to have it read out to them [by text-to-speech software].

Just as digitising the card content so that it was available audially to faciliate session preparation was deemed a highly promising route forward for ensuring accessible card content, it seems fair to assume that converting the content of the booklet into an audially-accessible format for preparation will be a promising route forward too.

Interestingly, P8 brought up the issue of whether players will be able to take in all the information that is presented to them:

> P8: Once you're at page five and you've had all that information given to you, whether you're still taking it in at the end.. [is another matter].

This point is interesting in many ways. First of all, it invites us to consider whether there is a difference between the level of familiarisation required for the content of the booklet and the level of familiarisation required for the

content of the cards. If players only need a general level of familiarisation with the booklet content, like they do with the cards, then whether players "take all of it in" becomes less important. However, if a clear understanding is required to prevent friction in the sessions, then the ease of absorption of the information becomes far more important. Methods of making the information easier to absorb are discussed in the next section.

16.3.3 Recorded or live instructions

P8 suggested an elegant method of making the information easier to absorb, which is to break the audial content up into several small audio files:

> P8: […] try and think of a way of breaking down the instructions into simpler chunks.

> P8: But perhaps if there was, again, a group about to take on this playing this game, and you had an audio file you could play at the start. "You will encounter four cards, this, this, this, and this; and your aim is to determine X, Y, Z". You play [a file] at the start of each section, then you've got a much smaller set [of information] to consider.

By breaking the audio up into chunks that align with the stages of the game, one file could be played for the whole group at the start of each stage. Players would then rely on their short-term memory to get through the stage, which should be more than sufficient. A facilitator may help with the playing of each file. An audio file that gives the overall structure for the game would be advisable, so players can also get a general appreciation for the structure of the whole session.

As an intriguing alternative, P4 suggested that creating “a little YouTube video” that would explain the gameplay would be a viable way forward. For sake of clarity, P4 is not referring to a pure video-only solution here, but rather to a video clip which contains audio as well.

An obvious objection to this is that video is not accessible to VI players, but there is an important underlying reason for opting for a video-based method over an audio-based one. Although video may not be accessible to some of the VI players, the mainstream nature of video content allows us to help make the content of the booklet accessible without installing a blatant accessibility measure into the gameplay.

Recall that, during the early interviews with VI navigators, we learned that obvious accessibility measures typically result in feelings of stigma and embarrassment. With video being as ubiquitous as it is today, the choice of an audio-only method of description will likely be perceived as odd, and thus as an obvious accessibility measure. This would be highlighted further by the choice of audio being clearly a suboptimal choice for the non-VI players in the room . I’d, therefore, argue that the use of audio-only is more likely to result in feelings of patronisation than in feelings of equality.

Moreover, using video allows us to stay in line with the principle put forth by P9 of maintaining balance between making the game accessible for VI players, and providing value to sighted players. The use of video allows sighted players to leverage their vision to understand the game in a medium familiar to (and thus effective for) them, but still keeps the content accessible to VI players through the use of audio in the video. Using video, therefore, appears to be a win-win situation.

If either side of the argument between choosing video or audio-only is not convincing, there is always the option to simply ask a designated facilitator to explain the game

> Researcher: What about just having a facilitator that knows how it works, that guides people through it when they come.
>
> P8: Yeah, section-by-section is what needs to happen I think.

P8 points out here that the section-by-section approach is likely to be necessary, for the reasons of information overload mentioned earlier.

Regardless of which method is chosen, video, audio-only, or facilitator, P8 made a final overarching point that should to be borne in mind:

> P8: It relies on the narration having very clear guidelines.

Clarity will always be a fundamental marker of success when communicating instructions. Accessible, but unclear information is not useful to anyone. Because clarity is so important, one might suggest conducting trials to ensure that players understand the advice in the final guidance, and that they demonstrate this understanding by carrying out the correct actions.

It can be argued that, because of their more organic and unedited nature, the didactic explanations of a facilitator may not result in the desired level of clarity. Moreover, the groups designated facilitator may be new to using the game themselves, so the information provided may be incorrect. Finally, the facilitator may not have sufficient experience in the use of accessible language, which may result in further reductions in clarity.

To counter these issues, it is possible to give the facilitator a set of scripts to use at each stage, or simply to ask the facilitator to read out the booklet. This would be an expedient solution, and would perhaps help avoid the stigma issues, as the facilitator would likely be chosen by the consent of the group. Moreover, the facilitator is interactive, and players can ask the facilitator questions if they require further information. However, like simply

printing the booklet in large or giant font, this approach does not cater for groups in which no given player has a sufficient level of vision.

In absence of further data, no conclusive decision about the best method can be made at this point. I suggest that conducting trials to determine the best method would be a useful line of future work.

16.4 Summary

This chapter has focused on the ways that the game can be made accessible as a whole, and all the suggestions made by focus group participants have been discussed and evaluated.

We began by taking the game and breaking it into three essential elements: the cards, the gameplay, and the booklet. Thereafter, we looked at how each of these elements could be made accessible to VI players, both in VI-only groups and in groups with both VI and non-VI players. Throughout the discussion, we sought to maintain the balance between making the cards accessible and providing value for the non-VI players of the game, and we also attempted to find “middle ways” between any identified trade-offs.

This final section will present in summary format the suggested routes forward for making each of these different segments of the game accessible.

In terms of the cards, there were four actionable development points:

1. Make a screen-reader-compatible digital document that lists out, in a logical order, information about each of the different cards in the game. The document should be broken up into the same sections as the cards; i.e. there would be a “persona cards” section, a “navigation functions” section, and so on. Subcategories would also be listed.

Information for each card would include (1) unique card numbers, (2) category codes, (3) card titles, and (4) card descriptions. Typical word-processor document formats (.docx or .pages) or PDF files should be satisfactory for this purpose.

2. Ensure that the cards comply with the UKAFF guidelines on accessible text, by modifying the card design to accommodate at least 'large' (14 pt) font in an accessible typeface (e.g. Arial, Times New Roman, etc.). This should be done without losing important information due to space restrictions.

3. Ensure that all cards follow the WCAG guidelines for colour contrast, by ensuring that all cards have sufficient inter-card and intra-card contrasts. Colour contrasts can be checked using an online contrast checker, such as webaim.org or one of the other tools mentioned previously.

In terms of the accessibility of the gameplay there were two actionable development points:

1. Let VI players use the digital file mentioned above before sessions. It is hypothesised that will allow them to develop sufficient familiarity to allow them to engage, versus coming in "cold"; the effectiveness of this solution should be tested in future work.

2. Conduct a study investigating the impact of introducing a board for the game. The board would have distinct areas for each type of card, and use metallic railings to segment the areas. Using this method, cards locations can be restricted to narrow areas, thus making it easier for VI players to search for cards to use during discussions. The use of metallic material to divide the sections provides a tactile difference between the areas, that VI players can use to navigate the board. The railings will need to be high enough to stop the cards spilling over into

other areas. An iterative process of testing and redesign is encouraged so as to reach an optimal design.

3. The third approach is to make the gameplay booklet accessible. By making the information in the instruction booklet accessible, VI players will be more empowered to engage in the gameplay as an equal participant (see below).

In terms of making the booklet accessible, several methods were suggested, but it was not possible to reach a definite conclusion about the best route forward. As such, there is one actionable development point:

1. Conduct a study which investigates the differences between using audio-only instructions, video with audio, and instructions read aloud by a facilitator. The study should pay particular attention to feelings of stigma, as well as the correctness of understanding that the players develop after listening to the instructions.

By taking these approaches to development in unison, the accessibility of the card game can be significantly improved. Moreover, the accessibility will be improved by empowering VI players to be equal participants in a session, and without introducing any stigmatising mechanisms.

Part V

Conclusions and Future Work

Chapter 17

Conclusions and Future Work

This final conclusion chapter aims to review how I have addressed the aims of this thesis, and presents the thesis's main contributions, its limitations, and future work.

17.1 A Recap of Aims, How They Were Addressed, and What Was Learned

I set out to achieve five aims which were first presented in section 1.2. This section shall review how each of the thesis chapters have successfully addressed these aims, and what has been learned by addressing them.

17.1.1 Investigating Navigation Challenges

Aim 1: To confirm the general challenges faced by B/VI people that are reported in the literature, and to investigate the particular navigation challenges that B/VI people face in specific environments.

In chapter 7, I addressed aim 1, which was to confirm the challenges faced by B/VI navigators that I had found during my literature review (chapter 3), and to investigate the navigation challenges that B/VI people face that are particular to certain locations. My participants reported experiencing the 'universal' challenges referred to in the literature, such as unexpected obstacles, echoes, crowds, difficulties developing cognitive maps, and so on. The interviews also facilitated the exploration of some locations in more detail and afforded the opportunity to see whether there were any challenges that were more specific to certain locations. Although participants did offer many locations for exploration, due to time restrictions, it was only possible to explore the more specific challenges in some of them. Based on popularity and apparent necessity of use, the locations discussed were train stations, airports, and bus stations (collectively termed 'transport hubs'), as well as restaurants, cafes, shopping centres, supermarkets and shops (collectively termed 'shopping environments').

The 'transport hubs' were reported to present the following challenges to B/VI navigators:

Train Stations

1. Finding ticket office in unfamiliar stations
2. Navigating to the correct platform in larger stations
3. Unexpected platform changes (at both destination and departure stations)

Bus Stations

1. Inaccessible signage
2. Finding the appropriate bus bay
3. Lack of staff

4. Unexpected bay changes (at both destination and departure stations)

Airports

1. Finding check-in desk
2. Reading monitors to determine departure gate
3. Environment pace increases stress
4. Environment scale prevents familiarisation

The transport hub locations shared many common difficulties, such as finding an initial point of contact when entering the location (e.g finding the ticket desk at a train station or check in desk at an airport), determining the departure point for one's journey (platform, gate, bus bay), and were also susceptible to significant disruptions that could invalidate the prior preparation made by a B/VI navigators (platform/bay changes at point of departure and destination).

The 'shopping environments' were found to present the following challenges:

Restaurants and Cafés

1. Finding the counter
2. Unexpected obstacles (tables and chairs)

Shopping Centres

1. Discovering stores
2. Lack of landmarks, both auditory and physical
3. Crowds
4. Echoes
5. Store closures

supermarkets and Shops

1. Finding Products
2. Finding the checkout

Investigating the challenges faced by B/VI navigators also provided some insight into the effects that navigation challenges have on the quality of life of B/VI people. The main effects observed were a general aversion to indoor navigation due to its perceived difficulty, and an aversion to travelling to new places (or exploring more familiar ones) due to personal safety concerns and fears of becoming lost.

17.1.2 Investigating User Needs

The literature review pointed out that the field of B/VI navigation aid development has a long-standing issue with designs not addressing the full scope of needs that B/VI navigators have for the navigation aids, and thus navigation aids tend to have low adoption rates (Giudice & Legge, 2008; Gori et al., 2016; Padmanaban & Krukar, 2016; Sanchez & Elias, 2007). The next major step of the work behind this thesis was to determine what these needs may be.

Using Hassenzahl (2007)'s framework which presents products as having both pragmatic and hedonic qualities, I divided the needs that B/VI navigators may have for their navigation aids into pragmatic and hedonic needs. I define the term 'need' as a desirable quality. Hedonic needs, for example, are hedonic qualities that my B/VI participants expressed as being desirable for their navigation aids.

This lead to the following two aims:

Aim 2: To understand the pragmatic needs that B/VI people have for their navigation aids (functional, usability, and commercial needs)

Aim 3: To understand the hedonic needs that B/VI people have for their navigation aids

In chapters 8, 9, and 10, I addressed my second aim (Aim 2), which was to understand the pragmatic needs that B/VI people have for their navigation aids. Hassenzahl (2007) defines pragmatic qualities as qualities that help users to achieve 'do goals', and the term includes both functional qualities and usability qualities. Noting how important it is for aids to succeed commercially if they are to have a positive impact, I added to this definition the commercial qualities of the aid, which are the factors that contribute to the commercial success of an aid from the perspectives of both the customer and of industrial collaborators.

Identifying Functional Needs

In chapter 8, I focused on curating the functional needs that B/VI people may have for their navigation aids. I began by developing a model of sighted navigation based on the navigation literature (fig. 8.3). This allowed me to view navigation as a normative 'system' with various underlying components that work together to precipitate the phenomena we know as navigation. Then, by synthesising the literature on navigation (chapter 2), the literature on B/VI navigation challenges (chapter 3), and the data from my interviews, I was able to create a descriptive model of B/VI navigation (fig. 8.4) and compare it to the model of sighted navigation to see which areas of the navigation 'system' are impaired by sight loss. Approaching the task in this way allowed me to conceptualise the various ways in navigation aids help their users from the purely functional perspective of completing the navigation task. I was able

to demonstrate that sight loss affects one's ability to familiarise themselves with new locations, to perceive their environment, to avoid obstacles, to orientate themselves and to determine routes from their current location to their destination. In essence, sight loss negatively affects all areas of navigation system. Table 8.2 breaks these headings down into a set of 13 functional needs that a B/VI person may have for their navigation aids. From this, we learn that, depending on which area of the navigation'system' the aid is intended to provide support with, navigation aids will be useful to B/VI people on a functional level if they:

Familiarisation

1. Support landmark learning
2. Support route learning
3. Support direct survey learning

Environmental Perception & Obstacle Avoidance

4 Assist obstacle detection

5 Assist obstacle avoidance

6 Increase access to textual information

Orientation and Wayfinding

7. Provide location information
8. Provide heading information
9. Provide bearing information
10. Provide distance information
11. Assist route planning
12. Provide route guidance

Sighted Assistance

13. Support attraction of sighted assistance

Having the above list of functional needs is valuable When designers are considering how to address a particular navigation challenge, as it helps designers to focus on which parts of the 'system' of navigation may benefit from reinforcement in order to alleviate the challenge, and it also presents a variety of ways to reinforce a given part of system of navigation.

Identifying Usability Needs

In chapter 9, I used data from my interviews with B/VI people and another interview with two employees from Wayfindr to identify the usability needs of B/VI people.

The usability needs mentioned in that chapter were:

Confirmed from Literature

1. Preferred I/O modalities are either purely auditory or a combination of auditory and haptic information
2. Information should be a simple as possible
3. Aids should use accessible language
4. Aids should afford the user control over the level of detail their aid provides.
5. Usage of the aid shouldn't obstruct the user's hearing or occupy both of their hands
6. Usage of the aid should fall in line with the user's pre-existing orientation and mobility training and behaviour
7. Aids should be easily portable

Usability of Device

8. The aid should have an easy setup procedure from a B/VI perspective, both when first initialised and upon every use
9. It should be easy to learn how to use the aid from a B/VI perspective
10. The aid should only rely on technology that is already commonly in use among the B/VI population

Usability of User Interface

11. The user interface should be generous in its use of redundant space
12. The user interface should employ high levels of colour contrast
13. The user's interaction with the device should be highly consistent and predictable

Identifying Commercial Needs

I also used data from these interviews in chapter 10 to understand the commercial factors that are important to the success of a navigation aid from both a customer and industrial perspective.

These factors were:

Customer-facing

1. The device should be well-marketed so that B/VI people can discover useful navigation aids more easily.
2. Information used/provided by the device, such as digital maps, should be kept up-to-date

3. The device should be affordable to B/VI people

Non-customer-facing

A. Stable Collaborations

4. The various roles and responsibilities for all parties in the collaboration should be clear
5. The responsibilities of third parties should be easy to fulfil
6. The collaboration should be commercially beneficial for third parties

B. Legal

7. The safety risks of the device should be considered, as well as where any liability would lie in the case of an accident.
8. Any personal data collected by the device should be managed in accordance with relevant data privacy laws

Identifying Hedonic Needs

In chapter 11, I addressed my third aim (Aim 3) which was to understand the hedonic needs that B/VI people have for their navigation aids. I found no new needs here, but data from my interviews with B/VI participants did confirm the needs that are already present in the literature (see Giudice and Legge (2008), Shinohara and Wobbrock (2011), Williams et al. (2013), Slade and Edwards (2015)).

These needs were:

1. The aid should not increase the user's level of social stigma.
2. The aid should be discreet when being used and not attract extra attention to the user.

3. The aid should be concealable when not in use.
4. The aid should be conducive the the user's personal confidence and independence.
5. The aid should not make the user more vulnerable to theft.

17.1.3 Condensing the findings into a set of ideation cards and evaluating their performance

Creating the cards

Aim 4: To condense the findings from the previous three aims into a set of ideation cards, and determine the suitability of the cards for generating and evaluating navigation aid ideas.

In part III and part IV, I addressed my fourth aim (Aim 4), which was to condense the findings from the previous three aims into a set of ideation cards and determine the suitability of the cards for generating and evaluating navigation aid ideas.

In part III, I discuss how I condensed the needs mentioned above into a set of ideation cards (the VI Nav Cards), by following Golembewski and Selby's (2010) five-step method for developing an ideation deck. I also presented a discussion of how the VI Nav cards are intended to be used to conduct an ideation session (see table 12.6).

As discussed in chapter 5, the main reasons for choosing to ideation cards over other methods of democratising academic design knowledge, such as using design guidelines, was their utility in creative design sessions (Wetzel, 2017) and their ability to help designers to concepts relevant to a given design space that may otherwise be forgotten or under-addressed (Ojala et al.,

2015).

Evaluating the cards

To evaluate the cards, I conducted two trials with a total of seven human factors researchers, a trial with three executives of Guide Dogs charity, and conducted a further interview with one VI person. In part IV, I discuss the feedback that I received from conducting trials with the cards, and discussed how the cards can be improved. Overall, the cards were received positively and were found to be useful in generating and evaluating navigation aid ideas for B/VI people. Primary reasons for this were the clear and orderly structure of the gameplay, the (perceived) comprehensive coverage of the design domain by the game's decks, and the (perceived) comprehensive coverage of each of those decks by their respective cards.

Two major improvements that can be made relate to the user cards, and the tech cards.

In their current state, the cards require players to generate user personas from a set of "user cards". These user cards only present a very coarse set of parameters for players to choose from, as, in absence of other resources, they were developed from my personal impressions of the differences between my B/VI participants. Because the personas developed using the user cards can be coarse, players can be left without sufficient contextual information to make suitable choices between different technologies in the tech cards phase. Moreover, because the qualities in the user cards I present are based on my small sample size of B/VI participants, it is hard to be sure that a persona produced using them will be representative of a decent segment of the wider B/VI population.

As mentioned in part IV, participants' use of the tech cards was heavily in-

fluenced by the clarity of the personas. At present, due to the fact that the personas are rather coarse, some participants found it difficult to choose between similar pieces of technology when developing a design idea. Improving the quality of the personas would help alleviate this issue, but the structure of the deck of tech cards, and its content, could also perhaps benefit from having a clearer method of use.

Due to the level of detail in the feedback provided, the reader is kindly referred to chapter 15 for more information regarding the cards' strengths and areas for improvement.

Investigating how the cards could be made accessible

Aim 5: To understand how ideation cards can be made accessible to B/VI people.

Feedback from trial sessions was used to provide suggestions for improving the cards in future iterations. One key focus of doing this evaluation of the cards was to gather a set of suggestions for how the cards may be made accessible for use by B/VI people, which was the fifth and final aim of this thesis (Aim 5).

In chapter 16, I evaluated the various suggestions made by trial participants to suggest a list of potential methods of making ideation cards accessible to B/VI players. These suggestions apply not only to my cards, but to ideation card methods in general. Again, due to the level of detail, the reader is kindly referred to chapter 16 for more information.

17.2 Main Contributions

17.2.1 A Set of Ideation Cards that Support B/VI Navigation Aid Design

The primary outcome of this thesis is a new set of ideation cards that can be used to support the ideation and evaluation of navigation aids for the blind and visually impaired. By taking the wide range of pragmatic and hedonic needs that B/VI people have for their navigation aids and packaging that information in a way that is conducive for use in creative design sessions, the cards offer a significant step forward for addressing the long-standing low adoption rates that B/VI navigation aids experience.

17.2.2 Identification of Location-Specific challenges

One contribution of the needs-collection phase of my research (part II) was the presentation of the challenges that B/VI face in specific environments. As mentioned, discussion of B/VI navigation challenges in the literature has only focused on discussing the challenges faced “outdoors’’ and “indoors’’ in general, with no discussion of the contextual challenges that occur in particular environments. It is important to do so, however, as “indoor” and “outdoor” environments, although distinct groups, are far from homogeneous categories.

Recognising the same gap that I did, following the completion of my analysis, Jeamwatthanachai et al. (2019) published a paper which focused on the navigation challenges that B/VI people face in specific types of environments. Jeamwatthanachai et al. conducted structured survey-style interviews with a total of 45 participants. 30 of these participants were visually impaired

and the remaining 15 were a mix of sighted guides, orientation and mobility (O&M) instructors, and developers and researchers across a range of fields including human computer interaction, accessibility, assistive technology, and interior design for the elderly and disabled.

Jeamwatthanachai et al. discussed the challenges faced in several environments, including: Universities, Hospitals, Shopping Centres, Supermarkets, Shops, Museums, Cafes, Airports, Train stations, Libraries, and Auditoriums. The locations discussed by Jeamwatthanachai et al. cover the majority of locations that I discussed, except for my discussion of bus stations, which Jeamwatthanachai et al. didn't cover.

However, due of the quantity of locations that Jeamwatthanachai et al. cover, they were only able to cover the locations at a high-level. Jeamwatthanachai et al.'s high-level coverage is also partly due to their use of survey-style (structured) interviews, as opposed to my use of more in-depth semi-structured interviews. Although there is overlap between the locations we discuss, the challenges we report are often different: sometimes Jeamwatthanachai et al. discuss challenges that I was not able to detect, and sometimes I discuss challenges that they were unable to detect.

For example, in train stations, Jeamwatthanachai et al. mention that B/VI people struggle to board the train due to difficulties seeing the platform edge. They also mention that physical landmarks in train stations may be occluded by the presence of large crowds. While I didn't discuss these two challenges in my coverage of train stations, I did capture other issues that Jeamwatthanachai et al. did not; consider the issue of trains arriving at unexpected platforms, for example. Similar comparison can be drawn for the other locations that we both discuss.

Indeed, both of our discussions on the challenges faced by B/VI people in particular indoor environments contribute sets of original points for consider-

ation, and both of our works encourage the field of B/VI navigation aid design to consider the impacts of environments more closely.

17.2.3 Identification of Commercial Factors Related to Navigation Aid Success

Another outcome from part II is the identification of commercial factors related to navigation aid success. There is currently no such consideration of the commercial factors surrounding B/VI navigation aid design in the literature, yet it is important to consider these factors if prototypes are to go on to become successful products and impact the lives of their users. Considering these issues as early as possible in the design process lowers the cost of alterations, and packaging these needs among my ideation cards is therefore a valuable contribution.

17.2.4 Demonstrating the Use of Ideation Cards to Rigorously Evaluate Ideas

A unique feature of my cards is that they provide a research-backed way of evaluating navigation aid ideas. Others in the literature, such as Olsson et al. (2013), have noted the capability of ideation cards to foster better design evaluation of concepts. That said, I believe that my VI Nav Cards are the first to integrate into the gameplay a structured method of conducting this evaluation using a set of research-backed evaluation points.

Moreover, in the literature, decks of ideation cards are typically only used at a specific point in the design process, which is usually the very beginning (Wölfel & Merritt, 2013). My cards, however, particularly the evaluation deck, can be used at various points in the design pipeline to check that the

design is not falling into common mistakes as the design progresses. This usage can even be used to evaluate aids after they are finished products.

Section 14.2.1 demonstrated that this is also true when evaluating pre-existing third-party aids, which is particularly useful for organisations such as Guide Dogs or the RNIB, who may wish to make recommendations of viable tools to their service users. By using the evaluation cards to ensure that there are no obvious issues with the aids they come across, they can more quickly come to a decision about whether they should recommend particular aids to their service users.

This feature of my cards, therefore, demonstrates the potential for a set of context-specific ideation cards to be used at multiple points in the design process, which is a new perspective in the ideation card literature.

17.2.5 Identification of Methods for Making Ideation Cards Accessible to B/VI People

Another contribution of this thesis is a set of recommended methods for how to make ideation cards accessible to B/VI people, presented in chapter 16. This topic has not yet been discussed in the ideation card literature, and my thesis presents the first set of best-practices on the topic.

17.3 Limitations

In terms of limitations of this work, one limitation is that the sample sizes I have been using are small. It is worth noting that, as this thesis required qualitative methodologies, my intention was not to aim for a large and representative sample of participants, but to identify a rich set of ecologically valid

and important needs that B/VI people have. I believe that this has been achieved. Moreover, by endeavouring to confirm and incorporate the findings from the literature, it is worth noting that many of the contents of the cards are not based on the statements of my participants alone, but are also based on the statements of many other participants from the studies in the literature. Having a larger sample size may always result in the identification of more needs, but I believe that I have captured the most common and important ones. A potential avenue of future work for the academic community may be to explore what further needs may exist.

Another limitation is that the work in this thesis has mostly focused on pedestrian navigation of B/VI people within indoor contexts in the UK.

Due to this thesis taking a focus on pedestrian navigation, it does not discuss of various navigation challenges that B/VI people may face while aboard public transport, such as challenges in knowing which stop is coming next while on a bus or the challenges in finding the buttons to open the doors on a train. These are nonetheless very important issues that need to be addressed in order to facilitate seamless end-to-end travel for B/VI navigators.

Moreover, the challenges faced by B/VI people in the UK may not be the same in other countries, which may have different accessibility features available for B/VI people in certain types of environments. It may be the case that some challenges mentioned in this thesis for a given environment do not apply to other countries, or it may be that B/VI people in other countries face challenges that I have not been able to detect in a UK-based context.

Furthermore, I have only been able to explore the challenges for the locations that were mentioned by my participants. As stated in chapter 7, many different locations were mentioned by my participants, but the challenges that were reported to occur there were only contextualised instances of more universal challenges. For example, P8 mentioning that he falls over chairs

in his local council house is better considered as the universal challenge of "unexpected obstacles" being applied to his local council house rather than a specific issue with council houses per se. That said, it may have been the case that there *are* specific navigation challenges that only occur in council houses, or in doctor's surgeries, offices, or any the other locations that participants brought up but only mentioned what I have classed as 'universal challenges' applying there. Although it would undoubtedly be valuable, a detailed investigation of the challenges in each of these locations was not possible to achieve within the scope and resources of this project.

Another limitation of my work is that I only conducted three trials with the cards. Although others in the literature have also relied on three trials, such as Beck et al. (2008), others have conducted far more trials to test their cards, such as Hornecker (2010) who conducted ten. At this early stage of their development, conducting three trials for my cards is reasonable and has allowed many issues to be raised; however, as the cards and gameplay become more refined, it would be wise to conduct an increasing number of trials to check for quality, perhaps using Hornecker's ten trials as an ideal target number.

17.4 Future Work

This thesis opens up several strands of future work. Firstly, there is the need to act on the feedback from the trial sessions and to conduct future trials to improve the performance of the cards. As mentioned above, the major improvements that can be made to the cards fall into three areas: the user cards, the tech cards, and accessibility.

In their current state, the user cards only present a very coarse set of parameters for players to choose from which can leave players without sufficient

contextual information to confidently choose between different technologies in the tech cards phase. To address this limitation, I propose that, similar to the work by Williams et al. (2013), a significant body of future work should involve developing richly detailed and representative personas of potential B/VI users. Because doing this in a satisfactory way will require very large sample sizes, I call on the the larger organisations and charities, such as Guide Dogs or the RNIB, to collaborate with the academic community in this regard.

Secondly, although the trials showed that the use of the tech cards could be improved by providing richer personas, the structure of the deck of tech cards, and its content, could also benefit from being developed using a more rigorous method. By consulting technologists and engineers, I propose that the content and use of the tech cards be updated so that it better structured, which will help to reduce overwhelm for players with less technical experience. Key parts of this work would be to gather pieces of technology for inclusion, perhaps using brainstorming focus groups, and to also developing an improved way of taxonomising the various pieces of technology.

The cards should also be made accessible to B/VI players following the methods recommended at the end of chapter 16. After making the relevant changes, follow up trials will need to be conducted with B/VI people to test whether the cards have indeed been made accessible, and it would be interesting to investigate whether, after making the changes discussed in chapter 16, the cards could be used by an all B/VI design team. It would also be valuable to test the cards 'in the wild' with navigation aid designers, whereby the designers would actually use the cards to create new design ideas, and also to evaluate any of their pre-existing design ideas.

In terms of the broader avenues of future work, the approach taken to produce this set of cards for the B/VI community could be extended to support

people with other types of physical disabilities, such as people who are deaf-blind. It may not be necessary to focus only on navigation challenges, however. There are many groups of people who have needs that are less well understood (such as people with mental disabilities like autism and dementia) and by following a similar method to what I have adopted in this thesis—i.e, determining the pragmatic and hedonic needs of under-represented users in a particular domain, and then producing a set of ideation cards to allow designers to better consider those needs— there is likely a lot of positive impact to be had in the fields of accessibility and accessible/inclusive design.

Moreover, during our personal communications, Guide Dogs expressed interest in using the cards to develop a navigation aid recommendation system. By using the various decks in the VI nav cards, it may be possible to identify which navigation functions certain navigation aids provide, which pragmatic and hedonic needs they satisfy, and which locations they are suited for it. This information may make it possible to develop a filterable database of navigation aids that can be used to provide personalised recommendations of navigation aids to B/VI people based on their personal needs and lifestyle. Such a system may help B/VI people discover navigation aids that can help them in their lives, help Guide Dogs provide an even better service to their service users, and help navigation aid designers to better reach their target markets. All together, this is likely to make it easier for navigation aids to enjoy higher adoption rates, and make a greater impact on the lives of the blind and visually impaired.

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Appendices

Appendix A

Study Questions

A.1 Questions for B/VI Interviews

1. What eye condition do you have?
2. How long have you had that condition?
3. Tell me what your vision is like – Do you have much central or peripheral vision? Can you detect a friend at across a room/at arms length/close to face? [If no to both] Can you detect light levels?
4. So starting at your home, walk me through what an average journey is like for you.
5. If we consider indoor public spaces to be places such as shopping centres, train stations, airports, restaurants/cafes, leisure centres/gyms, museums and so on, which of these do you tend to travel to and how often?
6. Are there any indoor locations that you would like to travel to but don't? Why not?
7. [repeat for several commonly-travelled and rarely-travelled locations] What are some common issues and challenges you face when travelling in <location>?
8. What assistance, if any, do you require from members of staff or the general public when travelling in an indoor environment?
9. [If Yes to previous question:] How do you feel when you require assistance? How satisfying do you tend to find the assistance that you receive? How easy is it to get assistance?
10. Tell me how you might prepare for a trip to a new indoor location that you were unfamiliar with. What tools or resources are there for you to use to prepare?

11. Imagine that you have just arrived at a new indoor location for the first time? How are you feeling? What is going through your mind?
12. What would you do first?
13. Tell me a bit about how you orient yourself in a new place and know what is around you.
14. Once you arrive at the unfamiliar indoor location, are there any ways to get information once you are there apart from asking other people?
15. Do you tend to explore new places or do you tend to just go for what you came for without much deviation? Why?
16. [rephrase this question if participant is congenitally blind] Since becoming visually impaired, How did you get around indoors before you got your <base navigation aid>? What is different since having your <base navigation aid>?
17. What are your opinions on using technology for navigation?
18. [If participant is pro technology] What considerations would you need to make when deciding whether a piece of technology was suitable to help you navigate indoors or not?
19. [If participant is against technology] What would a piece of technology have to be like or have to do in order for you to use it?
20. What would you need to consider if you wanted to use technology while also using your <base navigation aid>?
21. How would it be easiest to operate the technology while travelling indoors with your <base navigation aid>?
22. Is it possible that there could be something about the technology that could interfere with how you currently use your <base navigation aid>?
23. What information or assistance that you currently receive from other people do you think you could get from technology instead?
24. What makes a navigation aid ‘good’?
25. What makes a navigation aid ‘bad’?
26. Imagine for a moment that there was a piece of technology that could solve all the problems that you currently have navigating indoors. What would it be like and do? How would it feel to have such a device? What would you do differently? How would it affect your life?
27. Describe for me the characteristics of a perfect piece of technology that would make indoor navigation easier for you but also not interfere with how you currently work with your <base navigation aid>.

A.2 Questions for Wayfindr Interview

1. What role do you think developments in the indoor navigation industry can play in the lives of B/VI people?
2. What is the current state of the B/VI indoor navigation aid industry?
3. What are some key challenges that the B/VI indoor navigation industry is facing at the moment?
4. What are some key opportunities in the industry, both at the present time and in the foreseeable future?
5. Where do you see the state of the technology being in the the next 5, 10 and 15 years?
6. What are some key factors that navigation aid designers need to address in order to ensure the successful implementation of their designs?
7. What are the key challenges that may be encountered when trying to install a system for use by B/VI people in an environment?
8. What would need to be in place to satisfy these stakeholders?
9. More specifically, what would stakeholders in charge of the approval of the installation of an indoor navigation project need to be assured of in order to give their approval?
10. What are some important pieces of technology that a novice designer might like to be aware of when building a tool for indoor navigation?
11. What considerations need to be made to make an aid as usable as possible for B/VI people?
12. In general, what makes an indoor navigation aid “good”?
13. In general, what makes an indoor navigation aid “bad”?
14. In general, what makes an indoor navigation aid “great”?
15. Show the needs that B/VI people said. Ask for comments/discussion/opinions.
16. Show what B/VI people said make good/bad/great aids. Ask for comments.
17. Any closing remarks?

A.3 Card Evaluation Questions - Sighted Participants

1. Gameplay
   (a) How did you find the session in general?
   (b) What worked and what didn't?
   (c) Did using the cards help you to ideate concepts? Why?
   (d) Did the overall gameplay structure make sense?
   (e) Did you understand the purpose of the different steps?
   (f) Did you get lost at any point? Where? How could that stage have been improved?
   (g) Was the game enjoyable?
   (h) General likes/dislikes/comments about the experience?
   (i) Is using ideaiton cards an appropriate method in this context?
2. Card Categories
   (a) What are your thoughts about the card categories?
   (b) Are the purposes for each card category clear?
3. The cards themselves
   (a) Do you think the card categories provide a useful representation of factors relevant to designing a navigation aid?
   (b) How well did the cards represent their intended categories?
   (c) How complete are each of the decks? Can you think of something that is missing?
   (d) Were any cards in the wrong category? Where should they be moved to?
   (e) Are there any cards that don't make sense? Which ones and why?
   (f) Are there any cards that you think are irrelevant? Which ones and why?
   (g) What do you think of the card design? How could it be improved?
4. Accessibility
   (a) How can we make the gameplay accessible to B/VI people?
   (b) How can we make the card content accessible to B/VI people?
   (c) How can we make the booklet accessible to B/VI people?

A.4 Card Evaluation Questions - VI Participant (P8)

1. Eye Condition
   (a) What eye condition do you have?
   (b) How long have you had that condition?
   (c) Tell me what your vision is like – Do you have much central or peripheral vision? Can you detect a friend at across a room/at arms length/close to face? [If no to both] Can you detect light levels?
2. Cards
   (a) What are your first impressions of the cards as a way of supporting B/VI navigation aid design?
   (b) The game aims to help designers create specific aids for specific challenges. What are your thoughts on this approach?
   (c) What are your thoughts on the validity of the issues presented by the cards?
   (d) Can you notice any issues that are missing that I should include?
   (e) Are the card categories suitably comprehensive? Did you notice any gaps?
3. Gameplay
   (a) What are your thoughts on the gameplay?
   (b) Do you have any suggestions for making the gameplay easier or more effective for a B/VI player?
   (c) Some other participants have mentioned using a board to help structure the gameplay. What do you think of this idea? How could that board be made accessible to B/VI players?
   (d) Other participants have also mentioned using physical props to represent the technologies. What do you think of this idea?
4. Booklet
   (a) How might the booklet be made accessible?
5. Discussion of accessibility suggestions made by non-VI participants
   (a) What are your thoughts on using text in larger font and high contrast image on the back of each card.
   (b) What are your thoughts on using Braille on the cards (how could this be done?)
   (c) What are your thoughts on making cards readable by text-to-speech software (for phones, etc.)

(d) What are your thoughts on having digital versions of the game contents that B/VI people could memorise themselves ahead of a session?

(e) What are your thoughts on having a PowerPoint version of the cards that could show enlarged versions of the cards on a screen?

Appendix B

Copy of Cards

B.1 User Cards



PERSONAL QUALITY

Sight Quality

Is your user blind or partially sighted?



PERSONAL QUALITY

Gender

What gender is your user?



PERSONAL QUALITY

Specific Personal Concerns

Has your user been a victim of theft in the past?
Are they sensitive to social stigma? Are they anxious around crowds?

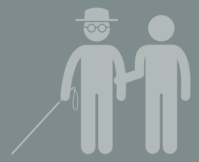


PERSONAL QUALITY

Age

Is your user a child, a teenager, an adult, or a senior?

B.2 Base Aid Cards



BASE NAVIGATION AID

Sighted Aid

A kind-hearted human being who will "be the eyes" of your user



BASE NAVIGATION AID

No Aid

The user will use no other aids



BASE NAVIGATION AID

White Cane

A trusty stick used to detect obstacles and understand the terrain



BASE NAVIGATION AID

Guide Dog

A fluffy companion used to avoid obstacles, find doors, and navigate steps

B.3 Location Cards



LOCATION

Friend's House

A cosy place to visit a friend



LOCATION

Cinema

A place to watch a movie



LOCATION

Bus Station

A central location for catching a bus



LOCATION

Doctor's Surgery

A place to get help for minor medical conditions



LOCATION

Café

A place to catch up with friends



LOCATION

Bank

A place to manage your finances



LOCATION

Community Centre

A place where community events are held



LOCATION

Bus Stop

A point along a bus route where you can catch a bus



LOCATION

Airport

A place where you can catch a flight

B.4 Challenges Cards



Universal Challenge

Echoes

Wait, is that sound coming from over there, or from over there?



Specific Challenge - Shopping Centres

Discovering Stores

What stores are in this place? I hope I'm not missing out...



Universal Challenge

Crowds

Will they bump into me? Am I safe? Why are they so loud?



Universal Challenge

Doors

Which way does it open? Where's the handle?



Specific Challenge - Train Stations

Determining the Platform

I need to get the 14:40 train to Good-Town.
Which Platform will that train be on?



Specific Challenge - Airports

Checking In

Where's the check-in desk?



Universal Challenge

Disruptions

Why is that way closed? Why is the lift broken?
I haven't learned any other routes!



Specific Challenge - Airports

Determining the Gate

I can't read the displays, so how do I know what my gate is?



Universal Challenge

Arranging Sighted Assitance

Where's the reception desk? Can somebody help me?



Specific Challenge - Bus Stations / Stops

Is That My Bus?

I hear a bus coming, but is it the one I want?



Universal Challenge

Finding Toilets

Where are the toilets?



Specific Challenge - Shopping Centres

Finding Stores

I've heard there's a Widgets R Us store in this place. Now... where might it be?



Specific Challenge - Train Stations

Getting to the Platform

So my train is on platform 3... where is platform 3 again?



Specific Challenge - Restaurants / Cafes

Finding the Counter

Where do I place an order?



Specific Challenge - Shops

Finding Products

Where's the milk?



Specific Challenge - Airports

Getting to the Gate

So my flight departs from gate 24... where is gate 24 again?



Specific Challenge - Shops

Finding the Checkout

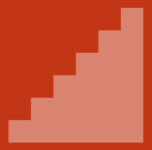
So, where do I pay?



Specific Challenge - Cinemas / Theatres

Finding an Available Seat

I hope I don't sit on someone...



Universal Challenge

Stairs

How many steps are there? Where is the handrail? Will I fall?



Universal Challenge

Noise

I can't hear the cues I use to navigate!



Universal Challenge

Lighting Levels

A: It's too dark in here! B: No, it's too bright!



Specific Challenge - Train Stations

Purchasing Tickets

Where's the ticket desk?



Specific Challenge - Bus Stations

Navigating to Bus Stop

How do I find my bus stop in this place?



Universal Challenge

Layout Changes

I don't remember this being here...



Specific Challenge - Trains

Pulling in on the wrong platform

This should be Platform 7... but this doesn't seem like Platform 7



Universal Challenge

Low Colour Contrast

I wish they would make better use of my remaining vision!



Specific Challenge - Shopping Centres

Lack of Landmarks

It's just a big wide open space



Specific Challenge - Train Stations

Unexpected Platform Change

The train is supposed to pull in here on Platform 4... but now it's going to Platform 14. How do I get there?!



Universal Challenge

Unexpected Obstacles

Who put this here?!



Specific Challenge - Bus Stations

Unexpected Bay Change

Normally we pull into Bay 4... but this is Bay 17.
I don't know how to navigate from Bay 17!

B.5 Navigation Function Cards



NAVIGATION FUNCTION

Provide Location Information

Helps the user to localise themselves within the environment



NAVIGATION FUNCTION

Provide Bearing Information

Helps the user know where other things are relative to themselves



NAVIGATION FUNCTION

Assist Route Planning

Helps the user to plan a route to their destination



NAVIGATION FUNCTION

Provide Heading Information

Helps the user know which way they are facing



NAVIGATION FUNCTION

Improve Access to Text

Helps the user to access textual information



NAVIGATION FUNCTION

Assist Obstacle Detection

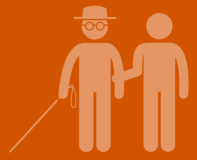
Helps the user to detect potential obstacles



NAVIGATION FUNCTION

Provide Distance Information

Help the user to determine distances to places or objects



NAVIGATION FUNCTION

Assistance Attraction

Helps the user to get assistance when they need it



NAVIGATION FUNCTION

Assist Obstacle Avoidance

Helps the user avoid obstacles, without the user even needing to know that they exist



NAVIGATION FUNCTION

Support Route Learning

Help the user to discover and learn routes



NAVIGATION FUNCTION

Support Landmark Learning

Help the user to discover and learn landmarks



NAVIGATION FUNCTION

Support Survey Learning

Help the user to learn environment layouts



NAVIGATION FUNCTION

Provide Route Guidance

Helps the user follow a route

B.6 Tech Building Block Cards



COMMUNICATION

Long-range Communication

Communication with no specific upper range limit
(The Internet, Cellular Networks, Satellite Communication, etc.)



INPUT

Camera

A device for capturing visual information as images or videos



OUTPUT

Bone Conduction Headphones

A way of outputting sound information discreetly, and without obstructing the user's hearing



OUTPUT

Heatpad

A way of providing feedback through heat



INPUT

Buttons

A component that performs a specific action when pressed



SYSTEM

Announcement System

A system of loud speakers used to broadcast information to a large number of people



INPUT

Digital Compass

A component that allows a device to be oriented relative to the global cardinal reference frame (North, East, South, West)



OUTPUT

Braille Reader

A device that can represent static or dynamic information in braille



INPUT

Accelerometer

A component that can be used to measure acceleration, and also to help electrical devices know their orientation in 3D space



INPUT

Radar

A way of using radio waves to detect the presence of physical objects



OUTPUT

Motor

A way of rotating physical parts or creating vibrations



SYSTEM

Microsoft Hololens

Self-contained holographic computer which enables you to engage and interact with holograms in the world around you



INPUT

Pressure Pad

A way of using physical force as an input to a system



INPUT

Motion Sensor

A way of detecting motion in the environment



INPUT

Microphone

A way of capturing sound input, perhaps someone's voice, and converting it into an electrical signal



SYSTEM

ORCAM

A camera that can be mounted on spectacles to help the user read text, recognise faces, determine colours, and more



SYSTEM

Microsoft Soundscape

Soundscape uses 3D audio cues to help you to build a mental map and make personal route choices within unfamiliar spaces



COMMUNICATION

Medium-range Communication

Communication within the range of a Local Area Network (WiFi, Bluetooth, Zigbee, Ultra-Wideband, UV, Infrared, VLC, etc.)



SYSTEM

Virtual World

A world created in virtual reality. Among other things, these can help users to remotely familiarise themselves with a target location



OUTPUT

Speakers

A way of outputting sound information. Less discreet than headphones.



COMMUNICATION

Short-range Communication

Communication that requires devices to touch (NFC, RFID, etc.)



INPUT

Touch Screen

A display which allows the user to interact with a device by touching areas on the screen



SYSTEM

Smartphone

A mobile phone that performs many of the functions of a computer



SYSTEM

Satellite Navigation

Many satellite navigation systems, such as GPS, allow navigators to be localised at any point on the globe. Not fully available indoors.



SYSTEM

Tactile Map

A map of a location that is designed to be explored by touch



INPUT

Slider

A widget allowing the user to select a value on a sliding scale



INPUT

Rotary Knob

A widget allowing the user to select a value on a circular scale



INPUT

Web API

A way to access live data from an online database or service

B.7 Evaluation Cards



USABILITY QUALITY

Easy to Learn

Is it easy to learn how to use the device?



HEDONIC QUALITY

Doesn't Attract Theft

Could the perceived value of the aid attract thieves?



HEDONIC QUALITY

Concealable

Can the aid be concealed when not in use?



USABILITY QUALITY

Doesn't Rely on Screen

Does the interface avoid relying on a screen and textual information?



HEDONIC QUALITY

Discreet

Does the aid avoid drawing attention to its user?



USABILITY QUALITY

Comfortable

Is the device comfortable to use?



USABILITY QUALITY

Doesn't Obstruct Hearing

Does the aid leave the user's hearing free to focus on other things?



COMMERCIAL QUALITY

Data Privacy

What personal data will the aid require? How will you keep it safe?



USABILITY QUALITY

Accessible Language

Is the interface communicating using concepts that are meaningful to your user?



HEDONIC QUALITY

Non-Stigmatising

Does the aid avoid making the user look strange?



COMMERCIAL QUALITY

Legally Compliant

Does the aid comply with all appropriate standards and policies?



USABILITY QUALITY

Good Colour Contrast

Does the interface have good colour contrast?



USABILITY QUALITY

Leverages Previous Training

Does the aid leverage the user's previous mobility training?



USABILITY QUALITY

Leaves a Hand Free

Does using the aid leave the user with at least one free hand?



COMMERCIAL QUALITY

Established Infrastructure

Does the aid require any infrastructure to be in place? Who will install it? Who will maintain it?



COMMERCIAL QUALITY

Legally Covered

Who is liable in case of a technical fault or accident? Will you need insurance? What type?



COMMERCIAL QUALITY

Kept Up-To-Date

Is the information the aid provides kept up-to-date?



USABILITY QUALITY

Easy to Set Up

Is the device easy to set up?



USABILITY QUALITY

Simple Interface

Is the interface simple to use?



HEDONIC QUALITY

Provides Independence

Does the aid free the user from relying on others?



USABILITY QUALITY

Predictable Interaction Method

Is the aid used in the same way each time?



USABILITY QUALITY

Quick to Use

Is the interface quick to use?



USABILITY QUALITY

Provides Control Over Information Detail

Can the user control the level of detail that the aid provides?



USABILITY QUALITY

Portable

Is the aid easy to carry around?



USABILITY QUALITY

Provides Simple Information

Does the aid provide simple information?



HEDONIC QUALITY

Provides Confidence

Does the aid increase the user's confidence in their own abilities?



USABILITY QUALITY

Not Distracting

Does the aid avoid distracting the user?



USABILITY QUALITY

Works Reliably

Can the user rely on the aid to work whenever they need it?
Is the aid dependent on something that may become unavailable?



COMMERCIAL QUALITY

Suitable Responses to Technical Failure

What could go wrong with the aid? How would the issue be resolved?



COMMERCIAL QUALITY

Well-Priced

Are all the costs made clear to the customer? Are they reasonable?



COMMERCIAL QUALITY

Stable Collaborations

Does the aid require the collaboration of a third party?
What is their role, and what will they gain?



COMMERCIAL QUALITY

Well-Marketed

How will your users hear about the aid? Where will they get it from?
Is that place accessible?



USABILITY QUALITY

Spacious User Interface

Does the interface give the user plenty of space?

B.8 Blank Cards

Blank Card	Blank Card	Blank Card
Blank Card	Blank Card	Blank Card
Blank Card	Blank Card	Blank Card

Blank Card