Opportunities for Supporting Self-efficacy Through Orientation & Mobility Training Technologies for Blind and Partially Sighted People

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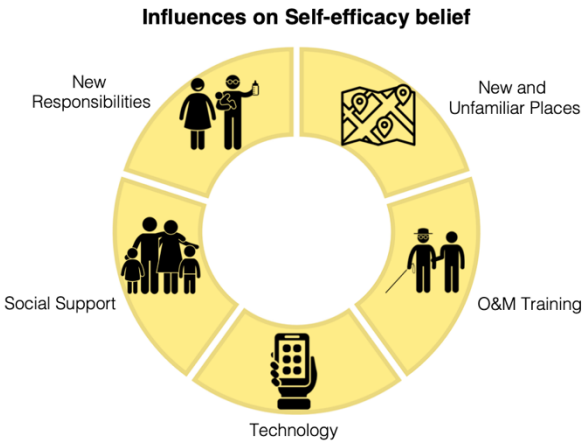

Figure 1: Factors that influence self-efficacy belief of blind and partially sighted people

Orientation and mobility (O&M) training provides essential skills and techniques for safe and independent mobility for blind and partially sighted (BPS) people. The demand for O&M training is increasing as the number of people living with vision impairment increases. Despite the growing research on O&M assistive technologies (AT), few studies have examined the experiences of BPS people during O&M training, including the use of technology to aid O&M training. To address this gap, we conducted semi-structured interviews with 20 BPS people and 8 Mobility and Orientation Trainers (MOT). The interviews were thematically analysed and organised into four overarching themes: Tools and Strategies for O&M training, Technology Use in O&M Training, Changing Personal and Social Circumstances, and Social Influences. Our findings show that the self-efficacy belief evolves over time and across different circumstances, therefore, requiring ongoing O&M support for BPS people. We discuss opportunities for accessibility research in multimodal technologies to increase access to and effectiveness of O&M training.

CCS CONCEPTS •Human-centered computing ~ Accessibility ~ Accessibility technologies

Additional Keywords and Phrases: Orientation and mobility training; self-efficacy; blind and partially sighted people

1 INTRODUCTION

Although a large number of the 2.2 billion people living with vision impairment are due to refractive errors and therefore easily correctable, the number of people who live with uncorrectable vision impairment and blindness is increasing, partially due to the ageing population, and is expected to triple by 2050 [12]. The leading causes of blindness in adults are age-related macular degeneration, cataract, diabetic retinopathy, and glaucoma. Vision loss can occur suddenly or develop over a long period of time and can either be present at birth or acquired later in life. Vision loss affects multiple domains of life as people depend on vision as the primary sense to integrate sensory information and a loss of vision can make it more challenging to perceive and create mental maps of the environment, especially for people who lose their vision later in life [25, 72]. Therefore, vision loss is an evolving challenge that requires significant adjustments to people's way of living.

Orientation and mobility (O&M) training is offered to blind and partially sighted people (BPS) to overcome the challenges related to mobility and to support the learning of independent life skills including developing safe, independent mobility and learning strategies for familiarization with one's surroundings. O&M training is delivered by qualified mobility and orientation trainers (MOT), also known as habilitation specialists and mobility instructors. O&M training focuses on the acquisition of skills and strategies necessary to complete daily activities and is often provided only at specific points in BPS people's life (e.g. at school [68]). Furthermore, the availability of continual support for adults in response to their deteriorating vision is severely limited – in the UK, only 17% of people are offered emotional support, 27% are in employment, 39% struggle to make ends meet, and 31% are rarely or never optimistic about their future [40]. Research shows that there's a strong association between O&M training and employment [11, 19, 27] - hence, it is ever more crucial to have continual O&M training and support.

Traditional ATs used in O&M training (e.g., long cane, guide dog) are now complemented with mobile apps that support better route planning and spatial awareness (e.g., Blindsquare[2], Soundscape[3], Lazarillo[4]) and problem solving (e.g., BeMyEyes[5], Aira[6]) and a growing number of different AT solutions, such as smart canes [7, 47] and wearable sensors [38], which have been developed to help increase the ease of mobility for BPS people. These newer technologies, however, are often not integrated into formal O&M training, due to lack of awareness and limited resources of many of the training programs [21]. Moreover, the focus of O&M training is subtly different to that of new digital technologies. O&M training aims to develop the skills and the self-efficacy for independent mobility and whilst new technologies aim to make it *easier* to navigate without necessarily building the confidence and self-efficacy of the user.

To better understand how technology can support access to and delivery of O&M training, we conducted semi-structured interviews with 20 BPS people and 8 MOTs. What emerged from their accounts was a strong desire to develop and maintain self-efficacy and confidence in O&M for BPS people to have a better quality of life. Our findings demonstrate that self-efficacy is influenced by the acquisition and the adaptation of O&M skills (increases) and by changing personal and social circumstances (decreases) (illustrated in Figure 1). In this light, O&M training becomes more than learning experience situated at a particular point in life and is instead an evolving and

[2] https://www.blindsquare.com/
[3] https://www.microsoft.com/en-us/research/product/soundscape/
[4] https://lazarillo.app/
[5] https://www.bemyeyes.com/
[6] https://aira.io/

personalized experience taking place across people's lives and within specific contexts. This calls for a rethink of how technology is designed to support self-efficacy through in O&M training for BPS people especially as the O&M needs of people change over time. Our contributions in this paper include:

- An in-depth insight into the factors which affect O&M training, including the role of technology, and how these impact self-efficacy beliefs of BPS people
- An exploration of the intersections of the individual's social network, life events and O&M challenges which impact self-efficacy.
- Evidence of multisensory nature of O&M training and a discussion on the possible future directions for technology design to support development and maintenance of self-efficacy belief across changing circumstances.

2 RELATED WORK

Below we review the literature on habilitation and accessibility research, building on the extensive work on O&M rehabilitation practices and AT for supporting independent mobility of BPS people.

2.1 O&M Training

Orientation and mobility (O&M) training refers to the teaching and learning of skills and techniques for safe and independent travel by blind and partially sighted people [76]. It aims to develop functional mobility and independent living skills by integrating the O&M learning in activities of daily living (ADLs) which are carried out in the home, at school, and in outdoor settings. O&M training is often delivered in different forms to children and adults. For children, blind at birth or soon after birth, who often experience developmental delays [18], an MOT works with the child, their parents, healthcare and social workers to support the development of the physiological, sensory, and cognitive skills required to understand, move around, and interact with the environment. For adults experiencing vision loss later in life, the O&M training focuses on rehabilitation and aims to improve self-management in ADLs and problem-solving through goal setting and the development of self-efficacy in functional mobility [59].

2.2 Self-efficacy

Self-efficacy is defined by Bandura as one's belief in their capabilities to perform a given task [6]. According to Bandura [6] and Rosenthal [60], the perception of self-efficacy is driven from four main sources; performance accomplishments, vicarious experience, verbal persuasion, and emotional and physiological states; each having a varying influence on self-efficacy belief. Performance accomplishments in past experiences have the highest influence on the individual's self-efficacy [2]. As self-efficacy perception is evolving, past performance on a similar task can affect an individual's belief about their ability to perform the task — previous successes raise the self-efficacy belief whereas previous failures lower it [6]. Cmar [19] suggest that, in O&M training, age-appropriate goals and increasingly difficult challenges are important to progressively develop the learner's O&M skills and confidence in goal attainment. Vicarious experiences modelled by others also affect how the individual perceives themselves to perform in an activity. Studies indicate that the impact of the vicarious experience is stronger if the observer considers the actor to have similar abilities to the observer– the greater the similarity, the stronger the effects of success and failure on the observer's perceived self-efficacy [1, 24, 36]. Jang et al. conducted studies on virtual vicarious experiences through avatars and found that avatar self-similarity influenced the player's general self-

efficacy in gameplay [36]. Research on behavior change and physical activity also suggests that observers perceive a higher level of self-efficacy when faced with actors of similar abilities who succeed in an activity [41]. Cmar [19] suggest that successfully employed BPS individuals can share their experience and serve as role models for young BPS people to develop self-efficacy belief and positive outcome expectations from their training and aspiration to pursue independent living. Verbal persuasion from O&M instructors, family members, and peers is effective in boosting the confidence in the short-term to improve performance outcome but is less effective in building a long-term self-efficacy belief as a sole strategy [6]. Bandura further emphasized that the impact of verbal persuasion on self-efficacy varies significantly depending on the trustworthiness and credibility of the persuader [6]. Finally, research has shown that emotional and physiological states, such as fear and anxiety may lower the individual's perceived self-efficacy and confidence in their capabilities [66]. Hence, strategies to manage fear, anxiety, and stress related to O&M training in BPS people are employed by MOTs, including, additional support, guiding the learner through verbal instructions, and reducing walking speed when navigating a route [76].

O&M skills are important to develop self-efficacy in mobility and support independent living. Research shows that higher self-efficacy belief in BPS people is linked to higher post-secondary education rates, employment, and better overall quality of life [19, 80]. A positive self-efficacy belief has also been found to improve an individual's judgement of their capabilities, personal agency, motivation, and affective self-regulation [7]. O&M training underpins the development BPS people's self-efficacy beliefs through progressive goal-based learning of O&M skills, opportunities to observe and compare performance with others, verbal persuasion and quality relationship with the MOT, and strategies to manage emotional and physiological stress (refer to Table 1).

Table 1: Self-efficacy Factors and Strategies for O&M Training

Factor	**Definition and Examples in Literature**	**Strategies for O&M Training**
Performance accomplishments	Self- assessment of accomplishments which are raised or lowered by historic perceived achievements [6]. Past performance accomplishments or mastery experience has been found to be a strong predictor of self-efficacy across academic domains [37]and physical activity [75].	Age-appropriate goals and increasingly difficult challenges in O&M skills training (e.g. learning to navigate small indoor spaces to large outdoor spaces) [19].
Vicarious experience	Alter efficacious beliefs through transmission of competencies and comparisons with attainment of others [6]. For example, observing others of similar abilities perform a physical activity task motivated others ('if they can do it, so can I') [41].	Opportunities to observe and listen to experiences of BPS role models and compare performance with others can help develop a sense of competition and motivate the learner to work harder and practice their O&M skills [19].
Verbal persuasion	Encouragement or discouragement from others. Receiving positive feedback and encouragement raises self-efficacy belief [73]. Supportive feedback from mentors and peers is linked with higher self-determination in BPS individuals [53].	Positive feedback, encouragement and reassurance from MOT, family members and peer group can help learners overcome self-doubt and raise self-esteem.
Emotional and physiological states	Stressful and taxing situations generally elicit emotional response such as fear and anxiety	MOTs employ systematic desensitization strategies to overcome anxiety and fear in training

	[6]. Many BPS people (particularly those who experience sight loss as opposed to being blind by birth [34]) experience fear of physical injury and getting lost [9]. Also common is the anxiety and stress related to making mistakes, shame and embarrassment and negative attitudes from the public [34].	by gradually exposing the learner to stressful situations with increased level of support [78], reduce the walking speed to gradually help the learner gain confidence.

2.3 Technologies for O&M

The majority of O&M technologies aim to support the functional needs of BPS people, such as travelling from one point to another — including mobile apps to support pedestrian route navigation, transportation, spatial awareness and wayfinding [49, 51, 77]. Notably, accessible mainstream navigation and transportation apps such as Google maps, Apple maps, Uber, Ola are also used by BPS people for independent mobility [39]. Furthermore, smart canes [14, 74] and autonomous navigation robots [14, 23, 29] have been developed to extend the mobility support in complex unfamiliar environments (e.g. airports [28]). Most of these devices use multisensory i.e., vibrotactile and auditory feedback to alert the BPS people user of obstacles and to indicate a change of direction when leading along a route [29].

Human-assisted commercial applications BeMyEyes [10] and Aira [35] have become increasingly popular in the BPS people community. These mobile apps are operated by volunteers (BeMyEeyes [10]) and trained agents (Aira [35]) and use mobile phone camera to provide sighted assistance to BPS people. As many BPS people depend on sighted support in homes and outside, human-assisted apps provide opportunities for BPS people to become more independent in activities of daily living (e.g., as cooking, grocery shopping, etc.) and mobility. Automated sighted assistance apps such as SeeingAI [63] and TapTapSee [70] are among the new wave of artificially intelligent mobile technologies that use computer vision to support independence of BPS people in ADLs, from reading books and labels, to identifying currency notes, colors, and describing photos of people and the environment.

More recently, Augmented and Virtual Reality (A/VR) [45, 52, 56, 58, 64, 81, 82] have been used to supplement O&M training by creating a virtual environment for BPS people to practice their skills and receive multisensory feedback similar to real life navigation with a long cane. For example, Canetroller [82] simulates navigation with a long cane for BPS people in VR by providing vibrotactile and spatial 3D auditory feedback as the cane interacts with different elements in the VR environment. Canetroller demonstrates the potential of VR assistive technologies in creating a sense of presence and providing a safe environment for exploration. Lahav et al. [43] used a force feedback haptic device to enable the participants to navigate a VR environment using an avatar. The participants used the Phantom® [55] stylus to control the avatar's movement on a VR map. The findings from this research suggest that VR environments can be used to supplement the traditional O&M training by enabling BPS people to build cognitive maps of unfamiliar routes prior to visiting them. Mott et al. [50] hypothesize that VR could support self-efficacy of BPS people by allowing MOTs and BPS people to explore complex environments such train stations, unfamiliar education and work settings, by virtually previewing training routes prior to travelling to increase familiarity. Additionally, auditory A/VR reality applications enhance spatial awareness and support mental mapping of the environment by announcing functional information [13, 26, 32, 42], i.e., turn-by-turn instructions, building entrances, points of interest, and road intersections.

These studies indicate the growing research on ATs for supporting independent mobility of BPS individuals and efforts to support O&M skills through technology. The literature reviewed also highlights that O&M training is essential for developing self-efficacy and self-confidence to maintain an independent lifestyle. We build on this

growing body of research to identify opportunities for technology to support BPS people's self-efficacy in independent mobility through changing life circumstances.

3 METHODS

3.1 Participant Recruitment

We conducted semi-structured interviews with BPS people and MOTs who provide O&M training, and family members of BPS people. A total of 28 participants - 8 MOTs (1 male, 1 partially sighted) and 20 BPS people (aged 25 – 65 years) participated in the interviews. The MOTs (Table 2) had formal qualification in habilitation and O&M training, were employed by the local authorities in the United Kingdom and worked between 15 (part-time) to 70 (full-time) simultaneous cases (full-time). All participants were recruited through authors' personal networks, social media, and non-profit organisations. Interviews were conducted remotely over the phone, Skype, Facetime, and Zoom according to participants' preference, were audio recorded and lasted between 30 and 80 minutes. Twenty BPS people (9 female) had varying levels of residual vision; 50% had total blindness, while the other 50% had vision varying from light perception to partial sightedness; 70% had congenital vision impairments (Table 3).

Participants responded to the study advertisement by email and on Twitter direct message. Further information about the study in the form of an information sheet and a consent form was sent to the participants prior to the interview. Accessible information sheet and consent forms were emailed to all participants; some were signed digitally and returned via email. Verbal consent protocol [16] was used for a majority of the participants to ensure full accessibility of the study. As part of this procedure, participants answered questions at the beginning of the interview confirming their age (18+), consent to participate in the study, and consent to be audio recorded. Any questions raised were answered to the participant's satisfaction before moving forward with the interview; verbal consent was recorded by the first author. Ethical approval was obtained from the university departmental ethics committee (anonymized for review).

Table 2: O&M Specialists (MOT) Participants

P#	Gender	Experience
MOT1	F	18 years
MOT2 (Partially Sighted)	F	32 years
MOT3	F	15 years
MOT4	M	5 years
MOT5	F	8 years
MOT6	F	10+ years
MOT7	F	10+ years
MOT8	F	5 years

Table 3: Blind and Partially Sighted Participants

P#	Age	Gender	Age at VI diagnosis	Visual function	Mobile phone	Primary mobility aid
P1	28	M	14	Partially sighted	iPhone	Guide dog
P2	40	F	0	Totally blind	iPhone	Long cane
P3	62	M	0	Totally blind	Not specified	Long cane
P4	38	F	0	Albinism, partial vision, No depth perception	Not specified	Long cane
P5	42	F	0	No vision in right eye; 2% in right eye	iPhone	Long cane
P6	25	M	0	Partially sighted	Not specified	Guide dog
P7	35	M	0	Partially sighted	Not specified	Symbol cane
P8	56	M	0	Partially sighted; night blindness	Not specified	Guide dog
P9	61	M	30s	Totally blind	Android	Guide dog
P10	36	M	24	Totally blind	iPhone	Guide dog
P11	60	M	0	Totally blind	iPhone	Guide dog and long cane
P12	36	F	0	Totally blind	Not specified	Guide dog
P13	65	M	0	Totally blind	Not specified	Guide dog
P14	40	F	10	Totally blind	iPhone	Long cane
P15	50	M	0	Totally blind	iPhone	Long cane
P16	40	M	5	Totally blind	iPhone	Long cane
P17	26	F	0	Light perception, color contrast	iPhone	Long cane
P18	25	F	0	Light perception, large shapes	iPhone	Long cane
P19	35	F	0	Light perception	iPhone	Long cane
P20	40	F	17	Light perception, color contrast	iPhone	Guide dog

3.2 Data Collection and Analysis

The semi-structured interviews with MOTs explored their experiences delivering O&M training, the challenges they encounter during training and strategies to overcome these, and their perception of mobile technologies in supporting O&M training. In the interviews, we asked BPS people about their experience of O&M training, their sociocultural environment, the technologies they used for mobility, and the impact of O&M training on their confidence and independence in daily life. Interviews were transcribed and thematically analyzed [15] using

inductive approach to coding which evolved throughout the analysis process and were collated to develop common themes across the data.

4 FINDINGS:

4.1 Tools and Strategies for O&M Training

MOTs used a variety of strategies and multisensory tools for indoor and outdoor O&M training. Prior to training, MOTs carried out an environmental assessment. The purposes of this were to identify multisensory landmarks and cues along the route which could support learners in mentally mapping the environment, and identifying challenging points such as road crossings, narrow pavements, and crowded spaces which could hinder the learning process. MOTs emphasized the importance of teaching the safest (not the fastest) route to ensure safety of BPS people when navigating independently - *"even if it's a little bit longer and I would teach the safest route" (MOT4).*

In O&M training, multisensory landmarks and clues were important to help learners orientate and learn routes. MOTs noted that they often used olfactory clues such as coffee shops and bakeries when teaching a route; they built these clues in the route to help the learners identify their surroundings and their location along the route – *"we would stop and smell and see if we could work out where we were on the route" (MOT3).* MOTs also used auditory clues such as traffic sounds and water bodies as clues to guide the learners along the route – "*They know they're going the right way because they're heading towards that sound" (MOT3).*

Tactile landmarks (e.g., road crossings, lamp posts, phone box, etc.) were used to divide the route; at which point the learners would take an action such as cross the road or turn right or left. MOTs divided the training route into sections that could be easily learned by the learners over a few sessions, and then gradually increased the route length and added more landmarks as the learners became more confident in navigating the route independently. MOTs also used tactile markers and maps to support indoor and outdoor mapping skills. Learners were encouraged to create tactile maps using LEGO bricks to explore the environment and enhance their cognitive maps of the space.

> *"I've used LEGOS for turning right turning left and to describe crossroads." (MOT8)*

The MOTs placed the tactile markers at key points in indoor environments such as door handles, handrails, and on the floor to indicate different rooms and floors in the building enabling learners to locate different classrooms and find their way around the school. These markers could also be employed to create tactile guidelines along the floor to help children learn the routes around the schools. For example, screws of different shapes were used along the handrails to help children learn the routes on different floors.

Tactile markers were also useful as landmarks in indoor and outdoor route learning and to understand the travel distance (measured in time travelled, number of trees, walls, and hedges - changes in the path) between markers. MOTs installed these markers at certain distances in the route to enable the student to gauge the distance between the markers and therefore understand the overall length of the route. This was particularly useful on routes which didn't have natural landmarks, i.e., *"no changes in the shoreline"*. MOT3 noted that the tactile markers also made route learning more fun and engaging for learners. Once the learners became competent in their route navigation, the MOTs gradually removed the tactile markers from the route.

> *"I put certain articles on it like a treasure hunt. We developed some little things to give him some support in learning that part of the route... Then, I took them away gradually... We use trees and*

things, all sorts, walls, brick walls, hedges because there's lots of different changes on your shoreline [pavement edge]." (MOT3)

4.2 Technology Use in O&M Training

4.2.1 MOT's Knowledge of Technology

Technology has been part of O&M training and as mentioned in previous section, MOTs use a variety of low and high-tech tools and strategies including tactile indicators and maps, as well as sounds as landmarks and clues. Some participants also acknowledged that technology has been a part of O&M training since before the wide availability of modern smartphones. P10 recalled using voice recorders and Dictaphones for recording landmark-based navigation instructions for memorizing the routes (similar to today's navigation apps), magnifiers to support wayfinding for low vision learners, and tactile maps for mental mapping. This is particularly useful for younger learners or those who may be used to mobile assistive technologies and aids in the learner's sensorimotor functioning and self-efficacy for independent O&M training.

Despite this, participants agreed that the use of navigation technologies was contingent on the MOTs' expertise and perception of technology. Some BPS participants reported that there was little encouragement from the MOTs to use technology for mobility – *"whilst they recognize the technology, there's not really a huge push to say it may enhance your O&M" (P10).* P1 noted that the little uptake in technology use in O&M training depended on how well the MOTs understood the accessibility features of the mobile phones and available navigation apps – "*even if the mobility teacher doesn't have to teach the accessibility features of that phone, they're still going to have to learn what the apps are and how to use them".*

4.2.2 Effectiveness of O&M Technologies

MOTs emphasized that existing navigation technologies (built on GPS) are not reliable as an effective O&M learning tool and can limit the learner's mental mapping abilities and self-reliance in the absence of such technology – *"When using satnav, you're not actually paying attention to the details of the route, you're just following instructions on the app. When satnav fails, you're stuck," (MOT4)*. P1 acknowledged that many navigation apps available are not suited for O&M training but could be used for outdoor route familiarization – *"The problem is that you've got these apps that are not specifically for learning mobility skills […] there are lots of apps that would help [with route learning]".*

Additionally, participants desire for technology to go beyond route navigation and support the challenges in locating building entrances and safe road crossings, [61]. Particularly, incorrectly tagged building entrances – *"entrance marked at the wrong side of the road" (P1)* and inaccuracy of GPS location *"suggesting the entrance is near when it is in fact 10ft further down" (P1)* was challenging. As many BPS people relied on route memorization and tactile paving to locate road crossings, participants expressed less trust in GPS technology alone for navigating for example: *"I would never use an app for the first time on a route I've never done before" (P5)* and *"figuring out where to cross the road would be tricky" (P1)* on unfamiliar routes. This was also elaborated on by P3 *"if you are crossing a road straight away you've and you've never done it before you could end up not knowing if you have cross the road and going up somebody's driveway. And technology won't help you there, would it?"*

4.2.3 Technologies to Supplement O&M Training

Despite the varying views on effectiveness of commercial navigation technologies for O&M training, many participants (including BPS people and MOTs) acknowledged that mobile technology is increasingly become a part

of O&M training practice. MOTs agreed that technology can be used to complement the O&M training practice by enhancing the learner's spatial awareness - *"It is important for pupils [BPS children and young people] to learn the physical route and landmarks and technology can enhance that." (MOT4)*. Mobile apps like Lazarillo and Soundscape that announce nearby landmarks and points of interest (e.g. bus stops, road intersections, and street names), were encouraged to improve spatial awareness while on public transport. Many of our participants used mainstream and AT navigation apps for outdoor navigation. Preferred features of these apps were announcing the landmarks using "clock face" directions (RNIB Navigator[7]) and audio beacons (Microsoft Soundscape) which P5 suggested was essential to their day-to-day navigation and should be integrated with the O&M training – *"I just think it should be built in as part of the whole mobility process. I don't see the point in it not being because it's so, so useful."*

P1 noted that there's a place for navigation technology for BPS people confident in their mobility skills but the current navigation apps alone are not suitable for BPS learning outdoor navigation and crossing roads without an MOT. Instead, participants suggested that a more suitable technology for O&M route learning should enable the MOT to "record landmarks" along the route which can be traced by the learner as they practice route navigation – *"like Clew app[8] for outdoors".* P1 further commented that the fundamental O&M skills should be taught by a human MOT, however, technology could be used to support practice and enforcement of O&M skills between training sessions by ensuring the learners practice the correct "patterns" of movement when using a long cane – *"if you think about it it's all based on patterns, walking in step is a pattern and sighted guiding is also a pattern. Technology can recognize those patterns and alert you based on small deviations. Maybe that is some way to look at it". (P1)*

MOT2 noted that integrating technology in O&M training could also help with engaging young learners, who are already familiar with various mobile technologies. She explained how suggesting navigation apps enabled a young learner (11 years old) to not only take more interest but also improved his confidence and develop a sense of agency in relation to mobility.

> *"The next session I met him at school. He said, 'The next bus is in 10 minutes.' I thought, 'Oh, goodness me, engagement! That's fantastic! He's taking responsibility.' He'd also downloaded Google Map, and actually traced his journey to his new address, with quite a lot of confidence as well as then listening to the bus." (MOT2)*

Some BPS participants also suggested that technology could be integrated with O&M training to overcome the shortage of MOTs such that remote O&M support could be provided to BPS people who are experienced and independent in their mobility, as suggested by P1 – *"If you are a local council then maybe you could augment your trainers through technology and think, right we are going to get you 75% towards getting able to walk in step with your cane, but then when you do your homework, or when you practice outside the session, use this app and it will help you reach 100%".* So, the fundamentals of O&M training (e.g., long cane techniques and negotiating navigation in outdoor environments – avoiding veering, detecting obstacles using long cane, and understanding changes in the floor surface) must be taught in a face-to-face through O&M training session with an MOT, and once the learner is confident in their mobility skills. They also added that further assistance such as sighted assistance in unfamiliar or challenging situation can be provided remotely by MOTs and volunteers through an app (e.g., Aira, BeMyEyes) which would be useful in building their confidence in outdoor mobility knowing that *"there's additional support there as and when needed is always comforting"* (P7).

[7] https://www.senderogroup.com/products/RNIBGPS/index.html
[8] http://www.clewapp.org/

4.3 Changing Personal and Social Circumstances

4.3.1 Deteriorating Vision

The experience of early O&M support varied between people who were blind from birth or at a young age to those who experienced sight loss or deteriorating vision as adults. While early O&M support for young children was available at schools and pediatric healthcare services, adult support was less accessible. Despite the statutory right to O&M support [17], participants (experiencing sight loss as adults) were often faced with long delays or lack of support from the local authorities, which was the experience of P9 - *"I kept persuading them [local authority disability team] to do so but they didn't have the disability team anymore, they [had] disbanded it".* The impact of the delays and the lack of appropriate mobility services, which are critical for blind and partially sighted people, were seen as a barrier in becoming independent. P10, who has as degenerative vision impairment, felt helpless due to the lack of early O&M support when first experiencing vision loss.

> *"I received zero mobility training when I left, that was it. It was cut lose, there was no facilitation for service. I wouldn't even know who to contact if I suddenly lost some more sight and I felt, gosh, I really can't' deal with it. I wouldn't know where to go or who to speak to." (P10)*

Participants who experienced severe vision loss as adults experienced a more profound impact on their quality of life; from being independent adults and having a full-time career and responsibilities to losing their independence completely – "*I ended up having to give up my nursing career that I was doing because of my sight change." (P8)*. P3 reported feeling loss of freedom and isolation; being unable to carry on with their normal activities *"getting frustrated and bored and getting angry for not having any freedom"*. Vision loss also impacted participants' family dynamics as they became dependent on family members for mobility, as P9 described -

> *"I was essentially housebound. I couldn't go out without my wife or one of my children hanging onto my arm." (P9)*

4.3.2 Familiarizing with New Environments

Moving to a new area can be a daunting experience for everyone, but for BPS people, this is often exacerbated by new accessibility challenges associated with a novel physical space and sociocultural environment. 'Sighted memory' is the mental representation of the local area developed through repeated sighted navigation or ego-centric mental maps developed through route learning over time, which participants described as - *"imagining what the place looks like. I've literally walked around, and I can remember it what the place looked like." (P10)*. This type of memory is dependent on the individual being familiar with the surrounding environment and often needs to be completely rebuilt when the person finds themselves in a new or unknown location. For people who are used to navigating based on sighted memory, learning a new route can be quite unnerving, as described by P10 – *"For the first time ever I was really nervous, and I had no idea what the area looked like."*

As many of our participants were confident in independently navigating several familiar routes learned through previous O&M training, they sought O&M training through their new local authority. However, the level of support available varied in different cities and the confidence regained from training varied, depending on the overall physical environment, opportunities to seek support from public if needed, and the distance participants had to travel.

"I am receiving training here, but the roads and the pavements aren't as clear. The bus stop is quite far from where I am and it's very complicated to get to, and there's hardly anybody outside to ask if you're stuck. It's this kind of thing. It isolates you a little bit, so I've decided to move back for that reason." (P2)

Similarly, when P5 moved to a new city for a new job, she found that being in a new unfamiliar environment made it difficult to be self-reliant. She relied on volunteer sighted guides until she could get further O&M training to familiarize herself with the environment. She described her experience as, *"I got my confidence back, and now I will literally go anywhere with my cane and I don't even think twice about it." (P5).*

4.3.3 Becoming Parents

Becoming parents is one of the most significant life transitions, demanding not only an adjustment to lifestyle but also a seismic shift of identity from non-parents to parents, from being independent and only responsible for oneself to being responsible for another person. Many of our BPS participants reported how their mobility needs changed when travelling with young children. For example, P5 reported that she lost her independence after having a baby as she could not go out with the baby in the pram. As a long cane user, she was unable to effectively navigate with the pram and the long cane, which led her to lose her confidence in independently performing outdoor activities - *"Consequently, I had to be completely reliant. I couldn't go out on my own. I had to rely on my husband at the time, or my mum and dad, or as I made friends who had young children, we could go out together, but I could never just go for a walk on my own with my son." (P5)*. P16, another long cane user, commented that using a child carrier (on the back) freed up his hands to effectively navigate using the long cane and enabled him to be independent and continue his regular activities and at the same time spend time with his son – "*I quite like that carrier for independence because I'm a cane user to it frees up my hands. One to use the cane and the other to open doors and carry things".*

P5 also indicated the lack of O&M support for new parents as they navigate practical challenges – "*I did go…to ask them [local authority disability team] what help there was, and he just said, there isn't. Come back when your son can walk".* P5 resorted to seeking support from her family and making social contacts with other new parents who could support her mobility needs to avoid losing her independence.

For our participants, the difficulties associated with the transformation from single individual to a parent often challenged confidence and self-efficacy. *"I started having kids and I realized I couldn't take them to the park, and I couldn't on my own. I couldn't be a dad in the way I wanted to be. I wanted to be independent for them so I could participate fully and if they had a doctor's appointment or if they had to go to hospital. I wanted to get to do those things on my own." (P10).* P10, who is a guide dog user, relied on sighted assistance for navigation prior to this realization that led him to pursue further O&M training privately to be able to navigate independently without the help of a sighted guide. P16 shared a similar concern about wanting to be involved in leisure activities with his son but often struggled to monitor his son's movements. He attached bells to his son's shoes to be able to hear his son and track his location around the house but still found it challenging to locate his son when in an open park space.

"I'm totally blind, so once I lose [son] and he's quite demanding and once he's run off or something and we're kind of stuck with that. And we're trying to kind of cope with that." (P16)

4.4 Social Influences on O&M

Although the majority of O&M training was conducted in one-to-one sessions with the learner, MOTs acknowledged that the home environment of the learner played an important role and family members' perceptions, and attitudes

have to be considered for effective O&M skills development. Particularly, parents of BPS children and young people influenced their independence the most. MOT6 who conducts workshops and counselling with parents reported that many parents initially react strongly when they find out about their child's vision impairment, *"They break down in fear and upset"*. Parents often cope with the anxiety and fear related to their child's vision impairment by becoming overprotective and inadvertently undermining their independence, *"I think the temptation is for majority of the families even though they get the awareness training from us, they still want to just guide. They want to have that physical contact with their child and keep them safe..." (MOT4)*. MOTs felt that this tendency towards shielding and overprotection was exacerbated by the lack of opportunities for many parents to observe the O&M skills of BPS children and young people as O&M training was often conducted at school. P2 commented that family members can be helpful in supporting O&M skills and promoting independence if they had awareness through proper resources and training to enable them to support BPS individuals – *"I think they need more awareness, some piece of technology that could -- or maybe now because we have apps and so on, maybe an app that can always, they can tap into and teach them how to guide a blind person in the family or so on." (P2)*

MOTs also commented that the sociocultural perspectives and parents' own self-efficacy beliefs affect their ability to support their children; having low self-expectations impacted their belief and expectations of self-efficacy and independence from their children - *You get different levels of expectations, like 'this is my child, but they will never be able to achieve independence. They certainly will never be working, and I don't expect them to be working,' their expectations of themselves are low so the expectations they put on their child is just at the same level." (MOT4).*

Our BPS participants shared experiences from their childhood which highlighted the key role of family members in influencing self-efficacy belief. Participants recognized that the lack of awareness and the attitudes of parents towards mobility limited their opportunities to practice and further develop their O&M skills. Many participants reported that they were often guided by family members when outdoors instead of using their O&M skills independently – *"In terms of anything outside of our house/garden, I would have just gone with my mum. I wouldn't have gone out on my own," (P1).*

Participants suggested that a positive and encouraging home environment can have a profound impact on the learner's self-confidence and create opportunities for families to spend time together. P6 commented that having his mother involved in practicing O&M skills enabled him to explore outdoors with confidence - *"I think the more I done it, the more confident I was. Obviously, mom was still there to make sure I don't get run over." (P6).* P3 also commented on how parents' support can support BPS children and young people by providing them with opportunities to explore new spaces – *"I would still recommend that they should learn the cane training and go to a park or something with their parents and go for a little wander on their own because it's a very great sense of freedom and the parents could keep an eye on them. It would be best for their child to feel that they are on their own and they can control where they're going. that could be done for the individual because of the parents make them a little map of the park." (P3)*

MOTs suggested that parents can also benefit from being part of a community of parents of BPS children and young people to share ideas and concerns about supporting their children – *"if you've got a parent that's reluctant, it's trying to get them to meet up with somebody else who's allowing their child a little bit more freedom and encouraging that freedom" (MOT7)*. Similarly, MOT6 commented that having a group outing can be an opportunity for parents to learn from others and for BPS children and young people to also learn vicariously from others by observing their O&M skills and sharing experiences; a healthy competition can also engage them with their O&M training and develop self-efficacy as they compete with each other – *"Then when you go into your next lesson and they go, 'Has he*

started doing this show? Can she do that?' I'll say, 'Yes, they've definitely,' even if they've not quite got there, just to pull them up a notch" (MOT6).

5 DISCUSSION

The stories shared by participants in this study highlight how the self-efficacy belief of BPS individuals is developed overtime through O&M training and that this belief is influenced by a series of factors– including personal (physical) factors such as changes to the individual's vision, environmental factors such as changes moving to a new city or getting a job in a new area, and lifestyle changes such as added responsibilities of caring for a new child. In addition to these elements, the self-efficacy belief is shaped by different social dynamics such as the home environment and the encouragement (or lack thereof) and feedback the individual receives from the family members and peers. All these elements play an important role in building up or destroying the individual's self-efficacy belief and confidence in independent mobility. Below we revisit our findings and discuss the opportunities for HCI research to support the evolving self-efficacy needs of BPS people.

5.1 Social Influences on Self-efficacy in O&M

Our findings illustrate the importance of O&M training in building self-efficacy belief and confidence of BPS people through the iterative learning processes that people undertake to be able to independently master life skills. In addition, we discuss the crucial role of the family environment and, as previously mentioned, the limited availability of specialist support from MOTs. Many BPS people receive limited O&M training over a set period of time and furthermore, the wider sociocultural environment affected participants' mobility and independence level outside of O&M training. Thus, the learner's family and friends play an important part in the maintenance and boosting of O&M skills outside of training, particularly for BPS children and young people who still rely on the family members as caregivers. Our findings show that, parents of BPS children and young people often tend to be anxious about their child's disability and feel unsure about their own capacity to help them fully become independent in mobility and other aspects of living. Their overprotective attitude harms the individual's perceived self-efficacy by denying opportunities to practice O&M skills outside formal training and lack of encouragement (verbal persuasion) from family members which might increase personal fears of the BPS individual.

The sociocultural context is important here, as disabled people and their families still face stigma and discrimination in many cultures leading parents to feel a sense of shame and guilt [47]. Parents often have low expectations of their disabled children, who they expect will not to be independent [67] or be employed [MOT4]. Particularly, when parents' own self-efficacy beliefs and outcome expectations are projected on their children, as reported by MOT4, this limits the child's opportunities to grow and become independent. We argue that technology-assisted counselling and behavioral interventions could support family members in developing their own self-efficacy beliefs and better equip them to not only support but also take active role in developing their children's O&M and life skills. We realize that these negative stereotypes of disability are deep-rooted within the social and cultural environment but are often a product of lack of awareness and understanding and can be improved through appropriate interventions [62, 71].

The importance of involvement and support from family members has been further highlighted by the recent COVID-19 lockdown due to which all in-person learning, including O&M training was discontinued – and MOTs were furloughed in the UK [33]. As the world moves to online communication and learning platforms, there is a crucial opportunity for online O&M training support to complement the face-to-face training in the future [21]. The

technology for making this possible exists today, for example, mobile assistance apps like BeMyEyes, Aira, and other technologies that support O&M skills like walking in a straight line [54] could be adopted to provide additional support for learners between training sessions.

5.2 Influences of Social Networks on Self-Efficacy in Changing Circumstances

Our findings show that there are various events that occur in the lives of BPS people which can influence their self-efficacy belief. These events occur at different stages in people's lives and are not always related to vision deterioration. In fact, these transitions can depict overall positive changes in people's lives, e.g., moving to a new city and having children, but they can also have a negative impact on people's confidence.

Particularly, having children means people have more responsibilities and require significant adjustments to their existing skills and strategies to adapt to their new identity as a parent. There is also a change in social network when one becomes a parent as parents seek support and information from other parents - this social network has been found to be important when understanding the needs of BPS people in previous research. For example, [8] explored the use of the social network in low resource settings for BPS people finding that interactions with technology could often be mediated and facilitated by various actors and allies both positively and negatively.

During the transition from single individual to becoming a parent, adapting to the new circumstances (e.g., navigating with buggies/prams as opposed to the mobility aid alone) can be challenging and have a negative effect on the individual's self-efficacy. Unfortunately, additional O&M training is often unavailable at this stage for many BPS people due to lack of resources and limited availability of MOTs. To overcome this lack of O&M support, BPS people develop personalized strategies to deal with both the physical and the emotional challenges presented by the added responsibilities. Many of these strategies involved tapping on their social network, as people would seek support from family and friends, alongside devising individual innovative techniques to maintain independent mobility while balancing their role as parents. This finding supports the existing work on BPS peoples' self-efficacy and involvement in parenting which has found that found that despite being good at mobility, blind parents experienced a loss of freedom and self-efficacy in mobility [20]. This resulted in people reducing their range of activities that required mobility when they became parents, unless their social network of family and friends could help with interactions with the child during physical activity and outings, then BPS people's activity levels increased [20].

As many BPS people are active users of mobile technologies and social media, sharing coping strategies in the BPS community (and thus supporting self-efficacy through learning from these vicarious experiences) via digital platforms can better prepare BPS parents to navigate the challenges of new parenthood. Recent research has explored how disabled people use social media for advocacy, supporting self-esteem and identity, addressing cyberbullying and accessibility issues, and developing online communities of practice. While we did not study how BPS people use online communities (Facebook groups, YouTube, mailing lists, twitter hashtags and sub-communities) as part of this study, future work should consider how communities of practice [69] in this area could support individuals overcome the shortage of O&M training, share personal experiences and further foster the self-efficacy in individuals and the community more generally.

5.3 Novel Interactions for Technology to Support O&M learning in New and Unfamiliar Environments

Another of the major challenges described by BPS participants was navigating new and unfamiliar environments. As outdoor navigation is heavily dependent on route learning through landmarks and clues in O&M

training, the BPS participants found it difficult to navigate new and unfamiliar routes. Despite a significant body of AT research focuses on navigation for BPS people, the availability of commercial AT for route familiarization is limited, therefore, BPS people often rely on sighted help for assistance in unfamiliar outdoor environments [30, 79]. As noted in previous research, having prior understanding of the route and surroundings is essential for independent mobility [4, 38, 79]. Virtual environments integrated within the O&M training program can be valuable to support route familiarization and independent mobility by enabling "walking" the virtual route and familiarizing with the surroundings – [44] found that integrating a virtual stimulation of a route can be effective in route learning and reducing frustration and fear of navigating public paths. Growing research on virtual delivery of O&M training using virtual long canes [82] and VR environments for route familiarization [31, 43, 44] is promising for supporting O&M skill development and practice to reduce reliance on face-to-face interaction with MOTs.

Although technology for navigation was broadly described as useful, our findings show that it was not always widely embraced by MOTs due to their limited knowledge of and experience with modern technologies. This is aligned with Deverell et al. [21] who found that MOTs need to expand their knowledge of mainstream and assistive technologies to better support the needs of their clients who may be proficient technology users. In our research the reasons for this lack of adoption appear to be the desire to ensure a working memory for BPS people, which will not be fully developed if people solely learn to navigate via mobile applications and therefore on 'autopilot'. However, it is clear that mobile applications in particular are being used by BPS people and have been shown in some cases to aid engagement in O&M training along with an increased confidence through improved performance accomplishments. There remain opportunities for novel interaction development within O&M training which takes account of the dimensions of self-efficacy and solves the last few meters problem (something we found, and was previously reported by [61]).

The multisensorial aspect of O&M learning was also evident in our findings — BPS people use sensory cues from the environment (olfactory, auditory, and tactile) to develop a rich understanding of their surroundings [4, 5]. These senses are an integral part of O&M training and navigation beyond training. One possible route for this is to incorporate multisensory elements into new O&M technologies, a second is in the development of virtual/mixed or augmented reality interactions to complement face-to-face learning.

The existing commercial AT and research predominantly employs haptic and auditory (verbal and non-verbal) feedback to convey spatial and navigation information to the user (e.g., obstacles, landmarks, and turn-by-turn navigation instructions) in real and VR environments. In addition, smell-based interactions can convey emotional, spatial, and temporal information for enhanced sensorial A/VR experiences [46]. For example, Season Traveler [57] demonstrates that multisensory stimuli can enhance immersion in VR environments using smell and haptic sensations (temperature and wind). Multisensory stimuli can also be used to provide safe experiences of dangerous situations and influence human behavior, e.g. in a fire evacuation VR [65], varied intensity audiovisual, thermal, and olfactory cues were used to indicate urgency and avoid adverse situations. Similarly, the effect of olfactory stimulations to promote emotional well-being and improve physiological response has also been studied with non-disabled persons in non-VR context [22, 48].

These studies emphasize the possibilities for immersive and novel interactions to support O&M training of BPS people where face-to-face O&M training is not available or due to environmental crises such as the recent COVID-19 pandemic, which made face-to-face instruction impossible. Harnessing novel interaction modalities to design and develop blended learning experiences for O&M training could lead to more resilient service delivery solutions. A second possible avenue of research would be to explore the role of O&M training beyond navigation and towards

exploration of surroundings. VR and AR could help people build confidence in exploring, which could then be used in everyday life, allowing people to hear or smell something which could serve as navigation clues but also encourage exploration and connect with the environment [3].

5.4 Limitations

Our BPS participants cohort was aged between 18 and 65 years and living in the UK, Ireland, and the USA. All participants were proficient mobile AT users and had experience of using a long cane or guide dog mobility aid. The majority of participants had received O&M training at some point in their lives and therefore the experiences of the participant group presented in this paper may not be generalizable to BPS population in the participants' countries or globally. Furthermore, the childhood experiences of O&M training have been synthesized from BPS participants' recollection of events from their childhood and experiences of MOTs working with BPS children and young people. As with BPS people, MOTs were recruited through convenience sampling and were located across the United Kingdom and had obtained a formal qualification in habilitation and O&M training. However, after the interviews, it became evident that the majority of the MOTs worked with BPS children and young people up to 19 years old. This points to the current state of O&M services in the country as also reported in the findings. Experiences of sight loss related to ageing and the impact of O&M training on the self-efficacy of older population (65 and above) was not in the scope of this study.

6 CONCLUSION

In this paper we presented the findings from semi-structured interviews with BPS people and MOTs exploring how self-efficacy belief is developed through O&M training and how different circumstances and situations (deteriorating vision, new environments, and new responsibilities) can affect the individual's self-confidence. We also report that the individual's sociocultural environment and lack of O&M support at these crucial stages can severely deteriorate their independence and quality of life. These findings have uncovered new possible opportunities for the ASSETS community to explore, including how: (i) BPS people can be better supported across different circumstances through technology-assisted interventions, (ii) the sociocultural environment can be adapted to reinforce self-efficacy and confidence of BPS people, and (iii) immersive and novel multisensory interactions can support and supplement the O&M training.

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REFERENCES

[1] Achterkamp, R. et al. 2016. The influence of vicarious experience provided through mobile technology on self-efficacy when learning new tasks. *Computers in Human Behavior*. 62, (Sep. 2016), 327–332. DOI:https://doi.org/10.1016/j.chb.2016.04.006.

[2] Ashford, S. et al. 2010. What is the best way to change self-efficacy to promote lifestyle and recreational physical activity? A systematic review with meta-analysis. *British Journal of Health Psychology*.

[3] Bandukda, M. et al. Audio AR to Support Nature Connectedness in People with Visual Disabilities. DOI:https://doi.org/10.1145/3410530.3414332.

[4] Bandukda, M. et al. 2020. PLACES : A Framework for Supporting Blind and Partially Sighted People in Outdoor Leisure Activities (In Press). *ASSETS 2020 - 22nd International ACM SIGACCESS Conference on*

Computers and Accessibility (2020).
[5] Bandukda, M. et al. 2019. Understanding experiences of blind individuals in outdoor nature. *Conference on Human Factors in Computing Systems - Proceedings* (New York, New York, USA, 2019), 1–6.
[6] Bandura, A. 1977. *Self-efficacy: Toward a Unifying Theory of Behavioral Change*.
[7] Bandura, A. 1991. Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes*. 50, 2 (Dec. 1991), 248–287. DOI:https://doi.org/10.1016/0749-5978(91)90022-L.
[8] Barbareschi, G. et al. 2020. The Social Network: How People with Visual Impairment use Mobile Phones in Kibera, Kenya. *Conference on Human Factors in Computing Systems - Proceedings* (2020).
[9] Baskett, L. Fear of orientation and mobility. DOI:https://doi.org/10.1016/j.ics.2005.05.104.
[10] Be My Eyes - See the world together: *https://www.bemyeyes.com/*. Accessed: 2020-09-16.
[11] Bell, E.C. and Silverman, A.M. 2018. Rehabilitation and Employment Outcomes for Adults Who Are Blind or Visually Impaired: An Updated Report Abstract. (2018).
[12] Blindness and vision impairment: *https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment*. Accessed: 2020-09-17.
[13] Blum, J.R. et al. 2012. What's around me? Spatialized audio augmented reality for blind users with a smartphone. *Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering* (2012), 49–62.
[14] Borenstein, J. and Ulrich, I. The GuideCane-a computerized travel aid for the active guidance of blind pedestrians. *Proceedings of International Conference on Robotics and Automation* 1283–1288.
[15] Braun, V. and Clarke, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*. 3, 2 (2006), 77–101. DOI:https://doi.org/10.1191/1478088706qp063oa.
[16] Brod, M.S. and Feinbloom, R.I. 1990. Feasibility and Efficacy of Verbal Consents. *Research on Aging*. 12, 3 (Sep. 1990), 364–372. DOI:https://doi.org/10.1177/0164027590123005.
[17] Care Act 2014: *https://www.legislation.gov.uk/ukpga/2014/23/contents/enacted*. Accessed: 2020-09-13.
[18] Cass, H.D. et al. 1994. Developmental setback in severe visual impairment. *Archives of Disease in Childhood*. 70, (1994), 192–196. DOI:https://doi.org/10.1136/adc.70.3.192.
[19] Cmar, J.L. 2015. *Orientation and mobility skills and outcome expectations as predictors of employment for young adults with visual impairments*.
[20] COLLIS, G.M. and BRYANT, C.A. 1981. Interactions between blind parents and their young children. *Child: Care, Health and Development*. 7, 1 (Jan. 1981), 41–50. DOI:https://doi.org/10.1111/j.1365-2214.1981.tb00819.x.
[21] Deverell, L. et al. 2020. Use of technology by orientation and mobility professionals in Australia and Malaysia before COVID-19. *Disability and Rehabilitation: Assistive Technology*. (Jul. 2020), 1–8. DOI:https://doi.org/10.1080/17483107.2020.1785565.
[22] Dmitrenko, D. et al. 2020. CARoma Therapy: Pleasant Scents Promote Safer Driving, Better Mood, and Improved Well-Being in Angry Drivers. (2020), 1–13.
[23] Feng, C. et al. 2015. Designing a Robot Guide for Blind People in Indoor Environments. *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction Extended Abstracts - HRI'15 Extended Abstracts*. (2015), 107–108. DOI:https://doi.org/10.1145/2701973.2702060.
[24] Fox, J. and Bailenson, J.N. 2009. Virtual self-modeling: The effects of vicarious reinforcement and identification on exercise behaviors. *Media Psychology*. 12, 1 (Jan. 2009), 1–25. DOI:https://doi.org/10.1080/15213260802669474.
[25] Gallagher, B. and Jackson, J.B. 2012. Ageing and the impact of vision loss on independent living and mobility. *undefined*. (2012).
[26] Gleason, C. et al. 2018. FootNotes: Geo-referenced Audio Annotations for Nonvisual Exploration. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 2, 109 (2018), 24.

DOI:https://doi.org/10.1145/3264919.

[27] Goertz, Y.H.H. et al. 2010. Factors Related to the Employment of Visually Impaired Persons: A Systematic Literature Review. *Journal of Visual Impairment & Blindness*. 104, 7 (Jul. 2010), 404–418. DOI:https://doi.org/10.1177/0145482X1010400704.

[28] Guerreiro, J. et al. 2019. Airport accessibility and navigation assistance for people with visual impairments. *Conference on Human Factors in Computing Systems - Proceedings* (2019).

[29] Guerreiro, J. et al. 2019. Cabot: Designing and evaluating an autonomous navigation robot for blind people. *ASSETS 2019 - 21st International ACM SIGACCESS Conference on Computers and Accessibility*. (2019), 68–82. DOI:https://doi.org/10.1145/3308561.3353771.

[30] Guerreiro, J. et al. 2019. Hacking blind navigation. *Conference on Human Factors in Computing Systems - Proceedings*. (2019). DOI:https://doi.org/10.1145/3290607.3299015.

[31] Guerreiro, J. et al. 2017. Virtual navigation for blind people: Building sequential representations of the real-world. *ASSETS 2017 - Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility* (New York, NY, USA, Oct. 2017), 280–289.

[32] Guerreiro, J. et al. 2017. Virtual Navigation for Blind People. *Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility - ASSETS '17* (New York, New York, USA, 2017), 280–289.

[33] Habilitation VI UK Virtual Conference 2021 - Full Schedule Available Now! - Habilitation VI UK: 2021. *https://habilitationviuk.org.uk/habilitation-vi-uk-virtual-conference-2021-full-schedule-available-now/*. Accessed: 2021-04-12.

[34] Hersh, M. 2015. Cane use and late onset visual impairment. *Technology and Disability*. 27, 3 (2015), 103–116. DOI:https://doi.org/10.3233/TAD-150432.

[35] Home - Aira : Aira: *https://aira.io/*. Accessed: 2020-09-16.

[36] Jang, Y.B. et al. 2010. An exploratory study on avatar-self similarity, mastery experience and self-efficacy in games. *International Conference on Advanced Communication Technology, ICACT* (2010), 1681–1684.

[37] Joet, G. et al. 2011. Sources of Self-Efficacy: An Investigation of Elementary School Students in France Décrochage scolaire View project Recherches REF View project. *Article in Journal of Educational Psychology*. (2011). DOI:https://doi.org/10.1037/a0024048.

[38] Kameswaran, V. et al. *Understanding In-Situ Use of Commonly Available Navigation Technologies by People with Visual Impairments*.

[39] Kameswaran, V. et al. 2018. 'We can go anywhere': Understanding independence through a case study of ride-hailing use by people with visual impairments in metropolitan India. *Proceedings of the ACM on Human-Computer Interaction*. 2, CSCW (2018). DOI:https://doi.org/10.1145/3274354.

[40] Key Information and Statistics: 2012. *http://www.rnib.org.uk/aboutus/Research/statistics/Pages/statistics.aspx*.

[41] Kim, J. et al. "If they do it, so can I": a test of a moderated serial mediation model of descriptive norms, self-efficacy, and perceived similarity for predicting physical activity. DOI:https://doi.org/10.1080/08870446.2020.1789641.

[42] Kreimeier, J. et al. 2020. BlindWalkVR: Formative Insights into Blind and Visually Impaired People's VR Locomotion using Commercially Available Approaches. (2020). DOI:https://doi.org/10.1145/3389189.3389193.

[43] Lahav, O. et al. 2015. Rehabilitation program integrating virtual environment to improve orientation and mobility skills for people who are blind. *Computers and Education*. 80, (2015), 1–14. DOI:https://doi.org/10.1016/j.compedu.2014.08.003.

[44] Lahav, O. et al. 2015. Virtual environments for people who are visually impaired integrated into an orientation and mobility program. *Journal of Visual Impairment and Blindness*. 109, 1 (2015), 5–16.

DOI:https://doi.org/10.1177/0145482x1510900102.
[45] Lahav, O. and Mioduser, D. 2008. Haptic-feedback support for cognitive mapping of unknown spaces by people who are blind. *International Journal of Human Computer Studies*. 66, 1 (Jan. 2008), 23–35. DOI:https://doi.org/10.1016/j.ijhcs.2007.08.001.
[46] Maggioni, E. et al. 2020. SPACE: Mapping out the Olfactory Design Space for Novel Interactions. *ACM Trans. Comput.-Hum. Interact.* 27, (2020). DOI:https://doi.org/10.1145/3402449.
[47] Marshall, J. and Price, M.J. Cultural models of child disability: perspectives of parents in Malaysia. DOI:https://doi.org/10.1080/09638288.2018.1474497.
[48] Metatla, O. et al. ``Like Popcorn'': Crossmodal Correspondences Between Scents, 3D Shapes and Emotions in Children. 13. DOI:https://doi.org/10.1145/3290605.3300689.
[49] Microsoft Soundscape - Microsoft Research: *https://www.microsoft.com/en-us/research/product/soundscape/*. Accessed: 2020-09-13.
[50] Mott, M. et al. 2019. Accessible by design: An opportunity for virtual reality. *Adjunct Proceedings of the 2019 IEEE International Symposium on Mixed and Augmented Reality, ISMAR-Adjunct 2019* (2019), 451–454.
[51] Nearby Explorer Online on the App Store: *https://apps.apple.com/us/app/nearby-explorer-online/id1095699328*. Accessed: 2020-09-13.
[52] Ortiz, V.H. and Doswell, J.T. 2016. A mixed reality intervention for augmenting the vision of VIIP impacted astronauts. *Proceedings of the International Astronautical Congress, IAC* (2016).
[53] Pacheco-guffrey, H.A. 2018. Towards Inclusion of All Learners through Science Teacher Education. *Towards Inclusion of All Learners through Science Teacher Education*. (2018). DOI:https://doi.org/10.1163/9789004368422.
[54] Panëels, S.A. et al. 2013. The Walking Straight Mobile Application: Helping the Visually Impaired Avoid Veering. *Proceedings of the 19th International Conference on Auditory Display (ICAD2013)* (2013), 25–32.
[55] Phantom Premium Haptic Devices: *https://uk.3dsystems.com/haptics-devices/3d-systems-phantom-premium*. Accessed: 2020-09-14.
[56] Picinali, L. et al. 2014. Exploration of architectural spaces by blind people using auditory virtual reality for the construction of spatial knowledge. *International Journal of Human Computer Studies*. 72, 4 (2014), 393–407. DOI:https://doi.org/10.1016/j.ijhcs.2013.12.008.
[57] Ranasinghe, N. et al. 2018. Season Traveller: Multisensory Narration for Enhancing the Virtual Reality Experience. (2018). DOI:https://doi.org/10.1145/3173574.3174151.
[58] Regal, G. et al. 2018. Mobile location-based games to support orientation & mobility training for visually impaired students. *Proceedings of the 20th International Conference on Human-Computer Interaction with Mobile Devices and Services - MobileHCI '18* (New York, New York, USA, 2018), 1–12.
[59] Rixt Zijlstra, G. et al. 2013. Orientation and mobility training for adults with low vision: a new standardized approach. *Clinical Rehabilitation*. 27, 1 (Jan. 2013), 3–18. DOI:https://doi.org/10.1177/0269215512445395.
[60] Rosenthal, T.L. 1978. Bandura's self-efficacy theory: Thought is father to the deed. *Advances in Behaviour Research and Therapy*. 1, 4 (Jan. 1978), 203–209. DOI:https://doi.org/10.1016/0146-6402(78)90008-5.
[61] Saha, M. et al. 2019. Closing the gap: Designing for the last-few-meters wayfinding problem for people with visual impairments. *ASSETS 2019 - 21st International ACM SIGACCESS Conference on Computers and Accessibility* (2019), 222–235.
[62] Scior, K. *Knowledge, inclusion attitudes, stigma and beliefs regarding intellectual disability and schizophrenia among the UK public: The role of ethnicity, religion and contact*.
[63] Seeing AI App from Microsoft: *https://www.microsoft.com/en-us/ai/seeing-ai*. Accessed: 2020-09-16.
[64] Sevilla, J.A.M. 2005. Tactile virtual reality: A newMethod applied to haptic exploration. *Touch and*

Blindness: Psychology and Neuroscience.

[65] Shaw, E. et al. The Heat is On: Exploring User Behaviour in a Multisensory Virtual Environment for Fire Evacuation. DOI:https://doi.org/10.1145/3290605.3300856.

[66] Singh, A. et al. 2017. Supporting everyday function in chronic pain using wearable technology. *Conference on Human Factors in Computing Systems - Proceedings* (New York, NY, USA, May 2017), 3903–3915.

[67] Stuart, M.E. et al. 2006. *Beliefs About Physical Activity Among Children Who Are Visually Impaired and Their Parents - JVIB - April 2006*.

[68] Susan Scott, B. 2015. *Opening up the world: Early childhood orientation and mobility intervention as perceived by young children who are blind, their parents, and specialist teachers*.

[69] Sweet, K.S. et al. 2019. Community building and knowledge sharing by individuals with disabilities using social media. (2019). DOI:https://doi.org/10.1111/jcal.12377.

[70] TapTapSee - Blind and Visually Impaired Assistive Technology - powered by CloudSight.ai Image Recognition API: *https://taptapseeapp.com/*. Accessed: 2020-09-16.

[71] Tekola, B. et al. 2020. Perceptions and experiences of stigma among parents of children with developmental disorders in Ethiopia: A qualitative study. *Social Science and Medicine*. 256, (Jul. 2020), 113034. DOI:https://doi.org/10.1016/j.socscimed.2020.113034.

[72] Thomas Pocklington Trust 2014. *Loneliness , social isolation and sight loss*.

[73] Tuckman, B.W. 1991. Motivating college students: A model based on empirical evidence. *Innovative Higher Education*. 15, 2 (Mar. 1991), 167–176. DOI:https://doi.org/10.1007/BF00898028.

[74] Ulrich, I. and Borenstein, J. 2001. The GuideCane-applying mobile robot technologies to assist the visually impaired. *IEEE Transactions on Systems, Man, and Cybernetics Part A:Systems and Humans.* (2001), 131–136.

[75] Warner, L.M. et al. 2014. Sources of self-efficacy for physical activity. *Health Psychology*. 33, 11 (2014), 1298–1308. DOI:https://doi.org/10.1037/hea0000085.

[76] Weiner, W.R. et al. eds. 2010. *Foundations of Orientation and Mobility - William R. Wiener, Richard L. Welsh, Bruce B. Blasch - Google Books*. American Foundation for the Blind.

[77] What is BlindSquare | BlindSquare: 2016. *http://blindsquare.com/about/*. Accessed: 2017-05-22.

[78] Wiener, W.R. et al. 2010. *Foundations of orientation and mobility*. AFB Press.

[79] Williams, M.A. et al. 2013. "Pray before you step out." *Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility - ASSETS '13* (New York, New York, USA, 2013), 1–8.

[80] Wolffe, K. and Kelly, S.M. *Instruction in Areas of the Expanded Core Curriculum Linked to Transition Outcomes for Students with Visual Impairments*.

[81] Yoon, C. et al. 2019. *Leveraging augmented reality to create apps for people with visual disabilities: A case study in indoor navigation*. ACM Press.

[82] Zhao, Y. et al. 2018. Enabling People with Visual Impairments to Navigate Virtual Reality with a Haptic and Auditory Cane Simulation. (2018). DOI:https://doi.org/10.1145/3173574.3173690.