Route Learning by Blind and Partially Sighted People

Marion Hersh, Biomedical Engineering,
University of Glasgow, Glasgow G12 8LT, Scotland.
marion.hersh@glasgow.ac.uk

Abstract

The paper aims to fill an important gap in the literature by reporting on blind and partially sighted people's route learning experiences and strategies from their perspective. The existing literature has largely reported the results of experiments in indoor and outdoor often artificially created environments rather than real experiences of travel and route learning. The results presented here were obtained from semi-structured interviews with 100 blind and partially sighted people in five different countries. They show that they prefer to keep to known routes where possible, in line with the literature, but do not wish to be restricted to them. The paper discusses the conditions in which they consider it worth learning new routes and the strategies they use to do this. The paper is interpreted in a theoretical framework of independence, autonomy and self-determination, understood, in line with the disability literature, as making choices and decisions and having control, rather than necessarily doing everything oneself. A further contribution is a confirmation of the role of the (greater) memory of blind people in travel and a suggestion that the ability to develop memory may affect differences in travel skills. The paper concludes with several recommendations, including for further research.

Keywords: blind; route learning; experiences; independence; recommendations; memory

1. Introduction

The ability to travel (independently) is very important for participation in education, work, leisure activities, and all other aspects of modern life. It involves complex cognitive processes and the perception, coding, learning and recall of spatial information (Espinosa et al., 1998). Many blind and partially sighted people are very successful (independent) travellers, though others rarely go out on their own. There is still limited understanding of how blind and partially sighted people process spatial information, despite the growing body of work. However, some of it seems to purely reformulate the inefficiency and difference theories of blind people being able to understand and manipulate spatial information, but do so less efficiently (Rieser et al., 1986) or differently and possibly more slowly (Juurmaa, 1973). Although the formerly considered deficiency theory has been discredited (Jacobson, 1998), the literature not infrequently takes a deficit approach and considers the spatial representations of blind people from the perspective of their spatial impairments e.g. (Thinus-Blanc and Gaunet 1997) rather

than the most suitable approaches for them. Unless stated otherwise, the term 'blind' will be used in the paper to cover blind, partially sighted and deafblind people.

The overvew of different types of sensory information (Ungar, 2000) in table 1 indicates that visually impaired people generally lack a preview of objects or obstacles. The ability to perceive a greater quantity of detailed information with vision than the other senses makes it much easier to integrate visual than other sensory information into a well-structured cognitive map (Espinosa et al., 1998). Blind people perform well on many spatial tasks, including those involving spatial memory and small scale environments (Thinus-Blanc and Gaunet, 1997; Ungar, 2000), and navigating complex mazes (Fortin et al., 2008). However, it is the improved processing of large scale space which gives sighted people their significant advantage with regards to travel. This gives rise to the question of how this disadvantage can be overcome, including through the use of technology. Despite the tendency to consider the representation of space a purely visual activity, there is evidence that vision is neither necessary nor sufficient on its own for spatial coding (Millar, 1988).

Studies indicate that blind people prefer egocentric representations (Thinus-Blanc and Gaunet 1997) and are more accurate and faster than sighted people in processing egocentric small space information. They are able to use allocentric representations (Passini and Proulx, 1988; Tinti et al., 2006), but congenitally blind people are less accurate in processing allocentric large space information and slower in processing both egocentric and allocentric large space information (Iachini et al., 2014). It has also been suggested that congenitally blind people's ability to find a target from egocentric auditory cues indicates the stability of their preferences for egocentric representations (Corazzini et al., 2010). However, they also note that studies showing blind people's reliance on egocentric information have rarely considered the influence of practice, the support of auditory information or encouraged participants to obtain an overall representation by exploring from different locations.

Similarly to sighted people, blind people have very great variability in their navigation and spatial skills (Halko et al., 2014). However, much greater attention has been given in studies to the differences between groups of early, late and (blindfolded) sighted people on mobility performance than within group differences, other than sometimes the extent of visual impairment. Many studies have found a correlation between visual experience and performance on a variety of tasks. In addition, early visual experience may affect the strategies chosen. For instance, early blind people have been found to use less effective strategies for exploring an unfamiliar room (Gaunet et al., 1995). However, some early blind participants had similar performance levels to visually experienced ones (Gaunet et al., 1997), which may imply the importance of individual factors.

Several studies indicate the importance of early opportunities to explore and early training in the use of a long cane and mobility skills and their ability to improve spatial skills (Casey, 1978; Nielsen, 1991) For instance, blind school children were able to produce increasingly accurate school plans using model buildings as their level of independent mobility increased (Casey, 1978) and regular exploration of a range of

objects in a specially designed small room to improve the search behaviour of blind infants (Nielsen, 1991). Since blind children generally have less opportunities for exploration than sighted children, it may be early experience of exploration rather than or in addition to vision that is the significant factor.

There are indications that blind people who travel on their own have more accurate spatial representations than those who do not and that this is related to the strategies used, with spatial imagery being more effective than verbal strategies (Schmidt et al., 2013). It has also been suggested that any limitations in spatial skills may be due to limited experience of mobility (Leonard and Newman, 1967) and in some cases a relative inability to develop particular patterns of movement (Jones and Kabanoff, 1975). There is evidence that blind people with good navigation skills have different and much more focused right temporoparietal junction (TPJ) activation during navigation planning and execution than those with poor skills navigation skills (Halko et al., 2014). This raises the issue of the potential use of studies of TPJ activation to improve mobility skills and how focused TPJ activation could be learnt or encouraged.

There is a body of work and some progress has been made in understanding the performance of blind people on spatial tasks and travel related skills. However, much of the research has involved performance on specific, sometimes slightly artificial tasks. Most of the studies use (very) small samples and sometimes have significant within-group participant variation. The resulting validity problems and possibility of bias or distortion have been noted for studies of blind people's cognitive map knowledge (Kitchin and Jacobson, 1997). However, little attention has been paid to within compared to between group differences. It seems to have been assumed that the same spatial strategies are optimal for everyone (Thinus-Blanc and Gaunet, 1997). However, different strategies may be optimal for blind and sighted people due to the additional cognitive load of memorising considerable additional information (Fortin et al.,2008) amongst other factors.

Many of the studies seem to be ignoring existing knowledge about the mobility of blind people when analysing the results. For instance, discussion of blind people's tendency to prefer egocentric references and route descriptions to allocentric ones rarely includes consideration of their general need for considerably more information for safe travel along a route than sighted people (Fortin et al.,2008). Thus tacit assumptions that the same spatial strategies are optimal for blind and sighted people (Thinus-Blanc and Gaunet, 1997) may not be valid due to, for instance, the different ways in which blind people travel and the greater need to reduce cognitive load, possibly including through the use of route rather than survey representations.

There are at least two further important limitations. The first is the perspective of blind people. The second is an investigation of blind people's experiences of travel, including their sources of information, the mental representations they use and how they learn routes. This paper and its companion paper on the use of sensory information by blind people in their mental representations aim to fill these gap. The paper draws on the experiences of 100 blind people to answer the following questions:

1. How blind people learn and remember routes and the factors that affect this.
2. The role of accompanying people in supporting route learning.
3. How different types of information are used to support route learning.

These questions will be discussed in a theoretical framework of independence, autonomy, and self-determination, as understood in the disability literature. As has been discussed in (Hersh, 2013) in the context of deafblind people, independent travel for blind people should not be understood as the ability to travel everywhere on their own without assistance from other people and/or technology. Instead, it is more helpful to link it to autonomy and self-determination.

Self-determination is about having agency in one's life and being able to take action to maintain or improve its quality (Wehmeyer, 2005) and involves making choices and decisions, setting and attaining goals, solving problems, and self-awareness, advocacy and efficacy (Wood et al., 2005). Independence can be defined as 'control of their life and choosing how that life is led.....(and) the amount of control they have over their everyday routine' (Brisenden, 1986). Attitudes, limited choices and lack of experience are considered the main barriers to self-determination (Adams, 1993). Further important barriers include poorly designed and inaccessible infrastructures, resources and facilities (Hersh, 2013). The paper will interpret the experiences and strategies used by blind people in terms of independence, autonomy and self-determination.

2. Method

The results presented here were obtained from semi-structured interviews with 100 blind people 20 each from France, Italy, Poland, Spain and the UK. They were selected from 299 blind people interviewed as part of a wider project (Hersh, 2009a, 2013). The smaller sample was chosen to be gender balanced and have a good distribution on demographic variables, such as age, age of onset of visual impairment and aid use, as shown in tables 2 and 3. Several blind people from ethnic minorities and/or with additional impairments were included in the sample. Two further criteria for inclusion in the smaller sample were experiencing significant mobility barriers and experience of unaccompanied travel to increase the likelihood of including participants with experience of route learning and who did not mainly use sight in spatial exploration. This resulted in the inclusion of only a small number of non-aid users and fewer partially sighted than blind people, since they are less likely to experience barriers to mobility. The smaller sample also facilitated analysis of rich qualitative data. It included significantly greater numbers of cane than guide dog users, as is the case in the blind population. It should be noted that the data represents both total numbers and percentages and, due to rounding, numbers may not add to 100%.

Semi-structured interviews were carried out by the author as part of a larger research project on travel issues for blind people. (Hersh, 2009a, 2013). Participants were treated as experts on their own experiences and requirements. A semi-structured approach was used to provide both a framework to ensure all the topics of interest were covered and sufficient flexibility to allow exploration of issues raised by participants and

the balance of time spent on different topics to be varied. The semi-structured approach also increased the likelihood of participants discussing their own experiences, opinions and preferences rather than reflecting back those of the researcher.

Contacts for interviews were obtained through organisations of blind people, and via researchers working with them. Issues related to sampling disabled people are discussed in (Hersh, 2010, 2011) and will not be considered here. The majority of interviews took place in the office of an organisation of blind people, and the remainder in another convenient location chosen by the participant, or by telephone. Interviews lasted between 30 minutes and three and a half hours, depending on factors such as the issues that arose and the participant's time availability. All the interviews on which this paper are based took place in the participant's language without an interpreter. This reduced the likelihood of misunderstandings and distortion. Informed consent procedures in line with institutional requirements were used, with consent generally given orally rather than in writing were this was more accessible.

Participants were initially asked to introduce themselves and to talk about their lives, activities, interests, visual impairment and the role of travel in their lives. Topics arising from this introduction were then explored in more detail. Other topics covered, though not all topics were relevant to all participants, included: (i) the use of travel aids; (ii) orientation and mobility training; (iii) public transport, buildings and urban environments; (iv) spatial representations, description of a route and a familiar room or other space; (v) learning new routes, landmarks used and any changes in them due to changes in vision/visual impairment; (vi) any changes over time in their experiences of getting around; (vii) attitudes and support from family, friends and the local community, and the communication strategies used by deafblind people; and (viii) education, employment, and interests.

All the interviews were recorded on a digital recorder and transcribed by a native speaker without translation. The analysis was based on transcript extracts identified using search terms related to route learning, sensory information and mental representations. The standard stages of open, axial and selective coding (Boeije, 2010) were carried out manually due to the multi-lingual nature of the material. An initial list of high and some lower level themes was obtained from coding a subset of the interview extracts in detail. These codes were then applied to all the interviews and additional codes added and applied.

It was only at the axial coding stage that sections of the transcripts relating to the chosen themes were translated into English by the author, trying to remain as faithful as possible to the style, spirit and meaning of the original. The author also referred back to the original language transcripts to verify translations and the context. At this stage the material was also divided into two parts for this and the companion paper on use of sensory information by blind people in their mental representations.

3. Results

3.1 New, Regular and Infrequent Routes

Most of the participants used a number of familiar routes regularly and did not feel particularly comfortable travelling on their own to other destinations. PY: 'I would not venture on my own [in a new place]' and SN: I cannot go to new places … I need to find someone who explains it to me.' RS was particularly decided about this: 'unknown [places] no.' This parallels findings that blind people frequently only travel learnt routes between known places (Golledge, 1993). In the case of one-off travel to a new destination that was unlikely to be repeated participants preferred to be accompanied and did not feel it worth making the effort to try to learn the route to travel independently. IB: 'If I only go once I am not interested in remembering it [the route] and VC: 'If I do not need to go back there then I probably am accompanied because then it is not necessary to learn the route.' This follows the literature on the stress and anxiety of travel in unfamiliar environments for blind people (Richards et al. 2010).

However, participants were interested in new routes which they expected to travel regularly, for instance as a result of changing job or moving house. SI: 'When I move to a new area next week I will need to do training. I have never been there before.' The closest discussion in the literature is about orientation and mobility training for (older) people increasing confidence and use of public transport (Engel et al., 2000). Stress and the unexpected were particular concerns when travelling a route for the first time. AN: 'I want someone to go with me in a new place on account of stress, road works … After doing the route with someone, I can go on my own.'

Participants generally preferred to be accompanied the first or first few times in order to learn the route. AD: 'If I need to stay somewhere else for a few days it is sufficient that a guide shows me the route once or twice so I know where and how to get there.' The number of times required to learn a route varied with its complexity and participant factors. AT: 'I have a small visual residue ... accompanying me twice is sufficient for me to know'. AD: 'If I do not remember I take him [guide] with me the third time.' HP: 'I need to do a route several times to learn it.' AA: 'if I actually travel the full length of the journey with the person, so once or twice, I then know the route.' Repeated travel made the travel process automatic and part of routine. JF: 'When you have been twice you know everything, where the places are that you need to get to … it is routine.' RS: 'it becomes automatic, when we have done a route several times we know it … it becomes routine.' This is related to the literature on cognitive maps being acquired without significant effort from observations during travel (Kuipers, 1978). Knowing a route in one direction was helpful in learning it in the other direction, but the two were not always identical. AS: 'I know that you do it the same way, but better to go on it … Sometimes there are different landmarks, because there is another crossing, you need to cross the road for the bus stop. … I generally remember, and manage to reverse it'.

Learning routes with qualified orientation and mobility (O&M) instructors had advantages. HP: 'It is best if I go with an instructor who can correct my mistakes if necessary' and PO: 'First I would ask the instructor to come with me to give me some tips … to enable me to get round the new building'. However, participants were happy to be shown routes by friends, family and colleagues, as long as they were able to

identify and point out landmarks of relevance to blind and partially sighted people. HP: 'It can be someone else as long as they show me. My mum has taught me one route, as she knows what landmarks to draw attention to.' In some cases, they even considered that there were advantages in learning from people who were not O&M instructors. BK: 'It is easier to learn the route if initially I go with someone who shows me. Sometimes I ask people who are not orientation and mobility specialists. They manage to do it just as well, sometimes better. … Sometimes someone simply takes my arm and tells me e.g. on the right you have a house, a bit further a bus stop.' AB: 'my friends, my wife, my children explain … details when you go to a new place for the first time'. This parallels the literature on the value of both support from family and friends and training by professionals, though in the slightly different context of adaptation to vision loss (Nyman et al., 2012).

However, problems could occur when the person did not know what to point out to a blind person. HP: 'One of my work colleagues explained a route to me, but as you would to a sighted person …. so I did not understand how to get there. However, this participant had found a solution, though it required additional time. HP: 'We therefore went together on a route I knew. I described it to him. I told him what we were passing, where the surface changes, where a barrier ends …. then he knew how to explain the route to me.' This illustrates a participant exercising self-determination by using agency (Wehmayer, 2005) and solving problems (Wood et al., 2005) to ensure that route information is provided in an appropriate way. It further illustrates the fact that blind (and other disabled) people are not just passive recipients of support, but know the type of support they require and are able to act effectively to ensure they obtain it, as well as the difficulties that could occur otherwise. Some participants felt that some routes and areas were too difficult to learn. SN: 'not all routes can be learnt. In the country there is not a well marked edge to follow and a lot of deviations, you run the risk of taking the wrong street. You need to know the place well, and to know it well you need to live there, go there frequently.'

3.2 Instruction and Support

Participants generally needed the accompanying person to point out obstacles and landmarks. MP: 'The mobility officer walks behind and also catches up with me and points out markers like benches and gaps and you know ...' and VC: 'It is best that [the accompanying person] shows me the landmarks.' Participants frequently knew what types of information they required, with tactile information being particularly important in line with analysis of route descriptions showing the importance of tactile and audio information to blind people (Kulyukin et al., 2008). VC: 'Generally I ask for the names of the streets we are passing and landmarks you can touch, columns, tactile landmarks, the angles of streets, landmarks I can use to distinguish the route better on my own, … if instead you describe what is around me, the landmarks … I can learn the route.' AR: 'Dad told me that e.g. I am going along the kerb, about various obstacles that could be useful, a depression in the road ... at the first post I need to cross at the lights'.

Participants also described a process of the accompanying person initally drawing attention to significant points and gradually withdrawing. SV: ‘The instructor explains the route you need to follow … turn to the left or right, the biggest obstacles, … how to return, they then follow you, but you only become aware of this at the end … then gradually they make you go on your own' This process of gradual withdrawal was helpful in increasing participants' confidence to travel on their own. JM: ‘my husband will go with me … he will stop and he will describe what there is round about ... I will latch on to that … when I see it I know I do this or I do that. And we will go a couple of times together and then I’ll go with him tailing me ... and make sure that I am going the right way. And it gives me the confidence to know that I am doing it on my own but I have got somebody there that is watching in case I go the wrong way or I miss something…. And then we just go over the route as much as I feel I need to do it to make sure that I have got it firmly fixed in my head.' A related approach involved the participant pointing out directions to the guide and asking for confirmation. AD: 'He tells me what’s there, how we go … I remember it in my head. The next time we go I tell my guide we go there or there and he corrects me.'

Route learning could involve physical learning with the participant's feet or body remembering what to do NL: 'once I have done it two or three times with somebody I can usually at least go part of the way and remember what is you know it is almost like me foot know what I am doing.’ Learning landmarks was an important part of learning new routes. BL: ‘a path I have been taken on often enough, after several times I will start finding landmarks’. Like the tactile landmarks previously mentioned, audio landmarks were also used AK: 'There is the noise of the water flowing in the fountain. After you have heard it once or twice you remember it.’ Participants also tried to organise the landmarks EK: ‘if I know I am going to be using the route … then I will try to remember it … I also ask about landmarks … which I try to put in order and remember.’ This is in line with the literature on the need for a combination of landmarks, route recognition and knowledge of the area to develop an ordered spatial representation (deFatima et al., 2015).

It was easier to learn routes when the other person did not walk too fast and plenty of time was available. BL: ‘It all depends on the speed at which we have walked’. It was easier at a sloiw speed. BL: '[If this was slow] I would not say that I would be able to manage 100%, but I would have a good idea how to get there on my own.' Both the participant and the other person needed to have sufficient time available. IN: ‘The best circumstances to learn are when … I have 7 hours available … there is no rush, it does not matter if it takes an hour, if it is 2 kilometres, if it is 5’. And SN: ‘ You need to find a person who is available to teach [the route], as it is not the first time you learn it.’

Concentration was important. FD: ‘At the start I need to concentrate, but it gradually gets easier’. Some participants found that travelling with other people could be distracting, leading them to focus on the conversation rather than the route. FD: 'But if the first time I go somewhere I go with someone and I talk to them it is more difficult to learn the route, as there is a certain degree of awareness.' and BK: ‘We cannot engage in conversation, as then I do not concentrate on the route … just the conversation.’ These participants learnt routes better on their own, as this avoided distraction, making

it easier for them to concentrate. IB: 'If I go on my own I remember things better. If I go with other people I concentrate less and therefore I learn less, as I am concentrating less.'

3.3 Memory and Practice

Participants considered memory very important due to requiring additional information compared to sighted people for safe travel (Fortin et al.,2008). BV: 'You need to make an effort to remember, which is probably even more important than for someone who has a map in their pocket.' NL: 'I also make my memory work hard.' It was suggested that the need to remember a lot of travel information had improved the memories of blind people. This is in line with the literature on blind children having better short term and working memories than sighted children for verbal tasks (Withagen et al., 2013) with blind people's better memories being due to training in serial strategies to compensate for the lack of visual information and greater memory use (Raz et al., 2007). BC: 'Blind and partially sighted people have wonderful hard disks, we need to remember everything. … When you remember various things, you test your memory.' SV: 'I have learnt to get around as it is a route I do frequently, I ask a bit, I remember a bit.' Having a good memory made it easier to develop area knowledge. SV: 'I've learnt this area well.' Some participants supplemented their memories with audio recordings or Braille, but other preferred to try and remember everything. BS: 'I try to remember. When that is difficult, I record short notes as a memory aid.' and MF: 'I rarely take notes in Braille, I remember'. In line with concerns about safety (though in this case personal safety) in the literature (Johnson and Petrie, 1998; Hersh, 2016), participants were careful about the type of device they used as a memory aide. BS: 'It is better not to use a phone, as it is not safe to get it out and it may not be in range.' Asking other people was also used to supplement memory and reduce the demands on it, particularly initially. AT: 'I can't see another solution than to ask so as not to have to learn so much the first few days.'

Participants' ability to memorise routes could be useful to sighted companions and enabled mutual support. LR: 'In other cities I first study the route with my wife … also with my son … they know my memory is different from theirs … clearly I would have a lot more trouble without their eyes, but they profit from my memory, otherwise they would have to study the route themselves.' This is also an example of interdependence (Reindall, 1999) to the benefit of everyone involved and illustrates how blind people are able to provide support to sighted people as well as receiving support from them. Participants also used existing knowledge CA 'with routes, you tend to be building on things you already know, because you have to be walking there to get to the start of the new route, because it's a route you don't know.'

Repetition and practice were considered important to support route learning. AT: 'You need to remember [the route] from doing it several times … You need to be able to remember a lot to find your way.' LA: 'Just by repetition. ... you do the route once, you become conscious of certain distances between each turn, certain kerbs or echoes,

sound deflections from particular buildings or objects, smells too.' Familiarity from repetition allowed participants to develop mental maps. LA: 'And out of repetition comes familiarity and from that familiarity comes the cognition you know a sort of map that you can plot your own progress along that route. … and then you check and recheck particular clues, distances, paces, lefts and rights and it gradually builds into a more comprehensive and fixed mapping.' Practice allowed participants to remember routes. For some participants repetition involved distinct learning stages. MT: 'I do the route with another person, but it is me who does it and I repeat all the landmarks and ask confirmation from the other person and then the third time with all I have memorised I am able to do the route.'

Practice and knowing a route increased feelings of security. VC 'The first time I go with someone and then I go on my own. … I walk more slowly and pay more attention to obstacles. … I do not feel as calm and as safe as on a route that I know and I do frequently.' However, participants also learnt from their mistakes. JF: 'going and going the wrong way … and returning … is the best way to learn … when you go the wrong way … the next time you do not and you know where the place is'.

3.4 Going on Your Own and Asking for Directions and Assistance

While most participants preferred to be accompanied when going somewhere for the first time, this was not always feasible. AS: 'I generally do not have time to prepare. I think one day that I need to go and I go.' And AN: ' If I need to get to a new place on my own, I somehow manage.' Advance descriptions could be sufficient, depending on factors such as the area and journey difficulty. MW: 'Sometimes it is sufficient that someone explains where to get on, where to get of, how to go. Sometimes I need someone to show me. It depends on the area of the city, if there are a lot of people, how difficult the journey is, if there are a lot of changes'.

Some participants were able to learn simpler routes on their own. AS: 'There are a few uncomplicated routes that I have mastered on my own.' A related option was working out the route and supplementing this knowledge by asking people. BK: 'When I couldn't find anyone to show me the route, I tried to more or less explain it to myself … the organisation of the place … e.g. office, post office, shop that I needed to get to. Using this description I simply went there. I also asked passers-by and tried to remember.' This description of different strategies when another person was available is one of several illustrative examples in this section of how participants exercise agency to obtain information to enable them to travel when full support is not available and thereby increase their quality of life (Wehmeyer, 2005). Going to a new place on their own could be stressful and frightening, though this did not necessarily stop participants. EK: 'there is always fear when it is a case of ... a new place. However, it often happens that I still have to go somewhere on my own ... a place where I have not been. ... I need to go to deal with something or to meet friends for coffee. The first journey to a place is certainly always very stressful.' However, factors such as age could affect participants' willingness to travel alone on new routes. ' LR: 'In a city I do not know … unless you are foolhardy like I was 30 years ago … now I do not take risks any more.' These

comments further provide a more developed and nuanced perspective than the stress and anxiety of travel in unfamiliar environments (Richards et al., 2010) and leaving known routes leading to 'disorientation and chaos, and fear and panic of being lost' Golledge (1993). These participants also illustrate how they can increase control over their lives, independence and self-determination (Brisenden, 1986) through choices about both when to and when not to engage in particular activities. Their experiences also show some of the barriers experienced by blind people that need to be overcome to avoid their choices being constrained.

Some participants were able to use route descriptions or directions, but preferred to be accompanied to new places. VC: 'You can describe [the route] to me on the phone and then I go there, but if it is a new place it is better to go together and for them to describe the landmarks and everything while doing the route.' The quality of the directions was also important in line with the literature on potential problems resulting from dependence on information from other people which may be incomplete or inaccurate (Golledge, 1993). CG: 'depends if I've been given good directions then fair enough.' Analogously to route learning with another person discussed previously, learning the route on your own generally required travelling it several times: CG: 'will be about the first three times that I go before I really know it'. While advance information could be useful, problems could occur in the case of small mistakes, as participants lacked the knowledge of the area to easily correct them, though they did find solutions. EK: 'I never travelled here with anyone … I had a sufficiently detailed description from a friend who had worked here … but I got off a stop too early. … I just made a mistake … A very stressful situation. I had to sort it out.'

As has been discussed in the literature (Johnson and Petrie, 1998), asking for directions and/or assistance was an important strategy for many participants. MD: 'Even when I do not know the place I do not make plans … I just ask people and friends'. LM: 'I am used to asking and they tell me: you need to cross three roads, first on the right, second on the left'. BR: 'When I am not certain I ask someone.' Asking was used by some participants to overcome the barriers they would otherwise have experienced to travelling without a guide. And SV: 'You need to have the courage to venture out and ask and ask ... we proved this going to the station in F.' It could also be used to confirm other information. BL: 'if someone has given me an idea I will ask people … in which direction I need to go … I will ask several times to get to the platform.' Responses were also checked against participants' existing knowledge, leading to backtracking until the two corresponded. GB: 'I talk to people, ask, listen to their replies and go around with the cane, I get to a street and ask what road it is. If it corresponds to my mental map, great, if not I turn round and try to return to a point I know.' Asking also helped participants find landmarks. GL: 'I ask people nearby if there are landmarks I can use, a kiosk or bar or particular businesses'.

However, obtaining information from other people was not without its difficulties. First the presence of another person needed to be detected, generally via sound. AS: 'I wait until I can hear steps, a voice, Then I ask how to get there. … I ask if it is this turning.' Other people did not always provide correct information and directions given by different people were not always consistent. EK: 'Often the different information is inconsistent.

One person says one thing, someone else another … Sometimes you get lost a bit before you get there.' Some participants asked if there was no other option, but preferred to initially travel with another person in line with indications in the literature of difficulties in asking (Johnson and Petrie, 1998). KA: 'sometimes when I go somewhere for the first time, I ask … I always have problems with this … I prefer to go with someone'. Sometimes undesired assistance was provided. BR: 'People are very friendly, they help even when you do not want them to.'

The need to ask could be reduced by limiting it to specific important information. KG: ' [I ask] only at crossings and bus stops to see which bus to take'. Obtaining information in advance was another way of minimising the need to ask. KG: 'I try to learn the route in such a way that I can manage on my own.' This included asking other people in advance. AS: 'If I know that someone knows somewhere that I need to go to I phone that person or ask them to open a map and describe to me how to get there. AS: Advance information could also be used to tell participants what they needed to ask for en route. 'If someone has information I want to find out in the context of a map or landmarks so I know what to ask for.' However, being able to prepare in advance did not necessarily prevent participants travelling. AS: 'If this is not possible … I go without knowledge.'

3.5 Using Technology to Obtain Information in Advance and en Route

Access to information is essential for successful travel. As indicated in the previous section, blind people both try to obtain information in advance and seek information while travelling. Technology, including the internet and maps, was another source of advance information. BC: 'I always try to identify a new place. I sit in front of the computer and look and when I get to the place I recognise the area. … I try to remember what the road is like, where there are steps.' Internet maps were considered useful by several participants. IB: 'above all with the internet with maps' and BR: 'When I go to an unknown place I try to analyse it in advance on the internet.' In addition to being studied in advance, maps on the internet could be copied onto a phone for use while travelling. FD: 'maps on the internet which show you the streets, the distances, I am managing to get to places I do not know, looking at the map before leaving the house. ... if they are long I put them on my phone and take them with me.'

A few participants used tactile maps, though they were rarely available (Lobben and Lawrence, 2012), and on some occasions needed to be specially requested . BV: 'On the campus I asked them to make a tactile map, because I had been getting lost for a few months.' Analogously to the examples in the previous section of the use of agency through obtaining support from other people, this is one of several examples of agency through the use of technology, in this case low tech. In particular, this example illustrates a participant taking action to overcome the barriers caused by the lack of tactile maps. This participant considered tactile maps of the underground both very useful and easy to make. BV: 'in L the underground map was really useful to me. There are four lines … It was easy to make a tactile version.' This is in line with the

literature on the value of tactile maps together with direct experience in O&M training (Espinosa et al., 1998) and the use of tactile maps in developing an accurate environmental representation (Ungar et al., 1997) and facilitating route learning (Blades et al., 1999). One participant had been shown spatial layouts using mats on the floor, but the use of objects in explaining routes and areas to blind people seems not to have been discussed in the literature. BL: 'She put mats along the room which represented pavements ... to reproduce the crossings ... it's there that I perceived the concept of a crossroad etc, how to direct yourself on a route ... now if someone says third on the right, second on the left ... I see myself circulating with the mats ... and I translate this to the exterior.' Some participants found that Braille notes could help them learn new routes by making it easier to learn the details. HP: 'When learning a new route … I write a description … in Braille … when I get home. … If that's not possible I record the description and later write it in Braille. … Reading the notes … in the end I remember all the details.'

Several participants used global positioning systems (GPS) and considered them helpful in finding their destinations. LR: 'GPS is useful for getting to places' and LR: 'Fortunately there's GPS and therefore I prepare the route first and then I go.' GPS could be used to check users were still on the correct route. BR: 'I have had a GPS for a few days. ... It's wonderful. I can stop and check where I am so I do not go too far wrong.' A GPS could also provide useful information about facilities and save participants having to ask. IB: 'It was really useful as it indicated bars and restaurants which I could find on the road or chemists ... and spared me having to ask for information'. GPS was considered most useful in preventing people getting lost in unfamiliar places in line with the literature about blind people's concerns about getting lost on unfamiliar routes (Johnson and Petrie, 1998), but also could be used in familiar places to reduce the need for concentration. RK: 'In unfamiliar places it is probably the most useful as you're not totally lost. It can be useful in familiar places as well, as I don't have to concentrate as much on the route. I have confirmation that I am on the right track. It is less stressful.' GPS could also be particularly useful when participants got lost. RK: ' If I start to go somewhere different from what the program Way Finder ... leads me from that point. It won't ask me to go back half a kilometre, but modifies the route so I get there.'

As well as providing information to support immediate travel, participants could use GPS to learn more about their routes. BI: 'I'm learning the names of the roads that I'm passing now. It's really helpful, ... If somebody said 'you've got to go to such and such a place' - I'll say "That's fine, but where is it." But ... now I'm beginning to learn. Walking around the information I'm getting from the GPS is - three way intersections, half lane crossing "so and so on your left" so I know that the next road junction is that particular road.' This parallels the literature on the value of spatial knowledge in supporting wayfinding (Passini et al., 1990) and environmental awareness facilitating spatial orientation (deFatima et al., 2015). GPS also enabled participants to travel on holiday to new places and obtain greater enjoyment and information. CC: 'You can mark the points for where you are and where you want to go ... and with the GPS I can go on holiday to places I do not know. You see less than a sighted person, but you can still manage a bit ... GPS ... gives directions and distances.' The discussion in this and the

previous paragraph illustrates agency through the use of high tech technology in the form of a GPS. In particular, it can improve participants' quality of life while travelling, including on holiday, by providing additional and more detailed information and enabling them to relatively easily find facilities they are looking for.

3.6 Route Learning with a Guide Dog

Guide dog users sometimes learnt the route on their own with a cane first, as this enabled them to detect obstacles, which a guide dog would have avoided without them being aware of this. IB: 'So I go with the cane, so I am able to identity more landmarks and then I go with the dog.' RB: 'If I need to learn a difficult route I will do it first with the cane holding the dog by the lead, so I can take note of where I am going. Then … I do it with the dog so he can evaluate the obstacles, where to cross.' Participants also considered it important to know the route themselves and not just leave the responsibility to the dog. RB: 'Before giving the responsibility to the dog I need to know the road myself … If I can I go with another person, if not I go calmly and ask for information'.

Most of the dogs were very good at learning new routes. JA: 'A couple times, and it does not take him long to learn the route.' and RB: 'My dog has an incredible memory, therefore if he does it once he remembers it the next time … it is enough to do it in one direction, on the way back he is able to go on his own.' However, this good memory made it essential that dogs were shown the correct route from the start. RS: 'if I didn't get it right for the first time then when dog is new to that area ... they learn the mistakes'

Participants also stressed the importance of working together with the dog. CA: 'Consider the building [route knowledge] as a partnership and if you and dog try to increase some of the areas you want to go to, or can go to'. RS: 'a lot of the time it is help by the dog. I tell dog find the path and dog finds it. Because I know roughly which direction I should be heading, between me and the dog we usually find it. We do get lost, but we usually get there!' This is in line with the literature on guide dogs increasing mobility confidence (Wiggett-Barnard and Steel, 2008).

4. Discussion and Conclusions

The paper has drawn on interviews with 100 blind people in five different countries to discuss route learning, including their experiences and the strategies used. The data was obtained from semi-structured interviews which formed part of a larger research project, including interviews with 299 blind people, on travel issues for blind people. Although the aim was to obtain rich data rather than a statistically representative sample, participants in both samples were chosen to have very diverse characteristics. Those in the smaller sample also experienced significant mobility barriers and had experience of unaccompanied travel to increase the likelihood of including participants with experience of route learning and who did not mainly use sight in spatial exploration. The term unaccompanied rather than autonomous travel is being used here in line with

the understanding of autonomy discussed in the introduction. This avoids assumptions about unaccompanied travel necessarily being non-autonomous.

The literature has tended to focus on experiments in indoor and outdoor environments on the performance of blind people or the comparative performance of early and late blind and (blindfolded) sighted people on particular spatial tasks. This research has a number of limitations, including very small samples and lack of consideration of within-group variation. A futher important limitation is the minimal research on the actual experiences of blind people of route learning and the strategies they use to do this. This paper aims to fill this gap and the presentation of blind people's experiences and strategies for route learning from their perspective is one of its main contributions.

The results present a picture of blind travellers who preferred to keep to known routes where possible, in line with the literature (Gollege, 1993), but who had developed strategies to avoid being restricted to them. This demonstrates their use of agency and taking control of their lives (Brisenden, 1986; Wehrmeyer, 2005). Participants considered it worth learning new routes if they were going to be travelling on them regularly, but not for one-off journeys, where they preferred to be accompanied. They generally preferred to learn routes with another person, but conversation could be distracting. Participants considered there were some advantages in learning from O&M instructors, who could correct their mistakes, but several of them had been successfully taught routes by family members and friends. They generally wanted the accompanying person to point out route features at least the first time. The number of times they required to travel a route to learn it depended on its complexity and individual factors. Route learning frequently involved a process of the guide initially pointing out obstacles and landmarks followed by them increasingly stepping back each time the route was followed until the participant felt confident to travel on their own. Participants generally needed to learn a route in both directions, as there could be differences. Learning landmarks was often an important part of route learning in line with the literature on the importance of landmarks for an ordered spatial representation (deFatima et al., 2015) and both tactile and auditory landmarks were mentioned, paralleling the literature on their importance in route descriptions (Kulyukin et al., 2008).

It was not always possible for participants to find an accompanying person. In this case many participants travelled on their own, but often tried to obtain as much information as possible in advance. This included asking other people and using a range of technologies, including GPS, tactile maps (which sometimes needed to be constructed specially), internet maps and even mats on the floor. The value of tactile maps and their lack of availability have been recognised (Espinosa et al., 1998; Lobben and Lawrence, 2012), but the use of the other technologies has received little attention in the literature. The use of objects to support route or other spatial learning by blind people is probably not uncommon, but has received little if any attention in the literature. GPS was found to be particularly useful and could be used both in advance to prepare the route and while travelling. It was considered most useful in preventing participants getting lost in unfamiliar places in line with the literature on concerns about this (Johnson and Petrie, 1998), but also able to provide additional information on facilities, road names and about the route and to check their location while travelling. Asking for

information and/or help en route was a very common strategy, in line with the literature (Johnson and Petrie, 1998). However, some participants tried to minimise the need for assistance by obtaining information in advance. The accuracy of information from other people could be an issue, leading to strategies such as asking several people for corroboration.

Guide dog users sometimes learnt the route first with a cane and then with the dog to learn about obstacles that the dog would avoid without their knowledge. They stressed the importance of working together with their dogs and, in line with the literature on increased mobility confidence (Wiggett-Barnard and Steel, 2008), indicated how the presence of the dog could help and support them. Many of the dogs were very good at learning new routes. 'The sample included participants from five different countries. However, there was no evidence of national differences, though there were significant individual differences.

The research reported here has confirmed preliminary findings of the author (Hersh, 2009b) and in the literature (Johnson and Petrie, 1998) on the significance of the difference between familiar and unfamiliar routes. It has also confirmed findings on blind people's general preference for egocentric and route representations rather than allocentric and survey representations (Thinus-Blanc and Gaunet 1997) and contributed to explaining why. The latter includes the greater cognitive load and the need to focus on information required to travel i.e route information and pay limited or no attention to area information that is not required. The research has increased understanding of how blind people learn routes and the specific strategies they use and the importance of memory.

It has also shown how the need to learn routes and remember a lot of spatial information has helped participants develop their memories. While none of the participants indicated that the memory demands of unaccompanied travel were a particular problem for them, it is possible that the difficulties in remembering the considerable body of spatial information required for successful travel by blind people are one of the factors that made it difficult for some blind people to travel unaccompanied. Existing research confirms the improved working and short term memories of blind people for verbal tasks (Withagen et al., 2013) and that this may be due to training in serial memory tasks to compensate for lack of visual information and the greater use of memory by blind people (Raz et al., 2007). However, there is no research on the relationship between memory and travel skills, including whether the ability to develop memory is a contributory factor to differences in travel skills of blind people. Further research will be required to investigate this.

The work has also identified some of the barriers blind people experience to safe and worry free unaccompanied travel. These include the lack of availability of both personal assistance and technology, as well as solutions for when they get lost. The lack of personal assistance covers both the lack of people able to accompany participants on one-off routes and the lack of sufficient trained O&M instructors and other people able to teach participants routes. Current approaches to supporting blind people who get lost use a combination of camera images and a phone line. However, when usage

increases the phone line could become very resource intensive and focusing the camera may be difficult. Therefore it could be useful to investigate purely technological solutions, for instance artificial intelligence based apps. In the area of technology more generally, some existing technologies, such as tactile maps and GPS are not as widely available as they could be and existing technologies are not yet able to fulfil all the information needs of blind travellers.

Thus, for these blind participants autonomous travel involved making choices about whether and how to travel. It should be noted that travel with other people for companionship is outside the remit of this paper. The main factors affecting their decisions were: (i) route familiarity, (ii) the likelihood of travel on unfamiliar routes being one-off or repeated; (iii) the availability of an accompanying person for one-off unfamiliar routes; (iv) preferences for route learning on their own or with another person; (v) the availability of an O&M instructor or a person able to point out appropriate landmarks to them; (vi) the availability of other people with knowledge of where they were going; (vii) the availability of technology, such as tactile maps and the knowledge and confidence to use it; (vii) personal factors, such as confidence and the strength of the need or desire to travel to the particular destination.

The research provides a useful example of interdependence (Reindell, 1999). LR: 'In other cities I first study the route with my wife … also with my son … clearly I would have a lot more trouble without their eyes, but they profit from my memory, otherwise they would have to study the route themselves.' This illustrates the ability of blind people to provide as well as receive support. It is also important in challenging perceptions of blind people as purely dependent and that interdependence for blind (and other disabled) people does work in practice. The paper also provides several examples of participants using agency through the use of assistance and/or technology to enable them to exercise independence and control how and where they travelled. It also illustrates some of the barriers which restrict blind people's choices about travel.

4.1 Conclusions and Recommendations

The paper has filled an important gap in the literature by giving a detailed presentation of blind people's experience and strategies of route learning in their own voices. The body of the literature in this area has largely reported on experiments rather than real experiences of travel and route learning. The results were obtained from semi-structured interviews with 100 blind people in five different countries.

The work has confirmed the significance of the distinction in the literature between familiar and unfamiliar routes (Golledge, 1993; Johnson and Petrie, 1998). The blind participants typically had a number of familiar routes which they travelled on unaccompanied. They preferred to be accompanied on one-off trips on unfamiliar routes and to learn routes they would be travelling repeatedly with the assistance of an O&M instructor or other person. However, some participants preferred to learn on their own due to being distracted by conversation and several participants had taught themselves routes. Participants also exercised agency relating to the use of assistance

from other people and/or technology to enable them to travel when these conditions were not met, as well as to resolve any problems that arose.

The paper has also demonstrated that the paradigm of independence linked to autonomy and self-determination as expressed in terms of agency, decision making and control over their lives (Brisenden, 1986; Wehmeyer, 2005; Wood et al., 2005) provides a useful theoretical framework in which to examine route learning experiences and strategies and to identify the barriers blind travellers experience to greater independence in terms of choice and control. The paper has provided numerous examples of independent travel in terms of agency, choices and control, as well as an example of interdependence between blind and sighted people.

A further contribution is the importance of memory and the greater memory skills of blind people, in line with the literature. However, there is a need for further research to determine the relationship between memory and travel skills.

This discussion in the paper and the conclusion then leads to the following recommendations, which include the need for further research.

Personal assistance:

- Measures to significantly increase the number of O&M professionals.
- The development of cost-free (or very low cost) accompaniment services, using paid staff as much as possible and volunteers when this is not available.
- Research on: (i) the best ways to teach new routes to blind people with some O&M skills; (ii) the relative benefits of using instructors or family and friends; the relative benefits of blind and sighted instructors; (iii) the spatial memories of blind people, strategies for developing memory and the relationship, if any between memory and travel skills.

Technology

- The development of tactile maps of urban and rural areas and transport systems to ensure widespread availability.
- Encouragement of the general inclusion of the effective use of GPS, mobile apps, internet maps and other wayfinding technologies while travelling in O&M training.
- Research and development: (i) technological solutions to support blind people who become lost e.g. artificial intelligence based apps; (ii) new apps to support route learning and provide travel information in ways that do not lead to information overload.

4.2 Implications for Family, Practitioners and Friends

The paper shows that blind people can have control over their own lives and exert agency in decisions about travel. Family, friends and practitioners should support the travel choices made by blind people, support and encourage them and avoid overprotection. You should encourage your blind family member, friend or client to develop their mobility skills, including through orientation and mobility training if they

have not yet had it. You should also encourage them to develop their confidence to travel on their own, including by encouraging them to seek addition training to learn new routes and/or accompanying them on new routes, learning how best to explain new routes to them and gradually withdrawing. It is also useful to draw on their skills, such as a greater ability to take note of the noise of traffic approaching from behind when walking without pavements or to do so from a greater distance or a greater ability to remember route features.

Acknowledgements

I would like to thank the Leverhulme Trust for the award of a Research Fellowship which supported this work, the many blind, partially sighted and deafblind people who gave of their time and expertise and the colleagues and organisations who provided me with support. While I cannot unfortunately mention everyone, particular thanks are due to Hanna Pasterny and CRIS, Monica Schmid and l'Instituto Maugeri, Mario Barbuto and l'Instituto Cavazza, la Fédération des Associations des Chiens Guides, René Farcy, Mike Johnson, ONCE in Santander and La Rioja and Polski Związek Niewidomych.

There are no declarations of interest.

References

Adams, J. (1993). Self-determination, Proceedings of National Symposium on Children and Youth who are Deaf-Blind. (pp. 223-228). Monmouth, OR, Teaching Research Publications.

Blades, M., Ungar, S., & Spencer, C. (1999). Map use by adults with visual impairments. *The Professional Geographer*, *51*(4), 539-553.

Boeije, H. (2010). Analysis in qualitative research. London, England: Sage Publications Ltd.

Brisenden, S., (1986). Independent living and the medical model of disability. Disability, Handicap and Society, 1(2), 173–178. doi: 10.1080/02674648666780171.

Casey, S. M. (1978). Cognitive mapping by the blind. *Journal of Visual Impairment & Blindness*, *72*(8), 297-301.

Corazzini, L., Tinti, C., Schmidt, S., Mirandola, C., & Cornoldi, C. (2010). Developing spatial knowledge in the absence of vision: allocentric and egocentric representations generated by blind people when supported by auditory cues. *Psychologica Belgica*, *50*(3-4).

deFatima, M., Almedia, X.M., Martins, L. B., & Lima, F. J. (2015). Analysis of wayfinding strategies of blind people using tactile maps. *Procedia Manufacturing*, *3*, 6020-6027.

Engel, R. J., Welsh, R. L., & Lewis, L. J. (2000). Improving the well-being of vision-impaired older adults through orientation and mobility training and rehabilitation: an evaluation. *RE: view*, *32*(2), 67.

Espinosa, M. A., Ungar, S., Ochaíta, E., Blades, M., & Spencer, C. (1998). Comparing methods for introducing blind and visually impaired people to unfamiliar urban environments. *Journal of Environmental Psychology*, 18(3), 277-287.

Fortin, M., Voss, P., Lord, C., Lassonde, M., Pruessner, J., Saint-Amour, D., ... & Lepore, F. (2008). Wayfinding in the blind: larger hippocampal volume and supranormal spatial navigation. *Brain*, *131*(11), 2995-3005.

Gaunet, F., & Thinus-Blanc, C. (1995). Exploratory patterns and reactions to spatial changes: The role of early visual experience. *Studies in Perception and Action III*, 225-228.

Gaunet, F., Martinez, J. L., & Thinus-Blanc, C. (1997). Early-blind subjects' spatial representation of manipulatory space: exploratory strategies and reaction to change. *Perception*, *26*(3), 345-366.

Golledge, R. G. (1993). Geography and the disabled: a survey with special reference to vision impaired and blind populations. *Transactions of the Institute of British Geographers*, 18, 63-85.

Halko, M. A., Connors, E. C., Sánchez, J., & Merabet, L. B. (2014). Real world navigation independence in the early blind correlates with differential brain activity associated with virtual navigation. *Human brain mapping*, *35*(6), 2768-2778.

Hersh, M.A. (2009a). The application of information and other technologies to improve the mobility of blind, visually impaired and deafblind people, in *Travel Health Informatics and Telehealth, Selected Papers from EFMI Special Topic Conference*, Antalya, Turkey, G. Mihalaş et. al. (eds.) pp. 11-24, Victor Babes University Publishing House.

Hersh, M.A. (2009b) Designing assistive technology to support independent travel for blind and visually impaired people, *CVHI '09*, Wrocław, Poland.

Hersh, M.A. (2010). Methodological issues in multi-country multi-language participative research with blind and visually impaired people, *SWIIS '10*, Pristina, Kosovo.

Hersh, M.A. (2011). Participative research with diverse end-user groups: multi-language, multi-country blind and visually impaired people, *18th IFAC Congress*, Milan, Italy,

Hersh, M. (2013). Deafblind people, communication, independence, and isolation. *Journal of deaf studies and deaf education*, *18*(4), 446-463.

Hersh, M. A. (2016). Improving deafblind travelers' experiences: an international survey. *Journal of Travel Research*, *55*(3), 380-394.

Hersh, M.A. (2017). Mobility Technologies for Blind, Partially Sighted and Deafblind People: Design Issues. In: Mobility of Visually Impaired People – Fundamentals and ICT Assistive Technologies, E. Pissaloux (ed.) Springer (in press).

Iachini, T., Ruggiero, G., & Ruotolo, F. (2014). Does blindness affect egocentric and allocentric frames of reference in small and large scale spaces?. *Behavioural brain research*, *273*, 73-81.

Jacobson, R. D. (1998). Cognitive mapping without sight: Four preliminary studies of spatial learning. *Journal of Environmental Psychology*, *18*(3), 289-305.

Johnson, V., & Petrie, H. (1998). Travelling safely: the problems and concerns of blind pedestrians. *British Journal of Visual Impairment*, *16*(1), 27-31.

Jones, B., & Kabanoff, B. (1975). Eye movements in auditory space perception. *Perception & Psychophysics*, *17*(3), 241-245.

Juurmaa, J. (1973). Transportation in mental spatial manipulation: a theoretical analysis. *American Foundation for the Blind Research Bulletin*, 26, 87-143.

Kitchin, R., & Jacobson, R. D. (1997). Techniques to collect and analyze the cognitive map knowledge of persons with visual impairment or blindness: issues of validity. *Journal of Visual Impairment and Blindness*, *91*(4), 360-376.

Kuipers, B. (1978). Modeling spatial knowledge. *Cognitive science*, *2*(2), 129-153.

Kulyukin, V. A., Nicholson, J., Ross, D. A., Marston, J. R., & Gaunet, F. (2008, March). The Blind Leading the Blind: Toward Collaborative Online Route Information Management by Individuals with Visual Impairments. In *AAAI Spring Symposium: Social Information Processing* (pp. 54-59).

Leonard, J. A., & Newman, R. C. (1967). Spatial orientation in the blind. *Nature*, *215*(5108), 1413.

Lobben, A., & Lawrence, M. (2012). The use of environmental features on tactile maps by navigators who are blind. *The Professional Geographer*, *64*(1), 95-108.

Millar, S. (1988). Models of sensory deprivation: The nature/nurture dichotomy and spatial representation in the blind. *International Journal of Behavioral Development*, *11*(1), 69-87.

Nielsen, L. (1991). Spatial relations in congenitally blind infants: A study. *Journal of Visual Impairment & Blindness*, 85(1), 11-16.

Nyman, S. R., Dibb, B., Victor, C. R., & Gosney, M. A. (2012). Emotional well-being and adjustment to vision loss in later life: a meta-synthesis of qualitative studies. *Disability and rehabilitation*, *34*(12), 971-981.

Passini, R., & Proulx, G. (1988). Wayfinding without vision: An experiment with congenitally totally blind people. *Environment and Behavior*, 20(2), 227-252.

Passini, R., Proulx, G., & Rainville, C. (1990). The spatio-cognitive abilities of the visually impaired population. *Environment and Behavior*, *22*(1), 91-118.

Raz, N., Striem, E., Pundak, G., Orlov, T., & Zohary, E. (2007). Superior serial memory in the blind: a case of cognitive compensatory adjustment. *Current Biology*, *17*(13), 1129-1133.

Reindal, S. M. (1999). Independence, dependence, interdependence: some reflections on the subject and personal autonomy. Disability and Society, 14(3), 353-357. doi: 0.1080/09687599926190

Richards, V., Morgan, N., Pritchard, A., & Sedgley, D. (2010). Tourism and visual impairment. *Tourism and inequality: Problems and prospects*, 21-33.

Rieser, J. J., Guth, D. A., & Hill, E. W. (1986). Sensitivity to perspective structure while walking without vision. *Perception*, 15(2), 173-188.

Schmidt, S., Tinti, C., Fantino, M., Mammarella, I. C., & Cornoldi, C. (2013). Spatial representations in blind people: The role of strategies and mobility skills. *Acta Psychologica*, 142(1), 43-50.

Thinus-Blanc, C. and F. Gaunet (1997). Representation of space in blind persons: vision as a spatial sense?, *Psychological Bulletin*, 121(1), 20-42.

Tinti, C., Adenzato, M., Tamietto, M., & Cornoldi, C. (2006). Visual experience is not necessary for efficient survey spatial cognition: evidence from blindness. *The Quarterly Journal of Experimental Psychology*, *59*(7), 1306-1328.

Ungar, S. (2000) Cognitive mapping without visual experience, R. Kitchin and S. Freundschuh, (eds.), *Cognitive Mapping Past, Present, Future*, Routledge, 221.

Ungar, S., Blades, M., & Spencer, C. (1997). Strategies for knowledge acquisition from cartographic maps by blind and visually impaired adults. *The Cartographic Journal*, *34*(2), 93-110.

Wehmeyer, M. L. (2005). Self-determination and individuals with severe disabilities: re-examining meanings and misinterpretations. Research and Practice for Persons with Severe Disabilities, 30(3), 113-120. doi: http://dx.doi.org/10.2511/rpsd.30.3.113.

Wiggett-Barnard, C., & Steel, H. (2008). The experience of owning a guide dog. *Disability and Rehabilitation*, *30*(14), 1014-1026.

Withagen, A., Kappers, A. M., Vervloed, M. P., Knoors, H., & Verhoeven, L. (2013). Short term memory and working memory in blind versus sighted children. *Research in developmental disabilities*, *34*(7), 2161-2172.

Wood, W.M., Fowler, C. H., Uphold, N. & Test, D.W. (2005). A review of self-determination interventions with individuals with severe disabilities. Research and Practice for Persons with Severe Disabilities, 30(3), 121-146. doi: http://dx.doi.org/10.2511/rpsd.30.3.121,

Property	Vision	Touch	Hearing	Smell
Landmark info	do not vary with time of day or season		varies with time of day or season	
Focus	Sharp	Sharp	less sharp	less sharp
Spatial field	Large	Small	Large	Large
Object location	Precise	precise within small field	less precise than vision	less precise than vision
Overview information	yes, many signal at once	no, field is too small field	no, signals interfere with each other	no, signals may interfere with each other
Object identification	Good	less precise than vision	less easy than vision	very imprecise

Table 1 Comparison of information from the different senses (Hersh, 2017)

Gender		Age					Where live				Additional		
Male	Female	16-25	26-40	41-60	61-70	71+	Big City	City	Town	Village	EM	DB	PD
50	50	9	28	43	17	3	36	37	20	7	5	9	6

EM = ethnic minority, DB = dual sensory impairment/deafblindness, PD = physically disabled

Table 2: Demographic information

Visual status		Age of onset of visual impairment					Travel aid use		
Blind	Partially sighted	Birth	Childhood	Adult	Middle aged	60+	No aid	Cane	Guide dog

77	23	54	27	12	7	0	9	68	23

Table 3, Visual impairment profile