INVESTIGATING THE SPATIAL UNDERSTANDING OF CHILDREN WHO ARE BLIND THROUGH THE USE OF THE CHILD'S VOICE

by

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ABSTRACT

This thesis is intended to impact positively on our ability to understand and describe spatial awareness of children who are blind by investigating children's explanations, understanding, feelings and coping strategies in their use of space in their everyday experience. It examines whether children who are blind are capable of providing reliable information that informs our knowledge of how they perceive space and how they achieve spatial understanding. The thesis also examines whether children's voices inform the ideas, the theoretical perspectives and the positions adopted by researchers over the years that are found in the literature, in this complex field.

The results are discussed in terms of their implications for the theoretical understanding of children's experience of spatiality and the diversity of environmental circumstances to which they need to adapt. The results are also discussed in terms of their implications for practice by providing practitioners with theorized evidence of practice that supports the effective learning.

Taken together, the evidence suggests that children who are blind are able to verbalize their knowledge about spatial relationships using a wide range of sensory and cognitive strategies and demonstrating a sophisticated understanding of space; thus suggesting that cognitive experiments may not be the only way to study spatial processing in children who are blind.

DEDICATION

I dedicate this thesis in the memory of Kyriakos, who left so early and so suddenly … I had so many to tell you but I never did … I always thought I had the time to do it later…

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CHAPTER 1

ORIGINS AND PURPOSE OF THE RESEARCH

1.1. Introduction

This inquiry began from my general interest as a specialist teacher in the educational development of children who have visual impairment, and over time evolved into an inquiry concerning the use of blind children's voices as a research method for developing understanding about their spatial experiences. The research is motivated by my desire to contribute to the understanding of the processes of the spatial understanding of children who are blind with a view to improving practice in the classroom and particularly in the area of mobility and independence education.

The title of my thesis is *"Investigating the spatial understanding of children who are blind through the use of the child's voice"*.

I have retrospectively tried to identify the key personal beliefs that influenced my choice of topic and shaped my approach and the development of my ideas in this thesis. These beliefs can be summarised as follows:

- The development of knowledge, skills and understanding is a synthetic process influenced by personal and environmental factors, which change over time. Education influences this change and all children should have access to structured and meaningful learning opportunities.
- Children have the right "*to express views in matters that concern them*" (Lewis, 2009: 20)

- Pythagoras[1] advised his followers to: "*Learn to be silent. Let your quiet mind listen and absorb"*. I feel that it is only now, after fifteen years of teaching and eight years of research that I have really learned how to let my mind listen and absorb children's voices, this I believe will make me a better teacher and a better researcher.

1.2. The statement of the problem

We rely upon the information obtained through our sensory systems and processed cognitively in order to understand and represent space. For most people, vision plays a key role in providing precise and real time information about spatial structure (Foulke & Hatlen, 1992). But how do people who are blind conceptualize spatial relationships and how does the fact that they depend on other senses affect their ability in this regard?

The question of how people who are blind perceive and process space, has been the subject of discussion among philosophers and psychologists for many years, and is still only partly answered. The question has been studied in a variety of ways, with differing aims, and from a range of theoretical viewpoints.

Researchers from different disciplines have used various subject groups with little or no sight, to investigate spatial understanding (e.g. sighted participants who are blindfolded, participants with low vision, participants who are blind). They have devised a variety of experimental tasks to make judgments about individuals' ability

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[1] Pythagoras (circa 582 BC – circa 507 BC) - Greek mathematician, astronomer, scientist and philosopher.

to make sense of the relationships between elements in their immediate or remote environment; they have tried to measure the spatial performance of participants with a range of visual conditions attempting to identify the spatial coding strategies adopted during navigation and exploration (Gaunet & Thinus-Blanc, 1996; Hill et al., 1993). Researchers have sought to measure the observable outcome of spatial performance over various spatial tasks, often within an experimental setting and have used these observations and measurements to draw conclusions on the nature of spatial experience. This has often let to results that appear contradictory, and the existing literature in this area could be said to be fragmented. There is not yet a generally accepted understanding of spatial ability or a universally accepted theoretical framework for explaining its nature.

In this study I have been able to identify only a relatively small body of literature that makes explicit use of the descriptions and spontaneous insights of people with visual impairment about their spatial understanding and attempts to investigate their meaning and structure (Karlsson, 1996; Kitchin et al., 1998; Gardiner & Perkins, 2005). In particular I am not aware of any study of spatial understanding that focuses on the voices of children who are blind and that attempts to use their explanations of the processes involved in making sense of space and their experience of spatiality to analyze findings from other studies. This inquiry is therefore intended to explore the potential of this approach by directly giving voice to twelve children who are blind concerning the processes involved in acquiring the concept of space across a range of activities in real life settings. Through careful analysis, the study seeks to interpret existing knowledge and develop new insights. It is intended to address Warren's (1994:117) observation about gaps in existing knowledge:

> *"The most serious gap in our knowledge in this area is the process of acquisition of concepts of extended space, particularly as concepts are acquired as result of everyday experience. We know a good deal about the nature of concepts once they are acquired, but very little about the process of acquisition."*

The inquiry was also intended to redress, to some extent, another gap in knowledge observed by Long & Hill (1997:54):

> *"Further research is needed to learn more about sources of individual differences in other subpopulations of individuals who are blind or visually impaired (e.g. children)……There is a need to determine the degree to which visually impaired individuals find themselves in travel situations that demand self – familiarization skills, and investigate the skills they bring to bear in these situations."*

In this study, my goal has been to investigate children's understanding of spatial relationships by letting them describe and explain their own experiences in an attempt to discover the strategies they invoke. Since this is an area that has important practical implications for the education of children with visual impairments and the development of mobility and independence skills.

The research questions which serve to guide the focus of this investigation, have traditionally been investigated by experimental psychologists and other scientists seeking knowledge in relation to spatial understanding who have often adopted a cognitive psychological frame of reference set up within experiments (Karlsson, 1996). To this extent, the research questions are directly related to the literature and the references to the literature in this introductory chapter will be expanded upon in literature review.

The present study diverges from other studies in this area as the method used is essentially qualitative in character. Data acquired from children's voices have been analysed to seek insight into the process of the acquisition of concepts of space and the strategies children employ to make sense of space. This question belongs to an area of traditional study that appears frequently in the literature of various academic disciplines. What is different with the present study is that it uses the voices of the children to seek to address this question.

The broad research question of "how do children perceive space and how they achieve spatial understanding?" is explored in relation to the following sub questions drawn from the literature:

- What is the role of the different senses in their spatial processing?
- Do children utilize predominantly self-reference or external frames of reference when engaged in spatial tasks?
- How do they reach conclusions about the relative size of objects in the environment?
- Do children who are blind use knowledge from cognitive maps to guide their actions?
- How do they reach conclusions about the relative location of objects or the direction of a designated location in the environment?

Finally, three further questions that relate specifically to the method of using children's voices will be explored:

- To what degree are children who are blind capable of providing reliable information that informs our knowledge of how they perceive space and how they achieve spatial understanding?
  - To what degree do their voices inform the ideas about spatial understanding that are found in the literature?
  - What are the methodological challenges of using children's accounts to help establish the processes of spatial understanding?

1.3. Definition of terms

The following definitions relate to the terms selected for the title of the study. Three essential terms: spatial understanding; blindness/visual impairment; and the child's voice; will be discussed here although a more detailed discussion of them will be provided throughout the thesis along with explanations of other key terms which will be introduced later on.

Spatial understanding

Although spatial understanding and its processing have been extensively studied, the notion of 'space' has many facets and its formal definition is problematic. It is not proposed to attempt a general definition of spatial understanding here. Instead this section will attempt to define how it is understood in this inquiry.

This thesis attempts to gain insights into spatial understanding through children's explanations about their performance on different spatial tasks rooted in everyday experience. Within this context, spatial tasks are defined as tasks which require individuals to make judgments about relationships between elements in their immediate or remote environment and knowing *"where something is"* (Millar, 1994: 11). Millar herself (1994) defines as spatial tasks those tasks we label as 'spatial' by common consent.

In this thesis, spatial understanding relates to the underlying strategies and techniques children acknowledge to employ in order: to recognize what is around them; to locate objects in their immediate or remote environment; to move from one place to another; to establish the direction of a designated location; and the strategies children employ in order to perceive the relative size of objects. Since the aim of the research is to contribute to knowledge about key areas in children's education that are directly related to the development of mobility and independence skills; the explication of these strategies and techniques by the participating children is considered indicative of their spatial understanding.

Blindness / visual impairment

The term 'visual impairment' is used in this inquiry as a generic term to describe individuals with different types of visual loss ranging from mild to severe visual impairment. The World Health Organization (1980; 1993; 2003) classified visual impairment based in part upon a clinical assessment of visual acuity as follows: low vision is defined as visual acuity of less than 6/18, but equal to or better than 3/60 and blindness is defined as visual acuity of less than 3/60.

Visual acuity is usually tested by asking the individual to read letters of various sizes on a chart viewed from a distance of 6 m or 20 feet. Thus "normal" visual acuity is 6/6 for Europeans or 20/20 for Americans. If the visual acuity of an individual is 3/60 or below (i.e. when a letter that can be recognized from 60 metres by an individual with "normal vision" can be identified only from 3 metres or closer) then that individual may be classified as 'blind'.

The term 'blind' used in this inquiry refers to children who have been registered as blind by an appropriate professional. Many people who are registered blind have some degree of useful residual vision. The way people who are blind use their remaining vision can vary from individual to individual. Although some of the participating children in the present inquiry were using their remaining vision and their other senses of touch, hearing, smell and memory to create cognitive images of the world around them and to undertake many of the everyday tasks; senses other than vision are their pronominal senses of learning. More information concerning visual perception including background information for each participating child are included in the methodology chapter and in appendix 2 (Students' background information)

The child's voice

> *"Recent writings in child welfare and childhood sociology regard the child's 'voice' as a matter of need, right and skill, and worthy of being listened to and studied in its own right… Discussions about the child's 'voice' have typically revolved around whether adult professionals are willing to listen to children, and how listening can be done successfully" (Komulainen, 2007:11).*

The idea of listening to children's voices has been given much attention in recent years and a number of researchers have stressed the importance of listening to what children and young people have to say and have acknowledged their right to express their views in matters that impact upon them.

> *"If children had greater access to a public voice through vehicles such as research, they would be able to contribute to the social structures that concern them" (Irwin & Johnson, 2005:821)*

The concerns of researchers are not simply a recognition of children's rights but, perhaps more importantly, they are a recognition that their perspectives can lead to better understanding of phenomena we seek to investigate (Messiou, 2008; Lewis, 2010). However:

> *"effective and authentic child participation is not easy to achieve in practice"* (Lewis et al., 2008:26),

and engaging children in research generates the need for serious consideration of the methodological and ethical challenges faced by researchers working with children. In the present study, methodological challenges related to establishing reliable procedures to capture the voice of the child. The ethical challenges included those related to consent, ensuring anonymity and confidentiality, building trusting and respectful relationships, establishing trustworthiness and identifying and dealing with misunderstandings and misperceptions. More detailed information concerning the methodological and ethical challenges in engaging children in research and seeking their perspectives are included in the methodology chapter. It is important to acknowledge that research of this nature is an interactive process:

> *"…researchers, research contexts and research participants impact on the nature of the research conducted and the identified research outcomes (Dockett, et al., 2009: 295)*

1. 4. Implementing the literature search

A literature review chapter is necessarily selective but needs to address each major area of writing which relates to the scope of the investigation and should inform and underpin the inquiry. Therefore I believe that it is important to clarify how the literature search was planned before I present an overview of the thesis.

The first lesson I have learn from the literature search is that it is a process of evolution; a novice researcher can panic when faced with the seemingly endless library resources and a successful literature search requires a great deal of time and systematic planning.

The first step in my literature search was to investigate the key books and journals that my supervisor suggested and then to trace relevant publications through the university's library catalogue. I used a variety of sources including the COPAC catalogue (National, Academic, and Specialist Library Catalogue - www.copac.ac.uk); ERIC (the Educational Resources Information Center - www.accesseric.org); and even internet booksellers like Amazon.co.uk. Any publications I traced that were not available at Birmingham University were ordered on interlibrary loan (De Montfort University, 2008).

I then used a variety of databases including: the School of Education's index to the theses catalogue; the e Resources and e Book catalogue; the periodicals catalogue; the e Journals catalogue; bibliographical databases; internet search engines like Google scholar and Google e books; and open access databases to find the books, journals and articles that became the key resources for my inquiry. Reference lists of publications I found were searched to identify further relevant documents. I also used the Social Science Citation Index in order to find which of the sources that I had found were the most cited. I was able to access the full text of many of the articles through the Athens Access Management System. Athens proved to be a very useful tool throughout my research since it gave me access to web-based subscription services, such as electronic journals.

In my literature search I tried to be systematic and find as much relevant material as I could, following leads from useful articles and books, often working backwards from recent publications to earlier sources, trying throughout to focus on areas of literature that most related to the scope of the current investigation.

1.5. Overview of the Thesis

The literature review chapter which follows begins with a consideration of the theories around spatial understanding. This is followed by a discussion of the role of the sensory modalities in the development of spatial awareness and understanding. This prepares the ground for an exploration of the processing of small and large scale space, following by a discussion on the frame of reference used by people who are blind when engaged in spatial tasks. Then the cognitive mapping of spaces is explored as it concerns the question of how people who are blind process and store spatial and environmental information. The impact of this information on blind people's understanding of, and performance in, the environment is also stated. Key issues arising from the literature are critically discussed, gaps in the research literature are identified and the contribution this inquiry seeks to make in this area is explained.

Chapter three, "Research Methodology", explores a number of issues relating to the research approach and methods selected for use within the study and the philosophical stance adopted. A more detail account is provided of the aims of the study and of the research procedure and design, the processes of data collection and analysis, as well as a discussion concerning possible limitations of the study. The main criteria adopted for selection of the children are stated and the ethical issues involved in interviewing children are discussed along with a consideration of questions relating to the authenticity of the results and the trustworthiness of the study.

The exploratory study is reported in chapter four, beginning with the results and implications of the pilot study and proceeding to a report of the main inquiry. Then the summary of the findings of the main study are presented. The findings have been clustered around a range of issues that emerged from the analysis of the interviews with the participating children; the opinions expressed in the interviews and the data gathered through analyses of observation of the children's spatial processing are linked with the literature. As much as possible the evidence is presented through direct quotations from the participants so that readers of the study can experience for themselves the participant's perspectives.

In chapter five, the themes that emerged from the analysis of the children's accounts is discussed in relation to the results of other researchers gained through quite different methods and the underlying processes utilized by children who are blind in making sense of space are further explored. The results are considered in the round and the general implications for future work are discussed. The section seeks to demonstrate how information derived from the voice of the child can shed light on the findings of other researchers and can offer a useful window for gaining insights that may inform or supplement knowledge about spatial understanding achieved through traditional experimental approaches.

In the last chapter, chapter six, the final reflections and conclusions are stated. Issues relating to the methods, the methodology and the trustworthiness of the study are briefly revisited and consideration is given to the major findings that emerge from the study and the conclusions that can be drawn from them. General implications for theory and practice as well as implications for future work are also discussed.

CHAPTER TWO

REVIEW OF THE LITERATURE

2.1. Introduction

The question of how people who are blind perceive and process space has been studied within a range of different disciplines which have their own perspectives, preferred methodologies and theoretical underpinnings. There is yet not a generally accepted definition of spatial ability or a universally accepted theoretical approach. The existing literature in this area is therefore fragmented and does not form a coherent picture, and it is therefore very difficult to develop a persuasive synthesis of current knowledge. Given these constraints, the review of the literature is presented under five headings which relate to spatial knowledge in an attempt to identify the theories, the key findings and the methodologies which are most relevant to the current investigation.

The decision to organize the literature under these headings evolved over a period of time. The first step in the process was to identify the broad themes that emerged from my study of the research literature. The second step was to group those themes in relation to the key research questions for the study. The third, and maybe the most crucial, step in establishing the final headings was to ensure they could capture what emerged from the analysis of the data collected in the current investigation.

Overall then, these headings were derived from an interaction between my reading of the literature before I started the field work and from the observations and the analysis of the data I collected after entering the field. The following headings therefore allow exploration of the areas of writing which are most relevant to the current research.

Space and Blindness: Theoretical perspectives on spatial development

Section 2.2 provides a brief historical overview of the research literature relating to the spatial awareness of people who are blind or visually impaired with a particular focus on the theoretical perspectives of researchers in this complex field. Numerous studies have attempted to assess various aspects of the spatial awareness of people who are blind with wide ranging, and sometimes contradictory results. The different positions adopted by researchers over the years are analysed and their significance to the study is explored.

Spatial awareness and sensory modalities.

Section 2.3 reviews the literature concerning the role of the sensory modalities in the development of spatial awareness and understanding. When children who are blind are building up strategies for spatial processing, they rely on the information they receive from sensory modalities other than vision. They develop sensory-based strategies for imaging and mapping objects and environments, and for perceiving their surroundings in small and large scale space. To make sense of the literature in this complex area of spatial understanding, it is important to establish the principles that underlie the use of the senses and the multisensory aspects of learning which inform many of the teaching and learning approaches in the education of children who are blind. It is not an exaggeration to say that the academic success of children who are blind relies to a great degree on their ability to integrate successfully the information they receive from their non-visual senses.

Spatial awareness without vision: the processing of small and large scale spaces

Section 2.4 reviews the literature on the processing of small-scale space by non-visual means, most usually through tasks involving “manipulating space” (Lederman et al., 1987; Klatzky et al., 1995) through manual exploration. It also analyses the literature on the processing of large-scale space in which people who are blind and sighted are commonly faced with integrating information over time through tasks involving locomotion in “ambulatory space” (Lederman et al., 1987; Klatzky et al., 1995). Although the focus of the present study is on the latter, research on small scale spatial tasks tell us a lot about the nature of spatial understanding in general.

The processing of small and large scale space through touch and movement is a key aspect in the curriculum and is fundamental for the development of fine and gross motor skills; ranging from fine motor activities such as reading braille, writing, etc and acquiring self-help skills like feeding and dressing; to movement and gross motor skills encouraging children to reach out and to actively explore their environment.

The frames of references (self-reference or external frames of reference) adopted by people who are blind when engaged in spatial tasks are also discussed.

Spatial representation: Cognitive maps knowledge

Section 2.5 reviews the literature concerning research into cognitive mapping and explores outcomes from a range of tests and techniques that have been employed by researchers to assess cognitive map knowledge.

The cognitive mapping of spaces, the development of knowledge of possible routes for navigating within these spaces, and the conficurational knowledge of the overall space are vital for the development of efficient orientation and mobility skills and contribute to the development of efficient spatial performance of people who are blind. A greater understanding of these processes not only can inform the teaching of orientation and mobility skills and other spatial skills in the curriculum but also may contribute to the development of wayfinding and independence which are key skills for children's inclusion, particularly in mainstream settings.

Discussion of the literature search

Section 2.6 provides a summary of my interpretation of the key issues arising from the literature review and their implications on my study. Gaps in the research literature are identified and the contribution that this study seeks to make to the literature in this area is explained.

2.2. Space and Blindness: Theoretical perspectives on spatial development

A number of different approaches have been used to answer the question of how blind people, especially those blind since birth, perceive and process space. This line of enquiry goes back to the eighteenth century when the British philosopher John Lock (1689), cited in Millar (1994), reported that Molineux asked whether a person who had been born blind, and whose vision was suddenly restored, would be able to recognize, by sight alone, simple geometrical shapes which he had formerly experienced only by touch. This enquiry has been developed through many subsequent studies which have sought to explore what characterizes the spatial understanding and performance of people who are blind. Three broad approaches to research into the area of the blind or visually impaired individual's ability to comprehend spatial relationships can be identified in the literature: the deficiency approach, the inefficiency approach and the difference approach (Fletcher, 1980; 1981; Kitchin & Jacobson, 1997). Although these approaches are often described in the literature as 'theories', (Fletcher, 1980; 1981; Ungar et al. 1996; Kitchin et al. 1997), they might be better understood as different beliefs that underlie research approaches to the question.

Deficiency 'theory'. The deficiency 'theory' states that lack of visual experience inevitably results in a lack of spatial understanding. Individuals who are congenitally blind have never experienced vision therefore they cannot develop the basic perceptual process required in order to perceive complex spatial arrangements (Fletcher 1980; 1981; Jacobson, 1998). Von Senden (1960) argued that people who have been blind from birth cannot achieve secure spatial concepts, and that visual experience during some early period is essential for even a minimal integrated understanding of space. He suggested that the representation of the ‘whole’ is simply not possible through the haptic and tactile senses:

> *“…it is not like a sighted person, looking at a whole wall there before him and being able to picture it long afterwards as a thing simultaneously given. This imaginative retention of a completed whole is not possible with tactual impressions. The individual parts disappear. The blind man can grasp only the succession and relation, but cannot later reproduce the completed whole, as the sighted do”* (Von Senden, 1960:288).

However evidence from subsequent research has largely discredited Von Senden’s position and has showed that this is an extreme view (Fletcher 1980; 1981a; 1981b; Warren, 1994; Millar, 1994; Jacobson, 1998; Ungar, 2000).

Inefficiency ‘theory’, states that people who are blind can understand and mentally manipulate spatial concepts but are not as efficient as sighted individuals in their perception of space because their information is primarily based upon auditory and haptic cues, and this knowledge is ‘inferior’ to that based upon vision (Spencer et al 1989). This ‘theory’ continues to receive support from some researchers (for example Casey, 1978); who suggested that spaces travelled by the congenitally blind tend to be re-constructed as linear routes e.g. people who are blind tend to interpret a gently curving path as a straight line and that they generally experience great difficulty mentally updating their position as they walk through an environment. According to Casey (1978) congenitally totally blind people are able to reproduce an experienced environment to a certain degree, although they tend to perform rather poorly in comparison with partially sighted and blindfolded control groups in this respect. Researchers such as Golledge (1993) argue that the inability to interact independently with the wider world is the most significant problem produced by visual impairment or blindness.

Difference 'theory', on the other hand, states that the visually impaired have the same abilities and potential to process and understand spatial concepts that are as secure as those of the sighted, but that they do so more slowly and by different means (Juurmaa, 1973). Juurmaa, (1973) additionally claims that any subsequent developmental delay can be minimised if visually impaired children are provided with quantity and quality of spatial experience from an early age. Millar (1988) argues that people with visual impairments have no less potential than the sighted for developing a fully integrated representation of space and, even though she agrees that senses other than vision required more effort for coding spatial information, the representation of space can be fully secured through different means.

> *"The fact that vision is specialised for picking up information about the relation between external objects and planes means that forms of coding which depend on this information will be more difficult to acquire by the blind. At the same time, such coding should not be impossible, provided the information is conveyed by other means."* (Millar, 1988:85)

From the perspective of Difference theory, the poor performance of visually impaired people relative to blindfolded sighted participants found in spatial tests is primarily seen as an effect of the design of the experiments, in that the processes tend to be more familiar to sighted than visually impaired participants (Juurmaa, 1973; Warren, 1984). For example, in a study by Worchel (1951), participants were led along the two sides of a triangle and then asked to return to the starting point. Congenitally blind participants performed less well than blindfolded sighted participants. Reviews of Worchel (1951) suggest that the sighted participants may have had a much stronger mental image of a triangle prior to the experiment than the visually impaired participants. Difference 'theory' looks for intervening variables that possibly affect blind persons' spatial performance other than those directly related to the visual impairment such as access to information, experience, or stress (Jacobson, 1998).

The deficiency 'theory' is today mainly of historical interest and there is general agreement that both congenitally and adventitiously blind and visually impaired individuals are capable of processing and integrating spatial data. However it could be argued that there are some overlaps between the inefficiency and difference 'theories'; for example Fletcher (1980) concludes that the results of her research on spatial representation in blind and sighted children do not provide conclusive support for either the inefficiency or difference 'theory'.

However Ungar (2000) reports that while in past decades researchers have focused on spatial tasks experiments without concerning themselves about the strategies used by the blind to solve those tasks, more recently researchers have begun to focus on the strategies underlying the spatial performance of the blind. He concludes that if the poor performance of blind individuals was simply due to lack of vision, this would favour the inefficiency 'theory'. If on the other hand blind individuals use a range of strategies and some of the strategies used by some individuals result in appropriate spatial behaviour then this would support the difference 'theory'. This idea suggests that the poor performance observed in people who are blind or who have visual impairments is not so much an indication that they do not have the ability to perform well, but more that they have not yet developed the appropriate skills to do so.

Carreiras and Codina (1992) have termed an alternative fourth position the *"amodal representation hypothesis"*. According to this hypothesis, blind persons are able to process spatial images in a similar way to that used by sighted persons, although such processing might require more time.

> *"If given sufficient training, blind persons are assumed to be able to acquire a configurational spatial representation, and solve spatial problems with strategies similar to those employed by sighted persons"* (Carreiras & Codina, 1992:55).

The amodal representation hypothesis suggests that with sufficient appropriate training, blind people can develop coding strategies equivalent to those of sighted people using much the same strategies as sighted people (Ungar et al. 1996).

Reviewing the literature concerning the investigation of blind children's spatial understanding one can notice a range of interpretations of the theories that already been mentioned and a diversity in the theoretical stances that researches adopt when conducting investigations.

These differences can be seen across a range of areas: in the attempt to assess configurational knowledge utilizing experimental tasks and the ability to relate different locations utilizing pointing tasks (Bigelow, 1991; Bigelow, 1996; Tinti et al., 2006; Gaunet et al., 2007; Ittyerah et al, 2007; Fortin et al., 2008); the ability to recognise tactile layouts when rotated (Landau, 1991; Ungar et al, 1995a); the ability to estimate various objects size (Smith et al, 2005; Andreou & Kotsis 2005; 2006a; 2006b); the exploration of the strategies used when utilizing and memorizing maps (Ungar et al, 1995a; 1995b; Ungar, 2000; Ungar et al, 2004); the ability to form spatial representations based on route and survey descriptions (Noordzij et al, 2006); the investigation of spatial coding concerning external and body-centered reference cues (Millar & Al-Attar, 2004); to make kinesthetic judgments about direction and distance (Tinti et al., 2006); and the study of blind's people sensory abilities, utilizing experiments which involve testing of hearing, touch and/or proprioceptive perception (Passini et al, 1990; Pow, 2000; Lai & Chen, 2006; Graven, 2005; Postma et al, 2007).

Much of the research into the development of children with visual impairment has drawn on a comparative approach in which the performance of children with visual impairment is compared with that of a group of sighted children. The general conclusion of many of these comparative studies, argues for the presence of a 'developmental lag', which suggests that the performance of blind and partially sighted children is inferior to that of their sighted peers (Tobin, 1972; Gottesman, 1973; Wan-Lin & Tait, 1987; Hollins & Kelley, 1988; Lister et al, 1989). Evidence from many studies which compare vision with touch and movement, suggests that children find it much more difficult to recognize shapes and estimate distances using touch and movement rather than vision, and that children tend to rely on vision, when it is available, to make spatial judgments. A body of authors have found that blind children are not as advanced in their spatial knowledge as sighted children of comparable age – a conclusion that appears to favour the inefficiency theory (Bigelow, 1991; Schwartz, 1984; Herman et al. 1983; Kephart, et al 1974). However another group of authors have failed to replicate these findings and have observed similar performance levels between late-blind and blindfolded participants and participants without visual experience. This latter conclusion appears to favour the difference 'theory', or perhaps the "amodal representation hypothesis" (Ochaita & Huertas, 1993; Passini et al, 1990; Klatzky et al, 1995; Fletcher, 1980; Millar, 1994; Ungar, 2000).

Moreover, it seems that results from other studies (Smith et al, 2005; Andreou & Kotsis 2005; 2006a; 2006b; Tinti et al, 2006; Fortin et al, 2008) concerning the spatial abilities of people who are blind do not make the 'picture' any clearer, since they seem to suggest that persons with blindness performed better than blindfolded sighted controls. And therefore one might propose a fifth position - that of the superior performance of people who are blind in some spatial tasks as a direct result of greater experience under blind conditions compared to sighted blindfolded participants. Tinti et al, (2006) investigated whether lack of vision affects the ablility to develop complex spatial inferential representations. They concluded that visual experience is not a necessary condition for creating spatial inferential representations of a survey type and that spatial information provided by nonvisual modalities may contribute to a proper spatial encoding. A possible intervening factor for this result might be that:

> "*...children with congenital blindness learn to extract environmental spatial information from sources other than vision (such as proprioceptive and kinaesthesis information or haptic perception), which is not the case for sighted* (blindfolded) *children"* (Tinti et al, 2006:1317).

In relation to this, it is may also be the case that people who are blind may develop spatial abilities which the sighted would have little reason to practice.

2.2. 1. *Discussion*

To summarise, the brief historical overview of the research literature outlined above, relating to the spatial awareness of people who are blind or visually impaired covered a range of studies relevant to this study, however they are diverse in their aims and methodologies, and sometimes contradictory in their findings. Although this diversity of findings precludes any firm conclusions about the effects of blindness on spatial perception, some general ideas can be extracted from them which can be useful in the study of spatial understanding of people who are blind.

Overall recent research has moved on from the position that the congenitally blind people are simply deficient in perceiving space. There might be differences between the spatial development of people who are blind and people who are sighted but researchers (i.e. Rieser et al. 1982; 1986; Millar, 1994; 2006; Millar, & Al-Attar, 2004; 2005) attempt to explain this in terms of differences in preferred strategies and in learning experience. It is argued for example that, with training, alternative spatial coding strategies might be develop in blind or visually impaired children that are equally efficient as those available to the sighted.

Some assign the differences to the observation that children who are blind often focus on learning the spatial arrangement of their surrounding in terms of self reference information (Carreiras & Codina, 1992; Noordzij et al., 2007), whereas the perception of space in the sighted is generally seen to rely on an allocentric frame of reference (Noordzij et al, 2006; Tinti et al, 2006; Thinus-Blanc & Gaunet, 1997). This question will be further discussed in section 2.4 (The processing of small and large scale spaces).

Others, (Juurmaa, 1973; Jones, 1975) attempts to explain differences in terms of differences in life experience, i.e. children who are blind are likely to move around less than their sighted peers and so have reduced chances to acquire spatial skills and spatial experiences. Jones (1975) has shown that ‘deficiencies’ in spatial performance observed in the congenitally blind compared to the sighted, were due more to their lack of motor experience than to their lack of vision. Passini & Proulx (1988) however, concluded that any differences observed between blind and sighted adults who participated in their experiments were due to distant cues and visual reference points that were not accessible to blind.

Finally, work such as that of Passini et al, (1990), and Klatzky et al, (1995), and Ungar, (2000) suggest that people who are blind are as effective as the sighted in spatial perception; and work such as that of Tinti et al, (2006) and Fortin et al, (2008) proposes that at least some people who are blind are able to carry out sophisticated spatial tasks and at times can even outperform the sighted blindfolded participants due to their greater experience under conditions of blindness.

In summary, therefore, although in the literature one can find a diversity of findings, many researchers agree that possible factors accounting for this discrepancy in spatial performance between sighted and visually impaired individuals may not be related to the lack of vision as such, but to the individual characteristics of the participants. They are also perhaps related to experimental factors such as the type of spatial tasks the participants are required to solve and generally the experimental situation (Thinus-Blanc & Gaunet, 1997; Gaunet et al, 1997). All these factors will be further discussed at the end of the literature review chapter.

2.3. Spatial awareness and sensory modalities.

2.3.1 Vision vs. alternative perceptual systems used by the blind

An understanding of the relationship between the sensory modalities and how movement, touch, sound and sight are linked to spatial representation is fundamental to the issues addressed in this thesis. Undoubtedly for most people, vision plays a very important role in perceiving precise and real time information about spatial structure. It would therefore seem reasonable to assume that children who are blind will have difficulties conceptualizing spatial relationships.

Vision is often held to be the primary 'spatial' sense and sighted individuals rely heavily upon this system to gain information about their surroundings. Blind people must depend on non-visual senses (auditory, kinaesthetic, and haptic) for information to help them locate and identify objects and persons or explore their environment. These senses have been described by Anderson (1984) as "less sophisticated" and "less efficient" than sight.

Comparison between the relative efficiency of senses have been made over the years and vision is considered to be the most sensitive modality for differentiating between locations and for discriminating between spatial locations in both large and small scale spaces (Bertelson, 1999; Pick, et al., 1969; Warren & Cleaves, 1971). Touch however, is held to be superior in the ability to sense surface and texture properties or to perceive the weight and temperature of an object (Schifferstein, 2006). In addition, vision and touch are thought to provide more detail about surroundings than audition while smell and vision gather information more rapidly than touch (Jones & O'Neil, 1985).

While touch can assists in the acquisition and coding of spatial information in large scale space (i.e. feet on pavement or hands along walls), it is particularly effective for experiencing small-scale spaces that contain manipulable objects. Smell and taste have the advantage of reacting to the chemical composition of an object, i.e. people will not eat something that smells bad. Smell also is useful for navigating through space. For example, the smell of fresh bread can assist in the location of a bakery.

People have long believed that those who suffer a sensory deficit would develop a stronger ability with the other senses as compensation. Boyd and King (1977) however proposed that the lack of one particular sense may not enhance the other sensory abilities; instead it would compel other senses to become more alerted. This suggests that blind people, not having the sense that is used the most to gather information about space, will use their other senses a lot more than sighted people do. Warren (1994:29) stressed that:

> *"…no preponderance of evidence supports either the notion of sensory compensation or, for that matter, the alternative. In short, basic sensory discriminative abilities are much the same in blind, partially sighted, and sighted samples."*

Lai and Chen (2006) also found that blind people do not develop better hearing ability because of a sensory compensation effect.

Each perceptual system provides different information. When one perceptual system is not available it is necessary to identify the types of information the other systems can provide and distinguish between them in terms of the quantity and quality of the information they provide (Foulke, 1992; McLinden, 1999; 2004). As McLinden and McCall (2002:54), state *"no one sense can fully 'compensate' for another"*.

Sensory modalities differ in their sensitivity to be able to perceive the properties of the surroundings. Some properties can only be perceived by a single modality i.e. vision is the only modality that can convey colour information; and touch is the only modality that can convey properties such as temperature or hardness; whereas other properties may be perceived by multiple modalities (Schifferstein, 2006; Roberts & Wing, 2001). For example, the shape, size, location, orientation, texture and movement of objects can be felt as well as seen (Lopes, 2000). To locate an object in far space someone might use olfactory or auditory cues or vision. The sound of an object or the intensity of its smell may provide cues that indicate the direction of its source. The ability to localise sound or smell sources enables us to determine the location of objects, and orientation can be refined by turning our head towards the direction where the sound or smell seems to come from (Schifferstein, 2006). However, visually impaired people may need to have a better developed ability to localise sound than sighted people in order to be efficient at investigating their environment on the basis of sound alone.

In addition, vision plays a key role during the early development of a child. Pehoski (1995:141) proposed that in young babies vision has been shown to be

> *"an integral part of the process of grasp and manipulation and in fact maybe the early motivator for object exploration…"*

McLinden and McCall (2002) add that vision plays an important role in linking different types of sensory information and it is the sense which helps us to understand the information we receive through our other senses.

The child who is sighted observes a wide range of objects from different perspectives, in his near and distance environment, observes different strategies that adults employ in spatial tasks and learns through imitation. The development of a child is linked with the exploration of its environment and the growth of its understanding and knowledge about the world (Pehoski, 1995). Children who are blind cannot see other people performing a task and so may not be motivated to develop a particular skill. They thus may have no "model" on which to base their physical actions. Furthermore blind children with access to a relatively limited environment may not be sufficiently stimulated enough to be motivated to explore different objects. For example, Lowenfeld (1974:34) identifies three constraints suffered by children who are blind in their perception of the outside world:

> *"Blindness imposes, as a direct result of the loss of vision, three basic limitations on an individual: (1) in the range and variety of his experiences; (2) in his ability to get about ; (3) in his interaction with the environment."*

Besides, many children with little or no sight may have a range of additional impairments, which might be physical, emotional, behavioural and/or sensory in nature (McLinden & McCall, 2002). It is difficult to generalise about the impact of visual impairment on a child's development. The needs of each child will vary and factors such as personality, age, degree of visual loss, the presence or absence of additional disabilities and cognitive ability make each child unique (Mason & McCall, 1997).

2.3.2. The auditory perception of space

The senses that provide information about the world are either 'distance senses' such as vision and hearing, or 'close senses' such as touch and taste. When the 'distance sense' of vision is absent or impaired, this can be compensated to some extent by the other distance sense: hearing (McLinden & McCall 2002).

Audio information plays an important role in the development of spatial skill. It is "*the main channel for providing distal information*" (Spencer et al., 1989:179). The auditory system can provide information about surroundings and the patterns that vary within an environment without the need for direct contact (Foulke, 1992). For example it can enable the blind person to comprehend the characteristics of the indoor environment (e.g. whether a room is full or empty) and outdoors (e.g. the sound of many people and heavy traffic). In a similar way, blind individuals can make use of 'sound shadows' to determine landmarks and locations or to detect an obstacle. A sound shadow is created when an object in the environment is between the sound and the individual. As the sound waves travel toward the individual, if there is something between that individual and the sound (such as a tree or a person), the sound is impeded where that object is. For example, as the individual walks down a sidewalk, breaks in sounds can indicate a building, a tree or a person (Spencer et al., 1989).

People with visual impairments can use the sounds that they create and observe the echo created by the objects that reflect the sound. In this way they can use their hearing to avoid obstacles while walking. If objects create sounds, they also can use sound cues to locate them. Some totally blind people are quite skilled in moving around their environment while listening for sounds (McGrath et al. 1999). McGrath et al. (1999) found that blind people can sense the size of a room by listening for the sounds of their own footsteps and by using the sound of their voices and listening out for the echoes. Taylor (1962:272) observed that many blind people have:

> "*A rudimentary perception of the positions of relatively large objects in their immediate environment, and can move about without fear of collision…In short, they behave as if they had some kind of dim vision of their immediate surroundings."*

Taylor (1962) observed that blind people are not consciously aware of the fact that this knowledge is derived from auditory sense. Coleman (1953) believed that some blind people are guided by a feeling of pressure on the exposed areas of the skin, especially the face. This phenomenon is called "facial vision" because it is thought to produce sensations on the face (Lopes 2000). Supa et al. (1944:133) argued that this is not the case; they state that Diderot (1749) was the first to record the ability of the blinds to perceive the presence of objects. According to Supa et al. (1944: 133):

> *"Diderot thought his subject judged the proximity of the obstacles by the action of the air on his face- that is by the increased sensitivity of the facial nerves and end-organs".*

Since Diderot's study several theories have been suggested (e.g. pressure on the exposed areas of the skin/ auditory cues) in order to explain this phenomenon, but as Supa et al. (1944:138) stated:

> *"Not only are blind who possess the "sense of obstacles" unable to explain the basis of their performance, but, as this review shows, the investigators of the phenomenon are themselves unable to come to any agreement regarding it".* [(For a review, see Supa et al. (1944)]

Supa et al. (1944) conducted seven experiments with four participants; two blind and two blindfolded. In the first experiment one of the blind participants, aged 22, couldn't explain why and how he was able to perceive obstacles from a distance but he thought that audition helped. The second blind participant, aged 20, thought that sound was not helpful and that his judgements were matters of facial pressure. The two sighted participants were not able, at the beginning of the study, to detect obstacles when blindfolded, they doubted if they could learn to do so, but they soon learned. In the following experiments the participants' heads were covered with a felt veil so as, according to Supa et al. (1944) to eliminate air-currents and "air-waves" but not sound. They demonstrated that stimulation of the skin by "air waves" is not a necessary condition for the perception. In the subsequent experiments they examined whether echoes and sound – waves were a necessary condition for the perception of obstacles. To do this, they plugged the ears of their participants and they uncovered their faces, arms and hands. Under these conditions they were blind (the sighted participants were blindfolded) and deaf to ordinary sounds. None of the participants under these conditions were able to detect obstacles. Their main finding, (Supa et al., 1944:183) after conducting all the experiments, was that:

> *"Aural stimulation is both a necessary and a sufficient condition for the perception of obstacles"*

Worchel and Dallenbach (1947) also found that audition was the basis of the perception of obstacles for visually impaired people and that auditory stimulation is necessary for it. In a study by Ammons et al. 1953, blindfolded participants walked towards an object positioned at a distance until participants perceived the object and stopped or collided with it. After a few trials participants could stop before colliding with the object. If, though, they had their ears plug in addition to being blindfolded, most of them collided with the object more frequently. Wickens and Meyer (1995) findings also showed that sensitivity in the skin was not an influential factor in perceiving objects and that facial sensation did not contribute to blind people's abilities of locomotion. This was also demonstrated by Ashmead et al. (1989). In their experiments congenitally blind children aged 4 to 12 years who had insignificant amounts of visual experience or formal mobility training, recognized objects on the basis of reflected sound. The results of their experiments suggested that blind children with little or no visual experience or formal training could make use of auditory cues to perceive objects. Similarly, Kellogg (1962) found that allowing the participants to make any noise they wanted (slap their feet down, click their fingers) to help detect objects, increased the ability to perceive objects.

Therefore "facial vision" is in fact, an auditory sense, a kind of echolocation. Echolocation is an attribute of hearing which may be broadly define as the ability to hear echoes. Echoes and other sounds convey spatial information about the location of objects their dimension (how big they are) and their solidity (solid, hard, soft). Echo signals strike every surface in the surrounding environment. The information about the surrounding surfaces that the returning sounds carry can be interpreted much as the seeing person interprets patterns of returning light. The echoes provide auditory images of the space, and these images bare many of the same characteristics as visual images (Kish & Bleier, 1994/2000).

But although this skill is an auditory one, those who make conscious use of it may remain unaware that they are using their ears. It is also stressed that object perception is not only auditory but it is a combination of touch, echo and movement. (Lopes 2000; Worchel et al. 1950). Ammons, et al.(1953:550), also found that:

> *"Sounds, pressures, warmth, cold and smell are under certain conditions adequate and sufficient for the perception of obstacles. None is, however, necessary, but audition is credited with being necessary…."*

Additionally, many blind and sighted people claim that echolocation is accompanied by feelings of pressure on the face and at times they describe it as a feeling that they can sense all over their body (Lopes 2000; Worchel et al. 1950). Maybe an explanation is that echolocation is an unconscious process (Juurmaa, 1970) and as Kish (1995:8) proposed:

> *"When a blind person collides with an object, it is typically the head and face that receive the most memorable impact. An unconscious connection is thereby made between actual object perception through unconsciously processed echo information and an involuntary response of muscle tension in the face".*

In other words this facial pressure could be the result of a tension in the face, due to the fact that it is the area most likely to be collided with an object first. Therefore, the person detecting a wall by echo might feel a rise in tension in the face muscles (Juurmaa, 1970).

Ono et al. (1986) suggest that those who became blind later in life may connect the presence of objects – which they previously experienced visually – with actual sensations upon the face. They based their suggestion on their finding that higher percentage of sighted than blind people reported experiences of tactile sensations in the face when objects were near.

What is interesting is that, there is a debate among researchers about whether sighted people can spontaneously echo-discriminate the spatial and textual features of objects with the kind of accuracy achieved by people who are blind or whether the sighted need training to do so. For example Lopes (2000:450) comments that:

> *"psychologist are reluctant to investigate the purely phenomenological elements of perception, so little is known about the mechanism underlying this phenomenon, or whether the phenomenon exists at all……… But if the phenomenon exists, it is additional evidence that the phenomenal character of spatial hearing is not like that of other senses".*

Other researchers like Ammons et al. (1953) established that sighted people perform as well as people who are blind after training. However Supa et al. (1944) and Miller, (1992), showed that sighted people do not perform as well as people who are blind, but that they can improve with training. McGrath et al. (1999) found that both blind and sighted participants were able to localise objects and to some extent identify objects but the participants who were blind, had a higher degree of expertise in the task domain.

2.3.3. The haptic and proprioceptive perception of space

Another system available to the blind is the proprioceptive system (Spencer et al., 1989). The proprioceptive sensory system provides information about a child's body position in space and it contributes to laterality, directionality, and spatial awareness. Proprioception also plays a vital role in muscle tone and balance as well as the development and maintenance of good posture. It is also a vital element in haptic perception (Rosen, 2000).

> *"Proprioception provides information on the physics of the body, the momentary distribution and dynamics of masses, forces acting on the limbs and their highly nonlinear interactions.........not only guide body movement, they also (together with touch) sense the size and shape of objects and measure the geometry of external space"* (Smetacek and Mechsner 2004:21).

Haptic perception is the ability to identify objects by size, shape, and feel. Haptic originates from the Greek word "aptome" which literally means to touch. The term tactile is used primarily in referring to passive touch (being touched), and haptic refers to active touch and involves intentional actions; such as when individuals use their touch to gain information independently, for example when reading a tactile code or when manipulating an object (McLinden & McCall 2002; Spencer et al., 1989). Touch makes for easier motor activity and permits the perception of nearby objects and spatial layout when viewing is not possible; it is the only modality that can convey object properties such as temperature or hardness, softness etc; also it can provide vital information about the object such as size, surface texture, shape and orientation. People who are blind rely a great deal on the sense of touch in their everyday activities (Loomis & Lederman, 1986).

Revesz (1950), who has been influential in the development of the concept of active touch, or haptics, as a perceptual system, stressed the role of movement in haptic exploration believing that only with active touch someone can recognize objects or materials and shapes. Therefore active touch is far superior to passive touch. He stressed that haptic perception relies more upon sequential exploration than vision in order to take in the same amount of information, which must be integrated by an intellectual process. He did however view haptics, particularly in the blind, as very limited in its ability to comprehend spatial information, something that is not widely accepted.

Millar (1994) and Loomis et al. (1991) also suggested that haptic recognition of objects is not immediate as it is with vision. Visual perception is rapid and more accurate, allowing the individual to take in a great deal of information at one time. The sighted individual needs only to look around in order to comprehend the composition of space. Thus it requires less work to integrate visual information into a well-structured cognitive map compared to information from other senses. The person who is blind may perceive only parts of that composition and must follow a complex cognitive process through which the whole is constructed.

Millar (1994) also remarked upon the quite specific nature of some of the reference information that is needed by blind individuals, and on the overlap required between the remaining modalities. However she also stresses that complete absence of sight, as such, does not produce lower cognitive efficiency; on the contrary, it demands more cognitive skill and more general knowledge about the environment.

Another major influence on theories of haptics, Gibson (1962), stressed the importance of movement and intentionality in haptic perception. Gibson suggested that active touch leads to better object perception than passive touch. Passive touch only brings *"to our attention events at the surface level of our bodies"* (McLinden & McCall 2002:31). In contrast with Revesz (1950) who talked of information which must be integrated by an intellectual process, for Gibson, active touch provides us with information about objects and surfaces in the environment that is simultaneously guided by the characteristics of an object; the hand movements directly perceive invariant properties of the object.

Nevertheless children with visual impairment rely to a large extent on information received through touch in order to develop further their knowledge and understanding of the world. Griffin and Gerber (1982) suggested that there are four stages of tactual development. The first stage is awareness of the tactual qualities of objects. Through movements of hands, children who are blind become aware of textures, the presence of materials, sizes and weights, temperatures, vibrating surfaces and different consistencies. A second stage of tactual development is shape conception and recognition of the part-whole relationship. The third stage in tactual development is graphic representation, which is a way of understanding the relationships between real objects and their representations. And a final stage is the utilization of a symbolic system in which representation simply stands for an object but does not have to resemble the original.

Rogow (1988) also stressed that exploration through touch is vital for children with visual impairments as a means of obtaining perceptual information about the world. Other researchers have suggested that in the absence of vision, the information that children receive through touch may be incomplete and difficult to understand; therefore exploration through touch has to be fostered early within the life of the visual impaired children (McLinden & McCall, 2002; Griffin & Gerber, 1982). *As* McLinden & McCall, (2002:55) put it:

> *"…careful structuring will be required before touch becomes an effective way for children to learn about their environment".*

Therefore, children with little or no vision should be made conscious, early in life, of the different sensations caused by touching different objects or walking over different surfaces and generally moving their hands to explore objects. By this means they could be aware, through touch, of the relative sizes, weights and textures of objects and places around them (Spencer et al. 1989).

2.3.4. Discussion

To summarize then, because children who are blind rely on non visual information in their learning, they may have to work much harder than children who are fully sighted to develop skills in areas such as orientation, mobility, and in related areas such as communication, independence and social skills. Without clear sight, many of the everyday skills that children who are fully sighted take for granted can be difficult for children with severe visual impairment to master.

Therefore, specific intervention and carefully planned curricula are required in order for children who are blind to learn self-help skills and to develop their awareness of space and their orientation so as to be able to know where they are, where they are going and how they are going to get there (Fazzi et al, 2005). Moving in and around the environment gives the opportunity to children to experience and explore the world and comprehend how the world develops (Mason & McCall 1997).

Spatial concepts relating to long distances or routes in the wider environment outside their school or their house may be particularly difficult for them to grasp (Mason & McCall 1997). That is why education must aim at giving children who are blind knowledge of the world around them and the confidence to cope with it. Practical opportunities in areas such as exploring, estimating and measuring, followed by discussion and interpretation, can be crucial to help clarify and strengthen their knowledge of the world (Koutantos 2005; Andreou & Kotsis, 2006a; 2006b).

Auditory perception enables the identification and localization of objects and facilitates distance and direction awareness. As Kish & Bleier, (1994/2000:3) propose:

> *"By the right training and experience blind humans can learn to fill the darkness with dynamic images derived, not from light, but from sound"*

Hearing however, does not easily and clearly specify the characteristics of objects that are recognized by vision and touch, such as shape, size, texture or colour. Sounds often are non-specific and can reach the ears from all directions offering a less certain "picture" than would vision. Nevertheless, learning improves the ability to acquire spatial information from hearing (McLinden & McCall 2002).

In addition, haptic and proprioceptive perception provides information about space, such as where we are, where objects are in relation to us, and what they are. They inform blind observers about the shapes and textures of objects, and about their relative positions in space. When compared to the visual system however, they have several disadvantages. Firstly, touch provides less information about the composition of space beyond the arm's reach; details that are quite obvious to sighted people are not accessible by observers who depend on touch; for example some objects may be too small to be perceived by touch or too large to be experienced as a whole or they simply cannot be reached (Foulke, 1992; Spencer et al. 1989). And secondly, the haptic sense whilst it may offer a more certain and defined picture than the auditory sense, can only really be useful through direct contact with surfaces, and therefore its use is limited.

Overall, children who are blind seem to have to deal with a triple integration process: their internal/inside world, the external world as experienced through perception based on tactile kinaesthetic and auditory input, and the external world as explained from visual perception which they absorb through second hand accounts but which are not based on personal experience (Spencer et al., 1989; Andreou & Kotsis, 2005).

2.4. Spatial awareness without vision: the processing of small and large scale spaces

In research on spatial awareness in blind and visual impaired individuals, a distinction is usually made between near space and far space. Far-space refers to the geographical or physical environment, and relates to large-scale space: areas in which locomotion is required for exploration. Near-space relates to small-scale or manipulatory space (Ungar, 2000; Laterman et al, 1987) and

> *"…refers to the space that surrounds the child within arm's reach, whereas far space refers to the spatial environment beyond that"* (Warren 1994:102).

Laterman et al (1987:606) distinguished between two types of *"movement space"* by which they meant the space explored without vision and apprehended by touch. This distinction was not based on the absolute size of the space but on the nature of the exploratory organ. Thus small- scale space would be explore through movements of the arms, hands and fingers, which they defined as manipulatory space; and large-scale space would be explored on foot, which they defined as ambulatory spaces.

This distinction is useful as small-scale space and large-scale space are experienced differently by people who are blind or visually impaired and hence must be studied to some extent separately. In small-scale space, where haptic exploration with hands and arms is used, an egocentric spatial organization may often be sufficient since locations and objects can be represented in relation to one's own body. In large-scale space in which locomotion is required for exploration an egocentric frame of reference might becomes less reliable (Warren 1994, Ungar, 2000).

2.4. 1. The processing of small-scale space and the frames of reference utilized by people who are blind

A number of studies have focused on the way blind people spontaneously code the locations of objects in small-scale space (for a detailed review of these studies, see Millar, 1994 and Warren, 1994).

Generally, the literature concerned with small scale space indicates that visual experience has some influence on the way in which spatial information is encoded or organized. For example, Warren (1994) suggests that is not surprising to find evidence that children with visual impairments organize the spatial world primarily in relation to the self rather than to external spatial references, since lack of vision does not facilitate the child's attention to external spatial factors. Warren (1994) however noted that the ability to use external strategies effectively increases with age.

In a similar vein, Hollins and Kelley (1988) asked early blinded and blindfolded sighted adults to learn by touch the locations of objects on a table relative to one location and then to point to them from a new location. The visually impaired group was less accurate than the blindfolded group when pointing from a new location, but there were no differences between groups when the participants pointed to the objects' locations from the position from which they had been tactually explored. Thus they concluded that blind participants tend to use self-reference strategies when learning the locations of the objects in small scale space.

Coluccia et al (2009) also concluded that people who are blind were as efficient as the sighted in the egocentric and rotated conditions but they encounter difficulties in recalling locations when an allocentric condition was required. In the same line Ruggiero et al, (2009) studied the impact of visual experience on the ability to use egocentric and allocentric spatial frames of reference by comparing the performance of early and late blind with blindfolded and sighted participants. Participants had to explore haptically and memorize the positions of three-dimensional geometrical objects. Then they had to provide spatial judgments of relative distance in relation to either themselves or to another object. They found that the level of accuracy in the egocentric performance was similar in all groups; however lack of visual experience affected negatively participants' ability to process allocentric information.

It seems that under blind conditions children tend to rely on egocentric frames of reference. However secure spatial information can be derived from hearing, touch and movement and people who are blind or visually impaired have the potential to utilize both egocentric and allocentric frame of references and to acquire spatial concepts equivalent to those of sighted (Millar, 1988; Millar, 1994; Ittyerah, 2009; Gaunet et al, 2007).

A few studies explored both small and large scale space, using a variety of methods in order to externalize the spatial representations of blind and visually impaired individuals. An example of such a study is Dodds, Howarth, & Carter, (1982). Dodds et al. (1982) compared the performance of adventitiously blind and congenitally blind children, on a series of tasks including a large scale route learning task and a small-scale route drawing task. All the children learned a short urban route by walking along it four times. As they walked the route children were asked to point to different locations along the route. When the test had finished they were asked to draw a map of the route using a Raised Line Kit. According to the researchers the children were familiar with this drawing procedure. They found that although all the children learned how to travel each route successfully after only one trial, only one out of four congenitally blind children could produce a two-dimensional drawing indicating both distance and direction. Overall congenitally blind children's drawn maps were less recognizable, and were also less accurate than late blind children in direction estimation.

Dodds, et al. (1982) stated that most congenitally blind children, despite being efficient travelers, were not able to form an overall survey-level representation of the layout, instead they develop an egocentric or self-reference representation of the route. Therefore they concluded that, previous visual experience assists not only in the decoding of spatial information but also in the encoding of it, a facility that leads to a better understanding of spatial properties; and that training should be given to help congenitally blind children to develop external references.

The study by Dodds et al. (1982) highlights differences between the ability to learn a route in large scale space and the ability to map that route mentally in small scale space. When requiring the children to draw a map on the basis of their experience with the route, Dodds et al. (1982) assumed that children's drawings should reflect and reveal the cognitive maps they have formed of that route. Drawing an accurate map of a route requires the ability to form a clear Euclidean representation of that route.

> *"For survey maps to emerge, routes need to be metrically scaled and interrelated into a global allocentric reference system*" (Ishikawa & Montello, 2006:94).

However the large scale task with which the children were presented can also be solved with topological operations, such as using sequences of landmarks and associated decisions (i.e. turn left at the corner or go straight). Dodds et al. (1982) therefore suggested that congenitally blind children do not use an allocentric reference system but rather tend to adopt self-reference spatial coding strategies.

However at least one congenitally blind child in their sample was able to perform as well as did the adventitiously blind, and this might also suggest that visual experience is not a necessary condition for the ability to represent spatial layout adequately. What Dodds, et al., (1982) do not appear to have sufficiently acknowledged is the fact that adventitiously blind children are likely to have had more experience and greater understanding of two-dimensional representation than their counterparts. Furthermore drawing an accurate map relies not only on forming a clear Euclidean representation of a space but also upon the ability to cognitively organize and reproduce a replica of that space. Therefore the less accurate drawings of children who are blind do not necessary mean that are not capable of perceiving all the elements of the surrounding space in a holistic manner. It might mean that children who are blind need training in order to develop the skills necessary for conceptualizing, organizing and reproducing the surrounding space, especially when we consider that drawing is not an activity that blind children are engaged often.

Moreover lack of vision imposes limitations on a person's independent mobility; therefore children who are blind might reasonably be expected to require more experience of an environment and more time to formulate representations equivalent to those of sighted. It is possible that the blind participants in the above study needed more experience with the experimental setting. Therefore there is a need to consider whether the findings of Dodds, et al., (1982) are associated with lack of training and limited opportunities provided to persons who are blind to develop their spatial abilities and form survey representations of the environment. It is quite possible that the results suggest simply that people who are blind need more time and more trials in order to familiarize themselves in an experimental setting.

Another study which explored both small and large scale space was carried out by Fletcher (1980; 1981a; 1981b). Fletcher asked blind and blindfolded sighted students to explore either a real or a model room containing various items of furniture. They were required to work out the relative positions of the furniture either freely or guided by an examiner. When exploration was guided, the students were led around the room in a counterclockwise direction by the examiner and each item of furniture was named as it was reached. In the free-exploration condition students explored the room in any way they wanted either by moving their hand – in the model room – or their body – in the real room. And in this condition furniture was named as it was located. The type of room and mode of exploration to which students were assigned was randomly decided. After the students located each piece of furniture once they were asked questions about the furniture. Their answers required a sequential analysis of the task obtained directly from the route traversed; and other questions required the formation of a cognitive map for their solution. The cognitive map questions required the formation of a two dimensional map of the area. For example:

> *"…any "opposite-corner" or "straight –across- the room" question would be considered a map question"* (Fletcher, 1980: 383).

Fletcher unfortunately does not provide any more information of what she calls 'map' versus 'route' representations. Perhaps surprisingly, Fletcher (1981a: 2) found that:

> *"…neither type of room (real versus model) nor mode of exploration (free versus guided) produced any significant main effect".*

This is an interesting finding for two reasons. Firstly given that the spatial relationships in a model are available within the span of two hands, it would be natural to assume that children who are blind would find the model room easier to comprehend since it is easier to manipulate a model than to explore a full sized room; and they would have more experience of tactile manipulation and exploration than sighted children. Apparently though, according to Fletcher, this is not the case. Secondly, one would anticipate significantly different findings between free and guided exploration in both groups. This appears to be a particularly important finding because further research in this area might shed light on the selection of the most suitable educational methods and exploration strategies that should adopted by educators if they want to help their students to increase their comprehension of the surrounding spatial relationships.

Generally blind students were found to perform better on the "route" questions than the "map" questions, while sighted children showed no such difference. This supports the hypothesis that children who are blind find "map" questions more complicated to solve because they require the formation of a holistic view of an area.

It is also suggest that “route” questions could be solved with ‘topological’, sequential, and wayfinding techniques. This may not be a surprising finding, considering that as blind children move forward into a room, their perception of the room does not come from their eyes but from a range of sensory inputs including hearing, touch and movement. Their attention is likely to be centered on the ground under the next step they take and, unlike the sighted children, their “view” of the room will not be holistic but it will be partly based on the steps needed to cross it, on the floor’s surfaces and generally on information that usually access sequentially (Best, 1992: 62).

The study of small scale space and of the strategies involved in the process of its exploration was attempted by Lederman, Klatzky, and Barber, (1985) and Lederman Klatzky, Collins, Wardell (1987). Lederman et al. (1985) and Lederman et al. (1987) investigated the encoding of tactile spatial pattern information, giving attention to the ‘heuristics’ (i.e. strategic rules), which operated in this process.

> *“…we have seen evidence for a variety of heuristics: the use of implicit spatial axes as referents, estimates of inferred pathways from spatial extent to actual movement, extent estimates based on duration of movement, the use of knowledge about the geometry of the path, and a footstep metric”* (Lederman et al., 1987:612).

Lederman et al. (1985) asked blindfolded participants to move an index finger along a complex small scale raised pathway from beginning to end, and then to imagine a straight line between the endpoints (the Euclidean distance, which in most cases, was not the same as the pathway that had been felt). Interestingly, when asked about the length of the line, participants overestimated the Euclidean distance as the length of the pathway increased; thus indicating a heuristic that encodes the perceived total displacement by reference partly to the total distance traveled.

In a follow-on study, Lederman et al. (1987) asked blindfolded participants to judge the relative distance of pathways felt by hand and the straight-line distance between pathway endpoints. They also asked participants to perform an analogous task in large scale space, walking along a pathway and then estimating the straight line distance they had moved. They found that length distortion occurred in both types of spaces (small-scale and large-scale space) suggesting that greater movement along a pathway tends to increase estimates of the distance between its endpoints. Lederman et al. (1987) also investigated the role of the duration of movement exploration in length distortion, i.e. whether the participants will also judge the total displacement as longer if a movement takes longer to perform. This was tested by instructing participants to trace the pathway at controlled and different speeds. They obtained different results for the two scales of space. For manipulatory space pathway estimates of both the actual distance and the Euclidean distance were affected by duration, but for ambulatory space no speed or duration effects were obtained. In the large scale participants used time-independent heuristics such as counting steps for estimating the length of the pathway actually travelled.

The importance of the experiments Lederman et al. (1985) and Lederman et al. (1987) is that they attempted to study the heuristics that underlie non visual processing in both small-scale and large-scale space. They attempted to find the characteristics of small-scale and large-scale space, and they attempted to study the process of non visual spatial performance, something that relatively few studies have done. Their approach though could be criticized because of their decision to use sighted blindfolded participants. Sighted participants are much easier to find than blind participants and allow experiments to be carried out quickly however decrease the validity of their results in relation to people who are blind. For example, Warren, (1994) argued that results obtained with blindfolded sighted participants may not reflect the natural performance of either the people who are blind or sighted.

2.4.1.1. *Discussion*

It is possible to find in the literature a number of common elements between small and large-scale representation. These include the use of landmarks to encode spatial position (Nelson & Chaiklin, 1980) and the hierarchical organization of spatial elements (Allen, et al, 1989; Allen & Kirastic, 1985). Small-scale spatial displays such as models, maps and drawings symbolize large-scale geographical space and it is assumed that they constitute a practical medium for testing spatial understanding. In addition it is easier to set up and manipulate objects and settings in small-scale space (Millar, 1994). However we should bear in mind that small scale spatial representations (maps, models, and graphs) are symbols and for children who are blind they could be difficult to grasp. In using maps or models and graphs to interpret the spatial layout of a large-scale space, children must be able to translate the differences in scale. For adults who can bring abstract images to bear in a problem, a square is a square, large or small, but this is not the case with young children, since spatial thought is often still developing and is not independent of developmental factors (Potter, 1995). Furthermore several studies suggest that the representation of space learned from a map (small-scale spatial display) is orientation specific (Evans & Pezdek, 1980); whereas when learning about space by navigating through it, judgments are less tied to a particular orientation (Evans & Pezdek, 1980; Thorndyke & Haynes-Roth, 1982).

Thus it could be argued that small or manipulatory and large or locomotor spatial processes involve different mechanisms. Self referent encoding might be sufficient in small scale space when one is not moving however the body cannot serve as a stable reference in large scale space when one is moving. In large scale space the moving person must keep track of his/her own position by reference to external landmarks and continuous update the spatial relationships between themselves and the surroundings (Thinus-Blanc & Gaunet, 1997). This suggests that in the education of congenitally blind children it is important to develop their abilities to use external references; especially since many researchers have found that spatial relationships in both small and large scale spaces can be learned equally well by some blind individuals.

For example, Fletcher (1980; 1981a; 1981b) found that although sighted students generally performed better than the blind, some blind students in all age groups performed as well as the sighted students. This finding is consistent with findings from other studies which also suggest that at least some of the blind participants were able to perform as well as did the late blind or sighted participants (Dodds, et al, 1982; Spencer et al, 1989; Passini & Proulx, 1988; 1990) Therefore it would be very useful to explore the processes that enable some individuals who are blind to perform as well as sighted individuals; this could reveal insights into areas that educators should focus upon when seeking to develop spatial concepts in children who are blind.

Moreover taking into consideration the fact that individuals with visual impairments and blindness are part of a population that is a very heterogeneous one, it would be even more useful to identify how students who are blind comprehend the surrounding space by identifying the ways in which spatially skilled differ from the spatially challenged. Thus looking for similarities or differences on the spatial process involve within the population of children who are blind rather than comparing them with the population of people who are sighted (Warren, 1994). That was the main concern in my own investigations in the present study. I sought to explore children's who are blind own voices, to note individual differences and to identify what they themselves considered to be the best ways to overcome the challenges they faced in making sense of space.

2.4. 2. The processing of large-scale space and the frames of reference utilized by people who are blind

When learning about large scale space, individuals both blind and sighted are faced with the task of integrating information over time (Ungar, 2000).

Studies within the literature on large scale space have focussed either on the understanding of familiar environments or on the perception of novel spaces - either an unfamiliar part of real world or experimental layouts constructed in the laboratory (Warren, 1994; Ungar, 2000).

The question of whether spatial processes are impaired by blindness and whether the spatial concepts possessed by blind individuals are different from those of people who are sighted has been investigated within a variety of studies and through a wide variety of tasks, as has already been shown (Thinus-Blanc & Gaunet, 1997;

Ungar, 2000). However, as Warren (1994) has identified, only a few studies have attempt to investigate the process of acquiring spatial concepts.

In addition, only a few studies have focused on the understanding of familiar environments (Byrne & Salter, 1983; Casey, 1978; Lockam, Rieser & Pick, 1981; Rieser, Lockman & Pick, 1980; Bigelow, 1996). This is partly why a main focus of the present study concerns the way children perceive familiar environments such as their home and school. Warren (1994:110) define familiar spatial layout as the environment

> *"…in which the child has had extensive experience and has learned naturally".*

In reviewing the literature concerning large scale spaces I was forced to the same conclusion I reached in the case of small scale spaces: that there is no consistency among researchers' findings relating to the effects of blindness in spatial perception. On one side, when comparing sighted participants and participants who are blind, many studies report that participants who are congenitally blind are less proficient than sighted and late blinded participants. For example Casey (1978) gave a kit to blind and partially sighted children consisting of model buildings, and asked them to produce a plan of their school campus. Casey (1978) wanted to evaluate children's knowledge of a large scale space that was equally familiar to both groups. It was found that congenitally blind adolescents as a group were less accurate than the partially sighted group. Partially sighted students included more elements in their representation and constructed more organized models showing a better understanding of the overall spatial structure of the campus. Some blind students, however, were very accurate on the overall organization and made models as good as those of the partially slighted. Casey (1978) suggested that these students had more independent mobility than the others, both on and off the campus, however the process that caused their performance to be correlated with their level of mobility was not explored.

In reviewing Casey's study, Warren (1994) pointed out that any differences found were possibly due to differences in model making ability rather than differences between the cognitive maps of the groups. Casey's study provided an interesting insight into the cognitive maps of the participants; however the limitation is that the models were evaluated as 'well organized' by how closely they fitted in with a sighted individual's ideas of a good and holistic model of the campus. In an everyday familiar environment what is perhaps most important for a person who is blind, is their ability to find easily their way around and to understand where everything is. Knowing how to get from one place to another is a practical problem they need to solve; they might pay attention to cues and landmarks that are different from those used by people who are sighted and they may organize relevant information in other ways. The fact that people who are blind split a familiar environment into smaller units doesn't necessary means that they do not perceive the overall spatial structure. This might happen mostly for practical reasons. Therefore is vital to train blind children to build on the information and coding strategies currently available to them in order to put separate parts in a cohesive whole representation of space (Millar, 1994).

In another study Bigelow (1991) compared two children who were blind with two children who were partially sighted in their ability to point to specific locations in and around their houses. She found that children who were blind tended to point to the routes taken to the locations rather that to straight line distances. Thus she suggested that even in familiar environments children who were blind did not have an overall perception of the layout of the space. However in reviewing Bigelow's study, Warren (1994) argued that when the children were pointing in the direction of the correct route rather than the straight line direction, it is possible that they did not understand the instructions. In a later study Bigelow agreed with Warren's observation (Bigelow, 1996). She further stated that the task of pointing might have been less familiar and natural for the children that were blind compared to the sighted.

In a similar study Bigelow (1996) asked two children who were blind, two children who were visually impaired and twenty sighted children, not to point this time but to judge which of three locations in their homes was closest to a starting position. The children were asked to judge both by the routes necessary to get to the locations and by straight line distances – Euclidean tasks. The three locations were: 1) on different floor level from the starting position, 2) on the same floor and 3) in the yard; the starting position was on the ground floor. Bigelow (1996) found that totally blind children made more mistakes than the two other groups and that they had difficulty distinguishing between routes and straight line distances. She suggested that blind children's spatial knowledge of familiar space was based on their movements between familiar landmarks within that space and on sequential components rather than based on an overall perception of the layout of the space. She also found that in the Euclidean tasks, the yard questions were the easiest for all the groups of children because sighted children could see most of the locations and children who were blind could walk directly to them without making detours around obstacles. Distances between locations on different floors were the most difficult to judge because:

> *"…judging distances to locations on different floors involves changes on a vertical plane as well as a horizontal plane"* (Bigelow, 1996:813).

She also found that although the two blind children were delayed in mastering the spatial tasks compared to the sighted children, the older blind child's percentage of correct trials in the straight line task was similar to that of the younger sighted children. This later finding might suggest that the older blind child might have based his spatial understanding on the overall perception of the spatial layout rather than on sequential components; although this process might appear delayed compared to the chronologies of the sighted participants.

Bigelow's (1996) study is one of the few that sought to explore the spatial understanding of familiar environments by children who are blind. In her previous study Bigelow (1991) has been criticized by Warren (1994) that she did not make clear the instructions for the pointing task to the children.

> *"The instruction was to 'point to x' and did not specify whether to point to the location of x or to the direction that one would walk to get to x"* (Warren, 1994:111).

In her later study (Bigelow, 1996) made clear what she meant by 'straight line' and 'route' distances and focused the children's attention on differentiating between the two by asking them (for the Euclidean tasks) to imagine magic ropes going through walls, ceilings and floors in straight lines and judging which magic rope was the shortest. For the route tasks she asked the children to imagine rolls of real string that unrolled while they walked from the starting point to the three locations and judged which one was the closest.

One limitation though, is that this is a complex activity; the children were asked to image ropes and strings and then transform these in to real distances between the places; so it is possible that the observed differences were due to the nature of task itself rather than in the quality of the children's perception of the surrounding space. It is also worth mentioning that 'thinking' in terms of Euclidean distances is less familiar and less natural for the children who are blind since they acquire knowledge of the spatial relations among objects sequentially through tactile, proprioceptive and auditory cues. Thus it is natural that their spatial understanding to be more oriented to sequential components. Thinking about what route to follow is a sequential process, involving rotation and multiple changes in direction; the ability to transform one type of spatial representation - route distances - to the other - Euclidean distances- is a mentally demanding process and might be the reason for the 'delay' in mastering the spatial tasks, that has been observed in children who are blind when compared to sighted. It does not necessarily means that blind children's understanding of the overall layout of the space is impaired. Byrne and Salter (1983) for example found little difference between sighted and visually impaired participants in a task of pointing the direction of remote buildings and estimating their distances, if the task was carried out in a familiar setting.

Ungar (1994) also reported that in his study eighteen children who were visually impaired (six were totally blind and twelve had some residual vision) had a good impression of the spatial relations between locations within their school campus. Ungar (1994) selected nine locations from the school campus that children were familiar with and asked them to judge the relative distances between these locations using the method of triadic comparisons (Rieser et al., 1980). Locations were named in sets of three and the children were asked to decide which two locations were the furthest apart and which two were the closest together. On the whole, Ungar (1994) found that children's relative distance judgments related more highly to the route distances than to the Euclidean distances. This finding is consistent with the findings of Rieser et al. (1980) with adults. Rieser et al. (1980) found that in both visually impaired and sighted adults' distance judgments were highly correlated with route distances rather than Euclidean. However four of the children who had residual vision in Ungar's (1994) study, spontaneously made their judgments according to Euclidean distances. This later finding is not in agreement with the findings obtained by Rieser et al. (1980). Sighted and late blind adults, in Rieser et al. (1980) study, judged the distances in Euclidean terms only when they specifically instructed to do so while adults who were congenitally blind continued to judge the distances in terms of route estimates.

Generally the studies reviewed so far suggest that when children or adults who are blind or visually impaired are asked to estimate distances and directions in familiar environments, they tend to respond on the basis of the route they need to travel between two locations rather than on the basis of a straight line 'path' between two locations. However the fact that some of the children that participated in Ungar's (1994) study and others (i.e. Lewis et al 2002) spontaneously gave straight line estimates suggests that children who are visually impaired are not incapable of forming the overall layout of their surrounding space. And as Ungar (1994:130), points out

> *"it is possible that all the children in the present study had a mental representation of the school which included (implicit or explicit) Euclidean*

information, but the individual children simply felt it more appropriate to the perceived task demands to respond in one way rather than another".

In the same line Lewis et al (2002) concluded that lack of sight does not preclude the early development of Euclidean understanding although some children might be more successful in integrating separate items of spatial information into a coherent whole.

However, as already have been noted, many of the studies, concerning the processing of large scale space have tested the spatial performance of people who are blind in novel environments. Thus less is known about blind person's spatial understanding of well-known environments than about their understanding of novel environments (Warren, 1994). An explanation for that might be that individual differences in experience when testing knowledge of familiar environments cannot be easily controlled in experimental settings (e.g. Tinti, et al, 2006; Ungar, 2000; Espinosa et al, 1998; Ungar et al, 1996; Ungar et al, 1994; Hill et al., 1993; Passini & Proulx , 1988).

For example, Rieser *et al*. (1986) tested the ability of congenitally totally blind, later blinded and blindfolded sighted adults to keep track of their position relative to a number of landmarks as they moved or imagined moving through an experimental layout of objects. That way they were able to control more easily the different experimental variables without having to worry about individual differences in experience with the setting. Participants had to make judgments of Euclidian distances and directions among landmarks. The sighted and the adventitiously blind groups performed very accurately in the locomotion task but less accurately in the imagination task. However the performance of the early blind group was similar in both tasks and showed poorer spatial performance than the other groups. Rieser et al. (1986) suggested that the early blind group appear to have used a strategy of calculating the relative positions of the landmarks in both the locomotion and the imagination tasks. Whereas the other two groups seem to have used a calculation strategy only in the imagination task; in the locomotion task they seem to have updated their position automatically as they moved. Thus Rieser et al. (1986; 1982) accounted for early blind participants spatial deficits in terms of a lack of updating while walking. Rieser et al. (1992) have confirmed to some extent Rieser et al.'s (1986) suggestions.

However the above findings are not in agreement with the findings obtained by Passini & Proulx (1988). Passini & Proulx (1988) guided a group of 15 blind adults through a complex unfamiliar experiment and architectural setting and matched their performance with a control group of 15 sighted adults. After two guided tours participants had to make the journey on their own. After having completed the walk, they were asked to reproduce the route they had taken, identify detours made during the journey, propose shortcuts, give indications about general form of the building, and spatially situate the entrance of the building in relation to the exit. Finally they were given tactile maps of the building layout of the two levels experienced on their journey and asked to trace the route. Passini & Proulx (1988) concluded that: 1) Blind subjects tend to prepare their journey in more detail, make more decisions during the journey, and rely on more units of information, 2) blind adults are capable of representing the route taken without errors and also can demonstrate a general understanding of the spatial attributes of the setting, learning a relatively complex route, making the journey, mapping the route and understand and experience space sufficiently, and 3) any differences were due to distant cues and visual reference points that were not accessible to blind.

Passini et al. (1990) went on to test these findings in a complex maze setting where participants undertook eight different tasks including inverting a route, making short cuts and mental rotations, and building models of a layout. The performance of the visually impaired groups in all eight tasks led them to rejection of the deficiency explanation and to conclude that that the ability to perform spatial tasks with the same accuracy as individuals who are sighted can be successfully taught, provided age and education are taken into account. However they also concluded that the visually impaired groups, in general, took more time to complete such tasks than the sighted control group.

The findings from Passini's & Proulx's (1988, 1990) studies, suggest that blind and visually impaired people can form coordinated global representations of the environment and suggest that spatial awareness can be acquired without vision and without previous visual experience; unfortunately they did not show clearly and in detail the learning processes involved in this acquisition or the nature of the knowledge structures created by people who are blind to achieve this level of awareness.

The performance of participants who are blind in other studies involving tasks requiring inferential abilities and overall survey representations also demonstrated that participants' who are blind spatial performance were without deficits. Several authors (e.g. Passini & Proulx, 1988; Spencer, et al 1989; Millar, 1994; Warren, 1994;

Klatzky et al., 1995) have pointed out that visually impaired people can make use of alternative strategies that can be functionally equivalent to that of sighted people; (such as used perceptual cues - auditory, tactile, etc.) in order to perceive unfamiliar space but might require more time and cognitive effort (Tinti, et al, 2006; Espinosa et al, 1998).

Systematic work on search activities and strategies that persons with visual impairments utilized to explore a novel space was conducted by Hill et al. (1993). These researchers videotaped adults with visual impairments in order to observe the strategies they used while exploring new environments and interviewed them to learn what strategies they attempted to use. Hill et al. (1993) found that visually impaired participants used a variety of wayfinding strategies including: perimeter search (which provides information about the size and the shape of an area), the gridline method (series of straight line movements to and from opposite sides of perimeter), walking and sweeping the cane, back and forth between two objects, back and forth between the perimeter and another object or between the home base and another object. Hill et al. (1993) concluded that the best performers used more often an object-to-object strategy i.e. they used a clearly define anchor point as an origin or they used strategies linking the objects to other objects or the perimeter.

> *"Typically, these participants walked back and forth in a straight line among target objects, the perimeter and target objects, and /or the home base and target object"* (Hill et al., 1993: 299).

The best performers also utilized their canes more efficiently and willingly verbalized the means that they had used to collect the information and solve the task. Conversely the worst performers implemented only few object-link types of search patterns and implemented more perimeter search patterns. This led Hill et al. (1993) to suggest that search patterns like perimeter and gridline might facilitate the efficient location of objects but not the development of object to object relationships. Whereas walking back and forth among target objects or the perimeter and objects facilitates the development of object to object relationships. An interesting point is that Hill et al. (1993) observed correlation between the type of strategies implemented during exploration and performance, i.e. they found that egocentric strategies were correlated with the lowest performance levels. They also found similarities between the strategies used by blind or visually impaired individuals and blindfolded sighted groups participated in other studies (Tellevik 1992).

The findings from Hill et al. (1993) indicate the importance of considering individual differences in blind and visually impaired people's spatial awareness and of taking into account the variety of wayfinding strategies the participants use. Hill's et al (1993) study also illustrate that some 'early blind' people are able to reach the same performance level as 'late blind' and blindfolded sighted individuals and that they essentially use the same strategies to achieve this; thus supporting the amodal representation hypothesis, suggested by Carreiras and Codina (1992).

Similar results were found by Espinosa et al, (1998). In an attempt to analyse the effect of different instructional methods in a group of blind and visually impaired adults when learning spatial layouts of an unknown environment, Espinosa et al, (1998), concluded that people who are blind can use tactile maps to navigate successfully relating a map to the real world and having the spatial skills to appreciate Euclidian directions. Thus confirming other studies in which blind children used tactile maps to navigate successfully in smaller unfamiliar environments (e.g. Ungar et al, 1996; Ungar et al, 1994).

In the same line, Tinti, et al, (2006), compared the performance of participants with congenital blindness, late blindness and blindfolded sighted participants on survey representation-based tasks. They asked participants to explore two pathways of varying degrees of difficulty in an unfamiliar experimental room and then to estimate direction and judge distances by pointing in terms of straight-line directions and to draw a map of the explored pathways. Participants with blindness were given a “rubber blueprint” to draw, since according to the researchers they were familiar with. Tinti, et al (2006), concluded that lack of vision did not affect the survey-type spatial processing required in their tasks. In fact participants who were blind performed better than blindfolded sighted participants because as stated by the researchers the availability of information from sources other than vision plus the fact that people who are blind get used to collect spatial information in blind conditions through modalities other than vision allowed them to cope with different types of spatial tasks.

In another study, Ochaita & Huertas (1993) also suggested that vision is not necessary for efficient spatial cognition. They concluded that congenitally blind participants achieved a coordinated understanding of the environment; although their ability to do so was delayed relative to the chronologies that sighted children achieved Euclidean perception of space (at about the age of seventeen, compared to fourteen in the sighted). In the same vein, Cornoldi et al., (1991) have explained longer reaction times of participants who are blind in terms of short-term working memory overload, assuming that visual experience might help people manage a quantity of situations at the same time and that vision enables the perception of more information from the surroundings than other modalities (Foulke& Hatlen, 1992). Thus, when deficits are observed in participants who are blind compared to participants who are sighted, they

> *"…are probably due to difficulties in learning efficient spatial-processing skills, as opposed to the absence of potentialities to do so (Tinti, et al, 2006:1325)".*

2. 4.2.1. ***Discussion***

The studies reviewed above have been sometimes contradictory in their findings; however, some fairly consistent findings can be extracted from them which can be useful in the study of spatial understanding in the people who are blind. Some researchers like Casey (1978) for example, suggested that people who are blind perceive large scale space in terms of routes and walking distances rather than Euclidean directions and divide it into small elements. Others like Rieser et al. (1980) and Ungar (1994) suggested that people who are blind may naturally use route directions rather than Euclidean directions in their representations of large scale space. This is not surprising if we consider that people who are blind need to make more decisions when traveling, must rely more on sequential components along the route and have to take into account landmarks than are often different from those used by people who are sighted (i.e. they might take into account echoes, smells or they might notice the different textures under their feet; Passini & Proulx 1988). Thus successful navigation and wayfinding might become much more functional and route-oriented for people who are blind compared to people who are sighted.

However many of the studies reviewed also suggest that blindness has little or no effect on effectiveness in perceiving spatial relationships. It appears that although it might be easier to encode the sequential features of a route travelled under blind conditions, many people who are blind are competent in constructing overall survey representations. This finding directly questions the conclusion that visual experience is necessary requirement for achieving a higher level of spatial processing i.e. that corresponding to inferential abilities which involve the computation of spatial relationships that have not been actually experienced but are based on those already known (Thinus-Blanc & Gaunet, 1997; Tinti, et al, 2006).

The findings from the above mentioned studies although not completely conclusive, are valuable since the study of the processes of learning and using small and large scale spatial layouts has the potential to shed light on the process of understanding spatial relations in both small and large scale space. For example Fletcher (1980) examined the learning of spatial relationships in both small and large scale space, and found that the two could be learned equally well by her participants. However it is important to bear in mind when reviewing the literature that even if someone can apply spatial concepts to one situation there is no guarantee that they can apply them to another. Indeed Ratcliff & Newcombe's (1973) results provided evidence that knowledge transfer from one scale of space to another was very difficult suggesting that there might be distinct spatial systems for small and large scale spaces and that spatial processes involve different mechanisms, as already mentioned elsewhere.

Visual experience prompts children to use external cues, i.e. relationships between locations or relationships between objects. Congenitally blind children however are often thought to tend to ignore such cues and adopt strategies that are more efficient in the absence of vision, such as self-reference and movement coding strategies (Millar, 1988). Millar (1981: 263) however pointed out that this is may be a matter of preference based on experience:

> *"Blind children thus have little reason to believe that external relations can serve as useful references. By contrast, encoding relative to the body provides consistent feedback in many blind tasks".*

It appears that there is some agreement among researchers that the construction of route representation does not appear to be necessarily impaired by the lack of vision. Route – knowledge, it is argued, is characterized by a sequential encoding of space and is organized on the basis of an egocentric frame of reference (Thinus-Blanc & Gaunet, 1997). However there is more diversity of opinion among researchers concerning the construction of survey representations of space by people who are blind. Survey knowledge refers to configurational knowledge and to an understanding of space in terms of straight line directions between locations,often termed as a 'Euclidean' understanding of space (Lewis et al, 2002; Noordzij et al, 2006; Tinti et al, 2006). Survey knowledge however, is generally seen to rely on an allocentric frame of reference.

> *"The construction of this frame of reference itself heavily relies on the perception of distal cues… That may account for early blind persons' tendency to use spatial information organized as routes rather than maps"* Thinus-Blanc & Gaunet, 1997: 23).

Therefore, it is argued, any differences observed in spatial performance might be due to the greater use of self-referent information by the blind compared to the sighted on spatial tasks requiring a Euclidean understanding of space. Such a strategy is less appropriate than the external referenced alternative available to sighted participants. While people who are blind tend to encode spatial information in a more egocentric manner than those with sight, this is not a definitive distinction; it is rather an example of an adaptation to the lack of sight adopted by many people who are blind. Researchers like Millar (1994) and Warren (1994) agree that congenitally blind people do have the potential to adopt external coding strategies which facilitates the construction of configurational knowledge that might be functionally equivalent to those of the sighted.

Overall, future research should perhaps look for answers within the population of children with visual impairments or blindness and attempt to discover the process involved in understanding spatial relations in both small and large scale space, given its importance to the educational development of young children who are blind. Consequently, a concern in the current investigation is to seek answers to questions about blind children's spatial processing in their everyday environment by utilizing a design focused upon the differences within the population of children who are blind. I have adopted a qualitative approach partly in the hope that a different research tradition may produce insights that will help in the triangulation of the divergent results produced by comparative and experimental approaches.

2.5. Spatial representation: Cognitive maps

Cognitive maps represent the mental image that a person has of the world around them. Such maps might contain objective and precise knowledge about the location of geographic features and they also might contain more subjective and less precise information, such as impressions of places, rough estimates of relative size, shape, and location. Cognitive maps enable people to know what routes to take when travelling, comprehend what others say or write about various places, and develop an understanding of the world. Our cognitive maps are formed from sensory inputs such as sight, touch, smell, feeling and moving and are combined with experiences, values and beliefs. We have cognitive maps of our home, our neighbourhood, our town, other places we have visited and even places we have never been to but we have acquired information from a variety of sources such as media and other second hand sources (Kitchin, 1994; Jansen et al. 2010). These cognitive maps represent our knowledge of the spatial organization of our environment. Tolman (1948) first used the term "cognitive map" in order to describe how rats, and by analogy, humans interacted with the space around them. He theorised that we construct a map-like representation in the same way as a cartographic map which is used to guide our behaviour in the environment, gaining Euclidean properties with continual experience. However Golledge (2003) suggests that there is not yet evidence that humans store spatial information in a map-like manner in the brain, but it is more generally accepted that this is not the case. It is though assumed that cognitive maps are dependent on the particular cultural and social experiences and habits of a person and can be used to determine where one is in relation to other objects or how to get from one place to another.

Cognitive mapping research focuses on understanding how we make sense of our surroundings; how we acquire, learn, store and recall spatial and environmental information; and how we use and decode this knowledge to make spatial decisions and choices (Downs and Stea, 1973; Kitchin, 1994; Jansen-Osmann et al. 2007). Golledge and Stimson (1997: 229) identify cognitive mapping as

> "*a means of structuring, interpreting, and coping with complex sets of information that exist in different environments."*

Cognitive mapping is a mental process which we use in order to comprehend and code human interaction with the environment (Kaplan, 1973; Walmsley, et al., 1990), which includes:

> *"not just spatial information but also attributive values and meanings"* (Golledge and Stimson, 1997:235).

Cognitive maps are dynamic; the information we use to make spatial decisions are changing and developing through the new knowledge we gain from our interaction with the external world. As stated by Kitchin, (1994:3)

> *"there is no one cognitive map in memory but rather we construct them for specific events…which reside within a space-time context"*.

Tuan (1975) suggests that cognitive maps also act as imaginary worlds. We can construct mental descriptions of places we have never been to but we heard or read about, by fitting them into our schemata of similar evens we have earlier experienced. In this way we can create and cope with unknown place information (Kitchin, 1994; Tuan, 1975; Jansen-Osmann, & Wiedenbauer, 2004). The latter may have practical application especially to blind and visual impaired individuals. They can use their cognitive maps to plan novel routes in a familiar environment or to update their positions relative to objects in the environment. They can also use their knowledge of a familiar built environment to guide their actions and spatial orientation in a novel environment. They can use information about regularity and predictability of environments that are store in their cognitive maps in order to orientate themselves in a novel space. For example they can use the knowledge that kerbs are in predictable locations in most outdoor environments (e.g. parallel to streets), or passing by two parking meters in sequence means that they are walking parallel to a street. This kind of knowledge can be useful and can be use in a novel environment (Long and Hill, 1997).

The cognitive map as discussed provides information necessary for spatial decision making and actually influences the way we behave in our environment. Cognitive maps shape, as suggested by Garling et al. (1985:143), four vital spatial decisions: whether to go somewhere; where to go; which route to take to go there; and how to get there. That is why Kitchin (1994) stressed that cognitive mapping research has theoretical utility in understanding spatial decision making and applied utility in planning and education; and it can be used to design environments that are more enjoyable to live in and travel through. Kitchin (1994) also suggested that cognitive mapping research could be utilized with the view of creating environments more suited to our needs since our cognition of the environment affects our behaviour and our interaction with it. He also emphasized the need for research into how people with sensory and mental impairments form and use cognitive maps and how they deal with the spatial aspects of their environment on a daily basis, with the aim of facilitating and maximizing their interaction with, movement through ,and enjoyment of, their everyday environment (Kitchin, 1994).

2.5.1. Cognitive mapping research and spatial knowledge

There have been many efforts to review and categorize spatial and cognitive map knowledge. Many authors acknowledge three types of knowledge of geographic space: declarative, procedural and configurational knowledge (Mark, 1993; Mark, 1997; Liben, 1991; Kitchin et al. 1997; Jansen-Osmann et al. 2007; Buchner & Jansen-Osmann, 2008; Jansen et al. 2010).

Liben (1981) described declarative knowledge as a mental database of specific spatial features; such as facts about geographic space and the entities and phenomena in it like locations, sizes, populations, etc. and is regarded as landmark knowledge (Kitchin et al. 1997; Mark, 1993; Jansen-Osmann, & Wiedenbauer, 2004).

Procedural knowledge:

> *"consists of the rules used to synthesize the declarative knowledge database into information which can be used to facilitate an action"* (Kitchin et al. 1997:229).

It also consists of the information that forms the basis for navigation and wayfinding and it concerns how to get around in geographic space including spatial strategies, recognizing shapes, hierarchies and other spatial relationships. Therefore with this knowledge we could transform paths elements into a navigable route but we would not be able to make inferences about routes never experienced or we might be unable to estimate distances between locations along familiar routes especially by straight line distances if the route is twisting and curving (Kitchin et al. 1997; Mark, 1993; 1997; Jansen et al. 2010).

Configurational knowledge is the highest level of cognitive map knowledge. It includes knowledge of relative positions, distances, angles, orientations, locations, directions etc.

> *"so the possessor has knowledge of the associations between* (places), *and the relative positions of places; these form a comprehensive spatial knowledge system…"* (Kitchin et al. 1997:230).

This knowledge plays an essential role in our ability to estimate the direction of places, or when we need to work out spatial relationships among places than have not been previously experienced.

There are two main theories concerning how sighted individuals learn and develop cognitive map knowledge (Kitchin et al., 1997). One theory is that landmarks form the initial framework for cognitive map knowledge on which subsequent information, such as paths is added (Siegel & White, 1975; Golledge, 1978). The other proposal is that routes develop before landmarks and landmarks are then placed in relation to them which over the time are integrated into a complete cognitive structure (Garling et al., 1981; MacEachren, 1992; Allen, 1988). MacEachren, (1992) suggest that evidence for the development of routes before landmarks comes from sketch-map data.

Spatial representations have often been employed in order to externalize someone's spatial environmental knowledge; otherwise to assess the cognitive map knowledge of people who are visually impaired or blind and those who are sighted. For example, individuals might be asked to draw a sketch map of a familiar area to describe their knowledge of that area (Jacobson, 1992; Matthews 1980; 1984a; 1984b); might be asked to retrace or infer a route from the destination to the point of origin (Passini et al. 1990); others might be provided with a certain amount of spatial information and are asked either to place a location in relation to other locations (Thorndyke & Hayes-Roth, 1982) or by giving them a map with blank spaces might be asked to match given places to spaces (Robinson, 1974). Participants might be also asked to decide which one of a pair of distances is longer (Biel, 1982) or are presented with three locations and asked to judge which two locations are the closet together and which two are the furthest apart (Schinazi, 2005). Others might be inquired to build a model of an environment (Passini & Proulx, 1988; Schinazi, 2005); others are provided with a representation of the environment and they are asked to correctly identify features and configurations (Jacobson & Kitchin, 1995; Kitchin & Jacobson, 1997; Kitchin 1997; Blades & Spencer, 1994); or others might study how participants learned a way through a virtual environment (Jansen-Osmann, & Wiedenbauer, 2004; Jansen-Osmann et al. 2007; Jansen et al. 2010).

Considerable evidence indicates that differences exist between individuals in term of their spatial cognition. People seem to vary not only in terms of how much and what they know, but also in the way in which they organise cognitive spatial information of their environment (Moore, 1979; Ishikawa & Montello, 2006). Foley and Cohen (1984) also argued that individuals differ in their cognitive styles of thought because they use different types of strategies to encode and decode their knowledge. As a result, their answers to cognitive mapping tasks would be different, even when the knowledge base is the same. If this is the case with the sighted population then is not surprising that the literature on cognitive map knowledge of people who are visually impaired or blind is filled with contradictions and interpretations (Thinus-Blanc & Gaunet, 1997; Warren, 1994). While efforts have been made there is still lack of mutually supportive techniques to account for the heterogeneity between people who are blind or visually impaired and their skills. For example Kitchin & Jacobson (1997) noted that the different test that have been used to assess the cognitive map knowledge of people who are blind or visually impaired have produced different results for the same individual even when the tests had similar characteristics. Thus confirming the idea that incorrect conclusions might be drawn because a person is lacking the skills to perform a given test rather than lacking the ability to do so.

Kitchin (1997) tried to discover the strategies of spatial thought[2*] used in completing a task, designed to measure configurational knowledge. By comparing quantitative results with qualitative interviews, Kitchin, tried to examine whether the adoption of certain strategies led to more advance spatial decisions and choices. The participants (aged between 18 and 29) were interviewed while they undertook two of four different tests. The investigation was by means of semi-talk aloud protocol interviews conducted whilst respondents completed the tests. Eight common strategies of spatial though were found to exist, by Kitchin (1997). Some were common strategies that concern geographical knowledge (e.g. imaging a map; or imaging travelling along a route; imaging being at a location and looking in the direction of another location; or using a dominant feature of their environment and working out locations solely in relation to this main point). Others were common strategies that were problem-solving strategies usable over several tests; and finally others were task-specific strategies constrained by the nature of a particular task such as the use of logical deduction or the use of elimination.

The results from Kitchin's (1997) study allowed an introspective insight into the way in which people think about spatial geographic relationships. However, the results cannot easily be validated, as there are alternative possibilities for outcomes. Participants were first year geography undergraduates students and were recruited

[2*] [*"Spatial thought is a term first used by Liben (1981) to describe strategies used to complete cognitive mapping tasks"* (Kitchin, 1997:125)].

from geography practical classes and as is noted by Kitchin, (1997) these respondents had access to information and skills not normally available to most students, therefore replication it is not easy. Furthermore the relationship between the knowledge and the strategies of thought is not evident. Different strategies might occur because of different knowledge; so that differences occur because of knowledge not strategy. Also participants could have been using strategies, which they did not report. A further problem noted by Kitchin (1997), was that some participants found it difficult to talk and perform a task at the same time.

The way in which people develop cognitive mapping ability has been of interest to many researchers. For example, Matthews (1980) suggested that the way in which children perceive and depict space was considerably influenced by age. Children at the age range eleven to eighteen years were provided with a plain sheet of A4 paper and all were asked to draw maps of the centre of the city in which they lived. Matthews (1980) found that eleven and twelve year-olds perceive and portray reality different from older children. The mental images of the younger children were made of scattered buildings and shops which they found difficult to relate to paths and to other parts of the city. Older children were able to conceptualise space in a more coherent, sophisticated and accurate way.

In a later study Matthews (1984a) attempted to interpret the cognitive maps of school children aged between six and eleven. Matthews (1984a) examined how children represent their journey to school and their home area. A free-recall mapping was used for exploring the cognitive structures of young children. The children were asked to draw a map around their home showing things that were nearby and a map showing their journey from their home to their school including features that were in that route.

> *"When faced with a linear journey, the route itself becomes a well-remembered construct, but when describing an area, such as that around their home, spatial properties loom large in the minds of the young"* (Matthews 1984a: 93).

He concluded that with age children increasingly acquire more information about place. Thus the way in which children represent space varies with age, but the learning process cannot be described by a simple linear progression. He also found out that children learn about different environments in different ways and that the same child can show different appreciations of space when describing different environments.

Nevertheless it should be noted that the way children interpreted their everyday world might be influenced by the way in which they interacted with places (Ishikawa & Montello, 2006). In addition the ability to transform environmental images into map drawings might also depends on individual differences and on different drawing abilities each person has. The observed differences in the perception of space between children might be related not only to age difference but also to the nature of the specific tasks demanded; their spatial products may differ because one is more skilled than the other in transferring spatial knowledge into paper therefore leading to not easily validated results.

Murray and Spencer (1979) found that performance in a series of cognitive mapping tasks was related to an individual's geographical mobility, to the strength of their general mental imagery and to their basic graphic ability. Murray and Spencer (1979) proposed that individuals who had experience of a considerable number of places developed a better and more well organised spatial awareness to both novel and familiar areas therefore were more likely to produce maps which were more adequately and more complex and were able to develop a better mapping strategy. They also found that basic drawing ability was related to the level of organization and to the level of complexity of features indicated on the maps. Murray and Spencer (1979:391) concluded that:

> *"Mental mapping techniques may be flawed, but they do reflect differences in the skill of organizing the environment which could only otherwise be brought out by laborious interview or questionnaire techniques".*

Matthews (1984b) also examined whether gender influences a child's awareness of place. He found out that from the age of eight onwards, there were differences between sexes in terms of their images of place. Boys showed a much more broad understanding of space, mentioning places much further away from their homes than girls and their maps were more complex in form showing a good grasp of spatial relationships. He suggested that these differences exist due to the different ways in which boys and girls come into contact with the environment and that their spatial awareness is affected by the environment in which they live.

> *"The freedom of movement enjoyed by boys from a younger age leads to a fuller appreciation of the mesh of local roads, alleyways and footpaths……. It would seem that their* (girl's experience) *more restricted experience of places leads to a less integrated mental map"* Matthews (1984b: 333).

Sex differences in cognitive maps have often been explained with reference to motivation and to strategies males use (Coluccia et al. 2007). Armstrong et al. (1990) have shown than boys are more active than girls from the age of eleven years and that they spend more time beyond home than do girls. Valentine (1990) argues that women's interaction with certain spaces is limited because they fear of personal crime, and that their everyday activities are structured by what society expects women to do. Miller and Santoni (1986) found that cognitive map differences may occur because males made more use of Euclidean properties in their maps, whereas females tended to concentrate on more topological properties of space.

In the same line Coluccia et al. (2007) found that males needed less time to learn a map, were more accurate than females in map drawing and showed higher levels of spatial orientation abilities. Thus they suggested that male and females used different map learning strategies; males approached the map from a global perspective, whereas females focus on local features. Kitchin (1996) noted that many studies find no reliable differences between boys and girls in cognitive mapping tasks; but when differences emerge, boys tend to do better than girls. He suggested that differences in cognitive map knowledge and abilities between males and females are likely to be socially and culturally produced influenced by gender roles and that are limited when given the same geographic training and patterns of spatial knowledge.

Fear of interacting within certain spaces due to lack of vision, socially and culturally produced differences, restricted opportunities to explore surroundings and underdeveloped mobility skills might be factors that lead to the perceived differences, in cognitive map knowledge and spatial abilities between blind and sighted children. Therefore it could be quite possible that specific training in spatial knowledge for children who are blind would help minimize any differences that do exist.

Cognitive mapping research has the potential to be of benefit to blind people.

> *"…it could provide clues about how to enhance this group's wayfinding and orientation skills by supplying feedback on current knowledge and strategies of thought. Such feedback could provide mobility specialists with information on how to teach more effective strategies of spatial thought…"* (Kitchin & Jacobson, 1997:360).

In addition Kitchin et al. (1997:233) argue that:

> *"at present, we are unsure as to whether people with visual impairments differ from sighted individuals in what they know about geographic space or in how their knowledge is structured".*

Also Kitchin & Jacobson (1997:369) support that:

> *"despite a number of studies, knowledge of how persons with visual impairment or blindness learn, understand, and think about geographic space is limited….*

2.5.2. Discussion

Indeed although a number of researchers have examined the cognitive maps of people who are blind or who have visual impairment, they have been mainly concerned with the measurement and assessment of their ability to process, learn, store and understand spatial information (Passini & Proulx, 1988; Kitchin & Jacobson, 1997; Jacobson, 1998; Kitchin et al., 1998; Lahav & Mioduser, 2003; Schinazi, 2005). Researchers sought to understand the basic spatial abilities of people's who are blind or with visual impairment through navigation and wayfinding; through manipulation of objects or through secondary sources like tactile maps and other guidance systems such as talking signs; or through remembering and representing layouts; and generally through various tests and experiments in both real world environment but mostly in controlled laboratories (Kitchin et al., 1997; Kitchin et al., 1998).

However, very few studies have sought to explore the spatial experiences of people with blindness through their own voices and interpretations. One example is Kitchin et al., (1998), who explored through interview the main difficulties experienced by visually impaired people in navigating through an urban environment. Kitchin et al., (1998) concluded that the interviews in their study provided detailed suggestions which would make the urban environment experienced by visually impaired people more navigable. In addition it would reduce their levels of spatial confusion, fear and anxiety and increase confidence leading to greater independence. Their work emphasises the importance of listening to people who are blind or who have visual impairment and taking account of their interpretations during their interaction with the features of the surrounding space.

Taking into account the voice of persons who are blind in order to explore their spatial experiences is the least developed path in the area of spatial understanding and blindness (Kitchin et al., 1998). That is why primarily, my research seeks to add to this path of research by exploring children's voices concerning their spatial experience. A second factor is my concern about the tests traditionally employed to measure spatial representation and knowledge. It is questionable that artificial constructions are a suitable way to measure a visually impaired person's knowledge of a familiar space or to measure their ability to learn a novel area. Kitchin & Jacobson (1997) also questioned the validity of drawing conclusions from such tests. They argued that methods should concentrate not only on the content and accuracy of the representation but also on utility.

> *"For any individual, the utility of their knowledge- whether it can get them from point A to point B - is far more relevant than a correspondence between their knowledge and a geometrical abstraction. The utility of someone's knowledge is best assessed through tasks that demonstrate it in action, such as way finding in a complex environment"* (Kitchin & Jacobson, 1997:367).

Furthermore, they argued that multiple mutually supportive tests are necessary for the interpretation, application and generalization of results.

I would reluctantly agree with the suggestion of Thinus-Blanc & Gaunet, (1997) that spatial tests do provide useful opportunities to explore how people with visual impairments or blindness perceive and represent space around them; how they learn a new environment and update existing knowledge with new information and what exploration strategies they use. However, studies also have shown that these tests sometimes produce different results for the same individual (Kitchin & Jacobson, 1997; Matthews, 1984a) because of the differences in experimental settings and measurements. In addition these tests provide the participants with different amounts of given spatial information and vary in the amount of information that participants need to provide. Furthermore, some tests have discovered to be too abstract for participants, requiring them to use skills that were not well developed (Kitchin & Jacobson 1997).

Results from experimental studies are varied and need to be interpreted carefully. Clearly methods and research approaches in this area need further development, and it seems logical that utilizing the voice of the people who are blind or who have visual impairments may inform or supplement knowledge about cognitive maps and spatial understanding derived through traditional experimental approaches.

2.6. Discussion of the literature search

The literature review has provided evidence of the experimental and theoretical work that bears on the question of spatial processing in people who are blind or with visual impairments. It also has highlighted a number of gaps in current knowledge regarding the impact of blindness on spatial perception with the reported evidence appearing contradictory. This naturally limits the conclusions that can be drawn when comparing findings from different studies.

The broad conclusions to emerge from this review of the literature now follow along with an analysis of the contribution this study seeks to make to the knowledge.

The auditory and haptic sensory systems cannot give information to the brain about relationships between objects as easily as the sense of vision. Visual perception is rapid and more accurate, allowing the individual to take in a large amount of information at one time. The sighted individual needs only a glimpse in order to comprehend the composition of space that surrounds them. Thus it requires less work to integrate visual information into a well-structured cognitive map in comparison to the work needed to integrate information from other senses. Therefore, activities such as way finding are relatively detailed and difficult tasks for blind or visually impaired individuals. Because of these difficulties children who are blind often lack confidence in exploring their surroundings and depend a great deal on other people's help.

These findings made some researchers (i.e. Bigelow, 1991; Bigelow, 1996; Schwartz, 1984; Herman et al., 1983; Casey, 1978 ;) suggest that visually impaired children's reduced opportunities to interact with objects in the surrounding space would result in a delay in the acquisition of configurational, non- egocentric spatial knowledge. It has been widely assumed that people who are congenitally or early blind are generally restricted to a representation of the surrounding space at a route level, often comprising sequences of landmarks rather than an integrated configuration. A sequential knowledge of space permits efficient travel along well known routes since visual, auditory, tactual and olfactory landmarks provide the individual with direct sensory information about current position and orientation (Loomis et al., 2001; Golledge, 1993). However sequential knowledge does not easily support inferences about the relative locations of places not linked into a learned route; nor does it facilitate the integration of fragmentary landmark information into a coherent representation of the environment (Loomis et al., 2001).

These observations might be taken to imply that vision is necessary for the formation of a configurational spatial knowledge of the environment. However evidence from a number of studies does not support this position and there is evidence to suggest that at least some of the blind are as spatially competent as the sighted. For example, Fletcher (1980) found that, at least some of the blind participants in her research were as capable as the sighted in their judgment of spatial relationships, even though her sighted participants were better as a group than the blind. Similarly, Millar (1994) considers the poorer performance of congenitally blind groups on certain spatial tasks to be due to the different strategies they use; congenitally blind people tend to code spatial relationships egocentrically because this type of strategy is more reliable under blind conditions in most cases (Ungar, 2000). It has also been shown that young children can use external cues to code object positions and understand the straight line relationships between different locations when the experimental setting makes those cues salient for the children (Lewis et al, 2002).

Other researchers suggest that people who are blind can acquire representations or coding strategies, equivalent to those of people who are sighted, if they are given sufficient training, preferable from an early age (Carreiras & Codina, 1992). They also suggest that children who are blind need to be taught how to form a mental map and how to integrate all the information they receive about an area through their other senses into a well- structured cognitive map; that would make them feel more confident and more independent (Millar, 1994; 1988). Children with a secure cognitive map are more likely to explore their surroundings and be less anxious about hurting themselves or of getting in other people's way.

Finally there are also those researchers who clearly suggest that visual experience is not a necessary condition for creating spatial inferential representations of a configurational knoweledge. And that in fact, there are instances in the literature where people who are blind were able to outperform blindfolded sighted participants in spatial tasks due to their greater experience under blind conditions (Smith et al, 2005; Andreou & Kotsis 2005; 2006a; 2006b; Tinti et al, 2006; Fortin et al, 2008). Tinti et al, (2006) concluded that lack of vision does not affect the ability to develop spatial inferential complex representations. And Smith et al. (2005) found that blind individuals were more accurate than sighted individuals in representing the size of familiar objects because they relied on manual representations, which are less influenced by visual experience than are visual memory representations.

How can these contradictory results be explained? Many of the studies reviewed so far have compared the performance of sighted participants with that of the blind. However comparative studies are not the only approach that researchers can take. Warren (1994) has questioned comparative approaches highlighting the lack of an appropriate theoretical framework within which to analyze the development of children who are blind or with visual impairments. He describes the comparative method as 'inadequate' because this design seeks comparisons between populations (sighted children and children with visual impairments), which are different in their nature.

He proposed a new research approach, which concentrates on the blind individuals themselves and on the variables that affect their spatial performance. Those variables specifically related to the visual impairment, i.e. age of visual loss, degree of functional vision, additional impairments etc. Warren (1994: 129) remarks:

> *"What permits these exceptional children to do better? The existing literature is not sufficiently detailed to reveal the answer… The prospect of finding effective ways of intervening with blind infants and structuring their experiences so that they acquire good spatial concepts should surely motivate researchers to discover the characteristics of effective early experience; and they can accomplish this only by attending to individual differences."*

Spencer et al. (1989) suggest that another reason for these conflicting findings is the diversity of the experimental techniques used to examine spatial abilities. Spatial tasks range from tasks in small-scale space involving "manipulating space"; to tasks in large-scale space involving locomotion for exploration (Lederman et al., 1987; Klatzky et al., 1995). A number of commonalities in the learning of small scale and large scale spaces have been noted, such as hierarchical organisation and clustering of landmarks to encode spatial position (Nelson & Chaiklin, 1980; Allen & Kirastic, 1985; Colledge, 1993). The literature concerned with small scale space indicates that visual experience has some influence on the way in which spatial information is encoded or organized, i.e. an egocentric spatial coding system might be more appropriate for the performance of many spatial tasks in the absence of vision (Millar, 1988; 1994). It is possible that such processing differences also operate for large scale spatial tasks when external cues are unreliable. Millar (1988) for example cites the example of a person using egocentric cues, in order to tell that the next-door train is the one that is moving; when sitting in a train and looking out of the carriage window. Thus the nature and varying aspects of a task or the context in which it is set can prompt the person who is blind or sighted to shift from an egocentric spatial coding system to an external one and vice versa; depending on the requirements of a particular task. Therefore instead of discussing about two different spatial coding systems which one is replaced by the other, it might be more appropriate to talk about two systems existing in parallel, either of which may be used according to the nature of the spatial task a person is faced with (Ungar, 2000).

Moreover experimental settings might make the participants feel uncomfortable; especially blind participants, if, for example, they have to walk around in order to understand the spatial arrangement of an unfamiliar area without knowing what to expect. In addition in different experimental settings, often the participants have access to different information, sometimes richer and sometimes poorer which might account for differences found between studies. In real world environments, however, people have access to various environmental auditory, tactual and olfactory sources that are informative about specific locations in the surrounding space. For example the slope of the ground surface or the flow of the wind might provide directional information (Loomis et al., 2001). Therefore these observed differences in the perception of space between people who are blind and sighted may simply be related to the nature of the specific tasks demanded.

In addition many different means have been used in order to externalize participants' spatial knowledge, such as verbally estimating directions and distances, pointing with the finger, walking, drawing maps or constructing models. Each type of externalization might be easy for one participant but more demanding for another since for each type specific mental process is required. Besides individuals who are sighted usually have more experience with space and with the kind of tasks that are required in spatial experiments than do the individuals who are blind.

Also, should be taken into account individual factors such as age of the onset of blindness and methods of education. For example the age criterion determining the designation of participants as late or early blind varies among researchers. This criterion is very important if we consider that vision plays an important role in the development of sensory-motor coordination. Therefore variable data are likely to be found depending on the age researchers used to classify their participants as early or late blind (Thinus-Blanc & Gaunet, 1997). Rieser et al. (1992), for example, included in their early blind groups participants who lost their sight before 3 years. Millar (1979) considers as early blind only those participants that are blind from birth or have lost their sight before 20 months old. For others the limit of early blindness is the end of the first year of life (Hatwell, 1985).

Another factor that should be taken into account when interpreting the results from different studies is the education to which blind participants have been exposed. Some participants might have received locomotor training others might not. In addition overprotective attitudes may lead to fewer opportunities for exploration and movement thus may jeopardize blind children's understanding of space. Finally we also need to consider the wide variability across educators, methods, institutions and across countries.

Nevertheless what is important is that researchers should explore the alternative strategies used by those blind people who are as good as or even better than sighted people in their spatial perception, as a means of educating other people who are blind to do the same. Spencer et al., (1989: 201), point out that:

> *"If some blind individuals can outperform other blind subjects in the same task it is important to identify the ways in which the spatially good differ from the spatially poor. The identification of such differences leads to a better understanding of the problems faced by blind individuals and hence to better ways of overcoming those problems."*

Therefore, the main aim of the present study was to give an example of the potential of the method of using children's voices in research into aspects of visual impairment by showing how students who are blind explain their comprehension of the surrounding space. The present study seeks to explore the children's own narrative account of the strategies they employ to overcome some of the challenges they face in making sense of space. Further, since research into spatial understanding and visual impairment has produced divergent findings, the present study seeks to shed light on what other researchers have found through different experimental methods. In addition the present study seeks to explore if the child's voice can provide insights into spatial understanding that can be used to help triangulate the findings and understandings achieved from the experimental approaches that dominate the literature.

Thinus-Blanc & Gaunet (1997), propose that in order to better understand the divergent findings across different studies we should study the strategies used by participants to reach an observed level of performance. We could do that by

> *"…asking the participants at the end of the task what they 'had in their mind', how they managed, and what information they relied on to perform the task…"* (Thinus – Blanc & Gaunet, 1997:35).

We could also observe their behaviours such as hesitations or remarks while performing a task or moving around and attempt to work out the strategies that underlie their behaviour.

If a variety of strategies can be observed and there is a correlation between strategies and performance levels i.e. if some congenitally blind participants are better in their spatial performance and competences than others, then these strategies could be learned by the worse performers (Hill et al., 1993). This suggests that any observed deficits could be compensated for and that history and individual factors have strong influence on the development of spatial competences.

> *"In this respect, single-case or small-sample studies of individuals, whose history has been documented in detail, may be as important as group studies, assessing average performance, for teasing apart the roles of vision and other factors in spatial development"* (Thinus – Blanc & Gaunet, 1997:38).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Introduction

This chapter explores a number of issues relating to the research methodology and the design of the study, and, given the fact that the chosen approach is perhaps unusual among studies of spatial understanding, the chapter includes an analysis of the paradigmatic issues facing researchers in such studies.

There is broad consensus that each paradigm, approach or method in educational research has implicit strengths and weaknesses. Our task, as researchers, is perhaps to understand these strengths and weaknesses, to analyze each particular research situation in the light of those strengths and weaknesses, and to select the most appropriate approach, or combination of approaches, on the basis of that analysis (Punch, 1999).

The nature of reality and of knowledge, which underlies the ontological and epistemological assumptions of a research project, is an issue which cannot easily be addressed; diverse perspectives on the issue are adopted within different research paradigms (Mertens, 1998; Walker & Evers, 1999; Meredith et al., 1996; Maykut & Morehouse, 1994). A research paradigm, according to Bassey (1995: 12), is:

> *"a network of coherent ideas about the nature of the world and of the functions of researchers which, adhered to by a group of researchers, conditions the patterns of their thinking and underpins their research actions".*

Guda (1990), states that a research paradigm is a basic set of beliefs that guide action. The basic beliefs or paradigms that might be adopted respond to three basic questions: a) what is the nature of “reality”? The study of what there is that can be known (Ontology), b) what is knowledge? And what is the nature of the relationship between the knower and the known? (Epistemology), c) How is the researcher going to find out knowledge? What methods will he/she employ to address the research questions? (Methodology). The answers that are given to these questions are the starting points that determine what a research project is and how it is to be practised. Making a choice between the different research paradigms is a commitment to a particular way of understanding social science (Crotty, 1998; Mertens, 1998).

Positivist approaches to the social sciences argue that scientific inquiry should not search for causes deriving from some outside source but must concentrate on the study of relations existing between facts which are directly accessible to observation. There is a distinction between the ‘subjective’ knower and the ‘objective’ world; there is also a distinction between facts and values (Golafshani, 2003). The researcher is concerned only with facts; his/her own concerns and values must not interfere with the discovery of the ‘objective’ truth. That is to say that the status of truth and social phenomena can be studied in much the same way as objects in nature (Guda, 1990). There is order and reason in the social world as in the natural world; things do not just happen randomly or by accident. Consequently different observers exposed to the same data might reasonably be expected to come to the same conclusions. The goal of research, to develop general and universal laws that explain the world, is therefore argued to be common to both the natural and the social sciences. Through systematic observation and correct scientific methods, i.e. by being “objective”, it is possible to discover, explain, predict and control events and phenomena. Positivism may be characterized by its claim that science provides us with the clearest possible ideal of knowledge, but a common criticism of positivism is that researchers cannot detach themselves from the world they are researching, and cannot carry out their research unaffected by culture, values and social structure (Robson, 2002; Cohen & Manion, 1994).

Interpretive epistemology places emphasis on seeking understanding through looking closely at people's words; actions and records, to help us better understand the social world we live in. It is argued that, in social research, knowledge is concerned not with generalization, prediction and control but with the meaning, interpretation, and understanding of human phenomena in a careful and detailed manner as free as possible from prior theoretical assumptions, based instead on practical understanding (Maykut & Morehouse, 1994). It is assumed that all human action is meaningful and has to be interpreted and understood within the context of social practices. What's more, an action has one meaning from one perspective; from a different perspective it has another. The object of research is what individuals actually do when engaged in practical tasks rather than in an experimental task (Bleicher, 1980). Knowledge is therefore conceived as circular and interactive and not linear and cumulative as is often assumed in positivist epistemology. The research is a learning experience involving interactive communication between the researcher and the research. The researcher begins with individuals and sets out to understand their interpretations of the world around them and build his/her theory on them (DiCicco-Bloom, & Crabtree, 2006).

The collection of qualitative data is generally considered to be more in keeping with the interpretive paradigm in which the researcher attempts to understand a phenomenon in all its complexity and within a particular situation and environment.

Qualitative methods attempt to capture what people say and do and take into consideration the feelings, motives and thoughts that people have. The researcher tries to get closer to what is being studied. Samples are usually small and methods are less formalized than those in the quantitative approach; they are also multidimensional and less replicable. The qualitative approach is therefore seen as having greater flexibility, a characteristic especially valued in the field of special education (Lewis & Collis 1997).

On the other hand, the collection of quantitative data enables objective comparisons to be made. The quantitative researcher works to eliminate all of the unique aspects of the environment and conceptualizes reality in terms of variables and relationships between them. Samples in quantitative methods are typically larger than in qualitative studies and usually the research is more easily replicable because its methods in general are less varied than those used in qualitative research (Maykut & Morehouse, 1994). Research findings can therefore be generalised more convincingly to a great number of cases.

3.1.1 Summary and discussion

Everything considered, the way in which we understand the nature of reality directly affects the way we see ourselves in relation to knowledge. Our adopted ontology determines the way in which we perceive how reality should be viewed. Key ontological beliefs are: a) there is an objective reality, external to people's awareness and so it is possible for the researcher to maintain an objective, detached position b) reality should be interpreted through the meaning that research participants give to their lives and c) reality is built up from the actions, experiences and perceptions of people (Eriksson & Kovalainen, 2008).

Epistemology is concerned with the nature and scope of knowledge, it addresses questions such as what is knowledge? How is knowledge acquired? What do people know and how do they know what they know?

Different epistemologies exist; for example, the positivist epistemology places emphasis on knowledge confirmed by the researcher's senses and gained through gathering of facts. This fact gathering needs to be conducted objectively through the testing of hypotheses that allow explanation of laws. In other words, it places emphasis on the collection of objective evidence in order to test the truthfulness of theoretical concepts (Golafshani, 2003).

Critics of the positivist epistemology argue that the objectivism achieved in the natural sciences has not been repeated in the social sciences due to the complex nature of social science research. For example, by examining only phenomena that are observable, personal information about research participants which might influence the results is often overlooked. In addition, it is argued, researchers following a positivist epistemology attempt to measure objectively phenomena that are by their nature subjective (Sujin, 2003).

The interpretive epistemology places emphasis on the fact that social science is fundamentally different from natural science and that researchers should be rigorous but at the same time flexible and engage in exploring the subjective interpretations and meanings people give to their everyday lives. Further, researchers who adopt an interpretive epistemology need to critically reflect on how they produce knowledge, what kind of knowledge it is and how this new knowledge relates to the knowledge that already exists (Maykut &Morehouse, 1994; Potter, 1996; Eriksson & Kovalainen, 2008).

Critics of the interpretive epistemology suggest that the replication of the original research can be a laborious task and even when it is achieved the results cannot easily generalize to different settings since what is true in one situation or context may not be true for another (Eriksson & Kovalainen, 2008). Further, conducting interpretative studies can be costly and time consuming due to extended research time involved.

> *"In addition, as researchers' views are often reflected in the interpretive research process, their personal subjectivity may inherently bias the research conclusions……Many interpretive researchers acknowledge such bias as acceptable, but purists from the positivistic tradition believe such contamination is unacceptable"* " (Sujin, 2003:13).

It becomes obvious from the above analysis that the epistemological and ontological assumptions of the researcher may affect all the stages of a research process from the very beginning, including the selection of the area under consideration and of the research questions. Consequently, it is vital for the researcher to be aware of his or her assumptions and, whenever it is required, to be able to present and explain them. There is a range of different possible paradigms, approaches, methods and combinations of methods. Researchers may or may not take a particular paradigm position; they may aim at theory verification or theory generation, and may or may not mix methods, but is important that the researcher makes clear what the philosophical values and assumptions are behind their own research (Collingridge & Gantt, 2008).

3. 2. The philosophical stance of the present study

Debates on ontology and epistemology cannot lead to any philosophical solution; there is no right or wrong philosophical stance. However, if a researcher perceives ontology and epistemology as irrelevant to their research, then it is very difficult to be confident that their methods will be appropriate to the research problem they want to investigate. The inappropriate matching of methodology and the research problem will produce questionable results. Consequently it is essential for researchers to ensure a match between their philosophy, their chosen methodology, and the research problem, and these links should be made explicit in order to inform the reader wishing to review a research study (Eriksson & Kovalainen, 2008).

The philosophical stance adopted in the present study stems from my belief that there is a reality in relation to blind people's awareness of space and that this reality can be interpreted through the meaning that people who are blind give to their own perception of that reality, which in turn is built up from and through their own actions, experiences and perceptions. In research, this reality can be understood by gaining insight into the meaning that the research participants give to their world, in this case by listening to children's voices concerning their spatial understanding in their everyday life. This stance has required me to move beyond the role of a detached observer. In order to investigate children's responses and gain insights into their perspective I have engaged in face-to-face interaction with the children, exploring the contexts of their perspectives and the processes that underlie their spatial understanding as they emerge from the rich descriptions of the children themselves and from my own extensive field notes.

The ontology and epistemology associated with studies of the spatial understanding of people who are blind will inevitably vary as a result of the perspective and experiences of the researcher and, to some extent, will be affected by the discipline in which the researcher works. My own discipline is that of education and my experiences are those of a teacher of children, including those with visual impairment. The research literature on spatial understanding is dominated by the findings of professional researchers from a variety of other disciplines including experimental psychology. The findings reported from the research literature in this area, even when they appear to derive from a shared understanding of ontology and epistemology, often reflect results that are diverse and sometimes contradictory. It could be argued that many of these studies begin from epistemological assumptions that are different from those underlying this study, and therefore may define knowledge and "reality" in a different way, and have different criteria for recognizing truth. I would argue that by seeking to adopt a different standpoint my own study can make an original contribution to knowledge that is equally truthful and that can stand side-by-side with findings and knowledge derived from different perspectives. My aim in this study was to investigate the use of children's voice as a method for gaining insights that may inform or supplement knowledge about spatial understanding achieved through a more traditional experimental approach. And indeed I would argue that the findings from the present study have demonstrated that talking to children and carefully listening to their voices can produce valuable information about their spatial understanding that has an equal claim to validity.

From this point of view the chosen approach for the present study is perhaps unusual among studies of spatial understanding and I believe that this is the study's strength. Most of the studies in this area of knowledge have sought to measure the observable outcome of spatial performance in various spatial tasks set up within experiments. I have instead utilize children's voices and sought to explore the processes involved in their making sense of space by drawing upon their experiences in real life settings. I came into the research with an open mind, not seeking to confirm any specific theory or hypothesis. In order to discover what children thought, I observed them for a period of time and gained knowledge of the context, gaining familiarity with the setting but most importantly building rapport with them (see section 3. 2. 3. data collection). Then I have extensively analyzed transcripts of what they said, empathizing with them and asking them if they felt that my interpretation was accurate (Hoepfl, 1997: 53).

However what I believe to be the strength of the present study equally could turn into a weakness if questions and objections relating to the authenticity of the interview results are not taken into serious consideration.

3. 3. Questions relating to the authenticity of the interview results

Such questions relating to the present study can be summarized as follows: How can a researcher deal with the difference that might exist between what children say about spatial processes and the processes themselves? Children might well be reporting what they think is happening and not what is actually happening. Further, their reports may reflect a conceptualization or explanation they have received from others (e.g. what they have been taught in mobility training) and may simply express adults' views rather than reflect their own authentic voice.

Other questions, which are also related, apply to the process of interviewing, for example : how can researchers ensure that their attitudes, expectations and preconceived notions are not leading them towards seeking answers that support their point of view rather than the point of view of the participants?; what about the threat that the interviewer might misinterpret what the participant is saying?; and how sharp is the researcher in identifying and dealing with misunderstandings on the part of the participant in relation to what is being asked? (Cohen et al., 2000)

Further, Kvale (1994:147) lists ten standard objections to the qualitative interview:

> *"it is not scientific, not objective, not trustworthy, not reliable, not intersubjective, not a formalized method, not hypothesis testing, not quantitative, not generalizable, and not valid".*

However Kvale (1994:148) emphasizes that:

> *"these critiques may involve a prejudgment, based on a conception of social science where qualitative research is expelled or relegated to a secondary position".*

Kvale (1994) also suggests that where some of these critiques may be considered relevant to a specific study then they may be taken into account in the design of the study, thus improving the quality of the research.

To start with, I agree with Kvale that any general characterization of qualitative interview research as "unscientific" is meaningless and reflects a limited conception of science rather than perceiving it as the creative search for continual clarification in which each step produces deeper, fuller and more useful understanding than the previous one. The scope of the present section however is not to discuss the standard objections to qualitative interviews, this has been nicely done by Kvale (1994) and others (Cohen et al., 2000).

The scope of the present section is to outline a framework for treating some of the main issues which are relevant to the present study. For example that children might well be reporting what they think is happening and not what is actually happening.

To start with I will refer to two quotations which I agree with. One is from Block, (2000:758):

> *"…my first instinct has always been to take my research participants at their word, that is, to believe that they were providing veridical descriptions and evaluations of their lessons"*;

and the other one is from Kvale (1994:154):

> *"if you cannot trust the results of an interview, how can you trust the results of our conversation? And following this line of argumentation one ends in philosophical scepticism, as expressed in the liar's paradox – one man from Crete says all men from Crete are liars"*

In addition to concerns that the belief in the authenticity of interview results may resemble an act of faith, the lack of trust may also refer to concerns about deliberate deception which

> *"can be checked with careful interviewing techniques, even though deception is less probable here than in test situations where subjects have more at stake"* (Kvale, 1994:154);

or it might refer to unintentional bias, from both interviewees and interviewers.

Referring to the present study and taking into consideration that bias in research cannot completely avoided; it could be argued that children's voices might or might not truly represent what they think or would choose to say in a different situation or context and that they might change voices depending on the way they situate themselves towards a particular question and towards the researcher (Block, 2000).

I will try to explain the point I am making here through an example. When I interviewed the children about how they find their way around, very often they provided accounts that proved to be reliable reports of events when compared with my observations and also when compared to findings from other sources. On some occasions however, some of the children provided accounts that were inconsistent when compared with observations of their performance.

For example one of the children said that he could not move around with confidence. However my observations suggested that he could move around in places that were familiar to him without hesitation. In addition he would describe fairly accurately the approximate route required to reach a given destination. His mobility instructor also confirmed that his mobility skills were well developed. Further discussion with him in the subsequent round of interviews revealed that what he was saying was more a reflection of his perceived relationship with his teacher and fellow students than of his actual performance in wayfinding in his school building. He stated that he did not have friends and that his teacher was “nicer” with some of the other students than with him. Thus his self reported lack of confidence in his wayfinding skills was perhaps a reflection of his general low self esteem. Had he been asked at a time when he felt better about his relationships in school he may have expressed a different and more realistic view of his own abilities. However such inconsistencies do not necessarily invalidate the data, rather they suggest the importance of this kind of research in examining the issues relating to the environment of the child in depth and from different perspectives.

The above mentioned student perhaps viewed the interviewer as someone to whom he could express his negative feelings, as an individual who had nothing to do with a situation that he felt he was in. So it is clear that time and effort is needed to establish a rounded view of the individual and to place their responses into context. In getting to know the participating children and interacting with them, apart from getting a sense of the context and the setting, I was able to gain a deeper understanding of the subject as we discussed it. As Toma (2000:182) put it:

> *“…some significant connection between researchers and subjects is inevitable as they are participating together toward a common goal. These strong connections operate to help ensure that qualitative researchers are collecting and reporting good data”*

As far as the question about whether the children have reported what they have been taught in mobility training is concerned, the views they expressed across a wide range of issues relating to spatial understanding revealed that they draw on a range of sources to formulate their spatial strategies. Their spatial strategies incorporate both what they have learned from others and what they have learned through trial and error and it is simplistic to conclude that their views are simply a parroting of what they have heard from others.

Some of the questions that are related to general issues concerned with interviewing will be deal with in the rest of the chapter. It is however necessary to analyse in more depth why I believe that my research is not weakened by the potential problems highlighted earlier and how I ensured establishing trustworthiness.

3.3.1. Establishing Trustworthiness

Trustworthiness is frequently linked to reliability and validity which are essential tools of quantitative research (Miles & Huberman, 1994). In quantitative research, validity and reliability address the concerns of the effect of the researcher on the data collection. Validity is related to the accuracy of data and determines whether the research truly measures what it was intended to measure. Reliability is linked to the durability of results and is concerned with ensuring that those following the same procedures and using the same research instruments to measure the same phenomena would produce the same results (Hitchcock & Hughes 1995).

In qualitative research, the researcher is the primary instrument for data collection. That is why:

> *"Reliability and validity are conceptualized as trustworthiness, rigor and quality in the qualitative paradigm. …Therefore, reliability, validity and triangulation, if they are to be relevant research concepts, particularly from a qualitative point of view, have to be redefined …in order to reflect the multiple ways of establishing truth"* (Golafshani, 2003:604).

As already mention, in qualitative research, researchers bring to the study their own biases, values, and beliefs. Each researcher's character, social identity and background will affect how they interact with the research participants and to large extent will influence their selection and interpretation of the data therefore they must be reflexive (Robson, 2002). The qualitative researcher takes for granted the presence of multiple realities and endeavours to represent these realities sufficiently (Hoepfl, 1997). What the qualitative researcher must seek to demonstrate is a level of trustworthiness. The basic question addressed according to Lincoln & Guba (1985:290), is:

> *"How can an inquirer persuade his or her audiences that the research findings of an inquiry are worth paying attention to?"*

And as Porter et al., (2005:575) put it:

> *"Gaining authentic voices in the production of research includes reflection on the process of research itself"*.

That is why it was important for me to provide a detailed account of the aims of the study; and of how the work was carried out. Simultaneously seeking to recognize and set aside my own assumptions and beliefs from those of the participating children and from the collected data. Taking into consideration that a valid interpretation must occur or emerge from the data analysis and from the researcher's involvement in the setting, and not from what the researcher assumes is happening based on their preconceptions.

Effectively I believe that within this work I have provided a demonstration of how the interpretation of the data was reached: a) by presenting direct quotations from the data so that readers of the study can experience for themselves the participant's perspectives and b) by making explicit the key elements in the selection, design and implementation of the research. The process followed is laid out so other people could follow if they wished to challenge or review my work (Robson, 2002).

In the same line, Johnson (1997:282) emphasized that:

> *"When qualitative researchers speak of research validity, they are usually referring to qualitative research that is plausible, credible, trustworthy, and, therefore, defensible".*

I have sought to enhance trustworthiness:

- By actively engaging in critical self reflection about my own potential bias so as to prevent my views and perspectives affecting how to interpret the data and how to conduct the research (Johnson, 1997).
- By accurate and consistent capturing of observations through note taking and of interviews through audio taping, note taking, and transcription. The audio and transcription files of the data were maintained for future reference.
- By spending sufficient amount of time observing the participating children and familiarizing myself with the setting in order to build trust and rapport and overcome difficulties such as misunderstandings that might have occurred which might have led to misinformation from the respondents (Lincoln & Guba, 1985).

Concerning the crucial question about how I tackled the potential difference that might exist between what children said about spatial processes and the processes themselves, a spontaneous response is that I did this by triangulating my findings with conclusions arrived at by other researchers using other methods.

> *"Triangulation is typically a strategy (test) for improving the validity and reliability of research or evaluation of findings"* (Golafshani, 2003: 603).

In addition I tackled this question by comparing the interviews with observations and children's commentary on the processes involved in performing spatial tasks e.g. when following a familiar route. The interviews utilized a variety of pre-planned activities in addition to a traditional question-and-answer format, e.g. pointing to designated locations and participating in a tactile card came (see chapter 4: summary of the findings). These techniques helped reveal more fully the richness and complexity of blind children's understanding of space. They also provided children with more time to think and express themselves freely while not feeling pressured to give a quick answer; the practical activities also helped them to talk about complicated and abstract issues (Fargas-Malet et al., 2010).

Overall, by immersing myself in the context; gaining familiarity with the setting; getting to know the children well; comparing my findings with what other researchers have found, as well as by spreading the interviews and observations over time I sought to avoid the potential problems discussed earlier.

As Graue & Walsh (1998:120) nicely put it, an interview is an iterative process; usually comprising a series of interviews over an extended period of time and often in combination with observations, thus:

> *"Any single answer in an interview is situated within a much larger data record, allowing the researcher to make judgments about the believability of what who said when"*

3. 4. Design Approach: Case Study

As a general principle, researchers should design their study according to the research questions they are seeking to answer. My aim in this study was to investigate children's explanations, perceptions, feelings and coping strategies around their understanding of space in their everyday experience. As argued earlier, qualitative methods offer flexibility of use across a wide range of situations and for a wide range of purposes. They are perhaps the best way we have to capture people's perspectives; they can be used to study the lived experience of people, including their meanings and purposes (Robson 2002). Qualitative methods, because of their flexibility, are also suited for studying naturally occurring real-life situations to help find the "natural" solutions to problems - the solutions that people devise for themselves. The need for flexibility and individualization is especially essential in the field of visual impairment.

Most of the researchers exploring the question of spatial understanding adopt an experimental approach. However practitioners need knowledge that enables them to see beyond simple dependent variables. They cannot do much with studies that tell them little more than the conclusion that children who are blind are not as advanced in their spatial knowledge as sighted children of comparable age.

As Warren (1994: ix) suggests:

> *"…It is the variation within the population of children with visual impairments that we should be studying, not the norm…. Only with that kind of knowledge base will be prepared to intervene in the lives of children with visual impairments in order to allow them to achieve their optimal potential."*

Warren (1994) proposed a new research approach, which looks for 'answers' within the population of children with visual impairments. In my thesis, I seek answers to questions about blind children's spatial processing by utilizing a design focused upon differences within the population of children who are blind.

In order to understand the variation within the population of children who are blind, in its complexity and its entirety, as well as in its context, I have chosen the case study strategy as an appropriate approach in that it offers a vehicle for investigating the important features of a phenomenon and developing an understanding of it.

In a discussion of appropriate research methodologies for children who are blind, Millar (1997) identified a number of practical problems facing researchers. For example definitions of blindness vary, and while the numbers of blind children is very small, any group that is identified is likely to display more dissimilarities than similarities. There are also differences between these children that relate to the onset or the nature of their visual impairment (e.g. the condition may be ocular or cortical in origin). Lewis and Collis (1997:7), discussing research methodologies for children with disabilities, stress that:

> *"one of the main advantages of …case studies is that the observer is not channelled into making comparisons with other children in other groups and so is much more likely to focus attention on the child and his or her development rather than on how that child differs from, or is similar to, other children".*

A multiple-case study approach was used in order to examine blind children's spatial awareness in their school setting. I examined several cases, to help establish a range of versions and interpretations. A case study aims to uncover the interactions of significant factors or characteristics of a particular situation or a phenomenon and illustrate the complexities of the situation. Also the case study strategy is an effective approach for answering "how" and "why" questions, (Yin, 2003) and:

> *"…aims to understand the case in depth and in its natural setting, recognizing its complexity and its context"* (Punch, 1999:150).

The case study method may contain a single or multiple-case design. Because a multiple design must follow a replication rather than a sampling logic, the research may needs to build upon the first case/cases or perhaps carrying the investigation into an area suggested by the first study. Thus cases are selected to explore and confirm or refute the patterns identified in the initial cases (Robson, 2002; Yin, 2003). The findings from such a study can be put forward as being potentially applicable to other cases and strengthen the results by replicating the pattern matching. Yin (2003) suggests that six to ten cases are usually sufficient to satisfy the requirements of the multiple-case study although there are no rules about how many cases are required. The sample size is determined by the number of cases required until no significant new findings are emerged. The participants should be selected because of their characteristics which are likely to let the researcher explore the phenomena under study (Robson, 2002; Yin, 2003).

Yin (2003:46) emphasizes that:

> *"The evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as being more robust"*.

Moreover, analytic conclusions arising from several cases will be more powerful against the common criticism of the case study concerning its generalizability (Yin 2003; Punch 1999). Critics of the case study method believe that the study of a small number of cases can offer no grounds for establishing reliability or generality of findings. Others feel that the intense exposure to study of the case biases the findings and that there is a danger of distortion which could result in difficulty in being able to cross-check information across research participants (Bell, 1993). Lewis & Collis (1997) also state that although case studies provide depth of study in relation to a situation, they lacked breadth and conclusions need to be tested for their generality across a number of individuals.

Taking into consideration the above possible limitations in the use of case study, I believe that a rigorous multiple case study approach can help retain both the holistic and the idiosyncratic nature of individual cases and provide generalisability beyond the specific setting. The outcome of a case study might generalize findings to theory analogous to the way a scientist generalizes from experimental results to theory (Yin 2003). This is also supported by Kvale (1996:102) who notes that:

> *"A paradoxical answer, from the history of psychology, is that if the aim of a study is to obtain general knowledge, then focus on a few intense case studies. The contribution of Freud's case studies to the general knowledge of pathology and personality is one instance…"*

Bromley (1986) offered further support for this point. He suggests that if case studies are used rigorously this can lead to discoveries and can establish genuine truths unfolding a segment of an individual's life story which is based upon the most reliable evidence available.

Using a case-study design for the present study I tried to understand the situation and the meaning through the voices of those involved, seeking the participant children's opinions about what they believed, and how they interacted with the world around them in making sense of space.

For the purpose of the present research each individual case study consists of a "whole" study, which incorporates all the documents i.e. interviews, observations and field notes.

Data were collected from twelve students who are blind over a two years period. The first step was to observe the children in their everyday school life for a month. Then the pilot interview followed with three children. After the pilot interview was conducted, the data were transcribed and analyzed before the next group of interviews and observation was scheduled. Subsequently observations over a period of six months followed. Then the second round of interviews was conducted ten months after the pilot. This round of interviews was used both to investigate the new themes that emerged during the pilot and also to confirm or refute the patterns of behaviour identified in the first interviews. Later a third interview cycle followed, six months after the second interview cycle. A two weeks observation also proceeded (see section 3. 5. schedule of research). The final round did not produce any new themes however provided the opportunity to explore specific concepts in more depth.

The multiple case studies design used in the present study, allowed the identification of possible patterns in the data from the early stages of the research project. The engagement with the data analysis from earlier interviews before conducting the later ones allowed clarifications and revisions to be made. In addition new themes have been identified and explored in more depth during the later part of the process.

3. 4. 1. Participants

The main criteria for selecting children to participate in this UK based study was that the children:

- should be registered blind;
- have a visual acuity level of total blindness; or light perception only; or light and limited form perception only;
- senses other than vision should be their pronominal senses of communication;
- should be in the ten to fifteen years age range and have no additional disabilities;
- and finally should be able to express their experiences with clarity.

It was also important that I could have direct access to the children within their educational setting over a period of time in order to observe them during their school day and to establish natural contexts for interviewing them, and additionally to get to know the children well enough to identify and adjust to their own speech routines. Accordingly the head teachers and teachers of three special schools for the children who are blind within the Midlands region (UK) were contacted by telephone and by email. I visited the schools and the aims of the study were discussed with the relevant professionals and the children themselves. Schools obtained parental permission for the children that were identified as meeting the above criteria to be involved in the research. It was explained to those concerned that the children were to be visited by the researcher who would spend time getting to know them and observing them in their every day school activities.

Fourteen children were identified as meeting the above criteria, twelve of whom participated in the present study. Before and during the interviews it was made clear to all the participants that their participation was voluntary and they could withdraw at any time. Bearing in mind, Porter's (2009:351) suggestion that:

> *"…consent should be an on-going process. As individuals come to understand through experience what is involved, they should be given the option of stopping the activity…"*

All the families and children, apart from one, gave their consent to participate. One of the children, even though their family gave their consent, said that he did not want to be interviewed so he did not take part.

Ten out of the twelve children were congenitally blind and two of the boys had lost their sight at the age of eight years. One of the children – Janet (an assumed name) - lost her sight at the age of 14 months old but for research purposes she was considered as congenitally blind.

> *"Classically, a person is considered congenitally blind if he or she has lost visual abilities during the first 3 years of life"* (Thinus-Blanc & Gaunet, 1997:34),

although this view is not universally held. For example Millar (1979) for research purposes considered as congenitally blind only those participants who have lost their sight before 20 months old.

The children had no other diagnosed sensory, cognitive or motor impairments. Three children had no residual vision, four had light perception only, three had light perception/ limited form perception, and two had light perception and also recognised some well saturated colours. Background information for each participating child including age at first interview, gender, age of onset of blindness, cause of blindness and visual perception was collected from the school files and through interviews with the mobility instructor and the class teacher (See appendix 2: Students' background information).

3. 4. 2. Ethical issues

The researcher has the responsibility of producing a study that has been conducted and disseminated in an ethical manner, and of reporting the truth when presenting the findings. Also a researcher must ensure that: (a) each participant is been treated with dignity and respect and is been explained to them that they are free to participate or not without prejudice (b) their identities will be protected, (c) and that they are going to participate in a research study with specific parameters of interest (Marshall & Rossman, 2006). The BERA (2004-British Educational Research Association) ethical guidelines for this study were followed, taking also into consideration that there are special ethical issues involved in interviewing children.

Informed consent can be a complicated matter when children are involved. It is necessary to have the consent of a parent or legal guardian before interviewing a child for a research study. Depending on the age and developmental level of the child, ensuring that the child understands his or her right to refuse participation is also a concern (Lewis & Porter 2004).

Before I went to any school, it was necessary to obtain the consent of the head teacher, the teachers and the students. I also thought that it was necessary to gain informed consent to the tape recording of the sessions of the adults involved but also of the children themselves. I informed them in writing about who I was and what I was doing; what the purpose of my research was, and why their participation was necessary. Also I ensured them that I would stop the tape recording at any point if requested. In addition I gave them my personal details and asked them to communicate with me if they needed any further information**.** Schools obtained parental permission for the children to be involved in the research and for the tape recording to take place (See appendix 1: Consent letter).

Ethical issues and difficulties associated with the school setting were also identified. Such concerns were that children might have found it difficult not to take part in a research project once school staff members and/or their parents had given consent. As Lewis & Porter (2007:225) emphasized:

> *"…there should be opportunities for assent and dissent to ensure that their inclusion in the study is voluntary and not as a result of coercion".*

In addition children might have interpreted participation as school-work and felt pressure to give the right answers to the research questions (Fargas-Malet et al., 2010). I tried to minimize these concerns by explaining and emphasizing to children that I was interested in what they were thinking and that there were no right or wrong answers. Also I explained to them that they could withdraw at any time from the research without any obligation towards me or anyone else. In addition when it was possible I tried to choose a room that was not a conventional formal learning place, such as activities or leisure rooms (Fargas-Malet et al., 2010).

A further serious issue was that the selection of children for interview was determined to a great extent by their ability to participate in the interview format employed in the research. In this study, the views of blind students with profound and multiple learning difficulties were excluded because I was not confident about being able to access their views reliably.

Ensuring anonymity and confidentiality was another ethical issue which however might be difficult to sustain when there are small and readily identifiable samples (e.g. a few blind students in a school). That is why I interviewed students from three different schools; I used assumed names; and I made sure that the participants, schools, members of staff, the children that I worked with and their families felt confident that I was going to respect confidentiality. Simultaneously bearing in mind Lewis' & Porter's (2004:193) warning that:

> *"Researchers need to provide considered responses to participants rather that blanket reassurances of confidentiality".*

The whole process of research is an ethical endeavour and:

> *"is not just about carefully designed, randomized testing of children's lives but also about the processes of respectfully engaging in dialogue with children such that it is possible to 'co-construct' and report their views and experiences as they make sense of the world"* (Graham & Fitzgerald, 2010: 139).

This draws attention to a certain kind of ethical practice I sought to follow: to establish rapport with children in order that I might feel comfortable with the interaction and involvement with them and be ready to deal with their own speech routines and the messiness that conversation with children sometimes brings (Graham & Fitzgerald, 2010).

3. 4. 3. Data Collection

The choice of a particular research methodology influences the way in which the researcher collects data. In the present study I used in-depth interviews as the main tool for the data collection.

I also used observation data. Although it should be noted that observations were primarily used as a means of deepening understanding of the setting rather than as a means of data collection. However in practice they did provide interesting additional evidence, especially in terms of children's interactions with the surrounding space and their ways of responding to particular spatial situations such as wayfinding tasks. Also observations proved to be another way of reinforcing and checking initial understanding gained from interviews about how children were thinking and acting when engaged in spatial tasks.

3. 4. 3. 1. Observation

> *"Observation can lead to deeper understandings than interviews alone, because it provides knowledge of the context in which events occur, and may enable the researcher to see things that participants themselves are not aware of, or that they are unwilling to discuss"* (Hoepfl, 1997: 53).

Observing the children in their everyday school life helped me understand the context and gain familiarity with the setting in a way that can only come from personal experience; something that proved to be invaluable throughout the study. For instance observing the children help me identify and develop relationships with them and decide who to recruit for the study. Also I tried to identify natural contexts for interviewing and additionally to identify children's own speech routines. Further I use the data collected through observation to develop the interview questions and simultaneously better understand the data collected through interviews.

The field notes included personal information of the participating children and details of informal conversations and interactions I had with them, which also helped me better understand the physical, social and cultural contexts in which learning was taking place (Patton, 1990). For instance I recorded the children's commentary on the processes involved in performing specific spatial tasks i.e. when following a familiar route or when pointing to a designated location.

Among the several important issues I had to consider at this stage were:

- How to operationalise the observations and this included creating a list of things to pay attention to in order to gain an impression of how the children performed generally during way-finding. Also how to structure the sessions to gain a sense of children's observable mobility skills.
- How to select the times and dates for observation

While socializing with my participants I tried to gain their insights on how they make sense of the world around them and how they find their way around. The informality of the discussions provided opportunities to exploit incidental occurrences and gain detailed information including feedback on the emotions, feelings and experiences that students who are blind have when they interact with learning situations. I wanted to establish rapport with the children since I thought it was essential that the children felt comfortable enough to say what they really believed and not what they thought I would like to hear. On the basis of these observations and initial informal interviews, I tried to build the children's trust in me and to established rapport. It is thought that with the appropriate rapport, the interview becomes a *"personal sharing with a trusted friend"* (Morse & Field, 1995: 90). Thus the observational field notes added another dimension of information to the analysis before the formal process of interviewing began.

3. 4. 3. 2. Interview

As already argued earlier, many of the studies concerning spatial awareness of children who are blind which are reported in the literature, have been experimental in nature; seeking to discover relationships between variables and to quantify spatial experience by measuring the outcome of the participants' performance on different spatial tasks. However there is a considerable disagreement among the different studies found in the literature (Warren, 1994; Thinus – Blanc & Gaunet, 1997; Andreou & McCall, 2010).

The present study is methodologically different from many of the previous studies concerning spatial understanding of children who are blind in that it focuses more on the processes involved in perceiving space and less on the outcomes of these processes. My main aim was to investigate children's own perspective of their understanding of space and the coping strategies they deem to employ in their use of space in their everyday experience. Interviewing children allows them to give voice to their own interpretations and thoughts (Eder & Fingerson, 2002). Thus for the topic and the purpose of my investigation the interview approach was seen as the most appropriate. As Kvale (1996:105) notes:

> *"Interviews are particularly suited for studying people's understanding of the meanings in their lived world, describing their experiences and self-understanding, and clarifying and elaborating their own perspective on their lived world".*

Interviews enable us to gain explanations and in-depth information on material that is not otherwise directly accessible such as perceptions, attitudes and values. Patton (1990) points out that any face-to-face interview is also an observation. The interviewer is sensitive to nonverbal messages, effects of the setting on the interview, and nuances of the relationship. While the subjective interpretation of such factors can be considered threats to validity, they can also be seen as strengthening the reliability of the findings ensuring an in-depth, detailed understanding of the participant's experience.

An important issue I had to consider is that the skills and logistics involved in interviewing children are not necessarily the same as those required for adults. The performance of children in testing situations is known to be sensitive to factors like the familiarity of the setting and the examiner (Patton, 1990). A researcher who is conducting qualitative interviews with children should be familiar with the ways that children at different ages understand and use language. This is something well-known to me as I have been a teacher for fifteen years, though Fielding's (2001:103) warning should be borne in mind:

> *"whilst teachers may hear what students say, they do not cross the bridge to listening actively to what they mean".*

Thus in my research I carefully sought to gain insights by being attentive to the explanations of the participating children provided about how they interpreted and ordered the world around them.

Children can very easily misunderstand adult language and metaphors. It is not only the language used by the interviewer that shapes the children's responses, it is also the language the children think the interviewer wants them to use. Children are often unable to respond to "Why?" questions, which require them to analyse or interpret their behaviour or thoughts, and rather than posing a direct question is often better to use statements as prompts (Lewis & Lindsay, 2000).

Eliciting children's views presents challenges (Lewis et al. 2008). Children are taught to listen to, respect and obey adults; they are surrounded by adults e.g. teachers, parents, family, who have the power to ask questions and command children's actions. In the power relationship between adults and children, children have lower status than adults due to factors such as age, cognitive development, and physical maturity and so on. This power relationship may distort children's views or may be seen by the children as requiring them to make a compulsory response of some kind (Lewis et al. 2008). Thus my responsibility as a researcher was to reduce this power over children by making the interviewing context more natural for them and make explicit and clear to them their right to refuse participation or withdraw from the study at any time, before and during the interview (Eder & Fingerson, 2002).

Further I endeavoured to make clear to the participating children that I wanted to learn everything they could share with me about the processes involved in perceiving space. They were the experts and I did not have the knowledge they possessed about the research topic. I tried to pose questions in neutral manner; asking follow-up questions and probes based on children's responses and not to expressing approval or disapproval of what they were saying. That I believe allowed them to express more spontaneously their perspectives about their experience and understanding of space.

3. 5. Schedule of research

Taking a child-focused approach, the present study treated children as socially competent informants of their own lives (Eder & Fingerson, 2002); and aimed to identify the processes that underpin children's views of space and spatial processing. Further it sought to identify what children themselves considered to be strengths and problems in the conceptualization of these concepts, and the strategies they adopted for managing them.

Three interviews cycles were conducted. The pilot and the second interview cycle were conducted in the primary and secondary department (A1 and A2 respectively) of a specialist day school for children with visual impairments. The third cycle of interviews was carried out in a specialist residential secondary school for children with visual impairments (school B).

While designing the interview questions I kept in mind the principle that the questions should be brief and simple and unfold like a normal conversation. Although the children were encouraged to lead the conversation in relation to the specific questions, a set of standard value-free prompts (such as "What makes you think so?", "Can you tell me more about that?", "go on" etc.) were developed for children who found difficulties in beginning or completing their answers.

3.5.1. Stage 1 of research design and pilot

Before conducting the pilot study, the research methods were defined and the preliminary visits were arranged. In this first stage the following actions took place:

- Observations were carried out in schools A1 and A2, twice a week for a month.

- This was followed by the development and piloting of the first interview guide (see appendix 4: Interview schedule for the exploratory study)

After the observations, the initial interview was piloted with three students who are blind - Markus, Ahab and Harris (assumed names). The interview lasted approximately 50 minutes with each student. One of the students was from school A1, aged 11y.6m and two from school A2, aged 13. All the students used Braille and used a long cane as their primary mobility aid.

The initial visits to schools and the first interview cycle were conducted with a wide field of focus and the exact procedures were loose so as to prevent my own perceptions of how children who are blind process space from interfering with or shaping the kind of data I was going to gather. Thereafter progressive focusing enabled a narrower field of focus to be established and identified key foci for subsequent study and data collection (Cohen et al. 2000).

3.5.2. Stage 2 - The main research - second and third cycle of interviews

Following the pilot study and the initial data analysis, a second round of observations were carried out twice a week for six months in school A1 and A2 (seven children were observed: S1 Markus, S2 Ahab, S3 Harris, S4 Hans, S5 Alan, S6 Shimon, and S7 Sal; assumed names), so as to gain insights of how the children performed when travelling independently indoors and outdoors and how they coped with spatial tasks in their everyday life (See appendix 3: Observation findings, summary table). After the observation the questions for the main interviews were developed.

The key shapers of the questions used for the second cycle of interviews were the initial research questions expanded to accommodate the additional themes emerging from the literature review in conjunction with: a) the themes that emerged from the analysis of the data of the first interview cycle (the pilot) and b) the information obtained from the second round of observations prior to the interviews.

Each interview was designed to last approximately 3 x 50 minutes with each student from school A1 and school A2 (each child was interviewed in three different sessions). In practice the length of each interview varied. The shortest interview lasted 40 minutes and the longest session lasted over an hour.

Seven students, aged ten to fourteen years, three from the primary school (A1) and four from the secondary school (A2), participated in the second interview cycle. Five of them were congenitally blind and two adventitiously blind.

Each of the interviews in the second cycle- three with each student- was based on three interview guides (see appendix 5: Interview schedule for the main research). The sequence of the questions within each guide did not correspond with each other; however several questions inquired about information in similar areas. The questions did not always follow the sequence laid down in the interview guides. They sometimes followed the sequence I deemed best, based on the information that emerged during the interview; for example when the actual flow of the discussion led naturally towards a question that came later in the set order. That strategy provided the opportunity for topic areas to be revisited and enhanced the depth of the information obtained for analysis.

The second interview cycle was conducted ten months after the pilot fieldwork, with seven blind students, three of whom had participated in the pilot fieldwork.

There were three main reasons for the ten month gap between the pilot interviews and the second interview cycle:

- Sufficient time was needed for the analysis of the data from the first interview cycle to enable the main fieldwork questions to be driven by the children's experiences
- Enough time was required to carry out a supplementary literature review to inform the main fieldwork questions
- Because three of the children who participated in the first interview cycle also participated in the second, sufficient time had to elapse to minimize any influence of participating in the first cycle on their participation in the second.

Although the second interview cycle yielded rich data, I felt that a third interview cycle was necessary in order to explore further the general points that had been established in the second interview cycle. Also to further investigate new themes that evolved. Therefore a third interview cycle emerged and was conducted with five congenitally blind students, aged 12 to 15, lasting approximately 3 x 50 minutes with each student from school B (secondary school), six months after the second interview cycle and sixteen months after the pilot fieldwork.

A third round of observations proceeded the third interview cycle -every day for two weeks - in line with the Maykut and Morehouse (1994:68) suggestion that:

> *"in order to understand any human phenomenon we must investigate it as part of the context within which it lies".*

Also I felt that triangulation of observations and interviews would help reveal more fully the richness and complexity of the spatial behaviour of the children, providing a more detailed and balanced picture; thus enhancing the credibility and trustworthiness of the data (Cohen, et al. 2000).

Overall, case studies from the second and third interview cycle consisted of twelve blind students, ages 10 years and 11 months to 15 years from three different schools for children with visual impairment centre in and around Birmingham (U.K.).

3.5.3. Reflections on the research design

A very difficult task in any research project is the conceptual clarification and the theoretical analysis of the themes to be investigated. A researcher might have a good general idea of what he or she wishes to investigate however without awareness of the existing knowledge about the topic of the investigation and without a review of the research literature in the area, it is difficult for the researcher to ascertain what the scientific contribution of the study will be. Only with such knowledge the researcher is able to pose significant questions (Kvale, 1996). In an interview-based study, another difficult task is to translate the academic research questions into a natural conversational form in order to generate spontaneous and rich descriptions from the participants.

Having all this in mind and feeling "wiser" after the pilot I sought to approach each topic from several angles so as to obtain rich and varied information. Each theme that emerged from the research questions and from the first interview cycle needed to be translated into the interview questions that would form the interview schedule of the main research. I also had to take into consideration what type of interview questions to use. It was important to be able to follow up questions either by asking for clarification of what had just been said or repeating significant words of an answer. In order to achieve that, one must develop the ability to listen to what is important to the participants and at the same time to keep in mind the research questions (Kvale, 1996).

To ensure that the process of interview was scientific, it was necessary to develop a hierarchy of probe questions and some key principles were established:

- Allow pauses in the conversation for 6 to 8 seconds and if the child didn't respond then repeat the question
- Use content free probes e.g. "go on", "interesting can you tell me more…", "you told me you had no idea about … if you were to just guess, what would be a good guess?", "Can you think of examples of what you are describing to me that would help me to better understand?", "What makes you think so?"
- Prompt carefully, keeping prompts specific to the question without giving ideas to the child (prompt…wait approximately 8 seconds…prompt again).
- Clarify what the student meant if something was not clear during the interview by either asking the student to repeat their answer or asking them to tell the author in other words what they meant.

New leads in the interview situation were followed and the sequence and forms of the questions were changed in order to follow up the answers given. It wasn't always easy to keep the flow of the conversation going and motivate the students to talk about their experience and feelings. There were times when the children started talking about irrelevant topics; so in some occasions I had to interrupt. For example: "can we go back to what we were saying", or "you can tell me more about this later if you don't mind, now I prefer to talk about…" and so on.

I also decided that I was not going to ask all the questions to all the children in the same way. Some children needed more concrete explanations therefore some subsidiary questions were developed that broke down the components of the original question into simpler steps and worked like probes to help children who needed to use more concrete language to express their thoughts and feelings. The repetition also served another purpose, that of internal validation: the subsidiary questions defined more clearly the answers of the children and helped to make sure that the children completely understood the content of the question.

3. 5. 4. Interview considerations:

Before the formal interview started, I had a brief conversation with the children who already knew me from my previous visits to their schools and the purpose of the study was restated. They were asked to give their consent for the tape recording and next we played with the tape recorder, and had fun with our voices on the machine so that they might feel less uncomfortable about being recorded. We talked about ourselves and there were times that they interviewed me asking me questions about myself. Each interview was audio-taped and field notes were also collected during the interview meetings and immediately afterward. Children were reminded of their confidentiality rights and their right to not participate at any time during the interview or after.

The interview took place with each child separately in an empty room with glass doors and windows, so other people could see us but not interrupt us. I didn't use the same room with all the children, because each time we had to use any suitable room that was available. The interview was held in an informal and very friendly atmosphere which I believe gave them the opportunity to express their thoughts and feelings freely. Many of the children during the interview asked me if I understood what they said or if I needed clarification of what they meant because of my foreign accent and because English was not my mother tongue. That was tremendous and allowed me to clarify any uncertainties. Generally children were very cooperative with me and that left me with a feeling of gratitude.

3. 5. 5. Stage 3 - analysis of data

The purpose of collecting qualitative data is to understand in depth the phenomenon under investigation. There are different ways of analyzing and interpreting such data. Coffey and Atkinson, (1996:14) note that:

> *"There is variety in techniques because there are different questions to be addressed and different versions of social reality that can be elaborated."*

The variety and diversity in approaches suggests that there is no single best methodological framework or a single right way to undertake qualitative data analysis. However it is essential that the methods used for the analysis of data need to be systematic, disciplined, transparent and capable of observation and description. A researcher must be able to say how they reached their conclusions using the data (Punch, 1999).

After conducting my first interviews and fully transcribing the data I endeavoured to identify units of meaning in the data and emerging themes. Transcribing the data was not an easy task and was time consuming. However, it allowed me to engage with my data from the very first and meant that an initial analysis could commence almost immediately. This was the first step in the conceptualization of the data and it allowed emergent themes and ambiguities in the completed interviews to be explored further in the next interview cycle (Bryman & Burgess, 1994).

The first step of data analysis was to produce case studies that incorporated all the documents (interviews, observational notes, and assessments of the children's commentary when performing different spatial tasks, such as pointing to designated locations). This produced a large document or 'case study' for each participant. Every case study was read line-by-line and the data generated was coded and searched (Strauss & Corbin, 1990). The qualitative data analysis package NVivo was used. NVivo proved to be a useful tool for the coding of themes and allowed me to carry out complex search and retrieval operations quickly, and linked research notes to coding; thus facilitating depth and sophistication of analysis.

After the initial exploration of the data a list of codes representing themes identified in the data was created. This coded text was firstly stored in free nodes capturing general categories. Each free node was given a heading and all text relevant to that category was stored under that heading (King, 2004). Data was assessed and placed into existing categories, if appropriate, or new nodes were developed for data that did not fit the existing free nodes. The process of establishing data under existing nodes, establishing new nodes and reviewing previously coded interviews for newly developed nodes continued until all interviews had been coded. The themes were not always mutually exclusive and one piece of information sometimes assigned several themes. In some cases one student's short response formed a single unit of meaning and in others a unit of meaning was a whole paragraph or a whole page. If there were no similar units of meaning, a new category was formed. The focus was to closely examine the many propositional statements that emerged from analysis. Some propositions were clearly linked to an aspect of the research questions. While other propositions related to each other (Maykut &Morehouse 1994). I then sought to find appropriate literature and theories to explain and explore the data, considering that:

> *"Rigorous and systematic checking of the data, including a search for contradictory evidence, are important parts for the validation process" (Lewis & Porter, 2007:228)*

Once this phase had been completed, each broad theme was subjected to a more detailed analysis which led to the formation of more specific categories within each theme creating tree nodes (sub-categories) under the broad headings (King, 2004). Once tree nodes were grouped under the broad categories, they were re-examined and reanalysed: firstly for new concepts that might emerged, secondly for ensuring they were fitting within the broader thematic area, and thirdly in order to examine if some of the nodes could be merged together because they represented the same idea or concept. I could deal easily with second and third objective but with the first one, concerning new concepts emerged from the data, I had to start from the beginning, working through the entire analysis process again reading and inspecting line-by line each interview in order to identify patterns of commonalties, or differences among the cases concerning the new emerging concepts (each 'case study' for each participant consisted of many pages, in many occasions more than 20 pages of transcripts and field notes). This continued up to the point where new themes stopped emerging and I was satisfied that the categories had become so rich and sophisticated that any further data only served to illustrate what was already established (Glaser & Strauss, 1967, Strauss & Corbin, 1990).

The final results of this research are presented within the framework of the themes that emerged from the case studies. Any quotes found in chapter 4: "summary of the findings" and chapter 5: "overall discussion"; are written in italics surrounded by double quotation marks to indicate that this is the exact wording of the participating children. Quotations from the data were chosen with the purpose of illustrating the interpretations presented (Karlsson, 1996). Following each quote there is a reference to the relevant NVivo coding for instance in the case of 'Markus

[TN8/8c/ ¶ 23]', 'Markus' refers to the anonymised name of the participant; the sequence 'TN8/8c/ ¶ 23' refers to the Nvivo coding of the transcribed text and to the paragraph to where it has been taken; i.e. TN8: tree note 8: Techniques they use/ 8c: counting, measuring/ ¶: paragraph 23.

In addition one may find periods within the quotations. If three periods follow upon each other a word, for example "*I work out…*" this means that a section of the quote has been omitted from the participant's protocol. The aim in this case was to omit irrelevant information from the quotation. Where 2x3 periods appear in a row, for example "*……*" this is an indication that the interviewee paused and was quiet.

3. 5. 6. Reflections on the procedure

In the course of the study, I came to appreciate how time-consuming task the transcription of recorded tapes and field notes can be. Because of the problems of understanding children's voices, each hour of a school tape had to be replayed many times, and took at least seven to eight hours to transcribe. It took me a further two hours to check and add context notes. In order to compare the emerging themes across the data, I began by dividing each transcript up into conversations, which were essentially episodes of dialogue on a particular topic. The task of dividing up a continuous stream of talk into discrete conversations proved to be difficult and very demanding. One problem was how to decide whether and at what point a subject changed into a new topic (King, 2004).

As far as the interviewing procedure was concerned, I discovered that firstly, building rapport with children takes time and secondly, children might not fully understand the purpose of a research interview and the nature of the relationship that this context requires. Nevertheless, I feel that it is the responsibility of researchers to establish a working relationship with the children. I also discovered that in order to enhance rapport, the researcher needs to learn about how the child prefers to interact and what might facilitate his or her comfort in an interview context; for this reason it is important that researcher ought to get to know the child before the research study begins. In addition, I realised that researchers using this approach must be aware of the linguistic capabilities of the children they interview. Some children are unable to deal with the complexities of open-ended questions in the absence of other verbal prompts or cues, particularly at the beginning of an interview, and they might require direct questions to engage in the topic (Lewis & Porter 2004). In addition, I realised that when interviewing children one must be prepared to structure interviews in ways that meet the needs of each individual child.

Another issue I had to take into consideration, and it emerged only during the interviews, is that the way in which a child presents his or her experiences or tells a story during an interview might not make sense to an interviewer initially; the meaning systems of children are different from those of adults (Miller & Glassner, 1997). Sometimes (such as when a child is having difficulty finding the appropriate vocabulary or descriptions for his or her thoughts, or when the interviewer is having difficulty grasping what is being said) it is very tempting to offer the child words or suggest the descriptors that the child is struggling to express. However, good practice would be the researcher to use content free probes and to carefully provide prompts that are specific to the question the child is struggling with, without giving ideas to the child.

Overall, my aim in this chapter was to address a range of issues concerning the research methodology: a) to provide an overview of the research approach and methods selected for use within the study; and b) to identify and justify the ontological, epistemological and methodological stance adopted. Prior to embarking on a larger scale study it was considered necessary to clarify a number of these issues through a small scale exploratory study (the pilot). A report of this study will be presented in chapter four along with the findings from the main research. Chapter 4: "summary of the findings" and chapter 5: "overall discussion" will provide evidence of how successful I have been in applying the principles that have been discussed here.

CHAPTER FOUR

SUMMARY OF THE FINDINGS

4.1. First interview cycle – exploratory study

The sessions in the first interview cycle with Markus, Ahab and Harris lasted approximately 50 minutes with each child. Semi- structured, open-ended questions were used and as far as possible the children were encouraged to lead the conversation so that a rich picture of the children's perspectives could be obtained. The questions used were derived from the general research questions identified at the start of the study and from observations and informal discussions with the children within the schools setting prior to the interview.

The main objectives of the first interview cycle were to explore children's explanations of way finding in order to discover the underlying strategies they feel they employ in order to perceive space (Passini, 1984; Johnson, 1987; Golledge, 1993; Blades et al., 2002; Fortin et al., 2008). A second objective was to explore how Markus, Ahab and Harris explained their awareness of the approximate size of objects in the surrounding space and to discover whether they used self-reference coding strategies or external frameworks to comprehend the relative sizes of objects familiar to them (Spenser et al. 1989; Millar, 1994; Warren, 1994; Ungar, 2000; Millar & Al-Attar, 2004).

Way finding is defined for the purpose of the study as the way in which children orient themselves in physical space and navigate from place to place. A summary of the findings that arose from the first interview cycle are presented below.

4.1.1. Way-finding

The children were reminded that there were no right or wrong answers and that I only wanted to know how they think about things around them and how they find their way around.

To start with they were asked how they knew what was coming next as they were walking in familiar spaces. Although they struggled to give an answer at first they all indicated that in a familiar space, they could find their way around easily, knowing exactly where to go and how to get there. They all thought that this process of way finding had to do with mental calculations, taking into consideration either landmarks, paces or the time they took to go somewhere. They all added that this was not a conscious process and did not involve thinking what they had to do next in order to find their way around.

"…it's either counting doors or counting paces. It is to do with counting I think…as I said I have never really concentrated on it… it's all so subconscious …I know the stairs are about three paces in front……I don't consciously count one, two, three, it's subconscious but I still know that… it also has to do with the time that I need to go…" Markus [TN8/8c/ ¶ 23] [3*]

"… I remember the texture and I remember what I feel in my feet and I remember how many set of doors or windows I would pass… your brain automatically knows where places are" Ahab [TN8/8c/¶131]

[3*] TN8: tree note 8: Techniques they use/ 8c: counting, measuring/ ¶: paragraph

"…I remember things like the next corner…… you turn opposite you cross over you go through doors things like that, like landmarks" Harris [TN8/8d/ ¶ 70] [4*]

They each appeared to be implying that they use both self-reference and external coding strategies when trying to orient themselves in space. They would specify locations relative to their own body i.e. "*push the door and put your hand out and you'll feel like a sort of banister thing" or "trail across with your hand …"* and they would also specify locations in terms of one object relative to another object i.e. *"behind the table is the piano".*

"…follow the left hand wall down from the second room and you go to the dining room…the table is in the middle of the room…behind the table is the piano…" Markus [FN22 ¶ 255] [5*].

"… push the door and put your hand out and you'll feel like a sort of banister thing follow that across when you feel a different banister that goes up a bit and then turn yourself a bit to the right and then come upstairs, when you are up there turn right you see some doors one is got a window in it…… and you just open that door you go through and you turn left and there is a fire extinguisher there, you go past that and then…you feel a door but that's for the girls toilets you carry on going, then you feel some double doors, go through those double doors and then trail across with your hand …" Ahab [FN22 ¶ 139

In trying to explain further how they find their way around they all claimed that their experience of familiar locations enabled them to form some kind of

[4*] TN8: tree note 8: Techniques they use/ 8d: Landmarks / ¶: paragraph

[5*] FN22: Free Node 22: description of a familiar place / ¶: paragraph

cognitive image of that space which they were able to use as a frame of reference. This was variously described as 'a picture', 'an imaginary map' or 'an image'.

"… is just kind of landmarks that are fixed in your mind, you just remember… you could say is like creating a picture of the school in your mind" Harris [TN8/8d/84¶]

"…I have this imaginary map in my brain …so I memorized the route from one room to the other and I put it on my map…I don't know how I know… …I just know" Ahab [TN8/8c/¶133]

"…when I walk into a room I've been in a lot of times I know what the room is like, I've got an image in my mind of what kinds of things are around…." Harris [TN8/8L/ ¶ 240] [6]*.

Although the children's responses suggested some interesting new themes for further investigation relating to wayfinding such as the use of cognitive images and the use of landmarks as strategies for memorizing space, I kept the main focus of the second part of the pilot on the planned theme of estimating and identifying the dimensions of objects. Some recent studies (Smith et al., 2005; Andreou & Kotsis, 2005; 2006a; 2006b) had concluded that individuals who are blind are more accurate than individuals who are sighted in representing the size of familiar objects because they draw on manual representations, which are less likely to be influenced by visual experience than are visual memory representations. For example, Smith et al., observed that:

> *"…the memory representations of sighted individuals overestimate object size…* (and)*… blind people may have developed accurate haptic size representations in support of reaching and grasping actions"* (Smith et al., 2005:14).

[6]* TN8: tree note 8: Techniques they use/8L: walking around / ¶: paragraph

In the pilot study I tried to find out more about the processes involved in the measurement of familiar objects that were not physically present because:

> *"Once we learn more about the process of acquisition we can use it to teach both blind and sighted children how to estimate and measure the dimensions of objects, something that is going to be very helpful for the perception of basic mathematics and science concepts but also for their everyday life"* (Andreou & Kotsis, 2006b:259).

Markus, Ahab and Harris were therefore asked to estimate from memory the size of various familiar objects such as the length of their classroom; the length and width of the classroom door; the length of their desk at school and the length of their bed at home. They were also asked to estimate the height of the ceiling and the width of their Braille machine. It was not specified what unit of measurement to use so children could choose either a standard measurement tool (such as a metre) or a non-standard unit of measurement (such as their paces).

The purpose of these questions was twofold: a) to explore the process of acquisition: how the children reported encoding the relevant information about their surroundings and b) to find out if they had an accurate sense of the approximate size of various familiar spaces and objects and, if so, how they explained that awareness.

4.1.2. References to external items and self-reference frameworks

In the first activity, Markus, Ahab and Harris estimated with reasonable accuracy the length of their classroom choosing the metre as their unit of measurement. Markus said that he imagined he was walking from one end of the room to the other, taking strides about the length of a meter and in this way he worked out the length of the room. Ahab and Harris adopted a similar technique.

"I imagined I was walking from the door to the wall...... so I imagined walking but taking strides about the length of a meter..." Markus [TN8/8c/¶24]

"... It's about 12 to 14 steps...if there are three steps in a metre then it's about four, five metres" Harris [TN8/8c/¶88]

An initial interpretation might have been that they adopted a coding strategy that was more reliant on self-reference cues – their paces – rather than external cues. It was noticeable though, that they went on to compare their paces or other parts of their bodies with the length of a metre, therefore it could also be argued that they were using both external and self-reference frameworks simultaneously (Ungar, 2000).

"...when you said about the door I imagine in my head putting one of my hands on the left hand side of the door and the other hand on the right hand side and then I thought of the metre stick ......and take a measure and I've done like an estimate." Ahab [TN8/8c/108¶]

"I just thought ...the kinds of things around me ...and I thought how big or small things are against me ...and I knew how big or small are some other things around me as well and I put them against other things" Harris [TN8/8K/ ¶ 129] [7*]

The conclusion that children often use references to external cues seemed to be supported by Marcus' and Harris' answer to the same question. They explained that they compared directly the length of a metre ruler with the width of the door.

"...I imaging putting the metre across the door and see... imagine if it fits or didn't fit ..." Markus [TN8/8c/ ¶ 76]

"...working that out I thought about how many meters would fit into that space..." Harris [TN8/8c/¶101]

[7*] TN8: tree note 8: Techniques they use/ 8K: self-reference frameworks / ¶: paragraph

Furthermore, when they were asked about the length of their desk they answered, again fairly accurately, saying that they had compared a metre ruler with the desk and they thought that the desk was longer and worked out how much longer it was. Markus and Ahab used this technique to estimate the length of the Braille machine.

"…with the brailler I've been more tempted to picture it against a measuring device like a ruler …I think of a ruler, you know a 30-centimeter ruler lying across the top of the brailler, so its…comparing the brailler into a ruler… its just a little bit bigger…" Markus [TN8/8c/ ¶ 103]

In the same way the children did not appear to be referring exclusively to self – reference frameworks when they were asked questions about estimating the heights of ceilings. Markus, thinking aloud, said that the ceiling had got to be taller than the door, so if the door was two metres high then the ceiling must have been around three meters. He thought that logic and sensory feedback in the form of echo enabled him to comprehend characteristics of the surrounding environment, in this case the height of the ceiling.

"…as I said it has got to be taller than the door, so if the door is two metres it's got to be higher than two metres and……I looked up ……well I didn't look up but I turned my head towards the ceiling and there was a lot of echo so……it was quite a way up" Markus [TN5/5b ¶ 93] [8*].

Ahab and Harris also reported drawing upon logic but wove in accounts of what seem to be personal experiments in order to estimate the height of the ceiling.

[8*] TN5: Tree note 5: Other sensory modalities/ 5b:hearing, echo ¶: paragraph

"…at home, I stand on the sofa ……you know on the top of the back…… my sofa is quite big and I could touch the ceiling with my ruler…" Ahab [TN8/8B/ ¶ 64] [9]*

"… I think the ceiling is about three, four metres high…… if you put a chair on a table and you stand on the chair you can touch the ceiling… …so if you estimate the height of the table and the chair plus my height ……you have the ceiling's height" *Harris* [TN8/8B/ ¶ 175]

The children's logical deductions, although they seemed important, did not appear to necessarily produce an accurate answer and the method would sometimes create misconceptions. For example Harris thought that because the roof of a house "*…is sloping, one of the ceilings of the house will be higher" (Harris* [TN3/3C/¶ 179] [10]*) and Ahab thought that ceilings were lower on ground floors than on the upper floors "*… I think the ceilings are the same sort of height but, on the ground floor the ceiling might be a bit lower than upstairs, upstairs might be a bit higher*" *Ahab* [TN3/3C/¶ 68].

Further discussion with the children seemed to suggest that often they estimated the relative size of spaces and objects by comparing the unfamiliar with that which was well-known to them.

"I've got this picture in my head of my own house…… and I'd say this room is approximately twice size of this room in my own house and I go like that really…" *Markus* [TN8/8c/ ¶ 15]

However in the questions about "the height of the door" and "the length of their bed" self-reference coding strategies clearly played an important role.

[9]* TN8: Tree note 8: Techniques they use/ 8B: based on their actual experience / ¶: paragraph

[10]* TN3: Tree note 3: Common knowledge – logical explanations / 3C: Misconceptions / ¶: paragraph

"… I put myself against the door and I work out……against my height……how high the door was…" Markus [TN8/8c/ ¶ 80]

"I am 1 metre 50cm…… the door must be about 2 metres……" Ahab [TN8/8c/ ¶ 40]

In the same way they would estimate the length of their bed:

"…I compare my self to it because I lie on it every night…" Markus [TN8/8c/ ¶ 93]

"…cause I am 1 metre 62cm …… the bed is actually a bit longer than me …" Harris [TN8/8K/ ¶ 126]

It seemed that the children were commonly making use of both self-reference and external frameworks, however, Millar (1988, 1994) had found that children who have been blind from birth tended to use an egocentric frame of reference to encode information about objects in space, arguing that lack of visual experience prompted them to use self-referent coding strategies at the expense of the external reference framework provided by the surrounding objects. Nevertheless, Millar did also allow that visually impaired people have the potential to adopt external coding strategies that might be different but functionally equivalent to those of the sighted, and this certainly seemed to be the case with these children.

4.2. Discussion

My pilot study had enabled me to extract from the children's accounts, clues about the range of strategies that seemed to underlie their understanding of the surrounding space. It also seemed to provide clues about whether they used self-reference coding strategies or external frameworks when engaged in spatial tasks and this seemed partly to address the concern in the literature that there was not enough evidence on the relationship between external reference and body-centered reference cues in spatial coding (Millar & Al-Attar, 2004):

> *"there is little direct evidence so far on the relation of external reference and body-centered reference cues in spatial coding and none, as far as we know, for inputs from touch and movement without vision"* (Millar & Al-Attar, 2004:51)

My pilot had also allowed me to explore the participant children's explanations of way-finding. Observations of their behaviours and the analysis of their spoken accounts appeared to allow me to gain some useful insights into their thought sequences and decision making when orienting themselves in physical space and navigating from place to place. This led me to reflect how what I had discovered related to the findings in the literature.

Ungar et al. (1995a; 1995b) had tested congenitally blind and partially sighted children for their ability to learn and recall a layout of tactile symbols in small-scale space. The best performers that participated in their experiments had used both body-centered and external references. Ungar et al. (1995a; 1995b) concluded that it was the degree of use of alternative strategies rather than visual status that accounted for differences in the spatial performance of children.

In the same line, Millar & Al-Attar (2004) investigated how body-centered and external reference information affected spatial coding of an irregular sequence of locations scanned by touch and movement without vision. Millar & Al-Attar (2004:57) had found that combining external frame information with body centered reference:

> *"made spatial coding of locations twice as accurate as conditions either with intact body-centered reference alone or with external reference alone when body-centered reference was disturbed."*

The findings of my pilot also seemed to suggest that children who are blind use a range of strategies, drawing effectively on both self reference and external frameworks in order to comprehend the relative sizes of objects familiar to them or to perceive the spatial relationships in large-scale space. These strategies could be described as either '*egocentric*' or '*exocentric*' (Millar & Al-Attar, 2004).

Millar & Al-Attar (2004) had largely concerned themselves with small scale space activities, as had Ungar et al. (1995a; 1995b). In the literature, there was generally a greater emphasis on the analysis of the spatial strategies used by people with visual impairments in small scale spaces (e.g., Millar, 1994; Thinus-Blanc & Gaunet, 1997; Millar & Al-Attar, 2004) and less emphasis in learning an unfamiliar large scale space either in laboratory environments (e.g. Passini et al., 1990) or in real world environments (e.g. Passini & Proulx, 1988; Espinosa et al., 1998). In addition there had been far less research into the strategies that might be used in every day familiar environments (e.g. Bigelow, 1996) perhaps in part because is not easy to set experiments and control the different variables in order to collect that evidence. (The above mentioned studies and others concerning large scale spaces have already been discussed in the literature review chapter and will be further addressed in the discussion chapter).

The pilot study diverged from other studies of this area in that the method used was essentially qualitative in character and the focus was predominantly on large scale space, in everyday familiar environment but nevertheless it seemed to be providing useful data.

Gattis (2003; 2005) had argued that making sense of large-scale and small-scale space involved similar cognitive processes. She reasoned that:

> *"making inferences on the basis of spatial information is a commonality between what would otherwise appear to be very different tasks – such as taking shortcuts, and reasoning with graphs and diagrams"* (Gattis, 2005:120).

Knauff (2003) also agreed that spatial reasoning about small-scale and large-scale space had commonalities and that:

> *"…we probably can learn about large-scale reasoning from reasoning experiments in small-scale spaces"* (Knauff, 2003:1).

Conclusions from small scale space had been applied to large-scale space activities (Gattis, 2003; 2005) and my findings seemed to align with some of the key findings from these small scale space studies (Millar & Al-Attar, 2004; Ungar et al., 1995a; 1995b). However I was aware that orienting within small-scale space does not involve integration or transformation of spatial information since small-scale space can be viewed from a single vantage point, whereas finding one's way around in large-scale space involves transformation of spatial information that cannot be viewed from one point. Accordingly it seemed reasonable to assume that although large and small-scale space shared some commonalities (Gattis, 2003; 2005; Knauff, 2003) they might also involve different cognitive processes (Millar, 1994). As Kitchin & Blades, (2002:115), remarked:

"…many of the cognitive studies with people with visual impairments have tested people in "laboratory" environments, ranging from table-top layouts to simple mazes built in a room, and it may be difficult to extrapolate from these studies to how people develop cognitive maps in real world".

Since my pilot was focused on large scale space in everyday environments I felt confident that the approach might offer a viable way of investigating this under-researched area. I was convinced by the pilot study that using qualitative methods did allow a way of exploring children's understanding of large scale space in the day to day environment something that was very difficult to do through an experimental approach. Although a range of discrete strategies had been identified in the literature, what I was beginning to appreciate was how these different strategies were being used simultaneously in a way that seemed to provide a more holistic explanation of the process of spatial understanding.

Whereas the experimental approach allows the identification, isolation and examination of one strategy at a time, it does not provide a holistic explanation of the problem and often produces conflicting findings. I reasoned that using qualitative approaches in my study might allow a more detailed and a deeper explanation of what was going on, providing, in a holistic and naturalistic manner, useful supplementary evidence relating to some of the key findings in the literature.

The participant children in the pilot study certainly appeared to be reporting the use of self reference and external frameworks strategies when trying to orient themselves in physical space, when navigating from place to place and in specifying the size of different objects. These strategies seemed to align to some extent with some of the findings of Hill et al, (1993) and the findings of Millar & Al-Attar (2004) and seemed to be supporting some of the key findings in the literature. Hill et al, (1993) and Millar & Al-Attar, (2004) for example, had also found that the participants in their experiments obtained information of the relative positions of different places or specified the location of an object either relative to their own body or relative to another object or they combined external frame information with body centered reference.

The responses of the children in my pilot study suggested that they were using a range of strategies in large scale everyday environments:

1. Observations of the children's behaviours and the analysis of their spoken accounts suggested that they constructed appropriate strategies according to the particular circumstances of the 'problem' they had to solve, using both external items and their own body as frames of reference. They appear to do this automatically, subconsciously and sometimes simultaneously by:

- Comparing the size of objects (i.e. height or width) with their own body e.g. with their own height or with the span of their arms.
- Comparing an unfamiliar object to another one with which they were more familiar.

"Well with some of the questions like the one with the door, I compared it to my self, I imagined my self against the height of the door; but when you asked about the table and the bed I actually compared them between them, I thought how long the bed was and I compared it with the desk and I knew that the desk was shorter than my bed; it like kinds of depend on the question really; sometimes I use my self to find out

how let's say big or small is something and other times I use objects, I compare one object with the other…" Harris [TN8/8j/ ¶ 71] [11]*

"…if we take the brailler again …I wouldn't compare the brailler with the desk, because the desk is obviously a lot bigger than the brailler so it would be hard for me to guess how big it is from that …but I know roughly how big like a 30cm. ruler is and I can just picture that in my mind and then pictured how big the brailler is and I imagine putting the ruler on top of the brailler and see how much of the brailler isn't covered by the ruler and then I can roughly guess" Markus [TN8/8j/ ¶ 65]

2. They actively sought out experiences that would enhance their spatial understanding through 'informal' learning coming from self initiated personal experiments which enhanced their own understanding. Some of this 'informal' learning might be:

   - incidental

"…also I flipped a coin in my class from the table up to the ceiling and the coin hit the ceiling and then I lost it ……but that gave me a rough idea of how far up the ceiling was" Ahab [TN8/8B/ ¶ 88]

   - Or planned (e.g. standing on chairs to touch the ceiling).

3. They linked together a variety of information which helped them created a cognitive 'image' or 'map' of an area and they relied on information stored in their memory from previous experiences:

   - They systematically looked for known landmarks and information points while walking, from which they would obtain information about the spatial

[11]* TN8: tree note 8: Techniques they use/ 8j: references to external items / ¶: paragraph

relationships, keeping track of their own location in relation to the surroundings during locomotion.

"…turn left and there is a handrail so you can walk up to the steps…… just follow the handrail round and on the last step walk straight ahead take your hand of the handrail to a set of double doors… …Turn left there is a wall but there is a gap in the wall so keep walking straight, pass that gap, there is another set of double doors straight ahead you go through those and then cross straight over to the other wall …" Markus [FN22 ¶ 134]

- They tactually explored a spatial area in an active manner

"… I feel around and keep one hand in front of me so I can feel things before I bump into them…" Markus [TN5/ 5d/ ¶221] [12*]

"*…I would like……trail around ……and look at the different things" Ahab* [TN8/8h/ ¶ 167] [13*]

- They consciously exploited sounds and echoes in order to get information about the space around them

"If I looked up to the ceiling…… it's all to do with the sound of a room, you could tell if a room is tall or short, wide rooms and narrow rooms…… I can tell that from the sound and the echo…… from how loud I sound" Markus [TN5/5B/ 5B1/ ¶ 147] [14*]

- They memorized the routes travelled, the distances walked, the turns taken and counted either landmarks or paces and steps.

[12*] TN5: tree note 5: Other sensory modalities/ 5d: tactual perception/ ¶: paragraph
[13*] TN8: tree note 8: Techniques they use/ 8h: trailing on the wall / ¶: paragraph
[14*] TN5: Tree note 5: Other sensory modalities/ 5B: Hearing, echo/ 5B1: Hearing indoors/ ¶: paragraph

"…you have to turn at certain door or you have to turn left after you go around a certain corner or you have to go across … is like becomes a second nature once you do them a couple of times…" Harris [TN8/8d¶ 165]

On the whole, the results from the pilot study suggested that touching; exploring; memorizing; and experimenting with their surroundings enabled children to create a general knowledge base which they used to perceive the world around them.

More importantly the pilot study suggested new areas of investigation and helped developed my thinking. Firstly it gave me increased confidence that my original idea was entirely justified: children were able to talk meaningfully about their understanding of space. And secondly, although the first interview cycle was largely focussed on how children estimate and identify the dimensions of different objects and whether they use self-reference or external frameworks, novel and appealing themes were being introduced by the children themselves. Themes that seemed to be related to: haptic and proprioceptive perception; auditory perception; landmarks; analogical thinking; deduction from previous experiences; and forming cognitive images from spatial events. These and other emerging themes from the children's accounts were used to configure the questions for the main research and were more fully explored in the second and third interview cycle of the main research that follows.

4.3. Second and third interview cycle – the main research

After the initial analysis of data from the pilot, the questions were revised for the main interviews and new lines of questioning were developed. The account that follows is based around what emerged from the analysis of the main interviews (from the second and third interview cycles). The first step in the process was to look carefully at the themes that seemed to be emerging from the initial analysis of the pilot data. The second step was to group those themes under the broad research questions. Given the restrains of the word limit it has not been possible to present each individual response separately under each theme; therefore I have selected in each case examples that best illustrate the range of responses.

Children were asked about a range of spatial tasks relating to locomotion knowledge with the aim of identifying the specific skills or strategies that they utilized to overcome the challenges they face in making sense of space in their everyday environment. The spatial tasks that children were asked to talk about included: wayfinding tasks involving moving from one place to another and finding destinations; pointing in the direction of remote landmarks that were familiar to them; and estimating the relative size of different objects. In each case the children were asked to explain their thought processes. In my analysis I tried to make links between the opinions children expressed in the interviews and the data I had already gathered through my observation of the children's spatial performance in practical situations in the schools setting. In other words I was able to be reasonably confident that the children were describing in words performance that was consistent with their practice in real life.

As I have said an important aim was to identify the various strategies the children reported employing in processing spatial information. In the present discussion, the term "strategy" refers to the functional rules and specific skills the participant children reported implementing during their interaction with the surrounding large scale space (Gaunet, & Thinus-Blanc, 1996).

The children reported a range of different strategies that they appear to utilize interchangeably modifying them as required for specific demands of the task in hand. The children's responses have been organised around the following main themes: firstly, around evidence of references to sensory modalities; secondly around evidence of exploring relative locations in space and the relative size of objects in the spatial environment; and thirdly around evidence of directional strategies and children's explanations concerning the content of their cognitive images of spatial events. These issues will now be addressed in turn.

4.3.1. Spatial awareness and sensory modalities.

4.3.1.1. References to haptic and Proprioceptive perception

The proprioceptive sensory system provides information about the relative positions and movements of the parts of the body in space and it provides a base upon which body awareness can develop. It also contributes to laterality, directionality and spatial awareness. Touch is used to discover the properties of the immediate surroundings and to identify objects by size, shape and feel (Lederman & Klatzky, 1993; Rosen, 2000; Guth & Rieser, 2000). Haptic perception results from a combination of tactile and proprioceptive inputs and is the main way by which people who are blind recognize objects (Rosen, 2000).

The children participating in the main study were observed on various occasions moving around their school without difficulty. They appeared to be utilizing haptic and proprioceptive information in a highly integrated manner and I wanted to find out more about this link. In a familiar place they would move around independently without having to rely on other people to guide them or help them because they 'knew' where everything was. Haptic touch clearly played an important part in developing this skill.

"I've done lots of touching and feeling around and slowly-slowly I learn where everything is...;" Shimon [TN5/ 5d/ ¶ 152] [15*]

"... most of the times I automatically know where to go ... because I know all the routes very well and I just look where I am going and feel with my hands on the walls and stuff ..." Judy [TN5/ 5d/ ¶ 174]

[15*] TN5: tree note 5: Other sensory modalities/ 5d: tactual perception/ ¶: paragraph

In a familiar place most of them knew what was coming next while walking by using a combination of the haptic and proprioceptive cues afforded by the indoor environment such as walls or door frames, steps going up or down, and changes in the texture of the floor surface from one room to another.

"So this chair is a red chair and is over here by this other red chair but the difference is this red chair feels different to that, because this is like plastic and this is not…" Ahab [TN5/ 5d/ ¶ 323]

"… I can remember how it feels like under my feet …… I kind of pictured … but with feel…like imagine me feeling the concrete on my feet …and then the grass… …" Bob [FN 15 / ¶ 164] [16*]

"…feel around that's what I always do, you are looking around I am feeling around" Bob [TN5/ 5d/ ¶ 275]

"…if you can feel the carpet in here that feels different to a carpet in another room" Alan [TN5/ 5d/ ¶ 180]

"*…if you are not sure where you are you just feel around, there are everywhere signs in Braille and landmarks for you to follow……" Hans* [TN5/ 5d/ ¶ 138]

"…I feel…you know I have different textures in my house, for example the doors are not the same they all have different textures and I know that the kitchen has a different door, the door feels different…" Shimon [TN5/ 5d/153 ¶]

I was keen to discover whether touch processes were the same in outdoor environments. When talking about moving about in a familiar outdoor environment, most reported feeling confident and were able to give detailed descriptions of routes

[16*] FN 15: Free note: 15 imagery – pictures / ¶: paragraph

they knew; emphasizing that they were using tactile and proprioceptive clues to comprehend the surrounding space.

"…well the area I live is not a rough area, I wouldn't go out in the dark, even though the dark makes no difference to me but something unpleasant is more likely to happen in the dark, like to get mugged or something …but apart from that … I feel confident walking around my area…" Bob [TN2/2b/¶309] [17*]

" I follow landmarks…I trail with my hands on the walls and stuff …if I sense that something is there then I'll put my hands in front of my face in case I walk into something … if there is a kerb or something…I follow that with my feet" Janet [TN8/8d/ ¶ 315] [18*]

Four of them however would feel more positive being in an open space if they were with somebody else.

"I don't really go much out on my own; the only place I go is to a local shop really next to my house, …I don't feel much confident really" Sal [TN7/7a/¶ 243] [19*]

Walking around safely involves keeping up to date with the continuous changes in self-to-object relationships that occur during locomotion. Also involves coordination with the locations of the objects and the hazards in the immediate environment. Safety and efficiency in exploring an area depends on accurate perception of the immediate surroundings. As one would expect, from the children's accounts it emerged that they were very aware that tactile and proprioceptive clues played an important role in perceiving their surroundings.

[17*] TN2: tree note 2: Best things – worst things about moving around /2b concerns about moving around / ¶: paragraph

[18*] TN 8: Tree Nodes8: Techniques they use/ 8d: Landmarks ¶: paragraph

[19*] TN7: Tree note7: Restricted opportunities to explore / 7a: concerns about unfamiliar spatial relationships / ¶: paragraph

The children reported using touch strategies that would have been taught in formal mobility lessons. They remarked that they would keep their hands in front of them to help them detect an unknown hazard or an unexpected object and they would walk and touch around cautiously in order to familiarize themselves with a new space. They would try to gradually learn the layout by maintaining contact with a surface such as a wall by trailing, counting paces, walking around slowly, and using what they learn to guide their actions. Six of them reported that trailing on a surface could facilitate their perception of the surrounding environment; in particular when looking for specific objects or when trying to maintain a straight line of travel.

"I would feel around like look and find things… like I would put my hands in front of me and feel what is there and also I would use the cane and if I haven't got my cane with me I would use something called trailing on the wall…to check how the wall feels and see if there is anything on the walls but I would be very careful though…" Ahab [TN8/8h/240¶] [20*].

"I would just stand there for a while and then methodically and slowly move around the room, if I was in a room, so that I could create an image in my mind of what the room is like, how big it is, what kind of furniture it's got" Harris [TN8/8L/¶266] [21*].

"if I walk into a room and no one is in there I'll have my hands in front of me just in case there is something there …because is better if there is something there to bump into your hand than into your head …" Bob [TN8/8g/¶277] [22*].

[20*] TN8: tree note 8: Techniques they use/8h: trailing on the wall / ¶: paragraph
[21*] TN8: tree note 8: Techniques they use/8L: walking around / ¶: paragraph
[22*] TN8: tree note 8: Techniques they use/8g: put my hands in frond of me / ¶: paragraph

"…when I first need to get to know a room I walk around a couple of times and feel what things are there and examine things" Alan [TN8/8L/¶ 181]

One of the children explained that in order to move successfully through an area one must know their starting point and facing direction and they must keep track of where they were within that area.

"…just walk around … I'll walk a little bit by little bit…and think that's where I have gone from there…and then I'll go back and do it again and when I've learnt that I'll do the next bit …and trail the walls and stuff so I'll know what is around me…" Janet [TN8/8L/¶309]

Another child emphasized that while walking through an unfamiliar space indoors, he would try to discover what objects were there and learn the object-to-object relationships, either by relying on information from self-movement (i.e. walking) or relying on touch information about external reference and landmarks (Guth and Rieser, 2000).

"…when I walk into a room I haven't been before I would probably start from the door, go left and feel on the walls, I might just bump onto things and I would know where things are…… where about they are in correlation to the door and then I would go back to the door and I would go right and I just slowly go round the room in a very methodical way just try to feel where things are and stuff, and then I would go to the middle of the room and stuff, because I don't want to get lost in the room, and I would have the door like a center point, so I would come back to the door and then go the other way around…" Harris [TN8/8L/ ¶ 241]

Although they all thought that tactile and proprioceptive information played an important part in perceiving their surroundings they also thought that information from kinaesthetic and tactile sensory sources were not always adequately informative, especially when navigating to destinations in unfamiliar outdoor environment. None of the children felt very confident about moving in an unknown outdoor environment and they would use touch to explore only if it was necessary and if they had uninterrupted access to that space. Anxieties about any unforeseen hazards that might be in their way in an unknown place outdoors were common.

"I always think that I might bump into something, that's why I always put my hands out" Lisa [TN7/7a/¶ 178]

"I would be very careful and I would like…… stop to see if there is like anything in the way or if there is anything around that I don't like; I would stop and check my surroundings and I would possibly do everything more slowly and more carefully" Ahab [TN7/7a/¶ 302]

"…I feel uneasy … I get nervous if I don't know where I am…… it can be dangerous or something…" Ahab [TN2/2b/¶ 296]

"…is better to be safe than regret, you don't know what might be there" Shimon [TN2/2b/¶ 229]

"…I would feel a lot more conscious because I could walk in to anything or fall down, I would be very worry to be in a place that I don't know" Harris [TN2/2b/¶ 268]

They would feel uneasy about the amount of people that might be around, the noise, the traffic and the general complexity of an unknown route. Their main concern would be that they might get lost or hurt themselves. Most of them reported that they would not navigate around in an outdoor unfamiliar space without the presence of other people (family, friends or teachers).

"Because sometimes it can feel that everybody is getting in your way…is not like they do it deliberately but they are getting in the way and they are nuisance… …it's like when you are outside in the summer and there lots of flies" Markus [TN2/2b/¶ 337]

"…I just get confused when there are many people around, I feel completely lost and I cannot concentrate on the route…" Hans [TN2/2b/¶ 168]

"I don't like the busy streets, it's noisy and it's annoying, all these people, you bump into everything and everyone" Sal [TN2/2b/¶ 230]

"…honestly no blind person wants to be in a place they don't know …they don't know what's going to happen, it could be a place that there are really violent people…they could walk a few steps forward and the next think they know they might fall down from some stairs or something…" Bob [TN2/2b/¶335]

"… generally what I do……I walk with my mum or my dog, when I am walking alone I go to places I know"   Janet [TN7/7a/¶ 313]

"I don't really go much out … I feel happier when I am indoors doing my own things …I don't feel much confident really" Judy [TN2/2b/¶ 184]

A key source of tactile and proprioceptive information when navigating in an outdoor space was the white cane. In a sense, the cane extended the reach and scope of children's touch. Children reported its importance in informing them of curbs, steps or unexpected hazards. Canes would also help them to detect the changes in the walking surface. Sliding the cane back and forth across the walking surface could create felt vibrations and sounds, which would help them, perceive the surface properties. Sometimes the cane was used to investigate the textures of surfaces (i.e. its hardness or the difference in texture between different floors).

"…when you got a cane is closer to the sight isn't it? Because then you can tell, you got a warning, what is coming up" Harris [TN8/8f/¶246] [23]*.

"…I wouldn't worry if there is a lamp post in front of me because my cane would catch that …I would try to use my cane properly …if you tap the cane against the floor surface you can tell what material is under your foot, is it a concrete or grass?" Bob [TN8/8f/¶341]

The use of cane also occasionally gave children unexpected contact.

"The worse thing is if you are walking ……and you trying your best like using a cane or trailing and stuff and you walk into someone…if you can't hear them…… or your cane hit someone…it really gets me annoyed because I mean you try your best to move around but then accidentally you are walking onto someone and…… its embarrassing" Harris [TN8/8f/¶171].

On the whole, all of the children reported being able to detect obstacles, stairs, step-downs or drop-offs while walking through tactual means.

"… if I am inside I'll trail along the wall, or if I know the route I won't bother using the wall, I will just walk straight down in the middle of the corridor, like in school … if I am outside I'll use my cane or I'll follow the edge of the road with my foot usually" Lisa [TN5/ 5d/ 367¶]

"I don't know if you have noticed this but in every set of stairs there is a strange thing on the carpet and so if I am walking along and I feel that strange thing on the carpet through my shoes then I know that means there are some stairs there …" Bob [TN5/ 5d/ 172¶]

[23]* TN8: tree note 8: Techniques they use/8f: navigation aid / ¶: paragraph

Haptic and proprioceptive senses provide key information about children's location in space, about self-to-object and object-to-object relationships. As blind children move about they are gathering information about surface characteristics, landmarks, shapes, sizes, obstacles and so on. Children's accounts and observations of their behaviours suggested that they were developing important and sophisticated strategies to make sense of space based upon proprioceptive and tactile information. Some of these were informal strategies that had been developed individually and others were more formal strategies that they had been fostered through their educational experiences.

> *"as with audition, a haptic awareness has to be fostered early within the life of the visually handicapped child"* (Spencer et al., 1989:183)

4.3.1.2. References to the auditory environment

Obviously audio information plays an important role in the development of spatial skill. It is "*the main channel for providing distal information"* (Spencer et al., 1989:179). People who are blind use reflected sound to avoid obstacles while walking. If objects create sounds, they also can use sound cues to locate them precisely (McGrath et al. 1999).

The children in the main study provided plenty of evidence of the importance of how auditory perception helps them comprehend the characteristics of the spatial world around them. They described how reflected sound provides indications of the size of an enclosed space.

"I'll probably say hello, hello...... and if it echoes back to me I'll know it's big…" Ahab [TN5/5B/ 5B1/242 ¶] [24*]

"…I can't tell how big in metres a room is by the echo but I can tell if its really big or medium sized or small depending on how much echoing there is" Bob [TN5/5B/ ¶ 73]

"…I don't know how to describe it but its sounds like a bigger space really than my classroom …" Judy [TN5/5B/ 5B1/5B1D/ ¶ 79] [25*]

"……if I've been in a room enough times I'll be able to tell ……by how much echo there is… and if there is lots of an echo that means that it is either a very big room or a smaller room with nothing in it" Lisa [TN5/5B/ 5B1/5B1D/ ¶ 68]

[24*] TN5: Tree note 5: Other sensory modalities/ 5B: Hearing, echo/ 5B1: Hearing indoors/ ¶: paragraph

[25*] TN5: Tree note 5: Other sensory modalities/ 5B: Hearing, echo/ 5B1: Hearing indoors/ 5B1D: size of a room/ ¶: paragraph

"… if you do that (he claps his hand) *there is no echo in here because is a small room, if you do this in the hall it's echoing, and also in here there is a carpet and that makes a difference …It doesn't echoes" Alan* [TN5/5B/ ¶ 77]

"…the dining hall echoes when it's empty, the math's room doesn't…and so that means it's got a high ceiling and is like longer and wider …" Janet [TN5/5B/ ¶ 65]

"…I can tell if a place is big or small……when I am talking my voice bounces back to me and it's kind of compact so I can tell this is narrow, is small but when I am in a big place my voice echoes…" Harris [TN5/5B/ 5B1/5B1D/ ¶ 75]

Children reported actively experimenting with the acoustic properties of their surroundings. For example one of the children stated that in a small room if he rotated around himself he could perceive the sound coming back of the walls directly to him.

"…sometimes a small room because the walls are so close you can often…… if you spin around…you make a sound you could hear …the sound coming back to you" Markus [TN5/5B/ 5B1/5B1D/¶ 46]

What is noteworthy is that five of the children spontaneously reported employing auditory cues in order to estimate the height of the ceiling. They thought that the ceiling was roughly three to four metres high because of the echo they could hear when they turned their head up towards the ceiling; emphasizing that if the ceiling was really high they would hear much more echo. Others utilized their residual vision (light perception), their logic and past experiences.

"…if I turn my head up …I can see the lights, and I know that you need a ladder to reach it" Sal [TN5/5E/ ¶ 80] [26*]

[26*] TN5: Tree note 5: Other sensory modalities/ 5E:use residual vision ¶: paragraph

"…I just knew that it was more than two metres …because I can reach two metres up in the air … even if I jump I can't reach it …if I turn my head up towards to the ceiling it sort of echoes so it must be quite high …… roughly four metres? …" Janet [TN8/8b/ ¶ 85] [27]*.

"…I can hear the same echo here as I can when I turn my head up…when I had my head up it just sounds the same… maybe a little bit more echo when I had my head up than when I had my head like normally how you would do …from that maybe I could say that its quite tall, maybe three to three and a half metres" Bob [TN5/5B/ ¶ 87]

When children were asked to compare the ceiling in the dining room with the ceiling in their classroom, most of them confidently answered correctly that the ceiling in the dining room was higher. They based their argument on the fact that it was a bigger room and there was much more echo in the dining room than in other classrooms even though there were many objects in the way.

"…well there is more echo in there, in the dining room, is to do with echo and the way sound rebounds off things" Markus [TN5/5b/5b1/¶ 99]

"……you get quite a lot of an echo if you walk in there …there are lots of tables in there and you still get quite a lot of an echo" Lisa [TN5/5b/ 5b1/¶ 88]

"I think the ceiling in the dining room is higher than the one in here…well its the echo again; when I am walking and I am talking my voice bounces around a lot … and if I turn my head up and talk the ceiling seems higher" Harris [TN5/5B/ ¶ 93]

[27]* TN8: tree note 8: Techniques they use/8b:based on their actual experiences / ¶: paragraph

The auditory sense also facilitated the comprehension of the characteristics of an outdoor environment. For example it helped to differentiate between a shop, a house and a big building

"…I can't see it but I can sense is there … when I am passing a big building I can sometimes feel the shadow of the building……also the sound of traffic… … sort of changes when you are coming up to a big building…… it sounds a bit more echoey" *Lisa* [TN5/5B/ 5B4/¶324] [28*]

"…I could tell the difference if I was passing a shop or a house, if I am walking past I could tell there is a shop because it would be busy, people would coming in and out, there would be shopping trolleys and stuff…" Harris [TN5/5B/ 5B2/5B2c/ ¶241] [29*]

"…if you are passing by a shop, possibly you'll hear noise and people going and coming" Hans [TN5/5B/ 5B2/5B2c/ ¶176]

"You can tell you are passing by a house or a shop ……you can hear a lot of people in a shop …" Shimon [TN5/5B/ 5B2/5B2c/ ¶269]

The sound of traffic helped indicate the location and orientation of a street; if it was a busy street or a side road. And the sound of a car would indicate its movement i.e. whether the car was approaching or moving away. Additionally, most of the children emphasized that when crossing a road, "listening carefully" was extremely important. However four of them underlined that although auditory cues were very important they were not always accurate and sometimes could be misleading, therefore they would only cross side roads without much traffic.

[28*] TN5: Tree note 5: Other sensory modalities/ 5B: Hearing, echo/ 5B4: "sense" objects in their present/ ¶: paragraph

[29*] TN5: Tree note 5: Other sensory modalities/ 5B: Hearing, echo/ 5B2: Hearing outdoors/ 5B2c: unfamiliar space/ ¶: paragraph

"…it would really help me like just listening to the traffic going past; I could tell if the traffic is residential…" Harris [TN5/5B/ 5B2/¶239]

"…it's a technique that lots of the blind do, you listen to the right and you listen to the left, and if there is no traffic from the left and no traffic from the right and sometimes you have to listen behind you, basically you have to listen everywhere and if you don't hear anything then probably is safe to cross, but you must be really careful" Ahab [TN5/5B/ 5B2/5B2B/ ¶264] [30*]

"… if there is not a pelican crossing, just look around and listen very carefully and then cross but I only crossed side roads which there is not much traffic on them" Hans [TN5/5B/ 5B2/5B2B/ ¶180]

"…if I misjudge something I might not heard a car until I am in the middle of the road and then I will feel very insecure because I know that a car is driving up the road …very good chance of hitting me…" Markus [TN5/5B/ 5B2/5B2B/ ¶392]

They would know if there were trees around because they could hear their leaves rustling in the wind. Five of them even said that they would be able to guess the size of a tree from its sound

"…if the leaves like…rustling in the wind maybe I'll be able to guess how close or far the sound is coming from …but I won't be able to tell accurately…maybe just to guess if is a really big tree or a small one" Bob [TN5/5B/ 5B2/5B2c/ ¶327]

They could also recognize if there were any animals around and identify what animals were by the way they would sound and smell. Most of them remarked that they could distinguish between bigger and smaller animals using auditory information.

[30*] TN5: Tree note 5: Other sensory modalities/ 5B: Hearing, echo/ 5B2: Hearing outdoors/ 5B2B: crossing the road/ ¶: paragraph

*"……a dog's bark sounds like bigger than a cat's miao, if you know what I mean …" Bob [*TN5/5b/ ¶ 137]

"…I would listen and I would smell; you can smell animals can't you? Or if there are any animals or people moving you can hear them, you can hear a cat and tell is a cat from the way she sounds, you don't have to see her do you?" Ahab [TN5/5B/ 5B2/5B2c/ ¶288]

"…I can tell by listening … I can tell if there are little children around by their voices and stuff … and if there is something like a dog I can tell by their bark … and I can tell if they are big or small dogs because bigger dogs …their bark is a bit lower than little ones" Judy [TN5/5B/ 5B2/5B2c/ ¶311]

Much of what the children said about their use of sound was predictable but as the discussion was unfolding, unprompted nine out of twelve expressed with clarity their ability to sense objects in their surrounding environment through non tactual means. They often described their ability to detect an obstacle as "sensing" that something was there. They reported experiencing a "feeling" that an object was present, but had great difficulty describing how they knew or sensed objects in their environment while not being able to see them. It was not easy for them to verbalize this skill and they would often hesitate or expressed bafflement.

"…I can sense that there is a wall in front of us… I can't see it but I actually can tell ……don't ask me how because I have no idea…" Lisa [TN5/5B/ 5B4/¶232]

Five of the children went on to describe their ability in relation to orientation to a new room. From their accounts it appears that the process involves more than a simple matter of detecting that an object is present; it also involves perceiving the object's nature and features such as its location, size and relationship to other objects.

"…I can usually sense if I am like near a wall or something, I can usually tell if it's a low down ceiling or something …" Bob[TN5/5B/ 5B4/¶49]

"……I can tell where things are……for example in here I can sense where the pool table is in relation to the chairs……" Bob [TN5/5B/ 5B4/¶74]

"…you can sense how big or small is something" Harris [TN5/5B/ 5B4/¶203]

Children often compared their ability to "sense" where everything was with the ability of sighted people to see. They explained that just as when sighted people come in to a room for the first time and build up an instantaneous impression of its layout, children who are blind develop an immediate "sense" of the room. They could "sense" whether they were entering a small or a large space and as they were walking through the room they developed a perception where objects or obstacles were.

"…you can sense how big a room is… it's like your body can see it within itself ……but you are not looking through your eyes ……its like inside you …" Lisa [TN5/5B/ 5B4/¶294]

"*…all I know is as soon as I pass into a room I have an idea of how big the room is, without having to do anything…"* Alan [TN5/5B/ 5B4/¶183]

"…its like you can tell that something is in front of you, you can't see it or anything… …you can just tell its there …I don't know how you do that it's just something you can do…" Janet [TN5/5B/ 5B4/¶265]

One of the children who was congenitally totally blind with no light perception, felt so strong about her ability to "sense" objects in her present that she wondered whether the explanation was that she was actually seeing the objects but it was simply that her brain didn't recognize sight.

"…I always wonder whether what I can sense in front of me is me being able to see it but my brain not being able to tell……my body not being able to tell my brain that I can see if that's make any sense to you" Lisa [TN5/5B/ 5B4/¶78]

Children reported that their ability to "sense" their surroundings without direct physical contact not only helped them to locate where objects were but also was an essential element in safe mobility. It helped them reacted to the present of objects and protected themselves from injury for example by being able to avoid a wall or a tree or a post when walking. From the children's accounts it seems that being able to identify where objects are in space is important for two main reasons:

- It leads to additional independence and
- It allows the possibility of interaction with the surroundings

"…is like if you are running around the gym and there is a wall coming up in front of you …somehow you just know its there so you know to turn before you crash into it …" Janet [TN5/5B/ 5B4/¶67]

"…if I sense that something is in frond of me then I'll put my hands in front of my face in case I walk into something" Janet [TN5/5B/ 5B4/¶315]

Children tended to describe this sense as a special ability that people who are blind have; they suggested that it is a 'feeling', or conversely a 'skill' or ability that they have but they didn't understand. Nevertheless they appeared to regard it as a natural way of perceiving their surroundings.

"I am able to tell without feeling that something is there…it's just something that all blind people are able to do … …" Bob [TN5/5B/ 5B4/¶322]

"…I don't know how you do that …… is like when…… if somebody is watching you, you can't see them but you know they are watching you sort of like

that…you know its there but you don't know how you know it" Janet [TN5/5B/ 5B4/¶265]

They sometimes also describe this ability as an additional sense

"…when I go in to a room even though I can't see it …its like a sixth sense… …its like this sense is telling me there is a wall in front of me or a table in front of me like there is now …or if there is something behind me…" Lisa [TN5/5B/ 5B4/¶74]

Even though, initially children would describe their ability to sense objects in their presence as an inherent and intuitive extra sense, further and deeper discussion on this phenomenon led to the emergent of new insights; unprompted, six children out of the twelve directly linked this ability with auditory cues and all of them mentioned sound and echo. For example one child described the process of detecting an opening in the following terms:

" …Something like a hole and there is nothing in the hole, is just something empty and its got like……something strange……you just sense that something is there, is like when you walk… when you just approaching the door your footsteps sounds a bit different sometimes, sounds a bit more echo" Alan[TN5/5B/ 5B4/¶143]

Remarkably two children reported that they could hear a 'very slight echo' off the wall in front of them even if when they themselves were making no reflecting noise.

"…I just stand perfectly still making no noise and I can still be able to tell the walls are there by…… its just … …I don't know some kind of echoes or something …… its like I can sense where the walls are" Helen [TN5/5B/ 5B4/¶297]

"…maybe I know that there is something in front of me because there is a very, very slight…… erm ……echo off the wall in front of me……you probably

wouldn't be able to hear it …… but I can because I can't actually see it" Lisa [TN5/5B/ 5B4/¶ 232]

Six of the students were convinced that their ability to detect objects or perceive object's features such as size or location was connected to sound and hearing even though they thought that they couldn't explain the process to me.

"… sometimes if it's a very small room I can sense the walls it's hard to explain… … I *just hear and everything seems very dull, the sound in the room is very dull, …when it's a small room there is no echo at all and things sound louder in a small room"* Markus [TN5/5B/ 5B4/¶ 83]

"…your footsteps sort of change… …the sound of your footsteps changes when you are coming up to something" Alan [TN5/5B/ 5B4/¶ 269]

"…I suppose it has something to do with sound but I don't know how it works… …I think its to do with being able to sense the difference between emptiness and not empty …and I think you can sort of tell… …this is not empty … …so you sort of know …" Janet [TN5/5B/ 5B4/¶ 67]

"……I can sense if there is something in front of me, I don't know how because I cannot see …like when I'm walking to school I can tell whether I am in line with the main entrance or not … I think... …the sound is different …" Bob [TN 5/5B /5B4/ ¶ 317]

Overall it appears that participating children were able to tell the difference between small rooms and large rooms or between low ceilings and high ceilings by echo and sound. It seems that the size of a room alone provides sufficient acoustic information to create an identifiable spatial area; which could be valuable if we consider that blind individuals cannot instantly understand or survey a wide area.

Using auditory cues they could ‘sense’ objects, obstacles or hazards at their present through non tactual means. Half of the children went on to link their ability to comprehend the characteristics and location of objects with auditory cues. In addition they thought that using auditory cues enable them to quickly survey the acoustic characteristics of a spatial area which could facilitate the perception of the surrounding space, indoors and outdoors. They thought that olfactory cues could also be important but not as valuable as tactile and auditory information.

“……obviously use your ears, blind people use their hearing much more than other people I think…… I guess they could use smell a little bit but not that much …” Bob [TN5/5b/ ¶ 364

4.3.2. Exploring relative locations in space and the relative size of objects in the spatial environment

4.3.2. 1. Exploring relative locations in space

As a way of getting the children to talk about the strategies they used to make sense of space, children were asked to describe their houses to friends that were supposed to visit them during the weekend so as to help them find their way around. These imaginary friends had never been to their houses before so the children had to be as accurate as they could with their descriptions. The objective here was to identify the information children thought was noteworthy during way finding and the key cues that allowed them to identify the location of objects in space. It was also hoped that the questions might also shed some light on the strategies they employ during their interaction with the features of the surrounding space as they move through it (Passini, Proulx, 1988). Most of the children tended to describe their houses in great detail. Large fixed architectural elements such as doors, doors frames, window frames, handrails, corridors, walls, stairs and furniture featured prominently in their reports, often linked to directional information.

"…past the radiator, past the door to the kitchen walk not directly across because if you walk directly across you will find a little box and this is the electricity box, so you go round that and go up the stairs, you will find a banister on the left hand side walk up there …the wall turn to a corner so go to the right, walk down you feel a door, this door is the bathroom, carry on walking and you will find another door …carry on walking and you will feel that the wall will turn to a right turn corner again and you will find a radiator go past the radiator, and go to the right again and you will feel some stairs, the banister, is the same banister as before and is on the left,

carry on walking there are about thirty steps in total, and just like the second floor if you walk across you will find a big room exactly the same size as the bedroom on the second floor… you carry on walking only a tiny bit and you find a door, this door is the boiler, go past that walk a little bit more and the wall turn around and you will see another room, this room is a spare room, go past that room and then you will find my bedroom, mine and my little brother's room, then walk past that room and straight in frond of you is my big brother's room…." Ahab [FN22 ¶ 223] [31]*.

"…as you enter the dining room to your right there is the fridge, next to it the radiator, in front of you there is a table and in front of the table there is a piano and to your left there is a dresser and in front of you and to your left there is a computer and then to the right of the piano there is a quite small kitchen …" Bob [TN 8/8e/8e1b / ¶ 180] [32]*

From their accounts it emerged that small cues and distinct parts of space also seemed important. Their descriptions included space features formed by the arrangement of things in space such as small gaps between carpets, slopes, mats under their feet and so on. In addition their descriptions also included sensory information, for example the smell from the dining room was an indication of its location.

"…if you are new here you can use your smell to find the dining room..." Bob [TN5/5b/ ¶ 364

*"… if you go to the end of the doorway there would be a small gap between the carpets…you can feel it … and if you turn right from there you would find the stairs…" Markus [*FN22 ¶ 254]

[31]* FN22: Free Node 22: description of a familiar place / ¶: paragraph

[32]* TN 8: Tree Node 8: Techniques they use/ 8e: cognitive maps/8e1 The layout of a space/ 8e1b construct a map¶: paragraph

"…when you come in to my house you will feel a wall with a box on it which is the alarm and you feel a mat on your feet, and then if you walk across the hallway you will find a door, that door takes you to the kitchen, you walk a bit more and you find a radiator…" Ahab [FN22 ¶ 223]

While describing their houses most of them reported a process in which they imagined themselves walking in it and feeling around.

"It's like I was there and I was showing you around, I pictured my house in my brain" Hans [FN15/ 146¶].

"It was like I was there in the house and going around it, is like an image of me in the house" Shimon [FN15/ 174¶]

"I can picture myself walking in the house, go from room to room…I can feel the wall … I can picture my self, feeling the wall …that is it really" Markus [FN15/ ¶ 259] .

In a familiar place like their home or school, children emphasized that they were moving around quickly and independently without the need to ask other people's help.

"I feel safe and I know where everything is" Sal [TN2/2a/ ¶ 155] [33]*.

"I walk around the whole house by myself nobody has to guide me or show me around" Shimon [TN2/2a/ ¶ 156]

"…the best thing …is that you can go anywhere you want and anywhere you like, independently…" Harris [TN2/2a/ ¶ 157]

"…you know where everything is and you can just get what you want by yourself, for example where is my Brailler? Is right there… I just go and get it and I don't have to ask anyone to find it for me" Alan [TN2/2a/ ¶ 159]

[33]* TN2: tree note 2: Best things-worse things about moving around /2a best things about moving around in a familiar place / ¶: paragraph

"… I can walk anywhere in the house and talking on the phone at the same time without thinking where I am going, I just know and I just remember where everything is…and it feels great…" Bob [TN2/2a/ ¶ 151]

Children were then asked about how they would help someone to find their way around in school, a familiar but much larger space than their home. They were asked firstly to describe their school in as much detail as they could and next they were asked to talk about routes to designated locations within the school building. Most of the children were able to describe their school in great detail as they did with their homes. Overall the descriptions provided of their school were equally rich and detailed.

"its an old school, you go from the main entrance and you've got various rooms to start, if you turn right you go down past the principal's office …when you turn left from the main entrance you've got the staff's kitchens and the main stairs and the map of Australia opposite, a big huge plastic map… at the end of that corridor turn right, you've got two languages rooms and the gym…if you go back up the corridor and turn left and go straight ahead you've got the library …it's a bit like a maze its like a three way junction … if you go straight ahead from the main corridor where the staff room is you've got the math's department … there are hundred of different routes to go everywhere …there is never just one route… up on the top corridor you've got some of the English rooms, and then you've got the mobility and the music department … and then if you go back all the way and turn right you've got the computing corridor with all the computers…go directly along that corridor, go down the steps and turn left…you've got all of the cookery rooms … and then you keep going along that corridor and you come to a big open space and there is the

drama and the art room … I don't think I've miss anything, but it's a bit difficult to describe it when you are not actually going around it". Lisa [FN 22¶ 190]

The children described the routes to various locations within the school building giving precise and correct directions. They seemed to have memorized details of the environment such as the layout and the different routes within it mostly by considering the surrounding landmarks but also mentioning details and distinct parts of space as they did with their homes.

"…you've got this sign on the wall and the bumpy floor when you approach the steps…" Judy [FN 22¶253]

"……then if you keep on going along the main corridor …the carpet changes… you go down that and then there are some steps; when you get to the end of that you get a different surface and to your right there is like a cooking corridor and you go down some stairs through there…." Bob [TN 8/8e/8e1 / ¶ 208] [34]*

"…follow the wall down to the first classroom door then turn right there is a post on your way, a few glass windows and doors but you ignore… and if you keep going straight down those eventually you come to another set of double doors at which point if you lying up against the centre at those double doors you can walk straight up and there will be another set of double doors which is the dinning room". Markus [FN 22¶136]

"…if you turn left go up the steps, enter the double doors turn right, walk through the math's corridor and carry on going up there, when you pass the staff's room there is the main stairs go up the stairs turn left and there you are, that's the

[34]* TN 8: Tree Node 8: Techniques they use/ 8e: cognitive maps/8e1 The layout of a space ¶: paragraph

music corridor… you can follow the music when a lesson is going on …" Helen [FN 22¶207]

While describing their schools children reported a process in which they memorized the layout and the different routes within their school building.

"I've memorized what is around me and I've created like a picture in my mind of the things that is around" Hans [TN 8/8e/8e1 /8e1b ¶ 198]

"I just know where everything is, I can see where everything is in my mind" Alan [TN 8/8e/8e1 /8e1a ¶ 168] [35*]

"They showed me around so I just tried to memorize where everything was but it took me some time and eventually I did it;…now I know the place very well; I don't need to read the Braille or anything; I know the shape of the school, I know the corridors, …I don't have to follow the walls I can go to my class straight away; I just picture the route in my head and I follow that" Hans [TN5/5F/ ¶ 134] [36*]

The children often reported that it was important to keep everything in order, group things together and keep belongings in predictable places.

"…if I am untidy and everything is everywhere I am usually not being able to find a thing … …I usually put things in drawers, group things together……" Lisa [TN5/5F/ ¶ 146]

In addition five of them reported that counting paces or steps would help to learn a new route or a new place.

[35*] TN 8: Tree Node 8: Techniques they use/ 8e: cognitive maps/8e1 The layout of a space/ 8e1a automatically know ¶: paragraph
[36*] TN5: tree note 5: Other sensory modalities/ 5F Memorizing / ¶: paragraph

"……if I am in a new place I sometimes count paces just to help me learn the route……" Helen [TN8/8C/ ¶ 373] [37]*

"…I can tell if I go so many steps and then turn and then go straight I am in the right place" Sal [TN 8/8c¶ 180]

However one of the children thought that counting paces or steps, was a technique that children who are blind never use.

"Oh, no I never do that…(count paces) *even though lots of mobility teachers say that its a good thing to do, I don't do that and to be honest I don't know any blind people who do that, I usually tell by feel or by sound or smell and things like that …"* Bob [TN8/8C/ ¶ 105]

The children's descriptions of their homes and schools seemed to suggest that in order to find their way around or to locate an object in space, they utilized temporary information such as: auditory clues (i.e. listening to music can be an indication of the music corridor's location), tactile clues (a small gap between the carpets can be use to locate an object) and olfactory clues (i.e. smell can be an indication of the dining room's location).

Children' accounts also suggested that they predominantly utilized permanent landmarks which helped them to locate elements in the surrounding space and find their way. Most of them stated that they were taking into consideration flights of steps or changes in floor's surface and they were making reference to permanent fixtures such as door frames and window ledges while navigating.

"I never calculate with things that can be moved, if the bin is stuck down in the floor then I can calculate with it but if someone moves it , that will confused me,

[37]* TN 8: Tree Node 8: Techniques they use/ 8c: counting, measuring¶: paragraph

so I don't pay any attention to things that are not permanent there" Markus [TN8/8d¶ 198]

However seven of the children reported that sudden changes to familiar layouts were very unsettling, and the discovery of unexpected landmarks could easily confuse their sense of location in space.

"…I was walking and I used to know the route really well and suddenly there was a big bin in front of me and I walked straight in to it and I thought where am I going am I lost or something? …" Harris [TN 8/8d¶ 243]

Five of them reported that missing a landmark or encountering an unexpected one was sometimes useful in that it gave an indication that they were not going in the right direction. In these situations they would try to update their location and get back to the known route, while adjusting their way of thinking to include the new things that had appeared in their way.

"…for example if I want to go at the other end I'll cross the campus… I'll pass the first tree then I'll pass the second one and I know there is a third one coming so if I miss the third one I know I am not in the right direction…"Helen [TN 8/8d¶199]

"…I have like landmarks ……and if anything new suddenly turns up I adjust my way of thinking to include that" Lisa [TN8/8C/ ¶ 98]

What is also noteworthy is that they emphasized that was valuable for them to be active participants in their world and learn about their environment by themselves and not just passively receive stimulation from their teachers, parents or other adults; therefore raising the importance of active exploration of their environment without direct adult intervention.

"…my parents let me bump into things and it might sound really cruel but ……I learn to work things out … its like you say to any young child don't touch that its hot but because they have no concept of what hot is they touch it anyway and the only way they are going to learn is to do touch it because then they realize its not pleasant" Markus [FN 20 / 436¶] [38*]

"… you just try and do things …they taught us how to use a cane and how to cross a road and how to make a cup of tea and things like that; we do that with my mobility teacher; but how I remember things and how I realize where I am and what is around me is entirely up to me to figure it out; I personally have this map I told you about, I actually have the directions store in my brain…I would just say that you should try different methods: one smell, two look, three……check what method is actually good for you…" Ahab [FN 20 / 316¶]

[38*] FN20: Free Nodes20: suggestions for other blind children / ¶: paragraph

4.3.2.2. Exploring the relative size of objects in the spatial environment

In order to examine what strategies the participant children employed to perceive relative sizes in their environment were asked to estimate the approximate size of familiar and unfamiliar areas and objects. The theme of relative size was chosen since:

> *"good concepts of size, like those of shape and mass, likely influence spatial orientation during mobility. For example, knowledge that buses are almost always larger than cars, or that two-lane streets are narrower than four-lane streets, can be useful in travel"* (Long & Hill, 1997:45).

The participating children were asked to compare their classroom with the dining room at school and decide which one they thought was bigger and why. All of them said with assurance that they had walked around both rooms and they knew that the dining room was bigger; also the dining room could accommodate much more people and echoed much more than the other classes. The responses commonly referred to the acoustic qualities of rooms described earlier.

"…I've walked from end to end in both rooms and is just further to walk in the dinning hall than my class… also the dinning hall echoes when it's empty, the math's room doesn't…and so that means it's got a high ceiling and is like longer and wider …" Janet [TN3/3b/65 ¶] [39*]

But children also used the functional aspects of the room when making their judgements:

"There are lots of children and there are more tables in there, in our class we are just six students, and it's echoing more because is a much bigger room" Sal [TN3/3b/68 ¶]

[39*] TN3: Tree note 3: Common knowledge – logical explanations/ 3b: Logical explanations about spatial relationships/ ¶: paragraph

"I can't imagine about seven or eight of those big tables fitting in my class room, the dining room looks bigger to me" Helen [TN3/3b/70 ¶]

The children were asked to estimate the approximate height of their house from the ground to the top of the roof. They thought that this was not an easy question to answer. However, through thinking aloud most of them gave what they thought was a logical answer based on previous experiences. Markus for example, thought that his house must be around nine metres high because is a three storey house and he estimated that every storey would be about 3 metres so he multiplied three by three. He based his answer on his experience of the house.

"…well it was an estimate…based on my experience of the house, I thought of myself standing on my bed and touching the ceiling" Markus [TN3/3b/¶ 117]

"… our house is big and I imagine my self measuring it with a metre stick on a ladder, and I thought maybe two of my selves can reach the ceiling and we have two floors so I thought six seven metres" Sal [TN8/8k/ ¶ 98] [40]*.

Ahab compared the height of his house with the height of his classroom door.

"*I think is 10 metres, because I looked at this room's door…remember we estimated it was two meters tall and then I imagine my house and I thought that my house is much more bigger……it's a three storey house……If the door is two meters tall plus the wall up to the ceiling…yeah I think 10, 11, metres?"* Ahab [TN8/8J/ ¶ 115] [41]*.

Judy instead, tried to estimate the height of her house by utilizing her residual vision (light perception) and general knowledge that *"the ceiling isn't that far above*

[40]* TN8: tree note 8: Techniques they use/8k: Self-reference frameworks / ¶: paragraph

[41]* TN8: tree note 8: Techniques they use/8J: references to external items / ¶: paragraph

the door" [TN3/3a/97¶] [42]*; and she multiplied by two since she was living in a two storey house.

Alan was not sure about the height of his house and he did not want to guess; he remarked that based on his experience the ceiling was not always the same height in every room therefore he could not estimate the approximate height of the house.

"…once when I was at home I took a stepladder, I wanted to put some pictures on the wall, pictures that I draw, and I was climbing up the ladder, it was in the passage, I climbed up the ladder, and I climbed up to the top step and I could reach the ceiling if I put my hand up, but then I took the ladder in my bedroom because that's where I wanted to put the other picture and then I climbed up to the top step and the ceiling was not there, it was higher" Alan [TN8/8b/91¶]

Children were then asked to estimate the approximate height of the tallest building in their town. Initially they typically said that they couldn't do it. However after some thought, they generally based their answers on logic and they used their experience of their own houses, visits to buildings that they perceived as big such as shopping malls but they also drew upon their general knowledge including knowledge gained from media such as TV.

"Ten times bigger than my house… Because it's a very big town and it's got so much shops and so much buildings, and I've been to some very big shops and there must be very big buildings" Shimon[TN8/8b/118¶]

" Whoa… …maybe six or seven times my house or even more, its got lots of shops and escalators going up and coming down" Sal [TN8/8b/102¶]

[42]* TN3: Tree note 3: Common knowledge – logical explanations/ 3a: common knowledge/ ¶: paragraph

"……I imagine they have a few blocks of offices, museums, I've been to a museum with five floors… big shopping centers… some have basements and all that don't they?… so if we say that a three story house is ten metres tall then it must be around hundred metres…" Bob [TN3/3b/ ¶ 113]

As might be expected, deductive reasoning and logical explanations based on general knowledge sometimes revealed gaps and misconceptions. .

"I don't know …I would have thought that the tallest building would be about 14 to 16 metres roughly in my town but in a big city, for example in London the tallest building might be 20 to 25 metres I would imagine…but in America for example they have very big buildings, maybe 10 times those we have in England … like the world trade center …that was a very big building" Lisa [TN3/3C/¶ 110] [43*]

What is interesting about this quote is the reference to the World Trade Centre which had featured prominently in media reports following its destruction.

In order to explore further what strategies the children employed when estimating the approximate sizes of objects, they were asked to participate in a card came. They were given tactile cards with different animals in Braille (goldfish, blackbird, cat, dog, horse and elephant) and they were asked after reading all the cards to put them in a row from the smallest to the biggest according to the size of the animals in real life. They were also given tactile cards with different means of transport (bicycle, motorbike, car, bus, airplane and cruise ship) and the same procedure was followed. It was explained to them that they should verbally elucidated what they were thinking while working out the tasks. Most children's first reaction was that this was a difficult task because it was not easy to imagine space and size.

[43*] TN3: Tree note 3: Common knowledge – logical explanations / 3C: Misconceptions / ¶: paragraph

“It’s hard to imagine space and size” [FN15/ ¶ 159] Markus

*“Ok, it’s hard to do this but I will try…”*Ahab [TN7/7a/¶ 146]

“…I’ve no idea which one is the smallest and which one is the biggest…” Shimon [TN7/7a/¶ 143]

“Well…this is hard… I am not sure …” Alan [TN7/7a/¶ 129]

Even though most of the children were reluctant at first to perform the tasks with the cards later on most of them seem to enjoy it.

“I love this, can we please continue a bit more, I prefer being here than going back to the lesson” Lisa [FN 18/ 136¶] [44*]

The following table summarizes the findings from the card game:

Table 1

Tactile cards with animals		***Tactile cards with means of transportation***
Correct order: goldfish, blackbird, cat, dog, horse and elephant		***Correct order:*** bicycle, motorbike, car, bus, airplane, cruise ship
Children’s answers:		
Markus:	goldfish, blackbird, cat, dog, horse and elephant ***Correct***	bicycle, motorbike, car, bus, airplane, cruise ship ***Correct***
Ahab:	goldfish, blackbird, cat, dog, horse and elephant ***Correct***	bicycle, car, motorbike, bus, cruise ship and aeroplane. ***(2 errors)***
Harris:	goldfish, blackbird, cat, dog, horse and elephant ***Correct***	bicycle, motorbike, car, bus, airplane, cruise ship ***Correct***
Hans:	goldfish, cat, blackbird, dog, horse, elephant ***(1 error)***	bicycle, motorbike, car, bus, cruise ship and aeroplane ***(1 error)***
Alan:	goldfish, blackbird, cat,	bicycle, motorbike, car, bus, airplane,

[44*] FN18: Free Nodes: positive feelings / ¶: paragraph

	dog, horse and elephant ***Correct***	cruise ship ***Correct***
Shimon:	goldfish, blackbird, cat, dog, horse and elephant ***Correct***	Bicycle, car, bus, motorbike, cruise ship, airplane ***(3 errors)***
Sal:	goldfish, cat, blackbird, dog, horse, elephant ***(1 error)***	bicycle, motorbike, car, bus, airplane, cruise ship ***Correct***
Bob:	goldfish, blackbird, cat, dog, horse and elephant ***Correct***	bicycle, motorbike, car, bus, airplane, cruise ship ***Correct***
Lisa:	goldfish, blackbird, cat, dog, horse and elephant ***Correct***	bicycle, motorbike, car, bus, airplane, cruise ship ***Correct***
Helen:	goldfish, blackbird, cat, dog, horse and elephant ***Correct***	bicycle, motorbike, car, bus, airplane, cruise ship ***Correct***
Judy:	blackbird, goldfish, cat, dog, horse and elephant ***Not correct (1 error)***	bicycle, motorbike, car, bus, airplane, cruise ship ***Correct***
Janet:	goldfish, blackbird, cat, dog, horse and elephant ***Correct***	bicycle, motorbike, car, bus, airplane, cruise ship ***Correct***

Nine children out of twelve put the cards of the animals in the correct order and three children made one error. In a similar way, nine children put the tactile cards with the different means of transport in the correct order and three children made one, two and three errors respectively. Overall it seems that children were likely to have more familiarity with the size of animals than with the size of vehicles. However what is more significant than the accuracy of the results is the explanations given by the children.

For example Alan put the cards of the animals in the correct order explaining that "*…it's just general knowledge about animals, the descriptions in books and things, and I also have a cat, I've ridden a horse before and I can hear the blackbirds in my back yard and they sound like small animals*" [TN3/3a/126¶]. Shimon also explained that "*…some of them I felt and for others I heard on TV or my mum told me and I also read"* [TN3/3d/137¶] [45]*.

Markus also placed the cards of the animals in the correct order saying that he tried to 'picture' some of the animals that he was familiar with. Explaining further he said that he could imagine himself feeling some of the animals because he felt them before thus he knew how big they were; he tried to ride a horse once and he didn't like the height so he knew it was a big animal; and he knew that blackbirds are quite small animals by the way they sound. As he stated *"I can hear them (the blackbirds) singing in the morning and they have got a high-pitched sound"* [TN5/ 5b/ ¶ 181] [46]*. Finally he thought that the elephant was the biggest animal because other people "*often said that".*

Another child, Sal, thought that the goldfish was the smallest because *"…fishes are not big if they were big they wouldn't fit in the water tank..."* [TN3/3C/¶128]*;* he thought that next was the cat because he had one and third the blackbird even though he was not sure but he believed that *"…birds are not that big… if the blackbird was too big maybe it wouldn't be able to fly…"*[TN3/3C/¶130]. He knew that next was the dog because he felt dogs before and then the horse because he rode one. As for the elephant he knew it was the biggest animal because he had *"read that".*

Likewise, Ahab thought that the goldfish was the smallest because *"…it can fit in a fishing net can't it?", "…and…my uncle has one goldfish in his office in a small tank…"* also *"…unlike a whale is very, very small because I heard that a whale needs*

[45]* TN3: Tree note 3: Common knowledge – logical explanations / 3d: others said that / ¶: paragraph
[46]* TN5: tree note 5: Other sensory modalities/ 5b: hearing-echo / ¶: paragraph

lots of goldfishes to fill it up …" [TN3/3d/154¶] . Next he put the blackbird clarifying that*"…is like……a bird and in order for them to fly they have to be quite small …";* he knew that next was the cat because he felt cats before and then came the dog *"…the reason I put the dog next is because the dog is chasing the cat so it must be in the same category and a bit bigger…"* [TN3/3b/152¶]; as for the elephant *"…I heard people saying how big it is and how heavy it is and I also heard it on TV"* [TN3/3d/156¶].

Bob seemed to be using logic and deductions from previous experiences including auditory cues. For example, he though that blackbirds *"… have to be small enough in order to be able to fly…and also…I was just thinking depending of how low they were you might be able to like to get an idea maybe of how big their wings are …I mean I know that the birds fly very high but even when like birds are flown very low I never heard their wings flapping really big…they sound really small if you know what I mean …like when an elephant makes a noise it sounds much louder and it sounds like its from a big animal"* [TN5/ 5b/ ¶ 135]

Lisa as well remarked that birds have to be lightweight in order to be able to fly, therefore must be smaller than other animals but bigger than goldfishes because she owned a goldfish and she knew it was very small.

Janet thought that the smallest was the goldfish because *"…it can be eaten by a bird, so that means a bird is bigger than a fish …"* and *"… it's in lots of books and stuff…"* [TN3/3b/143¶].

Judy however thought that the smallest animal was the blackbird because it has to fly and then was the goldfish because she heard that *"goldfishes are quite small…"*

Finally many of them thought that the elephant was the biggest one because that was general knowledge.

"…an elephant it's one of the biggest mammals that's evident because everyone knows that or they should do, its biology and I love biology…" Helen [TN3/3a/118¶]

"…everybody knows that elephants are very big animals" Judy [TN3/3a/146¶]

Children were then asked to do the same with means of transport (bicycle, motorbike, car, bus, airplane and cruise ship) and the same procedure was followed. Most of them put the cards in the correct order. All of them thought that the bicycle was the smallest because only one person would be carried on it and most had either ridden a bicycle or a tricycle before or they had felt siblings' and friends' bicycles.

"Because my sister's bike is small…" Alan [TN8/8b/131¶]

"…I've ridden a tricycle before so I know how big it is, not very big really…" Markus [TN8/8b/193¶]

"I've got a bike … and my friend's mum has got a motorbike," Helen [TN8/8b/124¶]

"first is the bicycle … it's a lot narrower than a motorbike because I've seen a motorbike, you know I felt one, and I've ridden a bicycle, a motorbike is smaller than a car …you could only fit……like…… only two people on a motorbike, and only one person on a bicycle…" Janet [TN8/8b/149¶]

Most of them thought that next was the motorbike because it carries fewer passengers compared to the other vehicles and is like a bicycle with an engine.

"I think is the motorbike because is like a bicycle but is bigger and …it's got an engine…" Sal [TN3/3b/204¶]

"…the motorbike carries fewer passengers than a car so it must be smaller, the car it's got doors, it's got roof so it's bigger and is a fast vehicle and it carries more people, …" Alan [TN3/3b/131¶]

"…I pictured a motorbike as a bicycle with an engine, so that goes second because it won't be much bigger than a bicycle…" Markus [FN15/ ¶ 205]

Two of the children however thought that motorbikes were bigger than cars or buses. They came to that conclusion because of the way motorbikes sound.

"I've heard them…they are so loud…they must be bigger than cars, cars sound smaller to me" Ahab [TN3/3c/169¶]

"…I know that a car is bigger than a bike and I know that a bus must be bigger than a car because the bus fit in more people and I know that a motorbike is bigger than a car or a bus because it sounds bigger…" Shimon [TN3/3c/144¶]

They knew that a car compared to a bus was smaller since many of them would use the bus everyday to school. They explained that a bus would carry more passengers than a car and if it was empty they could hear a lot of echo in it. They also emphasized that a bus is smaller than an airplane; and even though both vehicles carry many people; they reasoned that an airplane has bigger engines and big wings and might carry more people so is bigger than a bus.

"…a bus is obviously bigger than a car……I go on a bus every morning to school and every afternoon when I come home and…it has a lot more people on it and if the bus is empty I can hear a lot of echo where as in a car I can't…" Markus [TN8/8b/ ¶ 207]

"…next is the bus…a bus is a lot longer than a car and is a bit wider, its engine is bigger and its a lot heavier, and I think it might have more wheels…" Lisa [TN3/3b/134¶]

"…the bus is bigger than a car because is supposed to curry lots of passengers, and I put the airplane fifth because it supposes to carry more people than a bus …" Alan [TN3/3b/132¶]

Almost all of them had trouble figuring out whether the airplane or the cruise ship was bigger. Although some of them had travelled by both means of transport before, they had never really had opportunities to explore them. Subsequently they tried to give what they thought was a logical explanation. Nine of them decided that the airplane was smaller because: a) it has to fly; b) the cruise ship is bigger because more people usually stay on it and for longer periods of times, c) The airplane is quicker so it doesn't matter if it's smaller, and d) that's what they heard.

"…Well because a plane has got to fly…then surely if it were too big it wouldn't be able to fly properly" [TN3/3c/¶ 211] Markus

"…The cruise ship is the biggest because my mates told me that a cruise ship is really big, they travelled with it" Sal [TN3/3d/204¶]

"…the biggest would be the cruise ship because you are on it for a longer time, they have to store lots of food, you've got to have bedrooms, because everybody would be sleeping there, you've got things like gyms, swimming pools and stuff like that …is almost like a hotel, so obviously is got to be very big …" Bob [TN3/3b/ ¶ 142].

"…I'll imagine… an airplane is massive …but the cruise ship must be bigger … because lots of people can stay on a cruise ship for ages …" Helen [TN3/3b/ ¶ 124].

"…the ship takes much more time to travel from one place to the other, but the plane is quicker so it doesn't matter if it's smaller because it can go somewhere return back take more passengers and go again and the ship would still travelling… the ship must take as many as possible in the first time…" Alan [TN3/3c/ ¶ 131].

Three of them however thought that the airplane was bigger than the cruise ship. They based their answer on personal past experience, on information from external sources and on what they thought was a logical explanation. For example Hans had travelled by airplane and remembered that the plane was very big. Ahab heard other people saying that a plane is very big compared to other vehicles. And Shimon thought that the airplane had to be the biggest of all because it can *"travel to the end of the world".*

"…the biggest one is the airplane, because I've travelled by plane and is huge; and I know that because I've seen all these when I was able to see" Hans [TN8/8b/117¶]

"…I never seen or felt a ferry or a cruise ship or a plane before but I've heard people saying you know that a plane is very big and holds lots of passengers" Ahab [TN3/3d/ ¶ 171]

"… I put the plane last because people travel to the end of the world with it…… so it must be very big…… with the cruise ship you can only cross the oceans" Shimon [TN3/3c/ ¶ 143]

The objective of the above questions was to examine if the children had awareness of the relative sizes of objects that they probably had never actually explored in their entirety and to examine the strategies they employ in order to estimate their approximate sizes. Overall it appears that they often used cognitive abilities such as logic, deductive reasoning and memory to acquire spatial information and negotiate spatial relationships. They used information from external sources such as books, media or information as explained to them through visual perceptions by other people or sources (Spencer et al., 1989). They relied on their memory relating their current spatial experiences to the previous ones to guide their actions; constantly trying to gather and remember new information and comparing it with old information in order to make new connections. The knowledge of basic concepts such as size, shape or location, and concrete experiences from everyday life activities as well as analogies seems to facilitate the perception of the surrounding world.

4.3.3 Developing directional strategies and children's explanations concerning the content of their cognitive images of spatial events

4.3.3.1. Developing directional strategies

During the observation period (prior to the formal interviews and the pointing tasks) the children were asked in an informal way to describe various routes to designated locations and to guide me along the same routes saying that I wanted their help to find my way around their school. Some of the routes were short and easy to follow and others were long and difficult to follow with lots of turns, changes of direction and/or changes of floors.

All the children were able to describe the various routes, supplying correct and precise directions, and they could also guide me to the destination I wanted to go. However according to Bigelow, (1996) route knowledge does not necessarily go beyond the information that is available during navigation (i.e. the traveller relies upon the sensory cues and landmarks available while navigating). Thus route knowledge does not imply a holistic understanding of the relative positions of locations or spatial layout even in familiar environments (Golledge et al., 1992). Conversely, she argues, knowledge of Euclidean directions (straight-line directions) between locations is based on the knowledge of the overall layout of the surrounding familiar space (Bigelow, 1996).

Therefore I wanted to explore the children's holistic understanding of familiar space by asking them to point to specific locations in and around their school. I based the pointing tasks on the routes that the children had already described to me and accompanied me along, so I was certain of the children's route knowledge. I developed an itinerary that linked up routes with which they were familiar, combining routes that were short and easy to follow with ones that were long and complex. The pointing tasks were different for each school but the children from the same school performed the same tasks.

For the pointing task itself, the children were asked to imagine that they had a magic bow and arrow that could shoot through walls. The arrow had a message on it and they had to send the message to various locations as instructed. They were asked to point in the direction they would shoot the arrow to reach the next location.

At various stages on the itinerary, the children were asked to "*shoot the magic bow*" from one location to another. After each pointing task they were asked to explain why they had pointed in that particular direction and then they walked the section with me. At selected destinations the children were asked to "*shoot the magic bow*" back to the previous starting point and explain their reasoning. The following tables summarize the selected locations for the pointing tasks for each school:

Selected routes for school A1:

Table 2

From the medical room to the science laboratory	Same floor
From the medical room to the entrance of the school	Same floor
From the medical room to the English's classroom	Same floor
From the science laboratory to the mathematics' classroom	Same floor
From the English classroom to the science laboratory	Same floor
From the entrance of the school to the mathematics' classroom	Same floor
From the medical room to the Art classroom	Different floor
From the Art classroom to the medical room	Different floor
From the Mathematics classroom to the cookery room	Different floor
From the Art classroom to the science laboratory	Different floor
From the Art classroom to the dining hall	Different floor
From the science laboratory to the Art classroom	Different floor

Selected locations for school A2

Table 3

From the medical room to the entrance of the school	Same floor
From the medical room to the dining hall	Same floor
From the medical room to the office	Same floor
From the dining hall to the medical room	Same floor
From the office to the entrance of the school	Same floor
From the office to the music class	Same floor
From the medical room to their classroom	Different floor
From the office to their classroom	Different Floor
From their classroom to the dining hall	Different Floor
From their classroom to the entrance of the school	Different Floor
From the Dining hall to the library	Different Floor
From the Dining hall to their classroom	Different Floor

Selected locations for school B

Table 4

From the leisure block to the hall of residence	Outdoor task.
From the hall of residence to the leisure block	Outdoor task
From the leisure block to the main entrance of the school	Outdoor task
From the main entrance to the hall of residence	Outdoor task
From the main entrance to the dining hall	Same floor
From the main entrance to the art classroom	Same floor
From art classroom to the dining hall	Same floor
From the art classroom to reception	Same floor
From reception to the music classroom	Different floor
From the music classroom to the dining hall	Different floor
From the music classroom to the art classroom	Different floor
From the art classroom to the music	Different floor

The main objective for the pointing activity was to discover if the children had developed a holistic understanding of the spatial relationships between locations in a familiar environment, independent of their knowledge of the actual routes between those locations, and to explore their explanations of how this understanding worked. In practice, the children were credited as pointing accurately if they pointed in the general direction of the target location. Errors generally resulted when, rather than pointing in the Euclidean direction, children pointed to the first part of the route that led to the destination. Errors were also assigned when children felt unable to complete the task.

The pointing tasks for the seven children in the first group (from school A1 and A2) were all indoor tasks. They involved pointing to six locations on the same floor and six locations on a different floor. Four children were able to point accurately to all the locations that were on the same floor as the starting point. Two children made one error and one child made two errors (see table 5).

All of them tended to think more carefully and take longer pauses when pointing to locations on a different floor. Only two of the children were able to point correctly to all six locations on a different floor, and one child pointed correctly only to one location that was on a different floor. The full results are presented in table 5.

The following table summarizes the findings from the pointing tasks from school A1 and school A2:

Table 5:

Children's names	***Same floor questions – six locations***	***Different floor questions – six locations***
	Number of locations pointed to correctly	***Number of locations pointed to correctly***
Markus	**6/6**	**5/6**
Ahab	**6/6**	**6/6**
Hans	**6/6**	**6/6**
Sal	**6/6**	**5/6**
Alan	**5/6**	**2/6**
Harris	**5/6**	**2/6**
Shimon	**4/6**	**1/6**

In addition to indoor pointing tasks, the second group of children from school B was asked to point in outdoor settings on the campus, this additional dimension to the task was possible because school B was residential and the children were very familiar with the layout of the large school campus. Four of the indoor tasks involved targets on the same floor as the starting point and four involved targets on a different floor.

Interestingly all the children completed correctly all the outdoor pointing tasks with no difficulty, however only one child pointed correctly to all four locations that were on the same floor as the starting point (see Table 6).

Not unexpectedly, the more changes in direction required to get from one location to another, the more difficult it was for many of the children to point in straight line directions to the location, especially when the locations were on a different floor.

Even so, one child was able to point correctly to three out of four locations on a different floor (see Table 6).

The following table summarizes the findings from the pointing tasks from school B:

Table 6

Children's names	***Outdoor space questions – four locations***	***Same floor questions – four locations***	***Different floor questions – four locations***
	Number of locations pointed to correctly	***Number of locations pointed to correctly***	***Number of locations pointed to correctly***
Bob	**4/4**	**4/4**	**3/4**
Lisa	**4/4**	**2/4**	**2/4**
Helen	**4/4**	**3/4**	**2/4**
Judy	**4/4**	**3/4**	**1/4**
Janet	**4/4**	**2/4**	**1/4**

The activities before the pointing task initially seemed to suggest that children's spatial knowledge of their school was based on their knowledge of routes between places; since all of them could describe in detail the routes to various destinations and they could also actually guide me there. When they were asked what they were thinking while describing their school and the different routes, they sometimes replied that they were going through their 'mind map' of the school.

On the one hand, however, some of their explanations seemed to suggest that they were describing a linear and a sequential map rather than a holistic one.

"…remember when I talked about the mind map earlier…I just going through my map of the school…as I describe the school I try to picture myself walking in the school…I don't know how else can I describe that…" Markus [TN8/8e/ ¶ 449] [47]*.

"…I just pictured the route in my head and I just know that here I'll go left or here I'll go right but I do this automatically" Judy [FN15/ ¶ 174]

"…I personally have this map I told you about, I actually have the directions store in my brain; is like when you are in a car and you have this satellite navigation system it's a bit like that…" Ahab [TN8/8e/ ¶ 316]

On the other hand, when describing their school and the different routes through it children often seem to be suggesting that they were drawing on mental 'pictures' with a clear sense of one location in relation to another.

"… it's a bit difficult to put the whole school in your head which is what I had to do … again it's pictures made of objects and shapes and corridors…… and you try to figure out in your head where each thing is in relation to the other… its very complicated" Lisa [TN4/4b/¶ 270] [48]*

"I imagine the picture of the school …and I imagine the arrow going through the walls; I have a picture in my brain of the outside space, outside of this room, my map is actually displaying to me at the moment and I have a picture of the actual place that the arrow is going to go to, so that's how I work it out …" Ahab [TN 8/8e/8e1 / ¶ 335]

Their ability to point to locations that were in outdoor settings on the campus and to point to locations that were on the same floor as the starting point suggested that

[47]* TN8: tree note 8: Techniques they use/8e cognitive maps / ¶: paragraph

[48]* TN4: Tree note 4: Directions / 4B: Route directions / ¶: paragraph

most children possessed spatial understanding was not only based on their knowledge of the routes between familiar places but also on their knowledge of the familiar space taken as a whole. It is noteworthy that in the outdoor pointing tasks questions children gave quick answers without pausing, suggesting that the outdoor questions were easier to answer.

"…when you get in the school it's even harder to do this, from outside its less difficult …" Lisa [TN4/4a/¶ 249] [49*]

They had to think harder in order to answer the same floor questions and many of them rehearsed aloud the relationship between locations. Nevertheless most of them were able to give precise and detailed descriptions of the most efficient route to follow in order to reach a particular location.

"……we go straight, and then go past the stairs, turn right keep going, there are two ways to go there…" Lisa [TN4/4b/¶ 251]

"……I know the art corridor is near to the leisure block; the leisure block in relation to the art corridor is to the right … …" Bob [TN 8/8e/8e1 / ¶ 238]

However when the children were asked to point to locations on a different floor they would take longer pauses and they would think much more carefully.

"…… well it's a bit hard…the routes are not complicated I can go wherever I want very quickly but to work out which direction to point …when you've got like lots of turns …when you've got to go down stairs or upstairs… like I mean when the directions change …because if I turn around then you are not going to be on my left but on my right …so because of that change its kind of hard to work out whether to

[49*] TN4: Tree note 4: Directions / 4A: Euclidian line directions / ¶: paragraph

point left or right …outside I had to point either left, right, in front or behind… inside is more difficult ……" Bob [TN 8/8e/8e1 / ¶ 273]

"…if I don't have to go up the stairs and down the stairs and take lots of turnings, like left, right, left and so on its easier for me to point otherwise its complicated and its difficult to work out where to point" Helen [TN4/4a/¶ 287]

The long pauses sometimes ended with the right answers and with descriptions of the space which would indicate the comprehension of the overall layout.

*"……well…it's kind of in front and to the right …because if we keep going down to this corridor, you get to the IT corridor and at the end of that are the steps where you can go down to the other entrance which is the one which was in front of us and to our left when we were in the leisure block…… " Bob [*TN 8/8e/8e1 / ¶ 244]

In cases where children made pointing errors, rather than pointing directly to the requested destination they tended to point in the direction of the first part of the route they would need to take to get to the target place. Five out of twelve children who made such errors reported that they were thinking about the route to follow when they were trying to work out where to point.

"I was trying to imagine the route, which route I would take to go somewhere and I tried to figure out in which direction I should point" Harris [TN4/4b/¶ 312]

In cases where children were confused they chose not to point at all. It was noticeable that in cases where the children made errors in pointing back to the starting point, they could mentally reverse the route and they could actually guide me back along it on request.

Although children's spatial knowledge of their school might initially based on their knowledge of routes between places their overall performance on the pointing tasks suggested that lack of sight does not preclude them from developing a basic framework of Euclidean space. Indeed most of the children exhibited aspects of spatial understanding that seemed to be based on knowledge of the overall layout of the target space which had become independent of the sequential components of the routes through it.

"I was thinking that the arrow would go through that wall and carry on until it reaches the science class, and it should stop there; but if not it could end up to the lift, if I throw the arrow through there (he points to the route to follow) *it might hit someone in the corridor"* Ahab[TN4/4a/¶ 327]

Five children pointed correctly not only to all the requested outside locations and same floor locations, but also to almost all the locations that were on a different floor. These children demonstrated that their spatial knowledge of a familiar space which might be acquired in sequential components can be transferred in many cases to a simultaneous knowledge of the space as a whole.

When the *"spatially good"* children in the study were asked to verbalize what they were thinking when pointing to the target space and how they were able to figure out where to point, most stated that their knowledge, experience and familiarity of their surroundings helped them form a mental image of space which they could use as a frame of reference. Struggling to explain, five of them, referred to this as a "map" that they used subconsciously.

"…Right its…erm… not a physical map it's a mental, a mind map, it's in the mind and…… I think I must use it subconsciously… …I imagine in my head where everything is. I supposed everybody has one (map)…it's really hard to explain" Markus [TN8/8e/ ¶ 286]

"I just think I want to go there and I go …I just walk there …I suppose there must be a plan or a map …in my head because I know if I go forward and turn right I am in that room …but I don't actually think of that … …" Janet [TN 8/8e/ ¶ 157].

"I have like a map of the school in my head and that helps me…it's like the classes and different corridors and they all linked together, it's the school as it is, shapes and colours, things that I see and things that I feel" Hans [TN8/8e/ ¶ 218]

All the children tended to think very carefully and take long pauses when pointing in straight line directions to locations on different floors. However five of the *"spatially good"* that pointed almost correctly to all locations would point only after verbalizing which room was on either side of them, or which room was above if they were on the ground floor, or which room was below if they were on the first floor. In addition they would use landmarks to align their bodies in order to point in straight line direction toward the designated destination. Thus not only indicating that they had an overall awareness of the surrounding familiar space but also they were able to do orientation checks.

"This corridor is above the corridor to the science lab so I would just point down that way" Markus [TN4/4a/ ¶ 467].

*"……the corridor below the music corridor is next to the smoking zone so its kind of in front of the reception its …pretty much straight in front… but there are obviously things in the way…"*Bob [TN 4/4a / ¶ 226]

Overall it seemed that some children had moved from a reliance on egocentric orientation to a more abstract understanding of space. They utilized a number of different strategies to find their way around and to orient themselves in the surrounding space and they appeared to vary between the use of self-referent orientation strategies and external coding strategies depending on the nature of the problem they had to solve (Millar, 1994).

4.3.3.2 Children's explanations concerning the content of their cognitive images of spatial events

Interestingly most of the children used terms such as "image", "picture" and "map", to describe their holistic spatial understanding and they suggested that tactile, auditory, kinaesthetic and olfactory cues are vital for forming such understanding. Thus it could be argued that people who are blind often use a language that seems to be dependent upon vision (Landau & Gleitman, 1985; Arditi et al 1988). And as already pointed out, children's accounts suggested that knowledge of, experience and familiarity within a particular space helps them to form cognitive images of that space which facilitates their comprehension of it.

"I memorized what is around me and create like a picture in my mind of the things around" Hans [FN15/ ¶ 198]

"When I walk into things say like an embosser, a Brailler embosser, and I feel it from top to bottom, I know where the buttons are and stuff and that automatically comes into my mind as a picture as if I could see it, feeling something in detail is almost as if I could see it, I supposed feeling is my equivalent of seeing…" Harris [FN15/ ¶ 201]

While describing familiar spaces most of them said that they imagined themselves walking around and everything would come automatically to mind. At school they could get from one lesson to another without asking other people to help them emphasizing that they had the layout of the school stored in their mind. They also stated that they tried to remember other people's descriptions about various places and they tried to recall their own experience of moving and feeling around. Piece by piece they gradually learnt not only the direct routes to destinations but also shortcuts from one place to another and eventually the relative layout of the whole school.

"…at first memorized bit by bit and then you just know…for example I know how to go to the swimming pool from my house because I know where it is in relation to my house and I know where the pool is in relation to the school and I know shortcuts to go there too" Bob [TN 8/8e/8e1 / ¶ 159]

"……I kind of have the layout of the school in my head…… well…when I think about the school the school is going to come into my mind, and when I think the languages corridor then the languages corridor comes into my mind its like a habit, is like seeing it in front of me" Bob [TN 8/8e/8e1 / ¶ 210].

A number of studies with people who are blind provide evidence that vision is not essential for the mediation of "visual" images recalled from memory (Aleman et al. 2001; Bertolo et al.; 2003, Bertolo, 2005). Bertolo et al. (2003) analysed the dreams of congenitally blind people and evaluated their ability to graphically represent the dream-evoked images. The dream reports were vivid with tactile, auditory and kinesthetic components but surprisingly, some appeared also to contain visual content. Bertolo found that congenitally blind people were able to represent graphically the scenes from their dreams they previously described orally, and concluded that *"…the congenitally blind, who have never experienced sight, are able to visualise"* (2005:183).

Furthermore, Johnson (1980), using onomatopoeic words to elicit verbal images which were then classified into different sensory modalities, found that individuals who were blind produced as many "visual" images as the sighted. Therefore he concluded that the individuals who were blind were as able as the sighted individuals to form visual images. However other researchers were cautious about this conclusion,

> *"… it is not clear whether blind subjects may have simply translated visual stimulus words into non-visual words - the stimulus word lightning can equally be interpreted to mean fast - or used visual terminology to describe non-visual images" (Kaski, 2002: 724).*

Aleman et al. (2001) tried to separate pictorial from spatial representations in order to examine whether people who are blind actually experienced visual images or whether those images are simply mental representations that preserve spatial properties. They concluded that although blind made significantly more errors than sighted people, they were able to perform spatial imagery tasks as well as they performed pictorial imagery tasks, and concluded that different sensory modalities (i.e. vision and haptics) might share common representations.

None of the participating students in the present study however, appeared to imply that the "images in their mind" included visual content. They described these images in terms of sounds, touch sensations or emotional experiences, although they used words such as 'picture', 'see', or 'look' to express this process. This is in line with Holzinger's (2000) and Kerr's (2000) findings that congenitally blind people have dreams which do not include visual content but contain mostly sensory experiences.

In the same line, when the participating students in the present study were asked how these "images in their mind" were made of, some of them explained:

"Made of things I feel and see sometimes, but mostly feel; but they are in my head; and is like I am talking to myself, I am thinking the shape and how something looks like" Sal [FN15/ ¶ 107]

"when I picture my self sitting down in my house, I picture… my self sitting in the chair so I can feel the chair, I can feel the floor, erm…I can feel a little table, erm…I can hear my brother and sister fighting" Markus[FN15/ ¶ 138]

"…it's probably quite hard for you to understand but is quite simple for me, is just……you know when you give directions to someone where to go……is just exactly the same as that, erm……I used pictures……well sort off, but it's almost oral…it's hard to describe…" Ahab *[*FN15/ ¶ 337]

In particular when one of the children was talking about her guitar she said that it was as if she could see it in her mind; this 'image' however was made up of tactile and auditory information.

"…… it's like seeing the guitar in my mind…… you know……what it feels like, the shape of it…how it sounds…" Lisa [FN15/ ¶ 118]

Similarly, when another child was trying to estimate the relative size of different objects he said that he used "pictures" made up of sounds and tactual information. Giving an example he emphasized that in order to estimate the length of his brailler, he imagined himself feeling it and it was like having a tactile picture of it in his mind.

"…I just try to imagine me feeling the brailler like… me having my hands on the brailler and then roughly know how big it is because I've seen it before, well when I say seen I obviously mean felt it … its like having a picture but not like a picture you see on TV …like a picture from me feeling so like… a collage…just like a picture that you can feel… if you know what I mean…I don't really know how to describe this to someone that can see …… I have a picture of what a brailler feels, in my head" Bob [FN 15 / ¶ 121]

It seems that he would formulate the cognitive image of a familiar spatial event and he would be able to reproduce it in his mind utilizing auditory and tactile cues.

"……I can tell this is a carpet now so I have a picture of this room covered in carpet …a few chairs, a desk, a pool table, there is also a piano in here …… so I can like picture that quite well……well I can't really picture it like a sighted person would do I guess but I can picture it and I know how it looks quite accurately … …" Bob [FN 15 / ¶ 164]

Giving another example, he would add that even though he could not see how high the ceiling was he would be able to hear it and imagined its height in his mind.

*"For the ceiling… I can't see how high it is but I can……sort of hear……how far it is and I can sort of… …picture that in my mind…" Bob [*FN 15 / ¶ 125]

Only the two children who were not congenitally blind reported seeing in their mind images that clearly included visual content, clarifying that they remembered those images from when they could see. This issue will be further discussed in the next chapter (chapter 5).

It seems that children discover similarities or differences between objects; compare properties of spatial events; and memorize where everything is. They experiment on their environment and utilize any useful residual vision or the remaining sensory modalities in order to form cognitive images, to process the information of the surrounding space and to develop their knowledge of the overall layout of a familiar space.

"…make sure you remember things…make sure you can see things in your mind… use all your senses really, make sure you listen to anything that is around you, smell sometimes gives you an impression of where you are … …obviously touching

and feeling is very important. So I would say basically explore…" Lisa [TN5/5a/ ¶[372] [50*]

"…try to use all your senses… use your hands to feel where you are and stuff … use the little sight you've got if you have any…… and listen carefully because that will help you and stuff …… sometimes smell can help you as well…" Janet [TN5/5a/ ¶[329]

[50*] TN5: Tree note 5: Other sensory modalities / 5a: other sensory modalities facilitate spatial perception / ¶: paragraph

CHAPTER 5

OVERALL DISCUSSION

5.1. Approaches to exploring space – conceptual frameworks

It has already been shown in the literature review chapter that spatial awareness has been studied within different academic disciplines, such as philosophy, psychology and geography and that there is often considerable disagreement among researchers within the same discipline, and between different disciplines, concerning how people who are blind perceive and represent space.

It has also been shown that most of the studies on spatial understanding which are reported in the literature were carried out within an experimental frame of reference that focuses, in essence, on attempts to quantify spatial experience. The researchers often have drawn their conclusions from observations in artificial settings of the behavioural achievements of people who are blind across a broad range of spatial tasks. These behaviours are then often analysed statistically to attempt to gain insights into this spatial understanding and the mental processes it involves. However Warren (1994: 113) emphasizes that:

> *"…there is a great gap in our knowledge about the quality of spatial concepts that are acquired as a result of natural experience in environments, and there is an even greater lack of information about what the process of that acquisition might be".*

It could be argued that many studies concerning the spatial understanding of people who are blind were designed to establish an understanding of general human spatial knowledge rather than to advance the welfare of blind people themselves. In these studies people who are blind represent:

"…unique opportunities for isolating the roles played by various sensory modes in the development of spatial awareness" (Casey, 1978: 297).

Similarly:

"special populations like the blind provide insight into the methods we all use in structuring our experience" (Casey, 1978: 301).

Moreover, many researchers within different disciplines have attempted to investigate the way in which people that are blind conceptualize and perceive elements of the environment compared to sighted people. Comparing the performance across groups who are blind and sighted can clearly provide important information on the role of vision in the development of spatial awareness and can assist in the formation of theories on human spatial cognition. At times however comparative approaches can be misleading. Individuals with visual impairments and blindness are part of a population that is a very heterogeneous one and often cannot be classified into one group or category. Lewis and Collis (1997) remarked that in the majority of cases people with visual impairments are often grouped together because they have been diagnosed with the same eye or medical condition, or because they have performed at a specific level in psychometric tests. However even though the lack of vision and the nature and history of medical condition can have important implications for the development of spatial understanding, in the development of spatial abilities other factors are involved; such as interaction and experience with the physical and social world and the individual's cognitive skills, capabilities and characteristics (Warren, 1994).

Therefore there are clearly fundamental difficulties in generating valid results from the process of comparing groups from a population that is already extremely heterogeneous with groups of sighted individuals who, by definition, experience the world in very different ways to people with visual impairments. Furthermore, comparative approaches to investigating spatial understanding do not generally shed light on the underlying processes and techniques used by individuals in perceiving spatial environment, but rather focus on measures of behavioural achievements and draw from them conclusions on the nature of spatial performance.

Warren (1994) proposed a new research approach that looks for “answers” “within” a population: the differential approach, which concentrates on the blind individuals themselves and on the variables that affect their spatial performance. Along these lines, I have looked for answers to questions about blind children’s spatial processing by utilizing a design focused upon differences within the population of children with visual impairment. The first step in my approach was to gain insights into the key characteristics of each participant child as an individual (see Appendix 2, summarised Background information). The next step was to seek to capture their observable mobility skills, thus giving a general impression to the reader of how the children performed generally when navigating independently in natural settings (see Appendix 3, observation findings summary table). Finally, and most crucially, I endeavoured to seek the participating children’s opinion about what they believed, what they knew, and how they interacted with the world around them in making sense of space. I utilized a method which was qualitative in character and which was designed to describe and explain blind children’s spatial understanding from within the population of children who are blind using their own introspective voices about their spatial experience.

In the summary of the findings chapter, I have tried to extract from the participant children's accounts clues as to the nature of the cognitive and metacognitive processes that underlie their understanding of the space around them.

In the following discussion the key themes that emerged from the analysis of children's accounts will be addressed in turn. My main concern is to critically analyse the findings from the present study and to compare them with the findings from other researchers who have used quite different methods to explore the underlying processes utilized by people who are blind in making sense of space. Further, since research into spatial understanding and visual impairment and blindness has produced widely divergent findings, another goal of this chapter is to assess how effective the voice of the child is for deriving information that will provide a new perspective on the findings of other researchers, and for enriching our understanding of these issues.

5.2. Utilizing children's voices to explore the role of the different senses in their spatial processing

As was pointed out in the literature review chapter, on the one hand, a number of studies have suggested that blind and visually impaired people experience difficulty in constructing an accurate mental representation of space, because of their inability to access the highly detailed spatial information that can be taken in, and integrated by, the visual system. (Casey, 1978; Rieser et al., 1982 ; 1986; Spencer et al. 1989 ; Bigelow, 1991).

On the other hand, it has also been shown that an interaction of information from different senses is required to create an overall understanding of the environment (Watanabe, 2001; McLinden, 1999; 2004; McLinden, McCall, 2002). Indeed it is suggested by some influential researchers that people who are blind have the capacity to develop perception of space that is functionally equivalent to that of sighted people, although this capacity might require more time and cognitive effort to acquire (Millar, 1994; Warren, 1994; Espinosa et al, 1998; Tinti, et al, 2006). In this section the results presented in Chapter 4 in relation to the senses of touch and hearing will be critically analyzed in the light of findings from research covered in the review of literature to see to what extent they contribute to this debate and to current knowledge in each of the areas explored in Chapter 4.

5.2.1. Using touch to negotiate space

Perception based on touch in large scale environments does not necessarily involve haptic touch. Many tactile cues such as curbs, walls, the elevation of slopes, the textures of walking surfaces, information about the location and orientation of openings along a path, can all be perceived indirectly, e.g. through a white cane, or by proprioception through movements of the body (Bach-y-Rita & Kercel, 2003; Zelek, et al., 2003).

As has been shown in the literature review chapter, touch, whether direct or indirect, and the proprioceptive sensory system are key elements in the development of knowledge and understanding of the world for people who are blind. However it is also widely argued that in the absence of vision, this information about space that they receive through touch may be difficult to understand and integrate, since the whole has to be constructed from parts (Griffin & Gerber, 1982; Loomis & Lederman, 1986; Millar 1994; Rosen, 2000; McLinden & McCall, 2002).

Although haptic exploration in relation to small scale space has been studied in depth by many researchers (see Withagen, et al. 2010; Warren, 1994), only a few experimental psychologists have focused on the exploration of large scale space in artificial environments and even less have focused on the understanding of large scale space in natural environments (see Ungar, 2000). As Warren (1994) observed:

"…there is surprisingly little work available on this topic" (Warren, 1994:110)

One reason may be because it is considered to be time consuming and generally impractical to familiarise participants with large scale spaces, especially when complex areas of the real world are involved (Ungar, 2000), and, as Millar (1994) proposed, large scale spatial tasks are much less convenient for experimental investigations. Indeed one unusual aspect of the present study is that it focuses on the underlying processes concerning children's understanding of large scale space in everyday environments.

The explanations derived from the accounts of the participating children in the present study seem to provide some support to those researchers who argue that haptic and proprioceptive perception can provide people who are blind with a way of 'seeing' their surroundings, in the widest sense of perceiving, exploring and understanding them (amongst them: Hill et al., 1993; Millar, 1994; Gaunet & Thinus-Blanc, 1996; Ungar, 2000; Guth & Rieser, 2000; McLinden, 1999; 2004; McLinden & McCall 2002; Andreou & McCall, 2010).

Children in the present study have reported (and also have been observed) on many occasions, actively reinforcing their perception of their position in space through touch e.g. directly by haptic exploration, or indirectly by feeling the surface under their feet or by touch through their cane. They reported actively verifying their conclusions concerning their location by using the tactual features of objects or tactual qualities of the surrounding space as they progress through it. Haptic and proprioceptive perception appeared to be key elements in developing a holistic comprehension of the characteristics of familiar indoor and outdoor environments, and touch was used in a variety of ways including:

- confirming the location of objects in relation to other objects or in relation to themselves, utilizing the information received from their hands, canes or feet
- assembling information and establishing landmarks by trailing a surface edge or walls with their hands

- actively utilising surface properties they received through their feet; and employing the associated sensory and perceptual experiences from locations in a known environment to help them determine their own position
- using touch to determine relative sizes and shapes and to distinguish between objects.

The above findings seem to question views found in the literature that people who are blind are inefficient in their perception of familiar spaces because of the paucity of touch as a channel of information (Casey, 1978; Bigelow, 1991). The participating children in the present study reported making varied use of touch and proprioception in locomotion in a rich and sophisticated manner. In a familiar environment they knew with accuracy the location of objects and landmarks and when they encountered them, they recognized their nature. They reported using touch incidentally to confirm their position in what often seemed to be an unconscious process of constantly updating where they were in familiar space. In other situations it was a conscious, active process of checking their synthetic sense of the environment and adjusting their way of thinking to include new things that might appear in their way.

Children reported having a well developed awareness of familiar space. They appeared to be experienced travellers who could move around with confidence, making effective use of tactile cues during locomotion. In time these cues seem to become sufficient of themselves to move through space following a familiar pattern to a familiar destination without conscious effort.

However the children's reports suggest that those touch cues were not always sufficiently informative and accurate of themselves to negotiate or provide a coherent view of the surroundings in less familiar space or in unfamiliar outdoor space. In unfamiliar space they reported worries about unforeseen hazards, veering offline, and compromising their safety. Children appeared to trust the information derived from touch cues to negotiate familiar environments but they thought that these cues were less reliable when negotiating unfamiliar settings. This is in line with Golledge's (1993) observation that blind people are more likely to limit their movement habits to known routes between known places.

As discussed in the literature review chapter, some researchers have attempted to explore experimentally how the sense of touch operates in unfamiliar large scale space e.g. the strategies used by people who are blind when moving through a large scale experimental layout constructed in the laboratory; (Fletcher, 1980; Rieser et al. 1982; 1986; Hill et al. 1993; Gaunet & Thinus-Blanc, 1996) or when moving through an unfamiliar part of the real world (Ochaita, & Huertas, 1993; Espinosa et al.1998).

The above researchers suggested that two different types of spatial reference frames might be utilized when people with visual impairments explore an unfamiliar space: body-centred references, in which objects and locations are represented relative to the self and information about space is referred to the individual's position; and allocentric reference, in which locations are represented independently of the self, based on coordinates external to the body i.e. relative to external objects and locations (Fiehler et al., 2009).

It has also been shown in the literature review chapter that congenitally blind people are generally believed to be more likely to encode information in an egocentric manner, and are more likely to be limited to an egocentric representation of space because they rely primarily on direct contact and self-referenced perception of space. Therefore, it is argued, any differences observed in spatial performance might be due to the greater reliance on self-referent information by the blind when compared to the sighted on spatial tasks that require a holistic understanding of space (Hollins & Kelley, 1988; Spenser et al., 1989; Ruggiero et al, 2009; Coluccia et al, 2009).

For example, Warren (1994:115) observed that in a large scale unfamiliar environment:

> *"…children tend to view objects in a spatial array in reference to their own bodies rather than to one another in an allocentric spatial framework" (Warren, 1994:115)*

However it is also argued that preference for egocentric strategies is not an inevitable consequence of the absence of vision, since children who are blind have been found to improve in proficiency in utilizing both egocentric and allocentric frames of references when they are allowed sufficient practice with spatial tasks (Millar, 1994; Warren, 1994; Millar & Al-Attar, 2004; Schinazi, 2005; Noordzij et al., 2006; Gaunet et al, 2007; Ittyerah, 2009). In line with this view, children in the present enquiry suggested that they simultaneously used both body-centred and external references in familiar space, but showed a preference for using coding strategies relative to the body in unfamiliar space.

"…I tend to walk a bit slowly and I need to familiarize my self with the surroundings …… I need to think carefully where I am in relation to the surroundings ……but after I learn a place I go anywhere I want automatically and I know where something is in relation to something else……"Bob [TN7/7a/¶ 178]

It could be argued that this preference for egocentric strategies in unfamiliar space is reflected in the educational training children receive in mobility which is heavily sequential and body focused.

> *"They do not learn things on the basis of cues such as "go to other side of the park and end up between the wooden bench and the large chestnut tree". Instead, it makes more sense to specify a route through the park on the basis of intermittent landmarks in relation to their own body position"* (Noordzij et al., 2006:337).

An allocentric frame of reference relies on the perception of distal spatial cues (Millar, 1994; Ungar, 2000). However in the absence of sight the amount of available distal information is reduced and landmarks become more difficult to process. Touch and proprioception are considered to be "close senses" since the information is acquired through exploration of space within reach and has to be continuously updated by self movement. Vision and hearing are considered to be the "distance senses" (McLinden & McCall 2002), therefore in relation to touch and proprioception it is not surprising that children report utilizing self reference and movement cues when engaged in spatial tasks in unfamiliar environments, simply because self reference strategies seem to be more reliable for them. As Millar explains:

> *"…information in that form is obtained more reliably in totally blind conditions than information about external configurations and relations between external planes.* (Millar, 1994:197)

Gaunet & Thinus-Blanc (1996) and Hill et al. (1993) are among the few researchers that have carried out systematic work on the search activities that people with visual impairments utilized to explore a novel space. In line with Gaunet & Thinus-Blanc (1996) and Hill et al. (1993), participating children in the present study reported that in an unfamiliar environment they would use touch to obtain information of the relative positions of different elements by walking around it and exploring the boundaries of an area and noting the key features around its perimeter. They also reported on occasions that they would investigate the internal elements of an area by touch and by walking from one side to the other in order to learn their spatial relationships using their body as a reference point i.e. they located objects and landmarks relative to their own body. These strategies are considered to be egocentric (Gaunet & Thinus-Blanc, 1996; Hill et al. 1993). However the participating children also appear to utilize object to object exploratory strategies that enabled them to locate an object or a place relative to other objects and places i.e. sweeping their cane back and forth among objects (Gaunet & Thinus-Blanc, 1996; Hill et al. 1993). These strategies are considered to be allocentric strategies since the reference used is relative to cues beyond, or surrounding, the target object.

Both Gaunet & Thinus-Blanc (1996) and Hill et al. (1993), found that in an unfamiliar environment, early-blinded adults tend to encode space as a sequence of places and they mostly used "perimeter strategies" and "cyclic patterns" which did not appear to facilitate the development of object-to-object relationships. "Perimeter strategies" and "cyclic patterns" strategies were correlated with the lowest performance levels. According to Hill et al., (1993:299):

> *"Six of the 15 participants from the best-performing group and 14 of the 15 in the worse-performing group had early onset blindness".*

And that the best best-performing group used:

> *"…a type of strategy conducive to the development of links among objects"* (Hill et al., 1993:301)

Hill et al., (1993) found that early-blinded participants have not performed as well as those with late onset visual impairments. However, the fact that at least some of the best performers, were early-blinded, made Hill et al., (1993:301) to suggest that individual differences in addition to group differences should be investigated and that much can be learn from examine the spatial performance of the "spatially good". Indeed, that was one aspect of the present study.

In the same line, Gaunet & Thinus-Blanc, (1996) emphasized that two distinct exploratory patterns were found in their experiment: the early blind adults mostly displayed cyclic exploratory patterns where as the visually experience adults implemented exploratory patterns between pairs of places; thus the poor performance of the early blinded was related to qualitatively different strategies of exploration.

However the children's rich descriptions of their spatial behaviour prompt me to agree with Millar (1981; 1986; 1988; and 1994) that sequential and egocentric strategies do not preclude the development of configurational knowledge and the development of knowledge of the overall layout of space in a holistic manner; nor do they preclude the development of external coding strategies . Indeed it seems that they are an essential first step in developing a holistic sense of space.

"when I learn a new route or a new place I learn it bit by bit and I like… …try to remember … but after I learn something I just go anywhere automatically" Judy [TN 8/8e/8e1b / ¶ 160]

Children's accounts seemed to suggest that, familiarity with an unfamiliar spatial arrangement is built up sequentially using coding strategies relative to the body and then develop into a more holistic understanding of the surrounding spatial arrangement; however this process might take time, effort and practice with spatial tasks, and vary for each individual. Thus, supporting conclusions from studies which have pointed out that although people who are blind might rely on strategies requiring more computational efforts in terms of memory resources or time of information processing, they do have the potential to fully develop their spatial skills (Passini &

Proulx, 1988; Spencer, et al 1989; Millar, 1994; Warren, 1994; Klatzky et al., 1995; Tinti, et al, 2006; Gaunet et al.'s, 2007)

In addition the choice of egocentric strategies does not imply that the individual lacks an overall understanding of the surrounding spatial arrangement; it maybe that this choice is determined by judgments about the nature of the tasks and previous experience. This is in line with Warren's (1994:115) observation concerning large scale environment in that:

> *"…there are important relationships between experience in an environment and the quality of the child's concept of the spatial layout of that environment" (Warren, 1994:112)*

This issue of the differences in children's previous experiences is worth exploring further here. Many of the touch strategies the children report in the present study may well have been taught to them by adults. The sophistication of these strategies will therefore vary according to the children's time at school and the degree of instruction they have received. The amount of instruction will be influenced by the perceived needs of the children, and the degree to which they employ and develop these techniques will be determined by individual characteristics (such the onset and nature of the child's visual impairment, the child's age, and prior experience, confidence, and coordination, physical and cognitive abilities). Differences observed in spatial ability among the children and the differences in the touch strategies they report will relate to the degree of relevant instruction they have received but also to differences in the way in which children who are blind socialize and participate in their everyday environment, and this may be influenced by cultural and social factors.

Much of what the children have said about using touch to negotiate space is not surprising and has already been discussed by other researchers (among others: Hill et al. 1993; Millar, 1994; Gaunet & Thinus-Blanc, 1996; McLinden, 1999; 2004; Ungar, 2000; Millar & Al-Attar, 2004; Gaunet et al, 2007; Ittyerah, 2009; Ruggiero et al, 2009; Coluccia et al, 2009). However children accounts have confirmed that:

- Touch provides information that is different from that provided by sight, but in some cases it does appear able to lead to not just a sequential but a synthetic sense of the environment.
- Haptic and proprioceptive information is used differently in familiar and unfamiliar settings.
- Children make use of touch to develop both self-referential and external frameworks when moving through space, but, perhaps inevitably, show a preference for using self referent strategies in unfamiliar spaces.

Whether or not touch of itself is sufficient to develop a holistic sense of the environment is unclear from the children's responses, but the results do suggest that coding relative to self referent frameworks is not necessarily related with "spatially poor" performance as Gaunet & Thinus-Blanc (1996) and Hill et al. (1993) suggest. Nor does it necessarily mean that the individual has not developed allocentric frameworks. As Millar, (1981:263) put it:

> *"…coding relative to the body provides consistent feedback in many blind tasks. A preference for self referent strategies by the blind is thus perfectly reasonable".*

Coding that is based upon sequential components clearly initially needs more effort and time however *"configurations can be derived perfectly well from movement sequences"* (Millar, 1994:195). The work of Millar is quoted here as evidence that the sequential and egocentric strategies that touch initially relies upon are not necessarily less efficient nor are they always correlated with lower performance levels. These findings are entirely consistent with Lewis et al. s' (2002:22) suggestion that:

> *"an alternative to the view that there are two qualitatively different modes of understanding is that the available information may be processed sometimes in an egocentric way, and at other times not, depending on which information in a particular situation is most salient and captures the child's attention".*

The above discussion has relevance to mobility education. Perhaps a clearer articulation of the sequence of development from egocentric to allocentric strategies and how to explore and learn novel environments independently should feature more prominently in mobility training. This point will be further developed in the final section.

5.2.2. Using touch to establish dimensions of objects in space

In the literature there is evidence that haptic identification of objects that can be held within the hands can be remarkably fast and accurate (Klatzky et al., 1985; Morrongiello, et al., 1994; D'Angiulli, et al., 1998; Smith et al., 2005). Objects can be perceived:

> *"…jointly by touch and movement information from active exploration by the fingers and palms of one hand and passive tactile information from the other hand"* (Millar, 1994: 96).

Klatzky et al, (1985) have demonstrated that people are very good at recognizing common objects on the basis of touch alone. They found that blindfolded adults were able to identify a wide range of familiar objects, of a size that could be held within the hands with almost perfect accuracy and within only a few seconds. Although it has been argued that children who are blind have faulty impressions of object form, size and position, because they have small range of experiences (Begum, 2003), Landau (1991) suggested that by second year of life, children who are blind can develop a wide range of systematic and effective means of exploring objects and they are able to become familiar with novel objects and discover and explore changes in them. On the same lines Simpkins (1979) and Morrongiello et al., (1994) concluded that the haptic system is a rich source of information about objects and that there is no difference in performance due to visual status between children who are blind and sighted in relation to object identification; although active exploration was noted to increase with age. In addition, Smith et al (2005), in an attempt to measure blind and sighted people's estimates of object size, found that blind individuals were more accurate than sighted individuals in representing the size of familiar objects.

Participating children in the present study also reported examples of how haptic skills are used in the identification of objects:

"exploring the shape or the surface of an object will help you to picture it in your mind and understand how it looks like… for example I know that an orange has a rough texture and I know how it smells because I felt it and smelt it before… …" Bob [TN 5/ 5d/ ¶ 362]

Clearly haptic information is crucial for gathering information about objects in the environment for all individuals, but it is especially important for those without vision. Haptic perception is clearly efficient in relation to hand held objects but has limitations in relation to large objects in the environment.

According to Weber (1834; 1836), cited in Millar (1994: 98), by moving our hands over a very large three-dimensional object we can build up a picture of its size and shape. However,

> *"recognition of very large objects has rarely been studied empirically since Weber's description"* (Millar, 1994: 98);

Medium scale objects and large scale three dimensional objects that cannot be grasped in the hand are difficult to perceive as a unified whole, and as Millar (1994:98), put it,

> *"…for really large new objects, coordinated two-handed movements will be needed to explore and understand their shape. For the shape of large objects, therefore, information from the joints and stretch muscles is crucial…."*

There is evidence to suggest that children who are blind conceive sizes of medium scale familiar objects - such as the desk surface or the door width for example - better when compared to sighted children (Andreou & Kotsis 2005; 2006a; and 2006b). Medium scale objects, for the purpose of the present study, can be defined as those objects that cannot be held within the hands but can be manipulated by hands or feet gaining information by movement sequences. Andreou & Kotsis (2005; 2006a; 2006b) and Smith et al., (2005) have suggested that the reliance of individuals who are blind on touch to match and sort objects of different sizes, shapes, textures and weights, enables them to think in abstract terms about differences between objects in terms of these features and helps them to grasp the idea of a “whole” object. This necessity to remember small details about physical space and objects, and the ways that these spaces and objects interact, plus the need for greater caution, might be some of the reasons why blind individuals were more accurate than sighted individuals in representing the size of familiar objects (Smith et al., 2005).

Similarly the children participating in the present study demonstrated that they could estimate fairly accurately the relative sizes of medium scale familiar objects that could be manipulated by hands or feet and by movement sequences. For example by grasping an object, moving their hands over the object’s surface, by walking about a medium scale object such as a desk or a car, they could get an accurate sense of the scale of that object.

“…my stride is about half a metre and it takes me about six or seven paces to get from one end of the car to the other which will make it about two and a half metres maybe three” Lisa [TN8/8K/ ¶ 94]

There is evidence that haptic perception can encode many different object properties, and explorers who are blind can be remarkably fast and accurate at recognizing real objects (Klatzky et al., 1987; Klatzky et al., 1993),

> “*such a modality, however, can operate only within a short range of distance, and some large objects cannot be entirely explored haptically”* (Coluccia, 2009:691).

When confronted with large scale objects, people who are blind must observed them serially and integrate different parts in order to form a whole image of an object (Foulke & Hatlen, 1992). Large scale objects may be inaccessible through direct contact and consequently cannot be experienced by touch; e.g. airplanes do not lend themselves easily to exploration by touch. The question arises as to the degree to which children who are blind are aware of the relative size of such objects.

As already has been outlined in the summary of the findings section, the children who participated in the present study were asked to estimate the approximate size of different objects that they were likely to have some familiarity with but not to have explored in their entirety. The rationale behind these questions was to establish the strategies the children employ in order to estimate the approximate and relative sizes of large objects that can not be manipulated.

What is noteworthy is that all the participating children often draw upon reasoning, general knowledge and previous experience to form analogies and create logical conclusions about such objects. Children's accounts revealed that they retrieved information stored in their memory when comparisons and conclusions needed to be drawn for objects that they did not have concrete experience with. For instance by drawing upon past knowledge and judgment, they tried to estimate the height of the ceiling. Some of them utilized their residual vision (light perception) and general knowledge that *"the ceiling isn't that far above the door"*. Others utilized auditory cues; and many tried to estimate the approximate height of the ceiling by drawing upon either self-referent frameworks (comparing the height of the ceiling with their own height); or by external reference (comparing the height of the ceiling with that of another object of known height – i.e. the door). Furthermore some of them tried to estimate the height of the tallest building in their own town based on previous visits to big shopping malls but also based on what they have heard from other people, or gained from books or other media. They used similar strategies to estimate the size of other objects that they were not familiar with.

In the exercise where the children were asked to explain why they thought one object was bigger or smaller than another, it was explained to them that I was more interested in the thought processes behind their answers rather than whether their answer was correct or not. This seems to have made the children feel free from the stress of success or failure and prompted them to give explanations for their answers. By thinking aloud and trying to explain how they perceive the surroundings, children proved able to share the processes they employ in spatial problem-solving, describing their own thinking and demonstrating their ability to consciously think about thinking. They were able to reveal the metacognitive knowledge which involves awareness of one's own cognition (Flavell, 1979). Although there are many definitions and models of metacognition, metacognitive knowledge includes knowledge of general strategies that might be used for different tasks, when and where these strategies might be used and if these strategies are effective (Flavell, 1979; Pintrich et al., 2000). Children tried to verbalize the strategies used and how or why these strategies worked for them when performing the given tasks.

"you know these question you are asking I don't tend to think of them when I am sitting there on my own but when you are asking me I have to think about them; and this is very helpful for me as well because you make me realized how I do some things…" Harris [FN16/ ¶ 191] [51*]

[51*] FN 16: Free Nodes 16: metacognition / ¶: paragraph

"its not easy to think about it…I have every day objects I guess like …take my guitar for instance which is up to there if I stand up, which is about where the metre stick is up to, on me erm……then I know that my guitar is approximately 1 metre long…I use things around me that I know very well and compare them with things I don't know or sometimes I use my self ……and I use general knowledge and what seems reasonable" Lisa [FN16/ ¶ 114]

They were able to put into plain words what they thought facilitated their perception of the size of objects which were inaccessible for direct contact. There replies suggest that the relative size of large objects is often perceived by strategies that rely upon analogy and extrapolation from objects actually experienced, for example:

- They identified features of a 'known' object that were similar to the 'target' object
- They found the similarities between the objects that were otherwise dissimilar and transferred the similarities from the 'known' object to the 'target'
- They identified the differences between the 'known' object and the 'target'

When comparing the size of an airplane with other vehicles in order to decide which one was smaller or bigger; most of the children drew upon their understanding of the properties of a bus on the basis that they both carry many people and both vehicles travel long distances. All the children had some experience of buses but not all had experiences of being on a plane; although they reasoned that since an airplane carries more people, has bigger engines and big wings, it consequently must be bigger than a bus. Another example would be when some of the children stated that a motorbike is like a bicycle with an engine and when compared to a car, it is smaller because it carries fewer passengers (again, all the children had some experience of bicycles and cars but not all had experiences of motorbikes). This suggests that in order to perceive the size of objects that cannot be explored by other sensory modalities in their entirety (or are difficult to do so) children retrieved previous knowledge from memory and applied that knowledge to solve the novel problem i.e. by comparing the size of a known object with the target.

Along the same line is Halford's (1993) claim that much human reasoning is basically analogical and that even young children can perform analogical reasoning and use familiar representations of everyday relational structures as a basis for creating analogies to new problems that share the same relational structures. Halford (1993) proposed that analogies can be used by children to suggest hypotheses about unusual or unfamiliar situations; also analogies can facilitate understanding by thinking of a new problem in terms of a similar problem that they had previously resolved.

The above strategies can be very useful in extending children's understanding, increasing flexibility of thinking, facilitate the perception of a given concept or situation and *"facilitate transition to higher levels of abstraction"* (Halford, 1993: 220). Especially for a child who is blind that does not have other means of perceiving large distance objects and spatial events in a whole configuration.

However analogical thinking may also lead to misleading associations and generate incorrect information. For example some of the children concluded that an airplane is smaller than a cruise ship because it has to fly therefore has to be lighter and smaller; other children reached opposite conclusions through the same process, as one of the children put it, an airplane is bigger than a cruise ship because it can travel to the end of the world where as the cruise ship can only cross the oceans. It appears that participating children frequently used their past knowledge and they tried to form what to them seemed like a logical conclusion; they constructed their own explanations about how and why things behave as they do but sometimes these conclusions are drawn from too little evidence, false impressions or lack of experience.

Attempting to organize and understand the world around them they often tried to come to a solution sometimes it is a correct one, sometimes it is a misconception. At other times they arrive at the right conclusion but through faulty reasoning. These mistaken beliefs or misconceptions might have developed by the combination or confusion of two or more different correct concepts or from vague information obtained from external sources such as siblings, the media or adults. The language used by textbooks or teachers at school or by the media might also be a possible source of misconception (Watson & Konicek, 1990; Pine et al., 2001).

Therefore is vital to truly listen to children's ideas in order to diagnose their misconceptions; and try to deconstruct them by structuring experiences so that there are opportunities for children to investigate the accuracy of their own ideas and compare them with those of others. As has already been shown elsewhere, prompting children to think about their answers often allow self correction. Also, having access to formal and informal learning experiences in order to develop basic skills such as classification, discrimination, and measurement of object sizes (such as comparisons between large, small, tall short etc.), seem to be valuable for children who are blind and can facilitate the process of moving from concrete to more abstract concepts

(Andreou & Kotsis, 2005; 2006a; 2006b; Smith et al., 2005). In addition by interacting with objects in the environment, deductions can be made from previous experiences and discovering analogies between the experiences of the past and the present can generate transfer from a familiar knowledge base to a less familiar area of knowledge (Zook, & Di Vesta 1991; Andreou & McCall, 2010).

On the whole, concerning the strategies used in order to estimate the size of three dimensional objects, children's accounts in the present study have revealed that:

- Firstly, deduction from previous experiences through the use of analogies is a key strategy in estimating the size of medium and large scale objects which do not lend themselves easily to exploration by touch.

Begum (2003) also suggested that very large or microscopic objects that cannot be accessed by touch can be perceived by analogies. However the findings in the present study strongly disagreed with her statement that:

> *"a visually handicapped child who has smaller range and variety of experiences has faulty impressions and little concepts of form, size, position and so on"* (Begum, 2003:21).

As has been shown, participating children in the present study utilize analogies and previous knowledge and try to logically explain why they conclude that objects, which were not familiar with, should be smaller or bigger than others; giving the correct answer to most occasions. The findings in this section underline the importance for children who are blind of having a variety of concrete experiences. These experiences facilitate the development of abstract thought which enables the children to utilize deductive reasoning and analogies in order to think logically and to solve problems in their everyday life.

- Secondly, concrete experiences from everyday life activities are clearly important but also external information from conversations with sighted people or from secondary sources such as books or the mass media is vital for them and can be applied equally in the perception of:
    - small scale objects that can be manipulated haptically,
    - in the perception of medium scale objects that cannot be held in the hand and require locomotion for exploration
    - And in the perception of large scale objects that might not be accessible by direct contact and cannot be experienced by touch.

5.2.3. References to the auditory environment

As was pointed out in the literature review chapter, the auditory system becomes the main channel for providing information about the surroundings and the patterns that vary within an environment without the need for direct contact (Foulke, 1992). Since vision is absent or severely impaired, it can be compensated to some extent by hearing which is the other "distance" sense (McLinden & McCall 2002; Foulke, 1992; Spencer et al., 1989).

As has been illustrated in the summary of the findings chapter, all the children in the present study employed sound and hearing to comprehend the characteristics of an indoor environment. Through sound they could differentiate whether a room was full or empty, and whether they were entering a small or a large space. For example, by turning their head up towards the ceiling and listening carefully, they would be able to perceive its approximate height.

*"For the ceiling… I can't see how high it is but I can…sort of hear…how far it is …" Bob [*FN 15 / ¶ 125.)

Auditory cues could also help them to figure out the characteristics of an outdoor environment - i.e. the type of environment they were navigating through, for example if they were passing by a house, a shop or a big building; and if there were any people, animals, cars, bicycles or trees around. Children sought to differentiate between large or small objects, between heavy or light objects from the way they sound and from the noise they make while moving. For example they thought that birds sound like small animals whereas horses sound quite big and heavy, indeed one of the children talked about dropping heavy and light objects to observe the differences in sound they would make.

"……what I mean is… for example if I drop my school bag on the desk it would make a big noise because its quite heavy and big, if I just drop a piece of paper it would hardly make any noise at all because its really light and small…" Bob [TN5/5b/ ¶ 137] .

Carello, et al. (1998) too found that individuals were able to estimate the size of objects (wooden dowels) with no previous knowledge of those objects by simply hearing the objects falling to the floor.

> *"Classically, hearing is considered a temporal rather than a spatial sense, and size is a spatial property. But size differences are at least crudely perceptible on the basis of sound"* Carello, et al. (1998:211).

Furthermore they suggested that when people hear leaves rustling or water dripping, they can not only tell what they are hearing but they also create a cognitive image of what they are hearing. In the same vein, Kellogg (1962) also found that individuals who were blind had the ability to distinguish objects of different size using auditory cues. They were able to discriminate the smaller object of two different sized objects placed at the same distance although performance was found to decrease as the task was set at further distances.

It appears that when vision is absent, people must rely more on auditory input in order to acquire distant information about the world and generally to interpret as best as they can whatever combination of tactile, auditory, kinaesthetic and olfactory cues are available. Ashmead & Wall (1999) noted that auditory perception can be considered in two broad categories. One involves the localization of sound-producing objects such as other people, vehicles, animals and the like, and the second broad category is the ability to detect and localize features of the surroundings that do not themselves produce sounds, such as walls, poles, door openings and so on.

The participating children in my study emphasized that not only could they perceive the approximate size of enclosed spaces but also they could locate features in a given environment by the variations of the ambient sound field; either through reflections of the sound they make while walking – by observing the acoustic pattern of movement and the echo coming from their feet or their white cane on the ground and walls, or directly through the sound the objects produce. For example, the sound of murmuring water could be the sign of a water fountain which could be used as an important landmark or in turn indicate other landmarks nearby, i.e. some of the children remarked that opposite the fountain, walking in straight line, there would be the school entrance. Moreover sounds reflected by objects enable the detection of obstacles; for example many of them remarked that they could recognize a wall in front of them because a very slight echo was coming off the wall. Thus hearing seems to be of particular importance to participating children in the present study and other people who are blind, as a means of familiarizing themselves in space beyond the reach of their hands or canes, and as the basis of the "obstacle detection sense" (Andreou & McCall 2008).

A range of explanatory processes for this ability -to detect large objects in space through non tactual means that do not themselves produce sounds - have been proposed over the years. It was initially thought that obstacle perception was associated with pressure on the face muscles and described as "facial vision" (Diderot 1749, cited in Supa et al., 1944), but a series of experiments found that this ability was linked to the auditory sense.

Similarly, children in the present study expressed with clarity their ability to sense objects in their environment. They could 'sense' without feeling obstacles or hazards in their surrounding space. They could also ‘sense’ as they were walking that something was coming up; a wall for example. One of the children emphasized that he could even ‘sense’, when walking towards his school, whether he would be in line with the main entrance or not, because the sound was different. Albeit that most of the children had great difficulty describing how they knew or ‘sensed’ objects in their presence, their descriptions indicated that they often use auditory cues.

Research findings from previous studies (Kells, 2001; Lopes 2000; Ashmead et al. 1998; Wickens and Meyer, 1995; Ashmead et al. 1989; Taylor 1962; Kellogg, 1962; Coleman 1953; Ammons et al. 1953; Worchel and Dallenbach, 1947; Supa et al. 1944) have suggested that most people who are blind may not consciously be aware of the fact that their ability and knowledge to locate objects or to identify general characteristics of their environment is derived from the auditory sense; they are aware only that the phenomenon exists and can often be relied upon to detect obstacles.

From the findings of the present study it appears that blind children may be more aware than adults who are blind, of the fact that the auditory sense is the principle factor of the “obstacle detection sense”. One explanation could be that in most of the previous studies with adults, researchers have adopted an experimental approach to the assessment of judgments about the presence and location of objects. Adults’ views of the phenomenon are often asides, incidental to the main business of the experiment. The apparent lack of insights in adults may be accounted for by the fact that it is not always easy for adults who are blind to explain this phenomenon that sounds remarkable to many sighted people without the fear of making themselves appear bizarre or ‘weird’. In one of the few qualitative studies on this topic, Kells

(2001) interviewed eight blind adults about obstacle detection and remarked that the blind participants described their frustration when trying to inform sighted persons about their skill to detect obstacles or objects in space while not being able to see them and they felt uneasy talking about it.

In my study, even though initially students offered explanations that appeared to see the ability to ‘sense’ objects as having a mysterious or incomprehensible origin, further and deeper discussion allowed new insights to emerge. Half of the children went on to link their ability to comprehend the characteristics and location of objects with auditory cues. Children perhaps are simply more likely than adults to express their thoughts and feelings and describe and explain their experiences with clarity, simplicity and without restraint, and can present a valuable source for researchers wishing to understand this phenomenon.

A key element in the present research was the development of a strong researcher-participant relationship. Rapport with children takes time to build and needs to be founded on mutual respect and honesty. It was important that the children understood that I needed their help; I was ignorant of something so familiar to them, so in that respect they had an advantage over me. The researcher- participant relationship required for research of this type differs greatly from those adopted in experimental research, not least in the amount of time that is involved. I was not the adult that “knew more” than children, I was the adult that knew nothing and I wanted to learn from them.

There appear to be very few studies into object detection involving children (Ashmead et al. 1989; Ashmead et al. 1998). Ashmead et al. (1989; 1998) explored the locomotor adjustments made by children walking along a course with obstacles.

The findings from their studies confirm that children can perceive obstacles in their presence and that this phenomenon can be measured empirically; however they do not seek to provide insights into the thought processes involved. By following a different approach I sought insights into these processes by listening to and analyzing the children's own explanations given during their interaction with their surrounding space.

Overall children's accounts suggest that:

- They could perceive the approximate size of an enclosed space through subtle auditory clues (i.e. the size of a room, or the height of the ceiling)
- they would use the sound that reflected from objects or passes through openings in order to perceive their surroundings
- They confirmed with clarity their ability to sense objects in their environment (i.e. to detect and locate obstacles);
- they reported that their ability to "sense" their surroundings without direct physical contact not only helped them to locate where obstacles were but also was an essential element in safe mobility;
- they tended to describe this sense as 'special' ability or an 'additional' sense concomitant with blindness;
- They often linked this ability to 'sense' objects with auditory cues.

Researching the auditory basis of obstacle perception is fundamental both for theoretical reasons and even more for practical considerations relating to the development of children who are blind. Recent studies have shown that blind individuals have equal or better auditory abilities and that they utilize auditory cues more efficiently than sighted individuals when acoustically exploring their environment (Lessard et al., 1998). One explanation might be that people who are blind are more dependent on gathering information about the distant surroundings through auditory sense and therefore many become very proficient at this skill. As Despres et al., (2005:753) conclude:

> *"auditory compensation leads to improved self-localization capacities in early-blind humans and indicates that prior visual experience is not essential for the development of spatial competence".*

Likewise, Roder et al., (2001) suggest that people who are blind encode auditory cues more efficiently and have better memory than sighted individuals for auditory verbal materials allowing them to recognize these items with a higher probability. However it should be noted that the empirical literature on this topic is not conclusive (Golledge, 1993; Foulke, 1992) and that both superior and inferior performance has been reported in blind compared to sighted people in spatial and auditory tasks.

The present study's findings stress the importance of listening to children's voices in order to identify the variables that affect their spatial performance and are perhaps indicative of the processes involved; however understanding the process more fully and applying this knowledge to intervention to ensure the best possible outcomes for children and adults in the development of independence through mobility and orientation remains a key challenge for the future.

Nevertheless, while recognizing the potential for training visually impaired children to use auditory cues to perceive their surroundings, there are certain important limitations of sound clues that should be taken into account. Firstly sound cannot be controlled by the senses; sight is continuous, but it can be "turned off" by closing the eyes (McLinden & McCall 2002). Secondly, sounds can reach the ears from all directions and often are non-specific offering a less certain and defined “picture” than would vision. Learning improves the ability to acquire spatial information from hearing, however, such learning takes time, and the auditory system needs the collaboration of other perceptual systems in order to supply the individual who is blind with all the necessary information about the features of the surrounding space (Foulke, 1992).

5.3. Utilizing children’s voices to explore cognitive map knowledge

> “*Cognitive mapping research focuses on how individuals acquire, learn, develop, think about, and store data relating to the everyday geographic environment and on the actual knowledge that is acquired*” (Kitchin, & Jacobson, 1997:360).

Researchers have used a range of tests to assess the cognitive map knowledge of people who are blind, [(for a review see Ungar et al., 1996; Kitchin, & Jacobson, 1997; Jacobson, 1998)]. However, although these tests have provided the opportunity to explore cognitive maps of people who are blind and have provided valuable information, they have also produced divergent findings:

> “*…these tests have weak methodological convergence. In other words, they produce different results for the same individual even when the tests have similar characteristics*” (Kitchin, & Jacobson, 1997: 370).

To improve the utility and validity of these tests, Kitchin, & Jacobson, (1997), suggested that researchers should used multiple tests, larger sample sizes with a minimum number of 10 respondents and assess:

> “*the knowledge and abilities within complex real-world environments that everyone inhabits, rather than inferring that results from laboratory will exist in natural settings*” (Kitchin, & Jacobson, 1997: 372).

I would add that a tool that could be used as part of the exploration of children’s cognitive maps is the voice of the child.

My aim in the present study was to explore children’s cognitive map knowledge using their voices, recognising that:

> “*cognitive mapping research has the potential to provide clues as to how to enhance visually impaired people’s wayfinding and orientation skills…*” (Jacobson, 1998: 290).

My aim was to explore the participating children's spatial knowledge – how they acquire, learn, and think about space; and what strategies they use to find their way around - as a result of everyday experience in large scale environments.

Research generally indicates that people develop two main scanning strategies for efficient orientation skills and cognitive mapping (Fletcher, 1980; Bigelow, 1996; Kitchin & Jacobson, 1997 Lahav, & Mioduser, 2003). These strategies are: a) the route strategies which are based on visual or proprioceptive cues and on sequential recognition of the target space that do not go beyond the information that is directly available and b) the map strategies which are holistic and include Euclidean directions and multiple perspectives of the spatial arrangement, indicating an understanding of the overall layout of the target space. The question arising here is whether blind children's spatial knowledge is essentially based on their knowledge of routes between places as has been suggested by previous research (Casey, 1978; Rieser et al., 1992; Bigelow, 1996), or whether it is also based on their knowledge of the overall layout of a familiar space.

People who are sighted instantly see how the world is organized and instantly interact with the surrounding environment. However, as has been discussed, individuals who are blind learn to extract environmental spatial information from sources other than vision. They need to spend more time actively researching their environment, locating or avoiding objects and building cognitive map knowledge of layouts and of routes. People who are blind also need to expend great effort in order to perceive how the direction of surrounding objects changes in relation to their own movement, and how the movement of objects changes object to object relationships.

They are constantly seeking to establish how the world has been repositioned (Millar, 1994; Thinus-Blanc & Gaunet, 1997; Tinti et al., 2006; Fortin et al., 2008).

Passini & Proulx (1988) in a way-finding experiment, found that blind adults could map and learn relatively complex routes and comprehend the surrounding space. They also found that blind adults tended to prepare their journey in more detail, made more decisions during the journey, and relied on more units of information compared with the sighted group. They concluded that blind adults could demonstrate a general understanding of the spatial attributes of the setting, and they could understand and experience space effectively.

Some aspects of the findings of the present study in relation to children seem to offer support for the above findings. Consistently, the children participating in the present study were observed making a variety of subtle decisions in way finding, involving small details which a sighted person might barely notice. For example the surface texture of a floor carpet or small gaps between carpets could provide an indication of the child's position in space or give an indication of the location of an object. Children were observed on a number of occasions utilizing subtle tactile and auditory cues to locate landmarks and information points along a route while simultaneously trying to avoid moving or fixed obstacles. They tried to comprehend and construct the spatial layout of a given spatial area, and memorize routes through it using a variety of strategies:

- They memorized the number and directions of turns involved
- They used reference points to maintain a walking direction, or as an indication of an approaching feature
- They counted paces

- they drew cues from architectural elements and furnishings
- They assessed the time needed to travel from one place to another.

Most of the children indicated that they drew on information stored in their memory from previous experiences, comparing it with real time information; a process that appeared to take place automatically, subconsciously and sometimes simultaneously. Their accounts revealed that stored memory of the layout of a given familiar space helps them to adjust for any subsequent changes to that space.

For the children in the study, memory was a key element for developing a basic framework of Euclidean space. This aligns with the findings of Raz et al., (2007) who reasoned that since people who are blind constantly use memory strategies to perceive the world around them, they have an advantage on memory tasks compared to the sighted people,

"this advantage is likely to be due to practice" (Raz et al., 2007:1133)

Pring (2008:167) confirmed that:

"we need to be aware of memory advantages that allow (blind) children to display significant strengths in certain contexts".

As have been shown in the results, children in the present study actively committed to memory the stable features of the surrounding environment. They described with detailed accuracy routes to various locations in their school buildings and had memorised the number of directional changes, changes in floors levels and key decision points.

Route knowledge, however, does not by itself appears to produce the type of spatial knowledge of layout and configuration that is required to perceive space holistically (Golledge et al., 1992). Therefore the pointing task described earlier was introduced on the basis that:

> *"pointing at targets is an easy and simple way to objectify different types of spatial representations and the underlying mechanisms"* (Gaunet et al., 2007:167)

Children were asked to point in what direction they would fire a "magic arrow" that could shoot through walls to reach a given location. They were also asked to explain how they reached conclusions about the relative location of objects or the direction of the designated location.

One way of exploring children's cognitive map knowledge in familiar space is by asking them to point to designated locations. Pointing in straight line directions can indicate an understanding of the overall layout of a designated space, and have been widely used in previous research (by, among others, Bigelow, 1996; Tinti et al., 2006; Gaunet et al., 2007; Fortin et al., 2008).

Although might not be a spontaneously-occurring gesture for blind children (Bigelow, 1996), there is evidence that infants do not need to see their hand to reach and contact objects and therefore proprioception is sufficient for pointing very early in development (Landau et al., 1981; 1984; Bigelow, 1986; McCarty et al., 2001). Fraiberg (1968) also observed that totally blind infants were able to reach to sound emitting objects located in their surrounding space and that reaching was a critical skill for locomotion. Thus the development of reaching and pointing is not dependent on vision and visual guidance of the hand is not necessary for pointing (Ittyerah et al., 2007). Indeed Tinti et al., (2006) found - as far as the pointing task was concerned - that their blind participants were significantly better than their sighted participants. Fortin et al., (2008) concluded that blind individuals were able to situate themselves in their environment with respect to a specific reference point since they found no significant difference between the performance of blind and sighted individuals in the pointing tasks they performed. In the same line, Gaunet et al., (2007) investigated pointing at memorized targets in congenitally blind and blindfolded sighted children between the ages of six to twelve. They found that early visual experience and age were not predictive factors for pointing ability in children and they remarked that:

> *"pointing is a critical behavior to ascertain the understanding of self in relation to the physical environment"* (Gaunet et al., 2007:167).

The pointing task in my study differed from most of the previous research in that the participating children were asked to verbalize continuously what they were thinking and to explain their decisions – whether their answers were correct or not. I was more concerned with establishing their thought processes than measuring the accuracy of their performance.

Giving children the opportunity to explain their thinking provided an additional perspective that experimental tests cannot achieve. For example it revealed some of the strategies that children employ to map out space, for example:

- Some children think in terms of pathways as entire structures and use the whole school as their frame for establishing one location in relation to another.
- others walk the routes in their mind and construct the layout by piecing together the individual elements of the journey

These cognitive strategies are clearly mentally challenging and demanding (Millar, 1994; Gaunet et al., 2007).

It appeared that the pointing task was easiest outdoors; because children could walk directly to the selected locations without having to make large detours (Bigelow, 1996). Indoors the children reported that the pointing task was harder since it was often necessary to accommodate a variety of turns and changes in direction to determine where the destinations were in relation to the starting point. Pointing to locations that were on different floors was particularly problematic, because it involved calculating not only on a horizontal plane but also on a vertical plane.

In this respect the results of the present study support the findings of Bigelow (1996) who found that in the Euclidean tasks the children's performance suggested that the yard (outdoor) questions were the easiest, followed by the same floor questions, and then by the different floor questions. However the results of the present study challenge Bigelow's conclusion that blind children's spatial understanding was not based on the overall layout of a familiar space but was derived from their knowledge of routes between places. The accounts of the best performers in this study suggest that some children do have this overall understanding but they cannot always make it explicit. It is an implicit knowledge that has to be drawn out through questioning. The responses suggest that children may be able to integrate their experiences into a configurational whole, and synthesizing them into their cognitive maps more easily than Bigelow (1996) concludes.

Asking the children to think about spatial events and to verbalize the thought processes behind their performance on everyday tasks can reveal their reasoning and can help bring out information that is implicit within them.

A key point is that at the beginning of the pointing task children were often hesitant and made spontaneous comments such as:

"*…This is hard …; I know the route is that way*" Markus [TN4/4b/ ¶ 469].

"*… It's complicated and it's difficult to work out where to point*" Helen [TN4/4a/ ¶ 287]

However, when they were asked to verbalize what they were thinking they were often able to reason out the correct answer. The opportunity to interact by reasoning aloud seemed to facilitate the process.

In cases where children failed to point correctly in terms of Euclidean direction to the requested location, they often explained that they were thinking about the route they needed to follow:

"…its like following the route in my head … and then when I get to the end … I think of which way I am facing and I point in that direction" Janet [TN4/4b ¶ 469].

In these situations it seems that some of the children relied on sequential rather than holistic strategies (i.e. a series of mental signposts which are used individually to reach a destination without necessarily relating them to one another). Superficially, this might suggest that children's spatial knowledge is limited only to a mental listing of instructions (e.g. *go straight ahead and turn left at the second door…*).

However other children in the study could figure out the direction to point in terms of straight-line distances between two places that were arranged at the ends of an "L" shape route. Even though their first reaction might be that they could not figure out where to point, and even when they had pointed to the wrong direction in their first instance.

In relation to way finding behaviour in large-scale space children were able to provide:

- rich descriptions of the spatial arrangements of their school and their home and
- detailed descriptions of the spatial thought processes behind their conclusions.

This finding challenges other studies which have concluded that people who are blind tend to have particular difficulties mapping large scale familiar space in terms of Euclidean direction (Bigelow, 1991; 1996), and generally perform poorly on way finding tasks in a familiar space (Casey, 1978). Some of the participating children in the present study appear to have a rich spatial understanding of their surroundings. These *"spatially good"* children reported integrating their experiences to construct their cognitive map knowledge utilizing a variety of strategies. For example, in order to determine the position of an object in space they:

- Coded locations in relation to a stable landmark, using an external, object-based reference cue (Millar, 2006).
- Coded locations in relation to themselves and could keep track of their own positional changes, by constantly updating localization information (Newcombe et al., 1999). A strategy predominantly based upon body-centered and movement coding;

> *"because their proprioceptive and kinaesthetic information is normally a far more reliable source of orientation and reference in relation to spatial planes than external cues"* (Millar, 1994: 238);

- they utilized real-time tactile or auditory information and incidental transient cues (i.e. they could easier locate and point towards the direction of the music room when they could hear music coming out of the room);
- they remembered the route required to reach an object or place by either using body-centered (egocentric) references (i.e. *"to my left is the reception"*) or external frames of reference (i.e. "*opposite the fountain, walking in straight line, there would be the school entrance"*) or a combination of the two (i.e. *"behind the table is the piano and to my left is the computer"*).As Millar &

Al-Attar, (2004), and Millar (2006) remarked, the combination of external and body-centered reference cues doubles the accuracy of location recall under haptic conditions.

Several of the findings from the present study in relation to mapping and coding objects location support findings from other studies. For example Newcombe et al., (1999), and Newcombe & Huttenlocher (2000) proposed that people might code objects location in a variety of ways; such as associating objects with landmarks, remembering distance and direction from landmarks, remembering distance and direction from the self using distance and direction of one's own movement and remembering particular motor movements. In addition the above findings support Millar's (1994) and Gaunet et al.'s, (2007:177) observation that:

> *"early visual deprivation does not prevent the integration of a global spatial arrangement of target locations in children…"*;

Overall many of the participating children in the present study seem to have moved from an egocentric orientation in which space is understood relative to their own body, to a more holistic understanding of the overall layout of the familiar space; in which concepts of fixed reference points and features in the physical surroundings would provide the structure of that space. This suggests that their knowledge of a familiar space is not only based on a sequential knowledge derived from the routes between places but also on their knowledge of the overall layout of that given space. Observations and conversations with the children also support the view that they have developed a generic understanding of common environmental features found in indoor and outdoors settings such as walls, doors, windows, furniture, sidewalks, telegraph poles, etc. They also seem to have developed specific layout knowledge about typical layout patterns found in the surrounding space i.e. dining rooms have repeating patterns and standard furniture.

Therefore it seems that the *"spatially good"* children in the present study have developed the ability to create cognitive map knowledge and cognitive images of familiar spaces that facilitate their understanding of their own position within that space in relation to the surroundings and the position of objects in relation to each other. This also seems to be supported by the information obtained from children's accounts emphasizing the importance of having as many experiences as possible with different objects, different materials and textures. A key finding that emerged from their accounts is that exploring and making discoveries about the surroundings enables children to form cognitive images of their surrounding space (Lehnung et al, 2003). Developing these images can be an important initial step in the processes of reasoning about space, understanding spatial relations and developing configurational knowledge.

5.3.1. Insights into the process of forming cognitive images of the surrounding environment

The issue of whether children form cognitive images of the surrounding environment emerged as an issue in the discussion with the children several times; therefore I thought it was worth exploring the question of whether people who are blind utilize cognitive images to explain spatial features. My aim though was not to offer an answer to the "debate" of cognitive images. The discussion around mental imagery and cognitive images has been controversial for a long time and still needs further exploration. My aim was to provide some additional information that shed light on what other researchers have found utilizing the information derived from talking to children.

A cognitive image can be defined as the mental representation of a physical object or event that occurs when the relevant object or event is not actually available to the senses. It might contain the characteristics of any sensory modality i.e. visual, auditory, haptic, kinaesthetic, and olfactory (Thomas, 2003; Cattaneo et al., 2008).

It is well established that proprioceptive and kinaesthetic inputs together with active tactual exploration are crucial in order for people with visual impairment to gain information about objects and environments (Millar, 2005). Sighted people instantly see and interact with the surrounding environment; they instantly determine the position of an object in space and its approximate size. Some of the processes for gaining this type of information are arguably slower and less efficient in people who are blind; however there is also evidence that they can develop effective alternative compensatory processes (Millar, 1994; 2006; Tinti et al., 2006; Gaunet et al., 2007; Fortin et al., 2008).

Children's accounts in the present study have revealed some insights into the nature of these compensatory processes. Despite the fact that they could not instantly perceive the surrounding space at a glance, they seem to have formulated and utilized cognitive images of their surroundings in which sounds and tactual information play an enhanced role. Heller (1989a; 1989b) proposed that cognitive images can help people to remember complex sequences of familiar objects and events and other researchers have suggested that the mechanisms underlying imagery in the sighted and the congenitally blind may share common representations (Aleman et al., 2001). In addition Noordzij et al. (2007) suggested that:

> *"extensive experience in either the haptic or the visual domain with a particular object or action allows equally efficient imagery processes from both domains."*

Thus it might be concluded that cognitive images based on previous haptic experiences can be as accurate as cognitive images based on visual experiences.

The children in my study suggested that they could form cognitive images of three-dimensional objects by analyzing the tactile feedback from the surface of an object to their hands; suggesting that these images are to a large degree haptic in nature. They could also form images of the surrounding spaces from kinaesthetic information when it was supplemented with verbal descriptions of those spaces. Giudice et al., (2007), investigated the use of verbal descriptions during spatial learning and navigation in large-scale space. Although the participants in their study were sighted-blindfolded, Giudice et al., (2007), found that accurate learning and wayfinding performance was possible using verbal descriptions and that it was sufficient to provide local geometric detail. The highly similar pattern of learning and wayfinding behaviour they observed between verbal and visual conditions among the participants who relied on verbal input and a control group that used visual input led Giudice et al., (2007), to conclude that the cognitive images built up from verbal learning were functionally similar to that developed from visual learning. While the above study used sighted-blindfolded participants, the value of verbal descriptions as a mode of providing access to the environment has obvious application to people who are blind as have been confirmed by the participating children in the present study. Children remarked that verbal descriptions of spatial layouts by other people especially during wayfinding and route navigation were very helpful. They emphasized that verbal descriptions could help specify landmark locations, provide sequential route directions and generally support environmental learning and wayfinding behaviour in relation to novel layouts in large-scale space; and thus enhanced spatial understanding:

"…well if I am learning a new route or if I am in a new place I would like people to tell me where to go, and to describe to me what is around…that would help me to get an idea of where I am" Bob [TN 9/ 9a/ ¶ 360] [52*]

Thus in line with previous research (Pring, 2008; Giudice et al., 2007; Gaunet, 2006; Gaunet & Briffault, 2005) it could be argued that verbal descriptions from others can be invaluable for people who are blind in facilitating their perception of the surrounding environment. However what is noteworthy is that some of the children separated this type of information from their personal knowledge and experience, confirming that touching and feeling created stronger impressions than information gained through the visual perceptions of other people or from other secondary

[52*] TN 9: Tree Nodes 9: things that other people do/ 9a things that other people do which are helpful / ¶: paragraph

sources. This again raises the importance for children of first hand experiences that will help them to comprehend their surrounding world.

"……its kind of memories but not like the memory of a chair for example where I will feel it and see it in my mind …it's a kind of memory …of things that they describe to you and things that you actually feel" Bob [TN 5/5F/ ¶ 186]

"…you feel things, you hear things, people tell you …let me tell you another example… … they give you a tactile picture of a tree … … so you can feel it and that gives me some idea of what a tree looks like …but its not the same as feeling or climbing the tree" Bob [TN 5/5F/ ¶ 188]

It seems that haptic and auditory sensory experiences along with verbal descriptions of the surrounding space are both important for generating meaningful spatial knowledge. Ochaita & Huertas (1993:40) concluded that:

> *"the more familiar blind people are with an environment, the better they organize and structure their memory of it".*

Likewise other researchers remarked that the development of spatial knowledge depends among other factors on the familiarity and complexity of the environment (Appleyard, 1970; Millar 1988; Bigelow, 1996; Kitchin & Blates, 2002).

Kaski (2002:722) emphasized that:

> *"whilst the sighted are able to use visual imagery to represent tangible objects mentally, the blind must rely on other imagery modalities or use semantic representations*"

and concluded that it is possible to form a cognitive image by touching or feeling an object alone.

However Thinus-Blanc & Gaunet (1997:24) argue that even if people who are blind can construct cognitive images

> “*the amount of information stored in the form of mental images is diminished (or lacking)”,*

something that seems to contradict the findings in the present study. The participating children in the present study gave detailed and rich descriptions of spatial features that a sighted person might not even notice and verbalized “the images they had in their mind” of the surrounding space. They emphasized that familiarity with a defined space was an important factor in perceiving its spatial arrangement and they remarked that storing in their mind images of spatial events facilitates their understanding of the surrounding space.

However, the question of whether people who are blind experience visual images or whether these images are rather mental representations that preserve spatial and metric properties has been debated for a long time and still remains an open issue. On the one hand, some see perception and imagery as strongly associated (Arditi et al 1988) and, others believe that imagery processes are independent of perceptual processes (Bertolo, 2005).

Zimler and Keenan (1983) compared congenitally totally blind and sighted individuals on tasks presumed to involve visual imagery in memory. They reported that in all three experiments they carried out, the blind subjects’ performances were remarkably similar to the sighted, suggesting that the haptic images of the blind were able to maintain spatial information equivalent to that provided by visual images to the sighted. Kerr (1983) lent support to the idea that congenitally blind people’s images preserve metric spatial information without visual content, and that accurate knowledge about space can be acquired from different sensory modalities. Similarly, Knauff & May (2006) remark that people who are blind from birth do not construct visual cognitive images, but they are able to construct and employ spatial representations or spatial images from haptics or auditory perceptions. In the same line Cattaneo et al., (2008) state that there is a growing body of evidence to indicate that the performance of blind people is similar to that of the sighted in tasks involving imagery, and that similar levels of performance can be achieved from alternative cognitive strategies such as verbal, haptic and auditory representations. Cattaneo et al., (2008:1347) argue that:

> *"it is likely that blind individuals compensate for the lack of vision both at a perceptual level, by enhancing their auditory capacities, and at a higher cognitive level, by developing conceptual networks with more acoustic and tactile nodes, thus contradicting the view that semantic networks are less elaborate in congenitally blind individuals".*

Along these lines I would argue that the findings from the present study suggest that children's cognitive images preserve tactile, auditory, kinesthetic and olfactory cues but there is little evidence that they preserve any visual cues. Something that conflicts with the findings of Bertolo et al., (2003), and Bertolo, (2005); who concluded that the congenitally blind people do have visual content in their dreams and even if they have never experienced sight, they are able to visualize images.

Kerr & Domhoff (2004:230) criticize Bertolo et al. (2003) arguing that there is no evidence that people who are congenitally blind experience waking or dreaming imagery of a visual character and that:

> *"…they have drawn inappropriate conclusions from the fact that the congenitally blind can draw images of their dream content…"*

In my study only two children out of the twelve specifically mentioned *"seeing visual images in their minds"* i.e. images that preserved a visual character. Both of these children however became blind later in life (at the age of eight years old). As these children explained, they remembered visual images from when they were able to see. However the congenitally blind children consistently emphasized with clarity that their cognitive images preserved tactile, auditory, kinesthetic and olfactory cues (Andreou & McCall, 2010). In line with this finding is Hurovitz et al.'s (1999) study which analysed dream reports from fifteen blind adults, six of whom were congenitally blind and could not perceive light. Hurovitz et al. (1999) found no indication of imagery with visual aspects in the six congenitally blind participants. Four children in my study who had light perception and limited shape perception stated that they utilized their residual vision in combination with tactile and auditory cues to form cognitive images of the surrounding environment. Kerr & Domhoff (2004) also noted that individuals who are blind from birth but who retain some ability to see visual characteristics such as brightness and colour are able to integrate information from different sensory systems including visual experience.

The findings from the present study also cast useful light on the argument that visual words may carry different significance for sighted people from that of people who are blind and that they are not always to be understood as visual images. The findings also have something to contribute to the proposal that children, who are blind, during language acquisition, synthesize their own meanings relating their sensory experience with vision related language often describing vision-like experiences (Landau & Gleitman 1985; Arditi et al 1988). For example, the participating children clarified the meaning of visual terms such as "pictures", "images" and "seeing" which they often used:

"…so (an image) it's made up of the feeling of the walls and the doors…the sounds of teachers talking from each classroom or people playing on the play ground…" Markus [FN15 / ¶ 474]

"…when I feel something I know how it looks like, its shape and stuff …and I remember it and if I see it again I know what it is…" Janet [FN15 5/ ¶ 129]

"…I picture myself standing outside the house, I picture myself feeling the door, and I'd hear the sounds of cars in a distance, possibly a train going passed because it is quite close to the railway…" Markus [FN15 5/ ¶ 95]

The discussion around mental imagery and cognitive images has been controversial for a long time and is far from being resolved. However the participating children's accounts in the present study have revealed an additional perspective that approaches carried within an experimental frame of reference could not provide; namely children have verbalized their underlying thoughts when describing their cognitive images of a defined space:

"(an image) its just made of all the things I sort of know … and it just sort of appears there …but I don't consciously do that…is like when you write something and you write it, and you've written it … but you don't stop to think how you write the individual letters …… you just write the whole word…" Janet [FN16/ ¶ 181]

"…I suppose there must be a plan or a map of my house in my head because I know if I go forward and turn right I am in that room …but I don't actually think of that if I am walking around my house ……its like when you can see and you are walking from one room to another you don't think ok if I want to go from here to there that's what I am going to do …there must be something that guides you around but you don't really think of it … it's the same when you walk trailing with your hands, you don't think ok that's what I am doing now… as sighted people using their eyes, we are using our hands" Janet [FN16/ ¶ 157]

Furthermore, they describe a process of locating objects and following routes "in their mind" and argue that they transfer that knowledge of routes between places into an understanding of the spatial layout as a whole; in many cases by mentally piecing together routes and sequential components.

"when I learn a new route or a new place I learn it bit by bit and I like ……try to remember … is like creating a plan …… a general idea …… of that new place and before I learn it very well I have to use this plan … I have to think how I will go from there to there… but after I learn something I just go anywhere automatically" Judy [TN 8/8e/8e1b / ¶ 160]

"…well I suppose……I don't know ……I have a map somewhere and its written down into my head …but now that I know where everything is I don't normally think about it, its just I know it by heart…unless I am going somewhere I don't go very often like the geography room…if I want to go there I have to think the route ……I have to think that part of the map…… but if I know a place very well it just sort of comes as a natural instinct" Janet [TN 8/8e/8e1 /8e1a ¶ 157]

On the whole the children's detailed accounts point in the direction of the potential of the child's voice for gaining a better understanding of the nature of the cognitive processes that underlie cognitive images and revealed some interesting findings, such as:

- Children can formulate the layout of a familiar space accurately and display detailed knowledge of it.
- Researching and exploring space, examining objects and experimenting on their environment enhances their spatial understanding and enables them to form cognitive images of the surrounding space.

- Their cognitive images are complex and conserve tactile, auditory, kinesthetic and olfactory cues.

The information obtained from the discussion about wayfinding behaviour in large-scale space and the discussion of the pointing tasks with the children, predominantly revealed that participating children:

- utilized known landmarks and information points, keeping track of their own location in relation to the surroundings and made future projections along the routes based on non-visual memories synthesizing cognitive map knowledge of layouts and routes and
- Stored in their memory cognitive images of spatial events in which sounds and tactual information play an enhanced role.

Overall children's accounts have revealed that most of them have developed and utilized complex cognitive images of the surrounding familiar space formulated from a range of inputs such as sounds and tactual information, information from external sources, and generally by actively involved in their environment such as exploring and making discoveries about the surroundings.

5.4. Concluding remarks

It appears that is very difficult to make firm conclusions about the spatial understanding of individuals who are blind on the basis of the available literature. As has been shown in the discussion section and in the literature review chapter, some authors have reported that individuals who are blind are impaired in spatial perception, while others have reported that they performed equal to or better than sighted participants on the same type of spatial tasks. How can these discrepancies found in the literature be explained? As has been discussed elsewhere in the thesis, individual characteristics, the idiosyncratic strategies used in dealing with the surrounding space, the type of education and mobility training the individual has received and experimental factors - such as the task's inherent difficulty, the degree of familiarity with the experimental layout, the required response, the presence or absence of adequate reference cues and so on - all interact in complex ways. It is hard to disagree with Millar's conclusions that the main differences between spatial coding observed in other sensory modalities and vision must be attributed to task and experimental conditions rather than to the input modality as such (Millar, 2006).

Taking into consideration Thinus – Blanc & Gaunet's (1997:39) proposal that:

> *"…the means spontaneously implemented by the participants when first acquainted with the experimental situation and while they are performing the task should also be the object of quantitative studies";*

and that the analysis of spatial descriptions is a:

> *"field of investigation that so far appears neglected"* (Thinus – Blanc & Gaunet's 1997:39);

I have adopted an approach that I believe allows for additional insights into this complexity. The approach I have used is based on the analysis of the accounts of children who are blind concerning the strategies they spontaneously implement when solving spatial problems in their everyday environment. Observations of the participating children's behaviour, and the analysis of their spoken accounts, including incidental clues such as hesitations or casual remarks, have been used to try to gain insights into their thought sequences and decision making processes when engaged in spatial tasks. My aim was to derive additional information about the strategies that underlie children's spatial behaviour. By asking the children to justify their answers and their preference for particular strategies my purpose was to gain a better understanding of the significance of the findings found in the experimental literature and possible explanations for the divergence found there.

Overall as have been shown in the present inquiry, utilizing the voice of the child does seem to offer a useful method for gaining insights that may inform or supplement knowledge about spatial understanding achieved through traditional experimental approaches. However researchers adopting this approach must be prepared to face questions relating to the authenticity of the results achieved. For example children's accounts include references to strategies they would have been taught in mobility training. This raises the possibility that the responses collected through this method do not necessarily reflect their authentic voice, but may simply be a repetition of adults' views previously expressed to them. However it is clear that the participating children were able to draw upon a range of sources to formulate their spatial strategies and these strategies incorporate both what they have learned from others and what they have learned through trial and error. Participating children's voices are inevitably shaped by their assimilation of a range of both first and second hand experiences. It is unlikely that the views they expressed across a wide range of tasks relating to spatial understanding are simply a parroting of what they have heard from others. Children's responses suggest that they are clearly capable of arriving at independent judgments that are often original and revealing (Andreou & McCall, 2010).

Inevitably the strategies children use will be influenced by a range of factors including input from mobility teachers and other adults. Nevertheless children's accounts have shown that they establish the differences and similarities between new objects or events and those they are familiar with and they apply existing strategies to solve novel problems, modifying them as required; using both external items and their own body as a frame of reference. Many of the children were able to provide detailed descriptions of the spatial thought processes behind their conclusions, demonstrating a sophisticated and coherent understanding of space. And as Thinus – Blanc & Gaunet (1997:38) propose:

> *"if some congenitally blind participants (even a tiny minority) can learn to develop optimal spatial abilities, then detailed studies of their development may suggest promising avenues for enhancing the development of all blind people"*.

The methods described here for investigating spatial understanding will clearly need further development and refinement but do hold promise. Triangulation through other sources clearly has an important role in establishing authenticity. Accounts from school records or from adults who know the children well (e.g. the children's teachers) can be used to help corroborate the children's perspective or provide additional information that can explain or interpret children's responses. Among the particular challenges for researchers wishing to apply this approach to study other areas relating to the development of children with visual impairment, is the fact that about a third to a half of children with visual impairment have complex additional needs. This does not mean that this participatory research approach is unsuitable for such children but careful thought will need to be given to its further refinement (Andreou & McCall, 2010).

CHAPTER 6

FINAL REFLECTIONS

6.1. Introduction

This final chapter will start with a brief restatement of the issues related to the methods, the methodology and the trustworthiness of the study. A discussion of the major results to emerge from the empirical work will follow, together with the conclusions that can be drawn from them. It is not my intention to summarise all the relevant information included in the findings; rather I aim to highlight and comment on the most significant aspects of the data.

I will then consider some of the issues concerned with the theoretical implications of the results. The findings have raised a number of implications for practice which are also examined here, although it should be noted that this study was not primarily designed as an intervention study. Possible directions for future work in this area are also highlighted throughout the chapter.

6.2 Selection of methods and research methodology

Although most of the researchers exploring the question of spatial understanding adopt an experimental approach, the evidence collected during the course of the present study was drawn from qualitative interviews with children who are blind. The study sought to explore children's voices concerning the processes involved in making sense of space in real life settings, and the data provide detailed illustrations taken from within the population of children who are blind. Some may put forward objections that challenge my conclusions, however given that research into spatial understanding and visual impairment and blindness has already produced widely divergent findings, and given that my methods suggest that the voice of the child can enrich our understanding around these issues, it is quite possible that my approach will be taken up by others and developed further.

Although the methods described in the present study do hold promise and there was an attempt to verify the interview findings with reference to a range of observed behaviours over an extended period of time, future research might usefully also consider incorporating other sources which can help further in establishing authenticity. Accounts from school records, as well as from professionals who have worked with the children or from their parents can be used to help further corroborate the children's perspective or to provide additional information that can be used to explain or interpret children's responses.

In relation to possible concerns about the chosen research methodology, the use of case studies in the present inquiry proved to be an appropriate means of collecting information across the population of children who are blind, making exacting but not unmanageable demands on the participating children or on my resources as the researcher. Given:

- the exploratory nature of the research (Robson, 2002)
- the resources available,
- the heterogeneous population of children who are blind,
- and the need for more evidence-based understanding of principles and issues in this field;

it could be argued that case studies provided evidence in a manner that was both effective and efficient. There is the obvious restraint of this method in that case studies may not offer a sufficiently strong base to support generalisable conclusions; however the approach has suggested initiatives for further research and may provide a framework for seeking information which could be of value to other researchers (Lewis & Collis, 1997).

6.3. The trustworthiness of the study

Robson (2002) reports that in order to ensure "trustworthiness", the concepts of "transferability", "dependability" and "credibility" are required.

Robson (2002) terms as "transferability" in qualitative research the extent to which the findings can provide generalisability beyond the specific setting. Johnson (1999:187) reports that:

> *"the 'horror' of indexicality is the implication that transferability is not possible, because explanations are only linked to a particular time and setting. However, reporting sufficient detail about particular instances and the theoretical framework makes it possible for others to assess how the data link with a body of theory, and thus whether they can be transferred to other settings".*

The heterogeneity among children who are blind makes it perhaps difficult to generalise findings of research across the wider population. And maybe it is even more difficult in the present situation if we consider that children who are blind with multiple disabilities were not included in this inquiry because I was not confident about being able to access their views reliably (as explained in chapter 3).

However the participating children do reflect part of the range of children who are blind and the present study was intended to contribute to understanding of blind children's spatial awareness. The evidence shows that children in this study who are blind are using a wide range of sensory and cognitive strategies, demonstrating a sophisticated and coherent understanding of space. Therefore it is reasonable to assume that other children who are blind will also use a range of strategies in a sophisticated and coherent manner to form their understanding of space until further evidence may shows that this is not so.

The present study attempted to make explicit the particular situation, the setting and the process of the research; in addition effort was made to compare the findings of the present study with conclusions arrived at by other researchers using other methods to enable the reader to make judgments about the wider applicability of the findings (Johnson, 1999). Future research might usefully seek to further examine the approach and the findings within a wider group of children who are blind, including children who are blind with multiple disabilities.

"Dependability" from a qualitative perspective can be seen as corresponding to "reliability" from a quantitative perspective (i.e. dependability is concerned with ensuring that the same results would be obtained by others using the same research tools) (Robson, 2002; Hitchcock & Hughes 1995). According to Robson (2002), dependability in qualitative research can be achieved through adopting a well-documented and systematic approach to the process of collecting and analysing the findings; with the findings laid open to scrutiny by others (Johnson, 1999).

Although it is very difficult to repeat a qualitative inquiry in order to test the dependability of the study, the report of the present study provides sufficient detail and structure for analogous work to be carried out elsewhere and for the data to be checked (Robson, 2002). An exploratory study was carried out in order to clarify the research focus and develop a framework in which data could be collected and analysed. Further, apart from tape recording and transcribing each interview with each child, a research file with ideas, findings, and observation notes was kept for each child. To this extent it can be stated that the present study has achieved a degree of dependability and while these files of raw data are not open to the inspection of the reader in this thesis due to the constraints of word length, they are nevertheless available as a research resource (Johnson, 1999).

Concerning “credibility”, Lincoln and Guba (1985) argue that credibility in qualitative inquiry seeks to ensure that any theoretical framework generated is understood and is based on the data. Further, credibility seeks to identify if there is an accurate match between the way the researcher represent participants’ views of the phenomena under study and the way participants perceive those phenomena.

Lincoln and Guba (1985) describe a series of techniques that can be used to enhance credibility including: “prolonged engagement” and “persistent observation”, i.e. spending sufficient time in the field to learn or understand the culture, social setting, or the phenomenon of interest; and “triangulation” in order to ensure that an account is rich, robust, comprehensive and well-developed, thus facilitating deeper understanding.

The multiple case studies in the present inquiry support and inform each other, and the development of the inquiry over a period of time adds confidence in the 'truth' of the findings and ensures it addresses the questions it was intended to. To ensure that the process followed was scientific, interview protocols were carefully constructed and subsidiary questions were included in the main body of the questions that broke down the components of the original question into simpler steps and worked like probes to help children who needed to use more concrete language. In addition to a traditional question-and-answer format, the interviews incorporated a variety of pre-planned activities e.g. pointing to designated locations and participating in a tactile card came (see chapter 4: summary of the findings). Thus the answers of the children were defined more clearly and helped to make sure that the children completely understood the content of the question.

In addition, comparing data from interviews with that from observations enhanced the detail of the description, and enriched both the data and the analysis. Gathering detailed information from a number of perspectives and sources through case studies provided 'thick description'.

> *"This description, it could be argued, allows relatively strong conclusions to be drawn about that particular situation and setting"* (Johnson, 1999: 188).

6.4. Summary of results

The purpose of this inquiry was to facilitate open discussions with children in order to identify key issues from their points of view, using collections of their articulated thoughts, feelings and experiences of spatiality so as to make explicit the meaning and structures of their accounts (Soulis & Andreou, 2007). It was an attempt to explore the strategies children who are blind employ to overcome some of the challenges they face by gaining insights into their thought sequences and decision making when engaged in spatial tasks (Andreou & McCall, 2010).

The idea of attending to children's voices has been given increased attention by researchers in recent years. It has been argued that capturing the child's voice should be a priority in research related to the inclusion of children with special needs (Messiou, 2008) and that it is important for researchers:

> *'to work actively towards eliciting views from all'* (Lewis & Porter, 2004: 191).

Lewis (2010: 20) welcomes:

> *'attempts to recognise the right of children to express views in matters that concern them'*;

and notes that a number of studies have gained valuable insights into effective practice through exploring the views of children (Daniels & Perry, 2003; Lewis, 2002; 2004). In addition, Wright (2008) argues that interpreting children's behaviour is fraught with difficulty and in order to establish whether our interpretations are reliable we may need to compare them with the views of the children themselves. Indeed, according to Thomas and O'Kane (1998: 152),

> *'children may be better and more consistent judges of what is important in their ` lives than are adults'.*

Given that researchers from different disciplines have often drawn contradictory conclusions from experimental procedures that attempt to measure and analyse behavioural achievements across a range of spatial tasks with no attempt to seek children's explanations (Andreou & McCall, 2010), the above statements could not be more relevant to the present inquiry. Exploring the potential of the method of asking children who are blind explain their comprehension of the surrounding space has revealed some interesting lines for further enquiry.

To start with, in the area of language this inquiry has shown that in their description of their spatial surroundings, participating children often used a vocabulary that seems to be dependent on vision. To some extent this might be expected since children have grown up in a culture where they are exposed to language that is rich in visually informed terms. They often used the word 'image', 'picture' or 'map' when describing their spatial experience. However the children's accounts suggest that these descriptions represent a different understanding of the meaning of vision-related words from that of children who are fully sighted. As children explain, these 'images' are not intrinsically visual but are made up of tactile, auditory, olfactory and kinaesthetic spatial experiences that sometimes overlap (Andreou & McCall, 2010; Millar, 1994).

Their detailed accounts of their spatial understanding suggest that they are using a wide range of sensory and cognitive strategies in a sophisticated manner to form their understanding of space; they are piecing together different types of sensory perceptual experiences (tactile, auditory, olfactory, and kinaesthetic) with both implicit and explicit reasoning to form the whole “image” of their surroundings. They build cognitive maps and cognitive images of layouts and of routes based on non-visual sources, using a range of frames of reference (Andreou & McCall, 2010). While it could be argued that these are the same sources of information and strategies that all children use, the findings suggested that there are differences in the degree of reliance placed on particular strategies by children who are blind. For example, in the absence of the integrating role that vision offers, participating children were reliant on other strategies and their perception of their surroundings is constructed from a complex set of direct sensory inputs and indirect inputs made up:

- from previous experience of direct sensory contact with objects, whether through active or passive touch or through proporioceptive, auditory and olfactory channels.
- from analogical thinking and deduction from previous personal experiences
- from indirect knowledge that is not tied to obvious personal experiences but is conveyed through the descriptions of other people and secondary sources such as books, media etc

Further, children’s accounts have suggested that:

- they use both self-referential and external frameworks to encode information about objects in space
- they use ‘cognitive map’ knowledge to guide their actions and consciously form ‘images’ by utilizing tactile and auditory memories within a framework of analogical thinking and deduction from previous experiences:
- they actively explore and experiment upon spaces and objects within spaces to enhance their cognitive map knowledge and their cognitive ‘images’ of structured and differentiated spaces

In short, their understanding of the spatial relationship between different locations is not simply dependent on mentally reconstructing the routes between them as Bigelow (1996) suggested, but often reflects a sophisticated understanding of the overall layout of space.

Based on these findings it could be argued that children in the present study are able to reason about spatial relations and have established a configurational understanding of their surrounding familiar space that seems sophisticated and coherent, (Andreou & McCall, 2010), lending support to Millar’s conclusion that people with visual impairments have no less potential than the sighted for developing a fully integrated representation of space. However the question of how their knowledge about specific routes and environments is integrated into configurational understanding, and what additional information or skills this process involves, can only be answered to some extent here, and is certainly worthy of further investigation.

What is important here to reveal is that talking to children and carefully listen to their voices can provide valuable information about their spatial understanding and constitutes a potentially powerful source from which researchers in this area can derive knowledge.

6.5. Theoretical implications

Taken together, in this inquiry, the evidence shows that children who are blind are able to verbalize the processes of understanding spatial layout and spatial dimensions and the wide range of sensory and cognitive strategies they draw upon to develop their understanding of space. They are able to do this across the areas of spatial understanding that have traditionally been common areas for investigation by scientists.

In chapter two, the positions adopted by researchers with regard to the nature of spatial understanding in people who are blind were reviewed, and they include conclusions that:

- lack of visual experience inevitably results in a lack of spatial understanding (*Deficiency* '*theory*' ; Von Senden, 1960)
- people who are blind can understand and mentally manipulate spatial concepts but are not as effective as sighted individuals in their perception of space *(Inefficiency 'theory'* ; Casey, 1978)
- people who are blind have the same ability to process and understand spatial concepts as the sighted, but that they do so more slowly and by different means (*Difference 'theory';* Juurmaa, 1973).
- people who are blind are able to process spatial images in a similar way to that used by sighted persons, although such processing might require more time. (*'amodal representation hypothesis'*; Carreiras & Codina, 1992).

Although some of these approaches are often described in the literature as 'theories', (Fletcher, 1980; 1981a; 1981b; Kitchin et al., 1997; Ungar et al. 1996), they might be better understood as different beliefs that underlie research approaches in this area (Andreou & McCall, 2010).

The data on which these broad beliefs are based have traditionally been obtained using an experimental approach based on the performance of people who are blind or on sighted people who are blindfolded in spatial tasks. The findings from these studies are important and are the basis of our knowledge of the processes that underlie understanding of both small and large-scale space. However, as already has been discussed, aspects of this experimental approach are problematic, for example comparing results from a blind population that is already extremely heterogeneous with results from groups of sighted individuals who by definition, have experienced, and continue to experience, the world different has obvious drawbacks (Andreou & McCall, 2010; McLinden and McCall, 2002; Mason and McCall, 1997). Very rarely have researchers explored the explanations given by participants about their decisions when performing spatial tasks.

The results of the present inquiry, that is essentially a qualitative "within population" study (Warren, 1994), cannot provide conclusive evidence for any of the general belief systems or theories mentioned above. However, they do appear to align most closely with the "*different means*" posited in difference theory and the *'amodal representation hypothesis'* of Carreiras and Codina (1992). These theories question views about the essential role of vision in the construction of holistic spatial representation, and acknowledge that with training and practice, other senses can be used to construct equivalent spatial representation. It also appears to favour Millar's

(1994) continuous argument that no sensory modality is singly sufficient for effective spatial coding.

In addition, even though it is perhaps obvious, it should be noted that my findings clearly suggest that the deficiency theory, which holds that individuals who are congenitally blind cannot develop the basic perceptual process required in order to perceive complex spatial arrangements, is invalid.

My findings also strongly suggest that the personal narratives of children who are blind can help in the triangulation and understanding of findings obtained by traditional experimental approaches and this in turn may lead to a better understanding of the nature of the cognitive processes that underlie spatial processing, and help in particular to explain how a participant reaches an observed level of performance.

Children's accounts revealed that while some may lack the skills to perform particular spatial tasks, they do not necessarily lack the facility to do so. The example of the pointing task suggests that the performance of children in spatial tasks may be inhibited by how tasks are presented to them. Pointing in terms of Euclidean directions and trying to express configurational knowledge was not a familiar task. Children needed time to think carefully, reassurance that the ideas they were expressing were valued and the sense that they were operating in a secure and familiar environment. They needed to have anxieties about their performance addressed.

One explanation for the divergent conclusions on children's spatial performance found in the literature might therefore be the nature of the approach used to collect the data and could be attributed in part to:

- the lack of relevance and inappropriateness of the tasks rather than children's ability to perform a task.
- The fact that the experimental setting might cause anxiety to children.
- It may also have to do with the way the task is presented i.e. the language and vocabulary used.
- It may also be that children need to be allowed time to think more carefully about what they been ask to do.

The participating children were able not only to explain the processes behind their spatial performance but also to justify their preference for particular strategies. Perhaps conclusions from different studies would have been more rounded if authors had sought explanations from the participants of the reasons behind their decisions taken during performing spatial tasks.

The theoretical implications of the evidence that people who are blind tend to code spatial relationships in terms of self reference frameworks rather than utilizing external frameworks have also been discussed in the thesis. Gaunet & Thinus-Blanc (1996) and Hill et al. (1993) found that self reference strategies were correlated with the lowest performance levels. However when the children participating in this inquiry were allowed to describe and explain their own experiences, they appeared to support Millar's position that sequential and egocentric strategies are not necessarily less efficient than allocentric strategies nor do they always correlate with lower performance levels when exploring large scale space. Thus future research might usefully examine and reconsider how children who are blind develop and utilize self reference and external reference cues during navigation.

The participating children in the present study reported using both self reference and external frameworks when trying to orient themselves in physical space, navigate from place to place and to specify the location or the size of different objects. Therefore I agree with Millar & Al-Attar (2004) that when children who are blind are processing space, they draw effectively on both external and self-reference frameworks, depending on the particular circumstances and the nature and demands of the problem they have to solve. Although given that in the absence of vision children might show a preference for using self-reference and movement coding strategies, (Millar, 1988; 1994), I agree strongly with Millar (1994) and Warren (1994) that congenitally blind people do have the potential to adopt external coding strategies that might be functionally equivalent to those of the sighted and that can facilitate the construction of configurational knowledge.

An interesting next step for future research would be to find out whether children who are blind would actually show a preference for using external reference strategies for certain types of spatial tasks if more emphasis is given to training them to understand the relationships which exist between objects in the environment independent of their own body position.

6.6. Implications for practice

Although vision is viewed as the most effective sense for gaining spatial information, children in the present study have demonstrated that they are able to talk about their insights and understandings of spatial concepts. This, I believe, can help advance our understanding as researchers and practitioners of what is happening to children who are blind in terms of their spatial understanding.

Thus the findings point to the need for the adults involved in their education to try harder to see from the children's point of view and listen to their voices (Lewis & Collis, 1997). As Porter (2009:349) points out:

> *"…children are the best source of information about the ways in which schools support their learning and what barriers they encounter".*

These results have a number of important implications for the education of children who are blind in general and for orientation and mobility instruction in particular. In the first place, educators need to really listen to what students have to say about their spatial skills. In this way educators will understand more about their students' needs and at the same time learn more about their teaching and the process of learning (Lewis, 2004b; Fielding, 2001). As Lincoln, (1995:89) emphasises:

> *'Children and adults combine power and create new forms of wisdom when they explore learning together'.*

Children who are blind have valuable information to share concerning their understanding of space and if researchers and practitioners are open to listening, they are more likely to understand what will help each individual child to improve their spatial skills. The importance of exploring their insights and understanding is especially important in the field of visual impairment where the population of the children who are blind is extremely heterogeneous.

Talking to children and giving them the chance to reflect and interact with an adult by reasoning aloud and justifying their approach towards a specific spatial task may prompt professionals to change their approach to instruction for that task, and develop their own understanding and skills. *As* Lewis & Collis (1997:134) state:

> *"…the most productive work on blind children is done when researchers succeed in trying to glimpse the world as it is perceived by a blind child, rather than proceeding by uncritically assuming that what sighted people apprehend through vision points to inevitable gaps in the way that blind children comprehend the world."*

A second key finding that emerges from this research concerns the relationship between tactile, auditory, olfactory, and kinaesthetic information. While hearing is considered the main source for distance information in the absence of vision and touch is considered to be a key sense for getting information about the immediate surroundings (McLinden & McCall, 2002; Mason & McCall, 1997; Millar, 1994) understanding of space is derived from combinations of senses. As children's accounts in the present inquiry have confirmed, sensory inputs are interlinked and successful understanding of space relies on combinations of immediate sensory inputs and their relationship to those already stored in the memory. Thus training should be provided to children who are blind to develop further their sensory skills simultaneously.

It is essential that practitioners recognise the importance of building on the information and coding strategies currently available to a child who is blind, and progressively integrate new information with existing knowledge (Millar, 1994). From an early age children who are blind need access to formal and informal learning experiences that develop basic skills such as classification, discrimination, estimation of volume etc in relation to everyday objects and spaces so they can develop the idea that individual parts fit together to make a spatial "whole" (McLinden & McCall, 2002; Andreou & Kotsis 2005; 2006a; 2006b). Teaching approaches that involve young children, who are blind exploring spaces independently while explicitly focusing on developing their appreciation of tactile, auditory, olfactory, and kinaesthetic cues, may well facilitate a holistic understanding of the structure of the surrounding space.

As Millar (1994:240) suggested:

> *"there is, in fact, no reason to think that independent exploration and assisted discovery are mutually incompatible".*

Providing young children who are blind with opportunities and encouragement to move independently in their environment through assisted exploration may help improve long term performance in unfamiliar environments.

Children in the present inquiry in their description of space often referred to a "mind map" stored in their memory that comprised details of the surrounding familiar environment including various routes and landmarks and the associations between them. Educators might consider exploring and extending each child's version of their cognitive map so that it becomes a more effective tool for making sense of the world around. An obvious potential tool that educators can use to facilitate cognitive map knowledge might be a tactile map. Although it should be noted that tactile maps are not within the scope of the present inquiry, some of the participating children stated that a tactile map might help them learn a new unfamiliar space more readily and help develop their "mind map". This finding is also supported by a number of experiments that have considered the potential of children who are blind to acquire spatial knowledge from tactile maps and to use this knowledge to make spatial decisions (Edwards et al, 1998; Espinosa et al., 1998; Ungar et al, 1995a; 1995b; Ungar, 2000; Ungar et al, 2004).

Thus it may be that if children who are blind are trained to use tactile maps in conjunction with direct experience of the environment, as some of the children in the present inquiry have suggested; and if they are also trained to consider the spatial relationships between the different locations on a tactile map through discussion and questioning; it may facilitate the expansion of their spatial understanding. However, the questions of how children who are blind develop cognitive map knowledge or how they develop external frameworks of knowledge, utilizing tactile maps is beyond the scope of the present inquiry and future researchers might want to examine these issues further.

Even so, as Millar (1994:247) emphasizes:

> *"there is no general prescription that can tell the parent, teacher or helper when to provide information overlap, and when a 'nudge' in the right direction is sufficient for children to make the crucial connection, analogy or inference that is needed for them to proceed from knowing 'that' to knowing 'how', from orienting themselves in space to representing that space on paper or mentally*".

What works best with an individual child is determined by a combination of the adult's understanding of children's individual characteristics and the creativity, inspiration and skills they can bring to their education.

6.7. Concluding remarks

This inquiry has offered, as previously stated, insights from within the population of children who are blind that have the potential to impact positively on our ability to understand, describe and develop their spatial awareness. Children's explanations, understanding, feelings and coping strategies relating to their experience of space in their everyday lives have been revelatory.

For me this inquiry has been particularly valuable and helped me formulate my thinking about my own personal journey of self – development as a researcher. In the last eight years, two as a master's student in a Greek university and six as a doctoral candidate in a UK university, I have taken the research opportunities that have come my way and I have tried to use the research knowledge and skills I have being taught to explore a complex area of enquiry. This knowledge has guided me through many challenges and difficulties and reminds me of the importance of responsibility and integrity in research as in other aspects of life. I do know that I have a long way to go and I need constantly to question, examine and re-examine my thought processes, realizing that the present work is not the end of the learning process for me.

Even so, I have learned a great deal about children who are blind and how they make sense of the world. I have also learned what research is about and the thought discipline it involves. My exposure to research opened new horizons for my self – development. I have developed my ability to learn, listen and observe what matters most to the children I work with; I have changed the way I think about aspects of my work and the way in which I work. Firstly I have learnt the importance of careful observation and of trying to comprehend children's views and perspectives while thinking about my own. Secondly I have learnt to examine and reflect on my work and to be critical of myself when needed.

Another valuable lesson I have learn is that knowledge can never be complete:

- Regardless of the efforts to accurately reflect the participating children's attitudes, beliefs, feelings and values;
- Regardless of how many interviews I conduct or for how long I observe children in their school environment;
- and regardless of how thoroughly I study the relevant literature;

I can never capture the whole picture and the messy reality of spatial understanding within the population of children who are blind. It seems that the more I have learned the less certain I am and the more I question, seeking ways to develop further as a researcher, as a teacher and as an individual.

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APPENDICES

APPENDIX 1: CONSENT LETTER

Dear (head teacher)

I am carrying out a study for a PhD at the Visual Impairment Centre for Teaching and Research (VICTAR), School of Education, University of Birmingham and I am writing to request your consent for me to work with children in your school as part of my research. My supervisor is Dr Steve McCall.

My PhD study is investigating the ways in which children who are blind learn about the spatial environment and the ways in which they use this knowledge. The purpose of the study is to help teachers and their parents to improve children's confidence and ability to navigate and use spatial environments.

To carry out this research, I plan to work with children who are blind aged 10 to 15 years old, who don't have any additional disabilities. The bulk of the fieldwork will be observing and interviewing the children in their classrooms and other parts of their school. I propose to start with observations twice a week for a month and then do the pilot interviews. For the main research I estimate that I will need longer periods of observations and then the main interviews will follow. I estimate that I will spend about 3 hours, interviewing each child, in three sessions. I have 10 years experience working as a teacher in Cyprus and Greece, 2 years of which were spent teaching visually impaired children. You, your school, members of staff, the children that I work with and their families will be given anonymity in the reporting of findings. Only Dr Steve McCall, my PhD supervisor, and myself will know the identities of those take part in the study.

The end result of my research will be a written thesis that presents the analysis and conclusions of the fieldwork data and I also plan to publish the findings in academic and professional journals. And I will, of course, be happy to discuss the findings with you.

I hope that I have given you enough information about the project but please phone or email me for any additional information. My telephone is …………………. and my email address is yxa330@bham.ac.uk.

Yours sincerely,

Yiannoula Andreou
Cc Dr Steve McCall

APPENDIX 2: SUMMARISED BACKGROUND INFORMATION

The following information was collected from the school files and through interviews with a number of key staff at the school, i.e. mobility instructor and class teacher

Table 1:

Students:	**Age at first interview**	**Sex:**	**Age of onset of blindness:**	**Cause of blindness:**	**Visual perception:**	**School records:**	**Setting:**	**Interview cycle:**
1. Markus	13 years old	Male	Birth	Bilateral Microphthalmus, Bilateral Colobomata	No vision at all	Excellent Mobility, Braille and communication skills Above average in most subjects	School for the blind which is not residential	First interview cycle- Pilot (1 x 50 minutes) second interview cycle (3x 50 minutes)
2. Ahab	12 years old	Male	Birth	Microphthalmus opacities of both eyes; Photo-phobic; Developed glaucoma in right eye	Light perception. Recognizes some well saturated colours	Excellent mobility, Braille and ICT skills Very good mobility skills Above average in most subjects	School for the blind which is not residential	First interview cycle- Pilot (1 x 50 minutes) second interview cycle (3x 50 minutes)

3. Harris	13 years old	Male	8 years old	Brain tumor, cortical blindness, optic nerve damage, hydrocephalus	No vision at all	Good Braille, and communication skills Average to low mobility Skills Average ability in most subjects.	School for the blind which is not residential	First interview cycle- Pilot (1 x 50 minutes) second interview cycle (3x 50 minutes)
4. Hans	14 years old	Male	8 years old	Horizontal and vertical nystagmus, post viral optic atrophy, optic nerve hypoplasia, Lebers amaurosis	light perception/ recognizes some well saturated colors	Good Braille, and communication skills Average to low mobility skills Average ability in most subjects	School for the blind which is not residential	second interview cycle (3x 50 minutes)
5. Alan	11 years and 6 months	Male	Birth	Anophthalmia	No vision at all	Good Braille, and communication skills Average to high Mobility skills	School for the blind which is not residential	second interview cycle (3x 50 minutes)

						Average to high ability in most subjects		
6. Shimon	10 years and 11 months	Male	Birth	Cryptophthalmia, Fraser Syndrome.	Light perception in left eye.	Average to low Braille, mobility and communication skills Average to low ability in most subjects	School for the blind which is not residential	second interview cycle (3x 50 minutes
7. Sal	11 years and 9 months	Male	Birth	Lebers Amaurosis	Light perception	Good Braille, and communication skills Average to high mobility skills Average ability in most subjects	School for the blind which is not residential	second interview cycle (3x 50 minutes
8. Bob	15 years old	Male	Birth	Microphthalmus and cataracts	Limited light perception only	Good Braille, and communication skills	Residential school for the blind	Third interview cycle (3x50 minutes)

						Excellent mobility skills Average to high ability in most subjects.		
9. Lisa	14 years old	Fe-male	Birth	Retinopathy of prematurity	Limited light perception only	Very good Braille, communication skills Good mobility skills Above average in most subjects	residential school for the blind	Third interview cycle (3x50 minutes)
10. Helen	12 years old	Fe-male	Birth	Lebers Amaurosis	Light perception/ Limited form perception	Very good Braille, and mobility skills not very sociable Average to high ability in most Subjects	residential school for the blind	Third interview cycle (3x50 minutes)

11. Judy	13 years old	Fe-male	Birth	Retino-pathy of pre-maturity	Light perception/ occasionally limited form perception	Excellent Braille, communication, and mobility skills Average to high ability in most subjects	residential school for the blind	Third interview cycle (3x50 minutes)
12. Janet	12 years old	Fe-male	14 months old	Bilateral Retinoblastoma	Light perception in right eye/ limited form perception.	Very good Braille communication, and mobility skills Above average ability in most subjects	residential school for the blind	Third interview cycle (3x50 minutes)

APPENDIX 3: OBSERVATION FINDINGS, SUMMARY TABLE

The purpose of the observation findings summary table is to give the reader a general impression of how the children performed when traveling independently and to provide a brief description of their observable mobility skills as they appeared to the author.

Participant Students in the 1st and the 2nd interview cycle:
S1 Markus, **S2** Ahab, **S3** Harris,

Participant Students in the2nd interview cycle:
S4 Hans, **S5** Alan, **S6** Shimon, **S7** Sal

Participant Students in the 3rd interview cycle:
S8 Bob, **S9** Lisa, **S10** Helen, **S11** Judy, **S12** Janet

Observation summary	Participant students	Additional Comments
1.Walked around in a **familiar** space		
a. with confidence (i.e. with a general level of safety and independence appropriate to their chronological age and their level of training)	**S1** Markus, **S2** Ahab, **S4** Hans, **S5**Alan, **S7** Sal, **S8** Bob, **S10** Helen, **S11** Judy, **S12**Janet	

b. with a lack of confidence(i.e. below the expected general level of safety and independence appropriate to their chronological age and their level of training):	**S3** Harris **S9** Lisa	**S3** Harris, either used his cane or relied on trailing walls, sometimes colliding with objects and passers by **S9** Lisa seemed to have a good awareness of her surroundings and could remember key landmarks, and location cues. However lacked the confident movement shown by most other participants
c. with no confidence (i.e. well below the expected general level of safety and independence appropriate to their chronological age and their level of training):	**S6** Shimon	**S6,** Shimon, could describe the approximate route to destinations in the school building but declined to find his way there unaccompanied
2.Walked around in an **unfamiliar space** (i.e. parts of school not regularly frequented) **a. with confidence** (i.e. with a general level of safety and independence in unfamiliar space appropriate to their chronological age and their level of training)	 **S1** Markus, **S2** Ahab, **S5** Alan, **S7** Sal, **S8** Bob, **S10** Helen,	

b. with a lack of confidence (i.e. below the expected general level of safety and independence appropriate to their chronological age and their level of training):	**S3** Harris, **S9** Lisa	**S3** Harris and **S9** Lisa, walked very slowly, trailed along walls and used their cane paying close attention to the information they were receiving through it.
	S11 Judy, **S12** Janet	**S11** Judy and **S12** Janet, walked very slowly trailed walls whenever possible, made heavy use of protection techniques and preferred to have sighted guide.
c. with no confidence (i.e. well below the expected general level of safety and independence appropriate to their chronological age and their level of training):	**S4** Hans	**S4** Hans, was reluctant to explore any unfamiliar space
	S6 Shimon	**S6** Shimon, avoided unfamiliar spaces and relied on guidance

APPENDIX 4: INTERVIEW SCHEDULE FOR THE EXPLORATORY STUDY

Interview schedule introduction

(Used for the exploratory and the main study)

First of all I want to thank you for taking the time to talk with me today.

I want to ask you some questions.
You may find some of the questions silly or difficult to answer but don't worry about it. It's not a test, there is no right or wrong answers, and I only want to know what you think**.** I want your help in order to understand how you find your way around and how you make sense of the world around you.

I will be taping the session because I don't want to miss any of your comments. Is that OK with you?

Anything we say today will be kept confidential; this means that your interview will be kept private. I will not discuss your interview with your teachers or any other person at the school. And I will ensure that any information I include in my study does not identify you.

Remember, you don't have to talk about anything you don't want to and you may end the interview at any time.

Do you have any questions?
Are you willing to participate in this interview?

Questions:

Way-finding

1. How do you find your way around in this room? Can you give me an example?
2. How do you know what is coming next while you are walking around?
3. How can you tell where to go and how to find different classrooms in your school? Can you give me an example?
4. Can you tell me how can I get to the dining room if I want to?
5. How would you find out what's in a room that you have never been to before?

Estimating and Measuring

Now let's try to do some estimating and measuring, it's like playing a game.

Probe: If the child doesn't respond to a question, I will ask them "if you were to just guess, what would be a good guess"?

1. How long is it from your classroom door to the wall on the other side of the classroom? How did you work that out?
2. How wide, is your classroom door? How did you work that out?
3. How long is your classroom door?
4. How long is your desk? How did you work that out?
5. How long is your bed? Can you please tell me what you are thinking when you are working it out.
6. Which one is longer, your desk in school or your bed at home?
7. Can you estimate the length of your brailler? (How do you know?)
8. Can you tell how big or small is a room? (How do you know?)
9. Which one you think is bigger, your classroom or the dining room? (How can you tell that?)

10. How high do you think the ceiling is?
    (If the child doesn’t respond then I will say: Try to estimate. What makes you think that?)
11. Is the ceiling always the same height in every room? (How do you know?)

APPENDIX 5: INTERVIEW SCHEDULE FOR THE MAIN STUDY

Interview schedule for 2nd and 3rd interview cycles

(Questions with asterisk * and *italics* were included in the 3rd interview cycle)

Each child will be interviewed in three different sessions: A, B and C. (3 x 50-60 minutes).

Part A

Probe 1: If the child doesn't respond to a question I will wait for 6 to 8 seconds and then I will ask them "if you were to just guess again, what would be a good guess"?
Probe 2: If the children respond with a yes or no answer then I will ask them "can you tell me a bit more?"

1. Estimating, comparing and measuring

Let's try to do some estimating and measuring, it's like playing a game.

Questions

A1. 1 Estimating, comparing and measuring sizes that children are likely to have direct experience of

1. Can you estimate the width of this classroom door?
   Can you tell me what you are thinking when you are working it out?
2. Can you estimate the height of this classroom door? How did you work that out?
3. Can you estimate the length of a brailler? What are you thinking when you are working it out?
4. Which one do you think is bigger, your classroom or the dining room? How did you work that out?

5. Can you tell if a room is big or a small? How do you work that out?
6. *How many bedrooms are there in your house? Which one is the biggest? How do you know that?* [1]*

A1. 2 Estimating, comparing and measuring sizes that children are less likely to have direct experience of

1. (Introductory question) How high do you think the ceiling is in this room?
   Probe: If the child doesn't respond I will wait for 6 to 8 seconds and then I will ask: "Try to estimate. If you were to just guess again, what would be a good guess"? What makes you think that?
2. Is the ceiling always the same height in every room? Probe: For example is the ceiling in the dining room the same height as the ceiling in your classroom? How did you work that out?
3. Does your family own a car? (If the child says yes I will ask: What car? What make? Can you estimate the length of your car?) (If the child says no then I will ask: Can you estimate the length of a family car?). How did you work that out?
4. Can you estimate the length of a Bus? (Prompt: Is it twice the length of a family car, three times, four, five or much more?) How did you work that out? What makes you think that?
5. Is your house a two-story house? How tall do you think your house is from the ground to the top of the roof? How did you work that out?
6. How tall, do you think is the tallest building in your town?
   (Prompt "Twice the height of your house, three times, four, five or much taller?")

You've done very well. I'm very impressed. Now I want you to help me to understand more about how you think about things. So here are some more questions:

- *When you were trying to work out the answers to questions like the ones I have just asked you, what were you thinking? (If the child doesn't respond I will ask:*

[1]* 3rd interview cycle

For example, when you were working out the size of your house from the ground to the top of the roof, what were you thinking?)[2]*

Can you tell me more about this?

Can you think of examples of what you are describing to me?

Activity 2

Introductory questions:

- Do you have any pets at home?
- Have you ever been to a farm to see the animals?
- Have you ever travelled by aeroplane or by boat?

I will give the children tactile cards with the names of different animals, labelled in Braille.

I will ask them to read each card.

1. Now let's play a game with some cards. I will give you tactile cards with the names of different animals on them, labelled in Braille; can you please read each card?
2. Can you please put the cards in a row from the smallest to the biggest according to the size of the animals in real life? (I will explain that when I say size I mean the volume, the amount of space the animal occupies).
3. I want to know how you understand things, so can you please tell me why did you put the animals in this order?
4. What goes through your mind when you are working it out?

Animals: goldfish, blackbird, cat, dog, horse, and elephant

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[2]* 3rd interview cycle

I will do the same with means of transport: bicycle, motorbike, car, bus, aeroplane and cruise ship.
Each vehicle card will be labelled in Braille. Can you please read each card?

1. Can you put the cards in a row from the smallest to the biggest according to the size of the vehicles in real life? (Again, when I say size I mean the volume, the amount of space the vehicle occupies).
2. Can you please tell me why you put the vehicles in this order?
3. How did you work that out? What makes you think that?
4. What you are thinking when you are working it out?

Part B

B. 2. Way finding in a familiar environment

B.2.1. General Questions:

1. Do you ever stay home alone? (If they say 'yes' then I will ask:) How do you feel about moving around your home when you are on your own? How do you know where everything is? (If they say 'no' then I will ask: How do you feel about moving around your home? How do you know where everything is?)
2. How do you know as you are walking what's coming next? If probe is needed: can you tell me a bit more? Can you give me an example of what you are saying?
3. *When you move from one room to another what are you thinking? If probe is needed: Can you tell me a little bit more about this?* [3*].
4. What are the worst things about moving around on your own? What are the best things?
5. Now let's talk about your school. Can you please describe it to me with as much detail as you can so as to help me to find my way around?
6. Can you remember the first day you came to this school? How did you work out what was around you and where everything was? How could you tell where to go and how did you find different classes? (If probe needed: interesting - can you tell me a bit more?)
7. I want to know more about how you find your way around in school, now that you are familiar with it. How do you find out exactly where you are and which direction to follow in order to go to different places? If probe needed: Can you give me an example of what you are saying?
8. What are the worst things about moving around at school on your own? What are the best things?

[3*] 3rd interview cycle

B. 2. 2. Imaginary situations

- Imagine that a friend of yours Mike is coming to stay at your house for the weekend. He has never been to your house before. Can you please describe your house to him so as to help him find his way around?
- When you were describing your house, what was going through your mind?
- Imagine I also came to visit you at your home and you were going to show me around your neighborhood. Can you describe the area around your home to me and tell me some of the things I might see nearby? (Prompt if necessary: Are there any shops or parks, other friends' houses?)
- How would I get there if I wanted to?
- *When you were describing your neighborhood to me, can you tell me what you were thinking?* [4*].

B. 2.3. Real-life situations

[(A week prior the formal interviews of the main research the children were asked to describe various routes to designated locations in their school. After the verbal description of the routes they were asked to take me to those locations. Comments were recorded and transcribed). I wanted to find out if the children can describe the routes to the destinations in the pointing tasks and whether they can guide me there before I introduce the pointing tasks.]

[4*] 3rd interview cycle

Pointing tasks

I will ask the children to imagine that they have a magic arrow that could shoot through walls. **"If you wanted to shoot that arrow with a message on it so it landed at the science laboratory which direction would you have to point the arrow?"**

- Can you tell me what you have in your mind while doing that? For example how do you figure out in what direction the science laboratory is?

We will then walk together to the science laboratory and asked them to "shoot the arrow" to another destination. I will ask them to do the same for different locations, and explain how they figure out in which direction "to shoot the magic arrow".

They will be prompted to have a second trial if they want after justifying their approach. All comments will be recorded and transcribed.

The same procedure will be followed for all the following routes:

Selected locations for school A1:

From the medical room to the science laboratory	Same floor
From the medical room to the entrance of the school	Same floor
From the medical room to the English's classroom	Same floor
From the science laboratory to the mathematics' classroom	Same floor
From the English classroom to the science laboratory	Same floor
From the entrance of the school to the mathematics' classroom	Same floor
From the medical room to the Art classroom	Different floor
From the Art classroom to the medical room	Different floor
From the Mathematics classroom to the cookery room	Different floor
From the Art classroom to the science laboratory	Different floor
From the Art classroom to the dining hall	Different floor
From the science laboratory to the Art classroom	Different floor

Selected locations for school A2

From the medical room to the entrance of the school	Same floor
From the medical room to the dining hall	Same floor
From the medical room to the office	Same floor
From the dining hall to the medical room	Same floor
From the office to the entrance of the school	Same floor
From the office to the music class	Same floor
From the medical room to their classroom	Different floor
From the office to their classroom	Different Floor
From their classroom to the dining hall	Different Floor
From their classroom to the entrance of the school	Different Floor
From the Dining hall to the library	Different Floor
From the Dining hall to their classroom	Different Floor

Selected locations for school B

From the leisure block to the hall of residence	Outdoor task.
From the hall of residence to the leisure block	Outdoor task
From the leisure block to the main entrance of the school	Outdoor task
From the main entrance to the hall of residence	Outdoor task
From the main entrance to the dining hall	Same floor
From the main entrance to the art classroom	Same floor
From art classroom to the dining hall	Same floor
From the art classroom to reception	Same floor
From reception to the music classroom	Different floor
From the music classroom to the dining hall	Different floor
From the music classroom to the art classroom	Different floor
From the art classroom to the music	Different floor

Part C

C. 1. Way finding in an unfamiliar place

C. 1. 1. Indoor navigation

1. I want to know more about how you understand things. Let's say that you enter a room, here in school, that you have never been there before, its completely unknown to you; you have a task: to find out what things are in there and where they are;
    a. How are you going to do that?
    b. How will you find out what is around you and where everything is?
    c. How will you understand if the room is big or small?
    d. How will you work that out? [5*].

C. 1. 2. Outdoor navigation

1. How often do you go out? Where do you go most often? e.g. visiting friends, entertainment?
2. Do you ever go anywhere by yourself? Where? Is there anything you don't like about moving around on your own?
3. Let's say that you took a taxi to go to a friend's house. There is no parking available outside your friend's house so the taxi driver goes past the house and drops you a little further down the road. There is a wide pavement for you to follow and you don't have to cross any roads. The taxi driver tells you that you need to walk for a minute in a certain direction to get to your friend's house.
    a. How you will figure out where are you going?

[5*] 3rd interview cycle

b. How will you understand what is around you?
c. How will you know whether there are any other houses or big buildings or shops in that street? How will you work this out?

4. Do you ever walk in your neighborhood on you own? Where do you go? Do you feel confident while walking on your own?
5. Have you ever been to a park? Let's say that you are with your parents or with friends in a park.
    a. How will you recognize what is around you?
    b. How will you tell if there are any people or animals?
    c. If there are any bicycles?
    d. If there are trees can you tell how tall they might be? How will you figure out that?
    e. Would you try to explore your surroundings? How would you do that? If probe needed: Can you tell me more about that?
6. Would you walk on your own along a route that you don't know very well?
7. How do you feel about being alone in a place that you don't know very well?
8. Do you cross any streets alone?
9. If you have to cross a street in order to get somewhere
    a. how would you work out the traffic?
    b. how would you decide where to cross?
10. *Generally, how confident do you feel when moving around a new place? When you move away from a know route? How would you do it? Does this often happen to you?* [6*].

[6*] 3rd interview cycle

C.2. Thoughts on spatial skills

1. *What things do you do that make it easier for you to find your way around?* [7*]
2. Can you tell me things you do that help you understand the space around you better?
3. Are there things that your family or friends could do that help you find your way around better?
4. Do you have any suggestions for what would make it easier for other children who are blind to understand the space around them, where they are and where everything is?

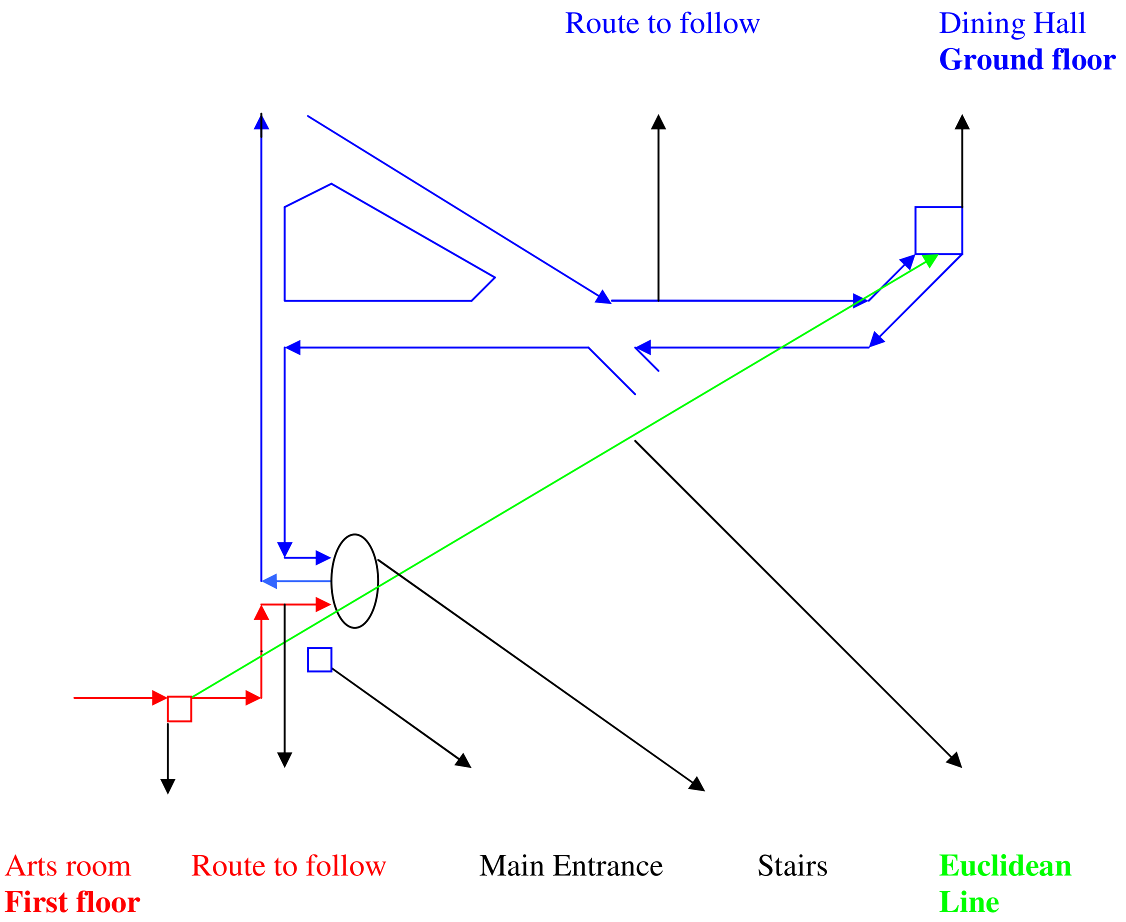
[7*] 3rd interview cycle

APPENDIX 6: POINTING TASKS

A. Diagram 1: An example of a pointing task in school A1 (Non Residential setting)

Below is an example of the approximate diagram of one the routes to follow from point A (art room – first floor) to point B (dining hall – ground floor) and the Euclidian line that connects the two points.

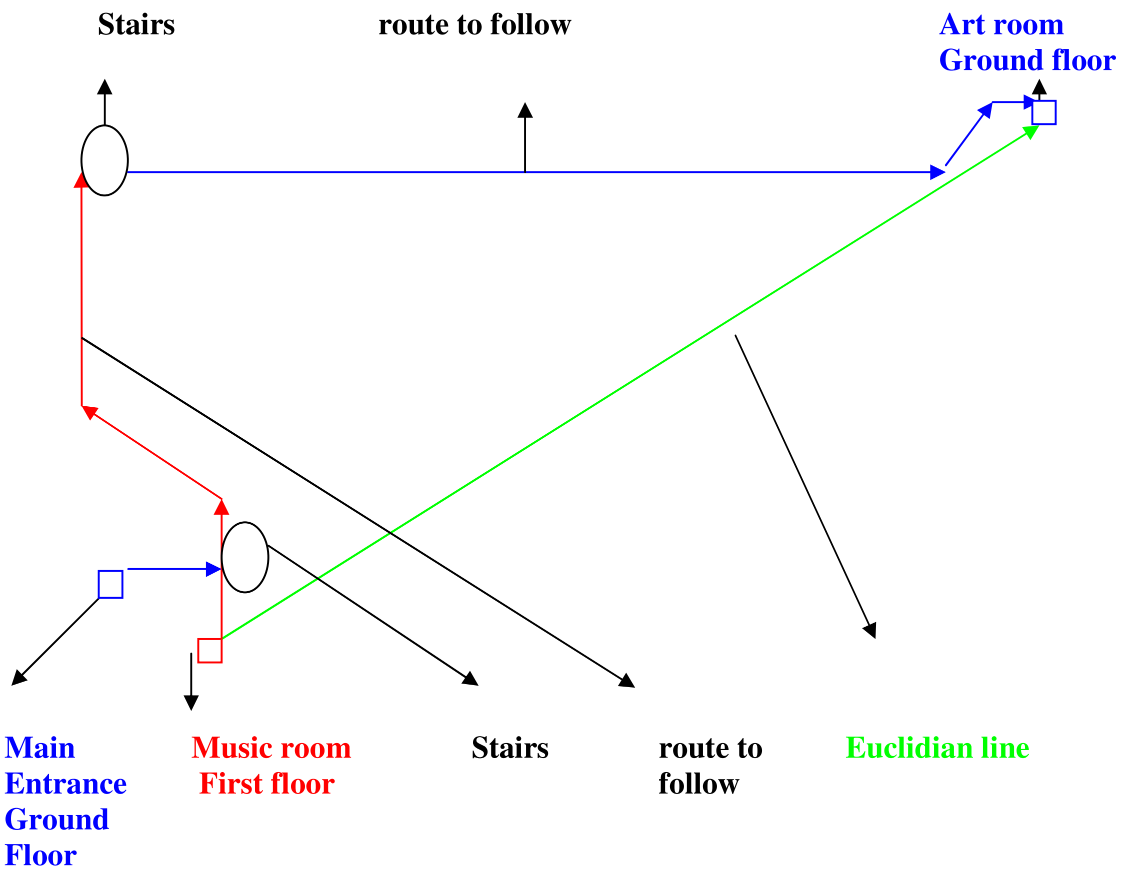
Art room (first floor – red color on the diagram) to the Dining Hall (ground floor – blue color on the diagram).
The green color represents the Euclidian line from Arts to the Dining Hall.



B. Diagram 2: **An example of a pointing task in school B (Residential setting)**

Below is an example of the approximate diagram of one the routes to follow from point A (music room – first floor) to point B (art room – ground floor) and the Euclidian line that connects the two points.

Music room, (first floor – red color on the diagram) to the art room, (ground floor – blue color on the diagram).
With green color is the Euclidian line from Music to Art.



Key (for diagram 1 and diagram 2):

Ground floor – route to follow

First floor– route to follow

Stairs

Euclidian line

C. Below are two examples of the records kept for each student for the pointing tasks:

The first example (example 1) is one of the best performances and the second example (example 2) is one of the worse performances

Example 1:

1. **School A1: S2 Ahab**

Locations	Same floor and Different floor questions		Accuracy of pointing For S2 Ahab		
	Same floor question	Different Floor question	Accurate Pointing 1*	Inaccurate Pointing 2*	Not Pointing 3*
From the medical room to the science laboratory	•		•		
From the medical room to the entrance of the school	•		•		
From the medical room to the English classroom	•		•		
From the science laboratory to the mathematics classroom	•		•		
From the English classroom to the science laboratory	•		•		
From the entrance of the school to the mathematics classroom	•		•		
From the medical room to the Art classroom		•	•		
From the Art classroom to the medical room		•	•		
From the mathematics classroom to the cookery room		•	•		
From the Art classroom to the science laboratory		•	•		
From the Art classroom to the Dinning hall		•	•		
From the science laboratory to the Art classroom		•	•		

Example 2:

2. **School A2: S6 Shimon,**

Locations	Same floor and Different floor questions		Accuracy of pointing For S6 Shimon		
	Same floor question	Different Floor question	Accurate Pointing 1*	Inaccurate Pointing 2*	Not Pointing 3*
From the medical room to the entrance of the school	●		●		
From the medical room to the Hall	●		●		
From the medical room to the office	●		●		
From the Hall to the medical room	●			●	
From the office to the entrance of the school	●		●		
From the office to the music class	●			●	
From the medical room to his classroom		●	●		
From the office to his classroom		●		●	
From his classroom to the hall		●			●
From his classroom to the entrance of the school		●			●
From the hall to the library		●			●
From the hall to his classroom		●		●	

1* accurate: within 45º either side of the target
2* inaccurate: not within 45º either side of the target
3* not pointing: includes don't know and don't want to point responses