# Pre-maps: An Educational Programme for Reading Tactile Maps

Helsinki 2009

Research Report 302

Helinä Hirn

# Pre-maps: An Educational Programme for Reading Tactile Maps

*Academic Dissertation to be publicly discussed, by due permission of the Faculty of Behavioural Sciences at the University of Helsinki, in Arppeanum, Snellmaninkatu 3, Auditorium, on the 5th of June 2009, at 12 o'clock*

Helsinki 2009

*Pre-examiners:* *Docent*
*Lea Hyvärinen*
*University of Oulu*

*Professor*
*Heikki Hämäläinen*
*University of Turku*

*Custos:* *Professor*
*Jarkko Hautamäki*
*University of Helsinki*

*Opponent:* *Professor emeritus*
*Michael Brambring*
*University of Bielefeld, Germany*

ISBN 978-952-10-4978-1 (nid)
ISBN 978-952-10-4979-8 (pdf)
ISSN 1795-2158
Yliopistopaino
2009

University of Helsinki
Faculty of Behavioral Sciences
Department of Applied Sciences of Education
Research Report 302

Helinä Hirn

Pre-maps: An Educational Programme for Reading Tactile Maps

Abstract

It is demanding for children with visual impairment to become aware of the world beyond their immediate experience. They need to learn to control spatial experiences as a whole and understand the relationships between objects, surfaces and themselves. In addition, environmental information is becoming increasingly visual and graphic, which requires a comprehensive spatial awareness. Tactile maps can be an excellent source of information for depicting space and environment. By means of tactile maps children can develop their spatial understanding more efficiently than through direct travel experiences supplemented with verbal explanations. Tactile maps can help children when they are learning to understand environmental, spatial, and directional concepts. The ability to read tactile maps is not self-evident; it is a skill which must be learned.

The main research question was: can children who are visually impaired learn to read tactile maps at the preschool age if they receive structural teaching? The purpose of this study was to develop an educational programme for preschool children with visual impairment, the aim of which was to teach them to read tactile maps in order to strengthen their orientation skills and to encourage them to explore the world beyond their immediate experience.

The study is a multiple case study describing the development of the map programme consisting of eight learning tasks. The programme was developed with one preschooler who was blind. He was a pilot case, and subsequently the program was implemented with three other children. Two of the children were blind from birth, one child had lost her vision at the age of two, and one child had low vision. The programme was implemented in a normal preschool.

Another objective of the pre-map programme was to teach the preschooler with visual impairment to understand the concept of a map. The teaching tools were simple, map-like representations called pre-maps. Before a child with visual impairment can read a comprehensive tactile map, it is important for him or her to learn to understand map symbols, and how a three-dimensional model changes to a two-dimensional tactile map.

All teaching sessions were videotaped; the results are based on the analysis of the videotapes. The progress of the children varied. Two of the children completed the programme successfully, and learned to read a tactile map. The two other children felt happy during the sessions, but it was problematic for them to engage fully in the instruction. One of the two eventually completed the programme, while the other developed predominantly emerging skills. The results of the children's performances and the positive feedback from the teachers, assistants and the parents proved that this pre-map programme is appropriate teaching material for preschool children who are visually impaired. The programme does not demand high-level expertise; parents, preschool teachers, and school assistants can carry out the programme with the guidance from an Orientation and Mobility instructor.

*Keywords:* child with visual impairment, tactile map, cognitive map, spatial awareness, orientation and mobility

Helsingin yliopisto
Käyttäytymistieteellinen tiedekunta
Soveltavan kasvatustieteen laitos
Tutkimuksia 302

Helinä Hirn

Harjoituskarttojen avulla kohokarttoja lukemaan

Tiivistelmä

Näkövammaisen lapselle on vaativa tehtävä, kun hän koettaa saada käsityksen itsensä ja eri kohteiden välisistä avaruudellisista suhteista ja muodostaa kokemuksista yhtenäisiä kokonaisuuksia. Ympäristömme muuttuu yhä visuaalisemmaksi ja vaatiii avaruudellisen hahmottamisen kykyjä. Kohokartat ovat yksi väline ja tietolähde ympäristön kuvaamiseen. Kohokarttojen avulla näkövammainen lapsi voi oppia ymmärtämään tilaan ja suuntiin liittyviä käsitteitä tehokkaasti verrattuna tilanteeseen, missä hän pelkästään liikkuu tilassa, vaikka hän saisi sanallisia ohjeita liikkumiseensa. Kohokartan lukeminen on taito, joka pitää oppia.

Järjestelmällisen ohjelman puute kohokarttojen oppimiseen on ollut puute. Tämän tutkimuksen tavoite oli kehittää interventio- ja opetusohjelma tilatietoisuuden opettamiseen kohokarttojen avulla sekä edistämään orientoitumisen taitoja jo ennen kouluikää. Tutkimuksen pääkysymys oli, voiko esikouluikäinen näkövammainen lapsi oppia lukemaan kohokarttoja järjestelmällisen ohjauksen avulla?

Työ on monitapaustutkimus, joka kuvaa kahdeksan oppimistehtävää sisältävän opetusohjelman kehittämistyötä. Ohjelmaan liittyvät opetusvälineet ovat yksinkertaisia, kartanomaisia representaatioita, jotka on nimetty harjoituskartoiksi (pre-maps). Niiden avulla lapsi voi oppia ymmärtämään, mitä kartta käsitteenä tarkoittaa ja miten kartta kuvaa ympäristöä osoittaen kohteiden sijainnin silloin kun lapsi ei ulotu koskettamaan niihin. Lisäksi hän oppii ymmärtämään karttasymboleita, ja miten kolmiulotteinen pienoismalli muuntuu kaksiulotteiseksi kohokartaksi.

Ohjelma toteutettiin tavallisessa päiväkodissa neljän näkövammaisen lapsen parissa. Kaksi lasta oli syntymästään sokeita. Yksi lapsi oli menettänyt näkönsä kahden vuoden ikäisenä, hänellä oli hieman näköä, mutta oudossa tilassa hän toimi sokeain tekniikoilla. Yksi lapsista oli heikkonäköinen. Kaikki opetustuokiot videoitiin, tulokset ja pohdinta pohjautuvat videoiden analysointiin. Lasten edistyminen vaihteli. Kaksi lasta suoritti ohjelman menestyksellisesti. Kaksi muuta lasta olivat iloisia osallistujia, mutta heillä oli ongelmia ylläpitää kiinnostusta koko ohjaustuokion ajan. Toinen heistä suoritti lopulta ohjelman, ja toinen lapsi saavutti lähinnä orastavat taidot. Lasten suoritusten tulokset sekä vanhempien ja opettajien antamat positiiviset lausunnot vahvistavat, että tämä kohokarttojen harjoitusohjelma soveltuu esikoulun opetusmateriaaliksi, kun ryhmässä on näkövammainen lapsi. Kohokarttoja voi oppia lukemaan systemaattisen ohjauksen avulla. Harjoituskarttojen parissa suoritettu työ tukee myös lapsen hienomotorisia taitoja, liikkumistaitoa sekä pistekirjoitusvalmiuksia. Myös näkövammaisen lapsen vanhemmat, esikoulun opettajat ja avustajat voivat käyttää ja soveltaa ohjelmaa erilaisissa arjen tilanteissa.

*Avainsanat:* näkövammainen lapsi, kohokartta, kognitiivinen kartta, avaruudellinen hahmottaminen, liikkumistaito

# Acknowledgments

My interest in teaching tactile maps was aroused years ago when I began to work as an Orientation and Mobility instructor with people who are visually impaired. I found that analysing the structure of the environment without visual perception requires mental efforts that demand a great deal of energy. This study process also made me realize the extent to which the human mind must process and analyse the enormous flood of information around us. During the process I also learned new features within myself. It was hard to accept my helplessness in dealing with psychological problems. This insufficient background knowledge forced me to sit in the library for hours and hours trying to understand human behaviour.

Many people have influenced the birth of my doctoral thesis. I want to give my special and warm thanks to my supervisor, Professor Jarkko Hautamäki. The sessions with him were not always easy, but I learned to appreciate scientific work and to understand the process involved in research. He has encouraged me and believed that this work is worth doing, and his humane approach allowed me to develop my study without the feeling of compulsion.

I warmly thank my reviewers, Professors Lea Hyvärinen and Heikki Hämäläinen for giving critical but encouraging feedback. Professor Teija Kujala's criticism made me think seriously about the demands of scientific work.

My special thanks go to the children with visual impairment who were my guides on my way. You were eager experimenters with the maps; you worked at the tasks surprisingly persistently; and you had the strength to encourage me in my efforts. I also thank the preschools, the teachers, the assistants and the parents of the children for their positive attitude, interest and participation.

I especially appreciate the help of neuropsychologist Liisa Lahtinen, with whom I had the opportunity to spend rewarding moments thinking about the processing of information and the cognitive problems encountered by those with visual impairment when moving around in the environment. My colleague Rilla Aura-Korpi motivated me to finish my study by using pre-maps in her teaching and by giving encouraging comments along the way. Thanks for your telephone calls Rilla; they made me believe in my work. Riitta Lahtinen, Jukka Jokiniemi and

Helena Thuneberg were my peer group and familiar with the pain of research. Thank you for telling that there is light at the end of the tunnel!

I thank Kari Perenius for his efforts to make the layout printable. Nancy Seidel has earned thanks for proofreading my English text. However, she is not responsible for the text added after her checking. I thank the Finnish Cultural Foundation for the grants which made the start of the project possible, and the Oskar Öflunds stiftelse, Sokeain ystävät ry, Sokeain lasten tuki ry and the Cartographic society of Finland for the financial support which gave me the opportunity to create international connections.

I also want to give my warm thanks to my children Riku and Sara and their spouses for their patience and understanding in regard to my intensive and peculiar working hours. Tilda's and Verneri's ‘Mumi’ has not always been present on important occasions during your first years, and still, I have always got the warmest of hugs from you.

Thanks also to my mother Helvi Santaholma; she is not able to take part in my achievement due to her high age and illness. She always emphasised that a woman has to be independent and have a profession of her own. This philosophy has had a great effect on my life.

A special thanks to my dear husband Jorma, who has had patience with and faith in my efforts during these long years. The slow progress has affected our life together in many ways. You had to spend so many one-man weekends and listen to my "library voice" whispering my changes in our plans. You have earned my loving hugs!

Helinä Hirn

# Contents

# Introduction

Laura is a first grader, a 7-year-old girl; she has been totally blind since birth. The goal of her orientation and mobility (O&M) programme is that she will learn to move about independently in her neighbourhood as well in the schoolyard. One day her O&M instructor introduces her to a tactile map for the first time. The map depicts the layout of the floor in front of Laura. The layout consists of four pieces of carpets made of tactually different materials with clearly different colours. The map is made of four corresponding carpet pieces glued on a rectangular board.

First, Laura starts to explore the map, determining the frames of this 'carpet map' aloud: the left, the right, the upper and the lower edge. During the exploration of the map, her father enters the room. Laura is sitting on the short side of the layout and her father stands opposite her. Laura thinks hard for a while, and then she asks: 'If my Teddy bear is on my left side, is it on the right side of my father when he stands opposite me?' This was a sign of a start in creating a mental map.

Laura is in an ongoing O&M programme; she knows the necessary routes in her school building such as her way from the front door to her classroom, and the route from the classroom to the dining hall. Next, she will learn to move more widely in other parts of the school building. On another occasion, Laura is becoming acquainted with the general idea of the schoolyard during her O&M lesson. She has a simple tactile map representing the schoolyard and the locations of the buildings in relation to each other. The main building is oblong; her class is located at the east end of the building and the dining hall at the west end. When walking outdoors in the yard alongside the school building from east to west Laura asks: 'If I walked inside the building, would I walk in the hallway going from my classroom towards the dining hall? Do I walk parallel to the corridor that leads from my classroom to the dining hall?' To me, an O&M instructor, this was a surprising question asked by a 7-year-old child. She was spontaneously transferring the layout of the indoor space of the school building to her outdoor location in the schoolyard. She obviously had formed a mental map of the building.

A third incident that prompted me to think of the spatial comprehension of this child happened when Laura asked: 'How is it? Can a person see a house at a distance of half a kilometre if there is a field between the person and the house? But if there is a forest, is it still possible to see the house?' Based on her questions, I began to wonder whether a tactile map could help her to conceptualize spatial and environmental concepts and relationships.

Later during the autumn Laura was learning orienteering in her physical education class. She got her own tactile map made of swell paper. The map represented the environment next to the schoolyard. By means of this special map, she could carry out almost the same learning activities as the other first graders. When using the tactile map, Laura learned to locate positions, to estimate directions, to search for control points, and to align the map when turning and changing travel directions.

These occasions made me to think about the significance of orientation skills, and how even a young child who is blind can start to draw conclusions about spatial connections. I also started to question whether I had paid enough attention to orientation when teaching young children in O&M. Thus, this was the starting point for the idea of using tactile maps at a very early age with children who are blind or severely visually impaired having difficulties in spatial awareness and concepts.

### *People-first language*

In this work, when describing people who are visually impaired, the writer uses people-first language. This expression is used increasingly in educational texts written in English, first and foremost in the USA (APA Manual, 2001). Words matter, because they influence attitudes. There is a difference between the expressions: 'this person has a disability' and 'this disabled person'.

People-first language puts the person before the disability, describing what the person has without labels or preconceptions. The rationale behind people-first language is that it recognizes that someone is first and foremost a person, a human being, and a citizen. The disability is a part but not all of the person. People are not the sum product of their medical conditions. They are individuals with diverse needs (Norwich, 1999). Disability is also a medical diagnosis, and diagnosis-first language can easily perpetuate negative stereotypes and reinforce a powerful attitudinal barrier.

People-first terminology has been rejected by some persons with disabilities. People who reject this terminology generally see their condition as an important part of their identity and cultural background, and so prefer to be described as ‘deaf people’ and ‘blind people’ and ‘autistics’ or ‘autistic people’ rather than ‘people with deafness’ and ‘people with blindness’ or ‘people with autism’. They see people-first terminology as devaluing an important part of their identity by suggesting that there is, somewhere inside, a person distinct from their condition. In any case, the writer of this work wanted to meet the pupils involved in this study as children who need support, and to focus on their learning of special skills to orientate themselves and travel around, instead of on their weaknesses.

Critics have also objected that people-first language is awkward and repetitive. This is not the case in English texts, but the structure in Finnish may make writing and reading people-first language tiresome.

# A traveller with visual impairment and space

'Blindness causes three basic limitations on the human being: (a) in the range and variety of experiences; (b) in the ability to get about; (c) in the control of the environment and the self in relation to it' (Lowenfeld, 1948). The sense of sight overcomes distance and gives simultaneous information about forms, size, and positions of the objects. Visual experiences permit contact with and control of the environment far more widely than those achieved by the other senses. Children who are blind or with severe visual impairment must continuously explore, synthesize, and reconstruct spatial information that sighted children can acquire at a single glance (Bigelow, 1992). They also need to learn to use tactual, auditory, olfactory, and kinaesthetic senses when developing concepts related to space (Hill et al., 1989). Hearing does not expose any concrete structure of the objects but it conveys information on the presence and location of large objects that reflect sounds. This phenomenon is called echolocation[1]. Tactual perception of space differs from the visual perception of space; it is sequential and slow.

## Perception of space

It is possible to relate oneself to space and the environment if a person with visual impairment has developed spatial awareness and orientation skills. The child who is blind needs techniques and structured remembering of the space in order to externalize spatial representations. In order to create a mental image of the environment the child has to have well developed sensory perception and integration of the information gained through senses other than vision. It is difficult to achieve a general spatial impression if the environmental information is available merely in a successive and fragmentary way (Huertas & Ochaìta, 1992).

Various functional activities are involved in spatial orientation and in navigation affecting the ability to relate one's personal location to

---

1 The movement creates sounds, and when the child listens to reflected sounds (echoes) he or she can sense objects in the environment by hearing. This phenomenon is called echolocation (Schenkman, 1985).

particular environmental frames of reference (Sholl, 1996, 158). The major components of spatial orientation include: (1) knowledge of the spatial layout of destinations and landmarks along the way; (2) the ability to keep track of where one is and in which direction one is heading; and (3) comprehension of the organizing structural principles embedded in a given environment (Rieser et al., 1982). Without the first component, travel can take place only by using search and exploration strategies. Without the second, the traveller will quickly become lost. Without the third, needless effort is expended in trying to memorize every component that can be encoded as a simple pattern.

Persons who are blind may organize the environmental experiences of large scale spaces as a whole; or they may organize such experiences sporadically, piece by piece. When Casey (1978) was investigating cognitive mapping skills of students who were blind and students with impaired vision wearing blindfolds, he found distinct individual variations in their ability to produce maps of their campus area. Some of the students were able to unify and to structure the multisensory information from the environment by conceptualizing the total setting. Other students organized elements into smaller and distinct units. When travelling, some individuals were able to unify environmental experiences in a holistic manner and to produce a tactile map. Other students worked more sporadically and had difficulties in categorizing environmental elements.

Vision plays an important role in the process of understanding and representing space. Spatial thinking affects a human being's actions through spatial coding (Rieser et al., 1982). The redundancy of reliable and consistent reference cues that result from the partial overlap of multisensory information is extremely important for the development of spatial coding, especially when a child with visual impairment is young and has inadequate spatial knowledge (Millar 1994, 1995). The specialization, the convergence, the overlap, and the consistency of reference cues are important in terms of orientation, which requires cognitive skills and general environmental knowledge. It is important to form substitute information to converge and overlap with existing reference cues and means of coding (Millar, 1995). Through independent functioning a child who is blind can develop an awareness of changes when extracting cues from touch, hearing, smell, and movement.

Several publications on spatial cognition claim that people who are blind lack the sensory-motor experiences provided by vision that result in unique and efficient coding of spatial information. In contrast, Landau et al. (1981, 1984) reported that a child who is congenitally blind can perform comparably to sighted children on a large-scale navigation task, and children less than three years of age can show accurate coding of Euclidean properties of space. In her study, two-and-a-half-year-old Kelli, who was totally blind, was able to travel in space and to become aware of relationships between four objects in the room. Thus, Landau et al. (1981) stated that children (both blind and sighted) were able to encode information for understanding directions and distances between objects in the room and absorb spatial knowledge based on Euclidean properties already at the age of two-and-a-half (Landau et al., 1981), and vision was not essential for the early development of understanding metric properties of space.

Morrongiello et al. (1995) replicated Landau's research array, but she did not achieve congruent results with very young subjects. In her study the youngest children were four-and-a-half-year-old, and she found that their performance on spatial tasks was relatively poor. Accuracy in spatial representation, however, increased with age. For example, for the navigation task, all measures of accuracy during the execution of novel routes showed improvement with age. The results of the youngest age group were clearly in contrast to those of Landau et al. (1981), who had concluded that Euclidean mapping skills were not only present, but well developed in children just over two years of age. It is justified to presume that Kelli's performances were exceptional and cannot be generalized.

Spatial coding does not depend on information from one modality or another, but rather on a synthesis of whatever information is available and captures the child’s attention, giving the opportunity to integrate pieces of information (Lewis et al., 2002; Millar, 1994; Morrongiello, 1995). Verbal descriptions, route knowledge, and inference from knowledge of precise Euclidean relations can be used alternatively or conjunctively. Cognitive and modality-specific features of information are interrelated aspects in spatial processing and representations. Movement imagery and mental training may be means of developing spatial organization also by children who are blind (Juurmaa & Lehtinen-Railo, 1994).

Vision is not a prerequisite for moving about or for perception of spatial relationships in the environment, although vision may play a facilitative role. Blindness does not inhibit the child from integrating different objects into a holistic entity or from establishing a systematic and structured knowledge of space. Children who are blind may code spatial information with respect to some referent, which can be an external landmark or egocentric frames or movement-coding. They can understand that the shortest distance between two locations is not always the same as the route they would take from one location to the other.

However, this does not happen if the child understands the physical world as egocentric coding (Lewis et al., 2002). Although the task of constructing a spatial world is comparable for blind and sighted children, further evidence is needed before assuming that these two groups have identical knowledge regarding structures and spatial coding strategies.

Tasks can be solved either visually or haptically[2] (Juurmaa, 1959). In optic perception the person first perceives the object or the space as a whole, and then its different elements. In haptic perception the person first finds details from which he can recognize one entity. For example, a person who is blind can try to analyze the environment by means of both the tactile sense and haptic perception when making active observations of spatial relationships and recognizing simple and comparable figures of objects.

In order to enrich O&M instruction, Juurmaa & Lehtinen-Railo (1994) studied possible difficulties caused by the lack of vision. They were interested in the significance of visual experience in actual and imaginal conditions for: (1) the speed of access to spatial information; (2) the maintenance of that information; and (3) errors in judgment. They found that lack of visual experience was no greater obstacle to orientation in either imaginal or actual conditions. They found great variation in the performance of subjects who were blind from a very early age, and some of these persons had the potential to reach the same level as sighted persons when forming concepts of spatial relationships in their nearest environment. They suggested studies on whether increasing mental training in O&M instruction would improve control of the environment among the persons who are blind.

[2] Haptic perception is a combination of touch and movement which provides information about shape, configurations, and the spatial relation between objects. It is a perceptual system incorporating inputs from multi-sensory modalities including thermal and kinesthetic sensing, vibration, pressure and gravity. Through haptic perception the person is able to encode forms of objects, limb positions and movements (Lahtinen, 2003; Millar, 1995).

## Familiarization with a novel environment

Most people have a method for exploring a new environment, a new apartment, or a new neighbourhood. A sighted person can take in at a glance the positional relationships of landmarks; a visual mental map can be created very quickly, and a great amount of exploration happens visually. Those who are blind gain environmental knowledge through conscious tactual exploration, auditory information, verbal explanation, and through the use of printed and enlarged, or tactile graphic representations like maps, models or drawings.

Even if the neighbourhood is familiar to an adult person with visual impairment, independent travel presents challenges. When trying to navigate, he/she encounters problems like recalling information about the surroundings, sequential learning of path segments and turns, and spatial updating. When travelling alone, the person with visual impairment needs to do mental pretravel route planning based on a cognitive map, on the mental path selection of a safe travel mode, on obstacle avoidance, and on the strategy for landmark recognition (Golledge et al., 1996, 216).

Familiarization with the environment requires a concept of self, knowledge of the environment, the ability to relate self to the environment, and a sensory system to collect data from the environment (Hill & Ponder, 1976, 3; Jacobson, 1993). Obtaining a functional understanding of the environment in a self-familiarization process requires a combination of the components of orientation (compass directions, distance assessment and measurement, landmarks and other clues), and environmental numbering or symbolizing systems. This familiarization is a cognitively demanding process; the person with visual impairment has to keep in mind the following questions (Hill & Ponder, 1976, 11.):

1. What information do I need to function within this environment?
2. How do I obtain this information?
3. How will I utilize this information?

A traveller with visual impairment also has to consider different subtasks such as: (a) the features and landmarks that are important to know in the environment; (b) how to establish the home base for exploring; the most purposeful and effective search pattern to use when locating objects in space; (c) determining whether his/her mobility techniques are adequate enough for effective travel; and (d) how to implement systematic search strategies for developing object-to-object relationships (Hill et al., 1993).

Hill & Ponder (1976, 32) introduced two types of familiarization processes in unfamiliar areas: In the *guided familiarization*, the O&M instructor takes the student through the novel area, and points out its salient features, as well as the relationships of the important objects in the layout. In the *self familiarization* process, the student explores and learns about novel environments independently and systematically. The self familiarization process is more time consuming and the traveller is much more actively responsible for learning to know the space than in the guided familiarization process (Hill et al, 1993).

The sighted instructor can use verbal descriptions, tactile maps and small scale models in the teaching process. Tactile maps can serve as the means to empowerment and emancipation when the persons with visual impairment have the opportunity to study the neighbourhood independently before entering it. They can acquaint themselves with a new route by exploring a tactile map, or familiarization can happen through direct experience when walking in the environment (Ungar et. al., 1997c).

## Exploring and explorers

In order to stay alive human beings have to be able to organize their actions in their environment. Spatial orientation skills vary; for some people it is easy to build a holistic overview of the space. Those with a map-based representation are able to formulate different routes. Their knowledge of the relationships among all the parts of the route enables them to select appropriate and equivalent paths (Fletcher, 1980). Some people prefer to learn just the lines of the routes; they are strongly dependent on the landmarks on the route and on the shorelines that can be trailed.

If the travellers are not able to create a mental map of the environment, any interference or slightest change may misguide them on the familiar route, and they have to rely on trial-and-error methods by looking for familiar landmarks in order to reach the goal of the journey.

*Wayfinding* refers to a person's cognitive and behavioural abilities to find the route from a specified starting point to a specified destination (Golledge et al., 1996, 220). It is more a cognitive skill than a physical ability. Wayfinding involves the *control of travel* through perceiving sequentially structured multisensory information. Required information includes landmarks for identifying current location and a destination; cues to indicate the spatial-temporal transition between origin and destination; information on where to turn; and a mechanism for generally determining the direction in which one must proceed or a mechanism for defining one's position with respect to the home base. Wayfinding is the ability to learn a route and retrace it from memory, including all aspects of cognitive mapping: encoding, processing, and retrieving information about the environment (Blades & al., 2002).

*Navigation* refers to *how people travel* in a space as they pay attention to landmarks, hazards and other significant characteristics in the environment. A traveller who is visually impaired navigating independently in a local neighbourhood or community faces considerable problems. During the travel he or she must remember and recall information about the environment, learn path segments sequentially and integrate turn angles, and update spatial information (Golledge et al., 1996, 215).

The type of visual impairment does not explain individual differences in the ability to travel independently or in having more effective search strategies for exploring novel spaces. The person's own activity when exploring the environment has a significant role. When exploring a large scale space, walking in a systematic manner is an essential skill, especially for a traveller who is blind. When familiarizing oneself with an unfamiliar environment, a systematic exploration pattern is a better strategy than random wandering around in a space (Fletcher, 1980; Hill et al., 1993).

Persons who are congenitally blind have very diverse methods of organizing environmental information. Some are able to combine their environmental experiences when travelling and to represent the layout as a map. Others work more sporadically, which leads to difficulties when trying to categorize the environmental features (Casey, 1978).

Hill et al. (1993) studied the travel performances of 65 subjects who were either blind or had only light perception. The subjects explored the relational locations of four objects in a large scale space, trying to find the most effective exploring and familiarizing strategies. He found the following strategies:

1. In the *perimeter search pattern*, the subject explores the boundaries of a certain area to identify the shape, size, and characteristics of the area around the perimeter.

2. In the *grid search pattern*, the subject explores the internal elements of the area in a series of straight-line travels between opposite sides of the area perimeter, crossing the area several times.
3. In the *object-to-object method*, the subject establishes and links connections between objects, relates the exploration to salient landmarks, and learns the relative locations between targets.
4. In the *object-to-perimeter strategy* the subject travels between the objects and the boundaries of the space.
5. In the *home base-to-object strategy* the subject walks back and forth between the home base and the objects in the space.

The perimeter strategy was the only clearly unsuccessful one. The best performers combined a variety of strategies, and often used the strategy of linking the objects to other target objects, or to the perimeter of the area they were exploring, or to the home base (Hill et al. 1993).

Also, Tellevik (1992) analysed exploring strategies of adults who were sighted but blindfolded. He defined similar types of strategies: the perimeter method, the gridline method, and the reference-point strategy. He found that the explorer could change the strategy depending on the familiarity of the space. A combination of the perimeter and grid-like search pattern was more effective for the estimation of relative distance, and the traveller learned the layout of an unfamiliar space more effectively. The reference point strategy, on the other hand, gave more directional and angular information regarding relative distances in a space that was known (Tellevik, 1992).

However, the subjects in his study were blindfolded, sighted O&M instructors; thus they obviously knew search patterns, and presumably formed visual images about the space. For this reason the results are not directly comparable with the strategies used by persons who are blind and have a varying O&M background.

When teaching new routes, O&M instructors often give a verbal description of a route or point between places, and sometimes they may also use modelling as a part of the instruction. Blades et al. (2002) investigated the effectiveness of different techniques for learning a new route: (a) a pointing task while walking the route; (b) giving a verbal description of the route after completing it; (c) modelling the route after completing it; and d) no spatial tasks after completing the route. The purpose of this experiment was to compare the participants' performance in these four experimental conditions. The participants traveled three times the route, and it was found that learning a route can be enhanced effectively by modelling. However, also repeated testing between the first and second trials when learning a new route had influence over the performance, but the effects of testing apply mainly to the early phases of learning.

Because there are various strategies, and some strategies function better than others, it is possible and important to test them and find an effective and individually appropriate exploring pattern.

## Route-type and survey-type coding of the environment

Two primary ways for presenting spatial information and object arrangements are the route-type presentation and the survey-type presentation. In terms of the ability to move around in the environment, the implications of these different representational modes are obvious.

### *Survey-type representation*

Dodds (1982) found in his study that children who were congenitally blind (11-year-olds) were able to form only an egocentric or self-referent representation of the route they were walking. They were not able to form an overall survey-level[3] representation of the layout, and they had difficulties in spatial inference when they tried to combine spatial information from separate locations.

Dodds suggested that children who are congenitally blind should get instruction in appropriate strategies to use external referents in order to lead them to control survey-type representations. Conversely, Casey (1978) found a strong correlation between a blind adolescent's ability to create maps comprehensively and the level of independent travel skills. People with a map- or survey-type representation of the environment are able to plan another route because their knowledge of the relationships among all the parts enables them to select between several, equally suitable paths (Fletcher, 1980).

Survey knowledge is encoded in the memory as mental images; it is an integrated representation of the environment, from which people can structure spatial relations between points that have not been di-

[3] Survey level in geography means the ability to make a detailed map of an area of land, including its boundaries, area, and elevation, using geometry and trigonometry to measure angles and distances.

rectly experienced (Newcombe & Huttenlocher, 2000, 134). It can be obtained, for example, through reading maps (Thorndyke & Hayes-Roth, 1982). A person who represents spatial information as a map extracts an overview of the area, and is aware of the relationships between the objects even though he or she has not experienced all these relationships directly (Fletcher, 1980).

Forming survey knowledge is a process that requires attention resources and cognitive efforts (Sholl, 1996, 165). Survey knowledge gives a holistic impression of the environment; it is an efficient method when mapping the environment. Procedural knowledge may be transformed into survey knowledge over time and does not happen automatically.

*Route-type representation*

In a route-type representation the functionally relevant objects are encoded sequentially rather than simultaneously, and persons who depict information as a route learn series of movements that have connections with landmarks (Newcombe & Huttenlocher, 2000, 134). The route-type subsystem generates a motor-kinaesthetic representation that incorporates object and landmark information using a self-to-object updating process when travelling and navigating through the environment. This type of process is a serial procedure establishing the travel mode fairly quickly.

The object-to-object information is used to monitor body location in relation to fixed objects in the environment. Sighted people create route knowledge by integrating visual self-to-object information with the motor-kinaesthetic representation of the route when they navigate in the environment. Signals from the kinaesthetic system can substitute for visual self-to-object information in persons who are blind when structuring route-type knowledge (Sholl, 1996, 181).

When Ochaita & Huertas (1993) studied the ability of children and adolescents with visual impairment to form a representation of a route after four walks in an unfamiliar environment, they did not find differences between the congenitally blind and adventitiously blind groups. Differences were noted between the young sighted children and blind children in the development of a haptic frame of reference. Significant factors for perceptions were previous visual experience, the complexity of the environment and the level of cognitive competence.

The main factor influencing the difference was age: the subjects who were congenitally blind achieved a coordinated, map type understanding of the environment relatively late. However, the difference diminishes with age from infancy towards the late teens, and ultimately subjects who are blind can perform at a comparable level in spatial tasks to subjects who can see (Fletcher, 1980).

These two types of knowledge (route-type and survey-type coding of the environment) are obviously formed by separate subsystems. The survey or Euclidean-based knowledge takes longer to develop than the route knowledge and is more comprehensive, and cognitively more demanding. Euclidean-based spatial understanding is more sophisticated than route-based understanding (Bigelow, 1991a; Fletcher, 1980).

There is no evidence for assuming that children who are blind from infancy have unambiguously poorer performance than children who have lost their vision later. There are always some individuals who are blind and still able to perform adequately in spatial tasks. For this reason it is important to give a child who is visually impaired the opportunity of learning different coding strategies.

In O&M training it is important to note that different search patterns may influence the availability and processing of different kinds of knowledge (Tellevik, 1992). Tellevik & Martinsen (1991) have discussed the significance of O&M training in familiarization with a novel space. They found that O&M instructors in general use either a route learning method or a mapping method.

## Children with visual impairment as explorers

Children of all ages are naturally curious about the environment. Infants who are congenitally blind should become familiar with the specially developed environment from the early stages so they can begin to exercise spatial activities and develop the ability to transfer their understanding of spatial relation from one environment to another. Early experiences may establish a habit of exploring and may develop early skills in independency (Nielsen, 1991).

The ability to move efficiently from one location to another in a large scale space is essential for children who are blind if they are to attain independence, and it is one of the greatest challenges that they must overcome. Children’s turning, rolling, crawling, toddling and walking in their home environment are an introduction to spatial and environmental features, locations, and movement. They observe and become aware of the characteristics of their immediate surroundings by using their senses to explore, discover and begin to make sense of their environment. This activity introduces them to the layout of the environment and provides the first steps of spatial understanding. Thus, children build their sense of the neighbourhood.

The lack of environmental experiences may continue until learning becomes motivating or until some intervention begins. If children have not had the opportunity of getting systematic help when learning about the physical environment, they will expend an enormous amount of energy and valuable learning time in trying to sort out the experiences, and perhaps get them wrong in the process (Buultjens & Ferguson, 1994).

Locations become significant if they are settings for doing meaningful things. If the instructor speaks about locations with which children have no physical or sensory contact, they may remain meaningless. If the children have been allowed to explore the environment without guidance, they may not spontaneously derive tactual, auditive, and olfactory information, which are essentially connected with purposeful movement for becoming familiar with a new environment.

When young children with visual impairment experience a new place such as a preschool class or a school yard for the first time, they are in a totally different situation compared with young children who can see. Entering an unfamiliar environment can be frightening if children do not have prior experience of different rooms, equipments, objects, and obstacles. In this situation those children can be apprehensive instead of being keen to explore the space. They also need tools for gaining a feeling of safety and confidence. A precane can be such a tool for independent mobility (Brambring, 1998) and a simple small scale model a tool for orientation.

In order to move about confidently children have to know the environment sufficiently. This can happen through direct travel in the space, and by means of structured teaching and overlapping reference cues (Millar, 1995). This is more important than learning to compensate for sight because the children who are congenitally blind cannot understand the real meaning of seeing (Nielsen, 1991).

The real problem of children who are totally blind is to understand the layout of a space with more than one dimension (Bigelow, 1991a; Knott, 2002, 6). They may not conceptualize the location of the requested place in relation to their current position regardless of whether or not they know how to get there. They learn to know the Euclidean directions of closer places first and then of places that are farther away. When children transfer from the route-based method to the survey-type method, it is important for them to understand the space on the survey level (Bigelow, 1991a).

If children with visual impairment understand the relationships between different locations in terms of routes but are unable to understand the Euclidean relationships between different locations, then learning the routes by heart is important for becoming familiar with the environment, and it can be considered as an early form of spatial knowledge. However, some children with visual impairment may be able to integrate separate items of spatial information into a coherent whole and develop an understanding of the spatial layout of their own home in Euclidean terms (Landau, 1986, Landau et al. 1984, Lewis et al, 2002).

## Orientation and mobility instruction of children with visual impairment

Orientation is a process in which people with the visual impairment use all their senses for establishing their position in relation to other important objects in a space. Mobility is the capacity to move about, and mobility techniques include skills like: sighted guide techniques, pre-cane skills, self-protection, obstacle perception, exploring techniques, auditory skills, cane skills, indoor and outdoor travel (Hill & Ponder, 1976). People with visual impairment need to master both orientation skills and mobility techniques in order to be able to move around independently, safely and purposefully, and maintain an acceptable quality of life (Brambring 1998; Hill & Ponder, 1976, 3; Jacobson 1993; LaGrow & Weessies; 1994 Lowenfeld, 1948).

O&M instruction was developed at the end of the1940s primarily to serve adults who were blind but who had built up a vast store of prior knowledge from the visual world. In the 1980s, O&M instruction expanded to also serve young children with visual impairment (Hill et al, 1989). At that time, the instruction expanded to cover sensory skills, community awareness, concept development, motor development, and environmental awareness, in addition to formal cane techniques and orientation skills.

At present, O&M instructors teaching young children with visual impairment teach movement skills needed for independent travel at home and in school, and basic concepts in orientation such as size, shape, function, and position of objects in the surroundings (Dodson-

Burk & Hill, 1989a). Mastery of age-appropriate, environment-related concepts is necessary. Instruction may focus on the positional (e.g., above), directional (e.g., on the left), and environmental (e.g., a city block) skills, as well as on the other sensory skills, such as auditory perception and echolocation, and the use of natural sound cues.

The early and basic O&M and independence instruction includes skills like sensory-motor development, spatial language, O&M in different settings, social and emotional development, social conventions, general manners, confidence and motivation. More advanced independence skills include learning about routes and technical aspects of travel, orientation, travel safety, cane techniques as well as kitchen skills, eating, hygiene, money handling and dressing (Pavey et al. 2003). Early and foundation independence skills form building blocks for the later learning of more advanced mobility and independence but the boundaries between different parts of this framework are not absolute.

It is important to integrate early intervention in O&M of children with visual impairment into all developmental areas (Brambring, 1998). Orientation may be considered to have three levels (Smith & Hill, 1992). The first is self-to-self awareness: they need to be able to dissociate the movement of various body parts, to understand how the different parts of the body move in relation to each other, and to learn how to move purposefully. The second level is self-to-object relationships: they begin to move and explore the relation between themselves and the surrounding objects by developing this relationship through sound localization and conceivable vision. The third level is the understanding of object-to-object relationships: they begin to develop the cognitive mapping skills that establish the relationship of objects to each other and are able to move purposefully from place to place.

The families of children with visual impairment are confronted with many parenting worries. Several questions come up regarding cognitive, motor, social, educational, behavioural, and sensory development. Parents have to deal with issues of safety, independence, encouragement of natural curiosity, and guiding exploration. It can be difficult to take care of the safety of their child and, at the same time, to avoid being overprotective or doing things for them (Knott, 2002; Morsley et al., 1991b). Thus, one of the major concerns is how these children with visual impairment can safely maximise their potential for independence. Mobility of children with visual impairment can become safe, efficient and even fun if their parents and teachers can build children's self-confidence and support their motivation by travelling.

*Indipendence*

In order to learn O&M and independent living skills children with severe visual impairment need a special intervention because they do not learn independent living skills incidentally in natural settings and they may have difficulties to achieve the same level of competence in the mastery of indipendence as their sighted peers (Lewis & Iselin, 2002).

Previously, these subjects were taught in schools for the blind. At present, children with visual impairment are mainly integrated in normal schools, and the timetable does not include these subjects. In any case, the children should have the necessary information, skills and self confidence that will enable them to join in activities with sighted peers in different situations at school during lunch and other breaks, as well as at home and in social life generally. They need to become familiar with the functional space and environment, and to learn to work with essential objects in order to be actively involved and achieve full social integration without being dependent on the family, friends, or society (Pavey et. al. 2003).

Children with visual impairment do not learn everyday activities in the same way as sighted children. Different activities need to be demonstrated at short distances, and the use of all modalities is necessary. They do not have the spatial concepts of adults, nor do they understand the world as adults do. One way of teaching concepts is to take the child to a natural environment to experience concrete objects (Hapeman, 1967). Such a concrete experience is not always possible, however, because of the object's size (an airplane), or because of its intangible character (parallel traffic lanes). Another method is to use models or other tactile and haptic representations of the object or the environment.

*Bodyimage*

Several studies have emphasized that body concept instruction should come before O&M training. Effective orientation is based on the recognition of body parts and planes, how they relate to each other and what their position is in space (Hill & al., 1984; Hill & al., 1985; Skellenger & Hill, 1997; Smith & Hill, 1992;). The body image is also the basis of spatial and directional concepts. Compared with a sighted child, a child who is blind is likely to have a delayed or deficient body image. Thus, this should be developed and strengthened before formal O&M training begins.

The above view on the importance of body image was challenged by a study on route and layout tests by Morsley et al. (1991a). According to this study, body image is unrelated to the spatial skills of the child. His study questioned the worth of spending too much training time on O&M instruction on the body image because a number of children who are totally blind or blind with light perception are able to create complex, allocentric maps of an area after only one experience (Morsley et al., 1991a).

If teaching concentrates simply on the body image, it tends to confine the child who is blind to the egocentric mode, which restricts the child from forming spatial representations based on the information he or she can draw upon when moving in space. Another view is that persons who are blind can have a good spatial understanding after receiving appropriate information and training (Juurmaa, 1973). It is not necessarily incorrect to start mapping the immediate neighbourhood early with some children who are either blind or severely visually impaired.

Orientation and mobility of children who are blind was one domain that was observed in the Bielefeld Developmental Test for Blind Infants and Preschoolers from the ages of one to six (Brambring 1998). As Brambring points out in his presentation of the main issues regarding O&M instruction of young children:

> O&M early intervention has to be based on knowledge from developmental psychology, and it must address the particular developmental level of each individual child. It should be included into cognitive, motor and social development as well as perceptual, personal and language development. O&M early intervention cannot be performed in isolation but has to be embedded within a comprehensive intervention program to promote the individual child. O&M early intervention has to be embedded within age-appropriate play.
>
> (Brambring, 1998)

O&M skills should be taught systematically as soon as the infant starts to roll over or shows other independent movements, because all areas of development are closely interrelated in early childhood. It is important that parents of children with visual impairment are taught in a way which gives them confidence to instruct their child, and knowledge of how to integrate O&M exercises into daily routines. Yet, the purpose is not to make parents instructors. The main aim is to integrate these skills into the daily routines.

# Effects of visual impairment on children

When the vision of adults deteriorates, they still have some vision, and they can use their previous visual experiences and familiar concepts when they make observations on their surroundings. In that case, children who are blind, they obtain information through hearing, smelling, touching and sensing the body position and limb movements. Thus, perceptions provide information for the visual, auditory, and haptic systems, and the child can collect varying impressions that make up the whole (Gibson & Spelke, 1983, 2).

When children with low vision develop functions and concepts, they have to learn to use their existing vision and other senses (Ferrel, 2000, 122). In this case, they may need a person to decode the ambient conditions. Without an appropriate early intervention, information can remain inconsistent and fragmented; it is difficult for the children to control stimuli from different sources without instruction and practise in processing perceptions.

However, sight is the sense that can form perceptions from distant phenomena, and it gives simultaneous information on the details and relationships regarding the form, size, and relative position of objects. Even if the observations and perceptions of the environment are stationary and self-explanatory, still they can offer the children with visual impairment aesthetic experiences, which can be different from the conceptions of people who can see. Visual experiences, therefore, have an 'object quality' (Lowenfeld, 1948).

## Visual impairment

Most people have visual problems at some point in their lives. They may no longer see objects that are far away or very close clearly; some have problems reading small print, or they may develop presbyopia. These conditions are easily treated with eyeglasses or contact lenses.

*Classification of visual impairment*

Visual impairment can be classified in many ways. In Finland, a person is considered visually impaired if the reduced visual ability causes significant difficulties in everyday life (Ojamo, 2002). The Finnish Register of Visual Impairment follows the same classification as The World Health Organization (WHO) when indicating visual acuity (Ojamo, 2002). The classification of vision impairment is based on the WHO definition of vision, while the measurement of visual acuity is determined with line tests and by the size of the visual field.

This type of assessment and definition is not appropriate for use with small children. The definition of the visual impairment of children cannot be based solely on the results of clinical or medical assessment of vision acuity because medical specialists spend a short time assessing young children in an environment that is different from the children's normal environment. A medical vision assessment, however, can give valuable information about the disorders and refractive errors in the eye.

There is a need for classification for documenting the characteristics of children and their growth, development, and health. The World Health Organization (WHO) has published The International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY, 2007), which 'is designed to record the characteristics of the developing child and the influence of its surrounding environment', can be used for educational purposes.

Instead of classifying people themselves, ICF-CY classifies people's health characteristics within the context of their individual life situations and environmental impacts. ICF-CY focuses on functional aspects providing specific information to cover children's body functions and structures, activities, participation and environment. It stresses health and functioning instead of focusing on the disability. It is a tool for measuring functioning in society, and by shifting the focus from cause to impact, and taking into account both the medical and social model of disability, it places all health conditions in an equal position when measuring health care and rehabilitation needs.

Also, the environment has physical, social and attitudinal factors that may be facilitators or barriers for the child. The functioning of the child cannot be seen in isolation, but rather in the context of the surrounding elements, keeping in mind the influence of family interactions, which have a big role in the child's functioning in different developmental phases.

## *Vision assessment of children with visual impairment*

A great majority of visual impairments in children are congenital or occur during the first year of life. Visual acuity of infants can be assessed only as grating acuity and the visual field only on the basis of its size. Many children with multi-impairment can not be tested easily with optotype acuity tests. Children with severe motor impairments and children with profound intellectual disabilities may not have the command of eye movements to respond to grating acuity tests or in test situations that require fixation of the gaze on a target of a certain size and contrast. Therefore, classification of their visual impairment cannot be based only on visual acuity (Hyvärinen, 2003).

### *Assessment of functional vision*

Visual impairment can affect different visual functions, such as visual acuity, visual field, contrast sensitivity, visual accommodation, visual adaptation, colour vision, or eye motility. Visual functioning is more than a mere sum of different components because numerous cognitive functions related to the use of vision have an effect on seeing. Therefore, the measurement of individual visual functions is important in evaluating visual acuity (Hyvärinen, 2003).

When examining the vision of infants and small children, it is necessary to use functional terms. The assessment should be based on what a child can do; the definition cannot be confined to literacy and sustained near-vision tasks. It is important to remember that visual impairment affects functional areas that must be considered by definition the criteria for services and educational procedures for a child with visual impairment: (a) communication and interaction; (b) mobility and orientation in space; (c) activities in daily life; and (d) sustained near-vision tasks like reading and writing (Hyvärinen, 2007).

The functional vision assessment can give a good and comprehensive understanding of children's needs (for example, the distance at which materials are shown; the ideal lighting conditions; and the best possible reading and writing tools for each child), which is necessary knowledge for educators when they modify teaching material and arrange educational settings. The functional vision assessment must be based on the observations of a child in a variety of settings, both indoors and outdoors. It has to be conducted at different times of the day and across different environments.

The functional vision assessment, accompanied by medical information, helps teachers, instructors and parents understand how vision impairment may affect children's daily life situations. The functional use of vision is dependent on many factors. Medications, the presence of other disabilities, positioning, the type of daycare, motivation, age, and health condition can all have an influence on children's performance.

Young children with disabilities are significantly dependent on persons in the immediate environment. They need a safe, nurturing, enriched, and supportive environment in which to learn from other children, a programme that meets their unique needs, and peers who can support interactive learning (Downing, 1999). The physical and social elements of the environment have a significant impact; negative environmental factors can strongly influence children in terms of their learning opportunities and abilities.

## Development of children with visual impairment

Vision is the key sense for most aspects of child development. All five senses interact and are to a large degree interdependent; thus, 'the impact of severe visual impairment on development is wide-ranging and cumulative, especially in the early months.' The development of sighted infants in all areas of visual functioning is rapid during the first year. The first four months are critical regarding the awareness of self, parents and immediate surroundings. During the next eight months sensorimotor and intersensory integration (tactile and kinaesthetic sensitivity, localization of touch and auditory perceptions), the emergence of motor skills and mobility (postural and saving reactions, hand skills) as well as perception of structure and composition of the environment have critical developmental phases.

All these aspects are fundamental from the point of view of the development of spatial awareness and orientation. If levels of vision and visual functioning are not the best possible, developmental progress in other areas may be restricted, and there is a risk that the infant with visual impairment will not develop interest and responsiveness beyond the closest arm reach (Sonksen, 1993, 78).

The development of concepts related to space and the environment is different in children and infants who are congenitally blind when compared with the development of children and infants who can see. Motor development and body image are influenced negatively if the infant does not have proper early intervention. Understanding the relationship between sound and the object develops later than the relationship between sight and the object, and as a result the development of object permanence is delayed. Seeing offers more continuity between the perception and object than hearing: eye-hand coordination is developed at the age of about five months while ear-hand coordination is not developed until the age of nine months (Gibson & Spelke, 1983, 9).

Observing the development of children with visual impairment is not a simple matter of age and cognitive skills (Warren, 1994, 5). The complex relationships among these children's environments, their developing abilities and characteristics, and particularly, how others respond to their ability all have an effect on development.

Jean Piaget's theory of developmental stages has dominated research and application in early human development (Stea et al., 1996, 346). Piaget's claim that development in early childhood always proceeds through certain distinct stages has provided one framework for examining the cognitive development not only of sighted children, but also of children who are blind (Fazzi & Klein, 2002; Piaget & Inhälder, 1977).

According to Piaget, development occurs in stages that all people undergo in the same sequence but not necessarily at the same chronological time. The sensorimotor, preoperational, concrete operational, and formal operational stages are considered hierarchical so that what children have learned in the earlier stages is used to develop more complex and mature schemas (Ferrel, 2000; Miller, 2004). In order to understand the surrounding world the child undergoes those developmental stages; in his theory of the cognitive-developmental model Piaget stressed the individual’s active role in this developmental process.

Comparing the development of children with visual impairment and the children who can see is questionable. When making such comparisons, the wide variation within the blind population can be easily overlooked. The point is not that children with visual impairment proceed through the developmental steps in a different order and at a slower pace compared with children who can see.

On the contrary, it is important to assess the children and the variables that affect the quality of their adaptation to the developmental tasks, to look within this population of children for variations, and the potential reasons for the differences (Brambring, 1994; Brambring & Tröster, 1994; Fazzi & Klein, 2002; Fletcher, 1980; Ferrel, 2000; Fogel, 1997; Warren, 1994). However, knowledge of the development of sighted children can provide clues for understanding the development of young children with visual impairment. Information on the development of children with visual impairment is contradictory because the study samples have been small and the diagnostic instruments insufficient (Brambring & Tröster, 1994).

### Spatial development

Vision is the primary system of sensory input for human beings. Lack of vision in early childhood has an impact on the development of motor functions, cognition, concepts and language, which are important elements when the child is developing more sophisticated skills (Fazzi & Klein, 2002).

A major part of a child's adaptation to the physical world is cognitive: the child must learn to understand the different properties of the world, especially its spatial characteristics. Vision is a predominant sense, and spatial perception has been often described as a visual functioning (von Fieandt, 1962). However, visual information needs to be confirmed by tactile and haptic information, first by mouthing, then by exploring with the hands and measuring with the whole body.

The child with visual impairment has special needs when interacting physically with the outside world, and must acquire motor skills, travel skills, and haptic exploration skills (Warren, 1994). In the same way as sighted children, children who are blind go through several stages when organizing their spatial environment: (a) accidental contact with objects; (b) conscious pushing and touching of objects; (c) grasping and letting go of objects, as well as grasping and keeping objects; (d) repetition of motor activities; (e) varied handling of objects; (f) listening and performing a kinaesthetic/tactile activity; and (g) searching for two objects at the same time (Nielsen, 1991).

Learning to name the body parts and understanding their functions are important additional aspects influencing the development of spatial understanding. It is also important to verbally support and physically reinforce the correct spatial choices of these children.

A stagnation of the developmental process sometimes occurs in children who are blind. It is not clear whether it is due to (a) imposed behavioural restrictions placed on them and the subsequent limitations in nonvisual exposure, (b) perceptual difficulties experienced as a direct result of permanent sensory restriction, or (c) a combination of the above two factors (Casey, 1978).

According to Bigelow (1991a), children who are blind are delayed in developing a Euclidean understanding of space, or they are delayed in developing a unitary, integrated model of the environment, and thus spatial organization develops slowly. However, according to Millar (1988) spatial information can be derived from hearing, touch and movement and also a child who is blind therefore has the potential to acquire concepts and representations of the spatial domain equivalent to those of sighted children.

It is conceivable that children go through a specific stage of development which is critical regarding the understanding of spatial concepts. Loss of vision before this critical developmental period might result in a lowered potential for development of skills which are fundamental to the development of orientation and mobility (Casey, 1978; Warren, 1994). Children who are blind may have difficulty acquiring an understanding of spatial concepts and learning about the environment if they have limited experience of the environment (Casey, 1978; Ochaìta & Huertas, 1993; Wheeler et al., 1997). However, little is known about the development of spatial representation and of the various factors that influence the ability to use a particular mode of representation among children with visual impairment (Fletcher, 1980).

*Object permanence*

Children who are functionally blind may have difficulties in developing object concepts and object permanence[4]. They may have problems in finding objects because they have not had access to information that is necessary in developing a near-space cognitive schema (Bigelow, 1991a). Lack of understanding object permanence, limitations in the child's ability to localize objects, and deficiency in developing relationships between objects can cause problems in the development of spatial representations.

According to Piaget's theory an infant starts life at the egocentric stage; knowledge of objects is tied to the infant's own immediate actions. During the sensorimotor stage, beginning at birth until the age of two, the infant gradually constructs the distinction between the self

[4] Object permanence is the awareness that an object continues to exist even when it is not in view. In young infants, when a toy is out of sight, the infant appears to lose interest in the toy and may forget its presence.

and the outer world, and develops a concept of objects. The child learns to understand that the object does not cease to exist although he or she cannot see, hear or touch it (Miller, 2004, 113). The child has acquired the concept of object permanence when he or she looks for a hidden object; then the child is also motivated to engage in the external world (Brambring, 2005; Warren, 1994;).

Visual experiences during infancy facilitate the acquisition of object permanence. The infant, on the other hand, needs to learn to search for a previously perceived object, not only in the location in which it was originally perceived, but also in other places within reach (Adelson & Freiberg, 1974; Nielsen, 1991; Warren, 1994). These infants must learn that lost objects actually continue to exist even if they can no longer be touched or heard. The child with visual impairment needs to understand object permanence before one can start to teach, for example, different exploring and search strategies.

*Perspective taking*

Miletic claimed (1995) that a child who is congenitally blind is not aware of how a display may appear to the doll sitting at different locations from where the child herself is sitting. In contrast, Bigelow (1992) found that children who are blind may understand that a layout appears the same to another person if viewed from the same position, but that the same layout is perceived differently from a different location.

This perceptual perspective taking is an advanced spatial skill that sighted children master generally by the age of four or five. Bigelow (1991b) argued that children who are totally blind still have great difficulties in perspective taking tasks at the age of seven or eight, especially if the distance between the child and the target is more than one metre.

Farrenkopf & Davidson (1992) examined perspective taking with relation to age, visual status, distance, and barriers. They studied children who had become blind between three and eight years of age, comparing them with sighted children. They underlined the importance of vision for perspective taking. They claimed that vision cannot be compensated by another sense in the process. The results showed that children who are blind do not show a significant increase in accurate perspective taking even with increasing age, although some emerging signs were noted.

Farrenkopf & Davidson (1992) suggested additional study with older children or adults in order to ascertain the possible role of maturation in the development of perspective taking. They did not consider a training programme for developing these skills. Their result diverges from the Bielefeld Longitudinal Study (Brambring, 2005), which found that perspective taking may be acquired early; one child in his study acquired correct perspective taking at the age of three.

Ochaita & Huertas (1993) studied and analysed the development of spatial knowledge and representation in children who became blind between 9.3 and 17.3 years of age. They claimed that generally children had three stages in the development of spatial schema:

1. The years between four and seven were the phase of the egocentric system and spatial organization was unorganized.
2. A second stage existed between 7 and 11 years of age, when spatial relationships were organized into categories but relationships between categories were vague.
3. The third stage developed when the children were 11 years old and older and spatial relationships were well organized.

Their claim was based on the Piagetian theories, according to which children cannot exhibit more advanced behavioural stages until they have grasped the essential concepts of the previous stages (Stea et al., 1996, 353). This would mean, for example that children could not understand map concepts before the age of 11, which is not true, and can be, and has been, criticized (Blades & Spencer, 1986; Stea et al., 1996, 356).

Ochaìta & Huertas (1993) did not find differences between the groups of congenitally and adventitiously blind children, but the complexity of the space and the route compared with the size as well as the age of the child was more decisive in the subject's level of representation and development of spatial knowledge. They also stated that children who were blind went through the same stages in the evolution of spatial representation as sighted children.

However, they argued that most children who were blind remained at the egocentric stage of spatial relationship development until 11 or 12 years of age and only at age 17 did subjects who were blind develop a normal recognition of known environments. But they also found that training could rapidly improve the ability to structure the environment. This finding supported the idea of early spatial awareness instruction in order to avoid stagnation of the child's development at the egocentric stage.

Environmental factors may explain excellent spatial capabilities of some children who are congenitally blind. This is related to how the parents experience visual impairment, how they allow the child to explore physical environments, or whether they inhibit the child from exploring (Warren, 1994). Instruction and other specific interventions are also environmental factors. Instruction generally is a way of structuring children's experience so as to allow them to reach the positive limits of their own capabilities. The aim is not to compare these limits to those of sighted children, or to pursue those limits. Instruction is inappropriate if a child with visual impairment has not yet developed abilities which he or she is likely to have. Thus it is important that training programmes should not attempt to induce behaviours before the child is developmentally ready for them (Warren, 1994). However, one should keep in mind that spatial awareness instruction later in life may be less effective than instruction when the child is young and more receptive to external influences.

Wheeler et al. (1997) reviewed different studies regarding spatial development and listed activities that assist the child with visual impairment to develop more structured spatial thinking:

- Objects and materials should be presented to infants at the mid-line of the child, allowing the child to grasp the object by both hands in order to form a concept of the mid-line of the body (Freiberg, 1977).
- Every person and caretaker should talk about what is happening and where items are located in relation to the child's own body (Griffin, 1981).
- A quiet environment allows the child to hear auditory cues for spatial organization (Nielsen, 1991).
- Children should be encouraged to use their hands actively when exploring the environment (Warren, 1994).
- Toys and objects should offer distinctive comparisons and interesting and diverse auditory and tactual stimulation (Nielsen, 1991).

**Fine motor development and tactual development**

Touch has a fundamental role in the development of spatial organization; even newborn infants use tactual exploration skills by mouthing the objects, but active manual exploration develops later. In its earliest phase it confirms visual information giving it a concrete form (Gibson & Spelke, 1983). Tactual perception of space of a child who is blind is different from the visual perception of the child who can see. Lack of tactual experiences can result in developmental delays. However, the child first needs to develop a sense of security before he can feel confident about exploring the environment (Adelson & Fraiberg, 1974).

A person's hands can receive a great deal of sensory information through: (a) manipulation of objects; (b) assessment of the mass of the objects; (c) sensing the texture of the objects; and (d) perception of the size, the shape and dimensions of the objects as well as the thermal and structural cues. Additionally, an effective procedure for exploring the figures is to use several fingers for scanning, as the fingertips are very sensitive to differences in the position from which the curve can be judged (Nielsen, 1991; Roberts & Wing, 2001).

However, even if children who are blind demonstrate sophisticated manipulation behaviours with a range of different objects, these behaviours may have a limited exploratory and information-gathering function. It is important to guide them to use their hands in a systematic way in order to maximize the use of the tactile and other senses for making conclusions about different aspects in the environment.

Roberts and Wing (2001) discuss the nature and the quality of touch: it is not purely skin sensation; as important is proprioceptive sensation arising in sensory receptors in the muscles and joints. They use the terms *passive* and *active* touch. In passive touch the child is the recipient and in active touch the child is the source of the movement. When a child touches himself he combines both experiences. Their aim was to show how a psychological approach helps to understand the use of tactual information.

The development of the tactual sense is critical when children who are blind are learning to read Braille or tactile graphics. The development of the brain is plastic; a given region of the brain may specialize in other than its usual functions due to experiences and stimuli (Hyvärinen, J et al., 1978). Such plasticity is illustrated, for example, by recent findings on the effects of Braille learning (Kujala & Hämäläinen, 2006). 'Blindness together with training of tactile acuity and skills indeed leads to improved tactile skills on a broader scale.’ If we want to improve perceptual skills we need systematic training; it improves sensitivity and accompanying changes in cortical representations (Bliss, Kujala & Hämäläinen, 2004).

By exploring tactile pictures and figures the child can learn to use correct finger placement and develop motor skills and finger strength (Fazzi & Klein, 2002). Fine motor skills like directed reaching, wrist rotation, grasping, and pushing an object are essential for learning Braille, tactile graphics and map reading, as well as for keyboard technology and O&M skills (Anthony et al., 2002). Therefore, the possibility of delays in fine motor development is a major concern. Fine motor issues are important, and they should not be overshadowed by issues associated with orientation and mobility instruction.

The development of literacy skills begins early in life. Sighted children have numerous incidental exposures to letters, symbols, and pictures. In other words, they have access to *emergent literacy* (Koenig & Holbrook, 2002, 155). Young children who are functionally blind also need early exposure to Braille literacy, tactile graphics, and other tactile experiments in a planned manner. An environment rich in tactile figures, symbols, and words can help children who are visually impaired develop an early understanding of language, literacy, and tactile graphics.

These children need interventions that promote organization of tactual awareness and the space around them (Wheeler et al. 1997). Appropriate interventions train them: (a) to use their hands at mid-line for developing egocentric spatial awareness; (b) require them to use their hands reciprocally (give-and-take activities with toys); and (c) use tactually interesting objects that facilitate recognition of important tactual features. It is important to foster motivation and enjoyment of tactual exploration. Tactile perception and discrimination, figure recognition, and the learning of hand and finger movements are fine motor skills that can promote preliminary Braille skills (Koenig & Holbrook 2002, 179).

## Gross motor development

Motor development functions as an activator and a 'time keeper' for the development of perceptual and cognitive operations (Ahonen & Viholainen, 2006, 272). The development of skills which affect the control of posture enables a young child to learn to control limb movements, and consequently independent mobility. During this process the child builds up the foundation for the development of cognitive skills.

Visual impairment may have an effect on the quality of movements. Early detection of any negative effects on the child's motor development is important. Early intervention may help the child to compensate lack of vision with the other senses (Brambring, 2006; Hyvärinen, 2003; Nielsen, 1991). The child needs supportive motor training before any obvious developmental delays have occurred. With skilful training an infant or a child with visual impairment can develop normal motor functions.

As a prerequisite of motor learning, the infant needs to experience spaces of different size, with different surfaces, and with different acoustics in order to develop spatial concepts, spatial understanding and orientation in space using the visual, auditory and tactile cues available. Developmental delays in stable gross motor skills like sitting or standing are usually slight, whereas delays in changing posture such as in rolling or crawling are more marked, leading to too wide a gait, outward-turned feet and poor body posture (Strickling & Pogrund, 2002).

Children with visual impairment should be encouraged to explore the environment through locomotion. Adelson & Fraiberg (1974) noted that the children who are congenitally blind have their own pattern of development consisting of normal motor developmental rates and plateaus. The plateaus of motor development can be found between seven and twelve months, when an infant is proceeding to sitting, crawling and walking. The plateau stage may be related to fears of the unknown and lack of stimulation to explore the environment (Wheeler et al., 1997). Early locomotion is critical in the development of spatial orientation and in finding the relationships between objects in the environment.

## Auditory development

Perception of sound begins to develop before birth (Bee, 2000). The first auditory step is simply to react to sounds. Subsequently, the infant learns to recognize familiar sounds and make distinctions between the sounds, and then begins to interact and communicate with the environment. The task of the hearing system is to localize the sound source and to define the direction of the target to be heard, as well as to recognize the sounds related to different activities.

The significance of hearing and auditory information increases in the perception of space when children with visual impairment begin to move about. Besides vision, hearing is a sense that gives information from far. By hearing children can sense phenomena that are located behind their body or around the corner. Auditory perception is generally a significant information source for an infant who is blind (Chen, 1999; Skellenger & Hill, 1997; Warren, 1994, 20; Wiener & Lawson, 1997).

The nervous system of a young child has greater ability to develop and to change its structure and function compared with older people. The cortical plasticity is effective between two and five years of age and early blindness affects auditory processing by enhancing processing of stimuli in the auditory cortex (Alho et al. 1993; J. Hyvärinen et al., 1978; Kujala 1996; Kujala & Hämäläinen, 2006). The developmental stage of the child has an effect on the plasticity of the cortex, and the process of auditory space perception is based strongly on neural plasticity, which 'could be due to the high survival value of spatial information for the blind, for example in locomotion' (Kujala et al. 1992).

Perceptual abilities and underlying brain mechanisms are modified by experience in utilizing different modalities. Following sensory deprivation, individuals learn to utilize more effectively other available sources of sensory information, for example, 'auditory and tactile by the blind, visual and tactile by the deaf'. This results from heavy reliance on these sensory modalities, thorough practise in using them, and changes in neuronal networks normally devoted to the lost senses (Bliss & Hämäläinen, 2005). The tactile sense of the blind child partially compensates for near vision and the auditory sense for distance vision.

Equally, there is activity in the visual cortex when listening to sounds, especially when localizing sound sources (Bliss & Hämäläinen, 2005; Bliss & al., 2004). The visual cortex of a child who is blind has taken over part of the processing of auditory information about space. Therefore, the versatile use of sensory modalities connected with overlapping, systematic and effective training as well as changes in neuronal networks support the development of good perceptual abilities and underlying brain mechanisms.

Children learn about distances and spatial layout also by listening to echoes when calling out in different directions. The term echolocation (echo perception) has been used to refer to auditory skills when perceiving objects from a distance and navigating without vision. Especially people who are blind may create sounds and echoes by tapping their canes, by whistling or by clapping their hands in order to make inferences about the space like estimating the size of the room. This procedure depends mainly on auditory perception. During early development, children can learn to use auditory information and to develop spatial ability spontaneously without systematic training (Ashmead et al., 1989).

However, sound by definition is not a rich information source for organizing spatial structure, but it can be used as a guide when children are looking for objects in the environment. Sound also provides information about the environmental characteristics (Gibson & Spelke, 1983, 9; Warren, 1994). Learning auditory-motor behaviour is important because children need to construct the relations between their own body and significant acoustic objects without the help of vision.

Sound localization in infants develops first in the horizontal plane and later in the vertical plane. As an orienting reaction to sound, infants turn their heads to the right or the left of their midline. Secondly, infants have two ears, on the opposite sides of the head. Because sounds around the head sound slightly different in two ears, the brain, which is 'listening' to both ears, can determine where various sounds are coming from. If the sound is coming from the side, then the ear closer to the sound's source will hear it a little louder than the ear that is farther away (Wiener & Lawson, 1997).

### *Auditory training*

Practically, the concept of hearing is wider than pure listening skills including the ability to process the auditory perceptions. Localization of a sound source has an effect on the determination of directions, distances, locations and obstacle detection. Nevertheless, people who are blind are not necessarily superior in directional hearing, and children need training to develop and to use directional hearing (Jokiniemi, 2007, 76).

Children with visual impairment need overlapping to practise in order to learn to perceive sounds for making conclusions based on auditory information and object perception. Auditory training is one part of O&M instruction and instruction should include training in echolocation and in detecting, identifying and discriminating sounds. Children need to learn to localize and to reach for sound sources, to follow both a continuous and discontinuous sound source and to travel towards the sound source without bumping into it.

Sound-producing objects are often used in O&M instruction as a target for straight line travel. It would be equally important to train children to use variations in the ambient sound field and to compare sound arriving at two ears because the binaural hearing system is capable of making subtle discriminations among sounds guiding locomotion for example promoting the ability to maintain a line of travel parallel to a wall (Ashmead et al., 1998; Skellenger & Hill, 1994).

Before starting O&M instruction, it is important to make a functional hearing assessment and observe, if the child turns the head, reaches for the sound, or points or moves to the sound source. The appropriate physical arrangements in the space can support children's listening behaviour. Environmental sounds can direct the child's attention and include information about the objects around. The child has then to learn, what event created the sound, how to understand and to use this sound in a purposeful way and what he or she is expected to do as a result (Downing, 1999).

In the case of hearing loss, O&M instruction has to rely more on the tactual and kinaesthetic information. Still, auditory training can be appropriate because some auditory cues at low frequencies can be useful and available allowing children to develop echolocation skills by detecting subtle changes in frequency and intensity changes (Wiener & Lawson, 1997, 152).

# Towards the theory of tactile pre-maps

When studying spatial representation in blind children, Fletcher (1980) identified three broad theories regarding the concepts and the ability to synthesize the information received through the tactile sense into a mental image or a cognitive map:

1. The deficiency theory by von Senden (as cited in Fletcher) claims that people who have been blind from birth are not able to build a cognitive map because spatial concepts are impossible to understand, and visual experience at some part of one's life is essential for even a minimal understanding of space.
2. The inefficiency theory by Revesz (1933) and Worchel (1951) claims that in people blind from birth spatial skills and concepts as well as representations of space develop slowly, and they are functionally inferior to those of sighted and adventitiously blind people.
3. The difference theory by Juurmaa (1973) claims that the haptic frame of reference and functional spatial cognition develop more slowly and through different strategies.

Young children who are blind have difficulties in developing cognitive maps and in tasks that require comparisons between modalities because they lack a general framework for fitting in sensory information. By young adulthood the haptic frame of reference has developed and these problems have disappeared (Juurmaa, 1973). Juurmaa's basic argument is that a person who is congenitally blind develops cognitive maps based on tactual, kinaesthetic, and auditory information. This capacity for cognitive mapping develops more slowly than in the sighted person, but the product is not necessarily inferior to or less efficient than that based primarily on visual input.

It is important to prompt children who are blind to organize spatial information by different coding strategies which differ from visual experiences. The lack of vision and the resulting difference in the quality of experience of space lead these children to approach a task by using strategies different from those of sighted children. The lack of vision is not a hindrance for images, but visual experiences make it possible to manipulate images.

Visual experience influences the coding of tactile and kinaesthetic information in non-visual tasks (Juurmaa, 1973). He also argues that the poor performance of persons who are blind in comparison with their blindfolded sighted counterparts in many tests of spatial competence is attributable to the use of experimental stimuli which are highly familiar to the sighted but less so to the subjects who are blind. He also stresses the importance of intervention from the earliest years, in order to minimize developmental delay. A child who is blind should get the widest range of effective strategies for processing spatial information (Ungar et al., 1994). For example, tactual experience must be structured in such a way as to lend itself easily to external reference systems, so that those systems can become flexibly available to the child.

In spatial tasks, persons with visual impairment have the potential of achieving the same level of efficiency as sighted subjects (Rieser et al., 1982), or even higher (Casey, 1978; Dodds et al., 1982; Fletcher, 1980). However, subjects who are blind from an early age may perform less well than sighted subjects, especially in tasks that require moving in large scale spaces (Rieser et al., 1992; Ungar et al., 1994). It is important to try to find and train a variety of strategies.

## Maps

A map is a physical array of symbols which represent and depict the spatial relationships among objects in some other physical array or environment (Landau, 1986), and it conveys spatial information (Berlà, 1981). It is a two-dimensional representation of the environment, usually on a flat surface, showing a group of features of the terrain as a whole or in parts in terms of their relative size and position (Thrower, 1996). Maps transmit information about the spatial world; they show relations of represented locations in a metric system. Maps are concrete, thus they differ from verbal descriptions and verbal maps (Newcombe & Huttenlocher, 2000).

By means of a map a child can become aware of the environment beyond his or her immediate experience in egocentric space. Maps make different kinds of information perceptually available, and depict spatial information in a two-dimensional, abstract way. The map allows us to look at, and study, sets of spatial relations without actually navigating through the space (Uttal, 2000). A map can be an essential orientation aid. It includes basic information about an area, giving an overview of an unfamiliar environment and making it easier to plan routes. By means of a map one can learn the layout of a certain area, a neighbourhood, a house, or a room.

Maps in some forms have been used through the ages. The simplest maps have been 'maps drawn into the ground with a stick, or a relief drawing on the wall' (Edman, 1992). The first known map dates to about 4,500 years ago. As late as the 1400s, all maps were still reproduced by hand, so maps were not generally available. The invention of printing made it possible to produce maps that faithfully represented the original view. Thus, more people had the opportunity to see and use maps.

Maps are one of the few everyday objects that are almost entirely dependent on the sense of sight, and this makes conventional maps difficult or impossible to read for people with visual impairment. Maps are used by sighted people to interpret and investigate their surroundings. It would be important for those with visual impairment to have the opportunity to do the same, even if they were accompanied by a sighted guide. By means of an appropriate map with symbols of the near and distant landmarks, travellers who are blind can decide themselves if they want to 'look at' features along a route instead of being dependent on the whims of a guide (Eriksson et al. 2003; Gardiner & Perkins, 1996; James & Gill, 1974).

The scale and the points of the compass are important elements in all maps, including tactile maps. The map scale means the degree of reduction necessary to represent portions of the earth's surface at understandable sizes, commonly stated as a ratio (representative fraction) of distance on the map to distance on the ground.

Map scales can be divided into large and small categories. A large scale map shows a limited amount of space and provides a considerable amount of detailed information about that space: the location and dimension of all the buildings in a city block, for example, or the location of all the churches in an urban neighbourhood. Small scale maps typically represent extensive areas, but they offer only a gross perspective on details. Maps on a large scale are suitable for O&M whereas small scale maps are appropriate for showing large countries and continents. The scale and the points of the compass were not included in the pre-map tasks because these concepts are not a required skill at preschool age.

Maps can also be presented verbally, but verbal descriptions are often inadequate when a person is developing environmental knowledge (James & Gill, 1974; Easton & Bentzen, 1987; Bentzen, 1997). Remembering instructions and explanations can be difficult, the spoken information may include unfamiliar spatial and other concepts, and it can be difficult to describe irregular spatial relationships, unusually shaped buildings, irregularly spaced turns, and inconsistent entrance placements.

## Cognitive maps

The term cognitive map can be defined as an internal mental representation of spatial knowledge (Marston, 2002). It is a result of the process of acquiring, storing, remembering, decoding, and encoding information about relative locations in a spatial environment (Golledge et al., 1996, 218). A cognitive map is an internal representation or a mental image of an external environment having interactive information about objects and their relationship, and about distances between objects in a place (Long & Hill, 1997), and can be formed through exploration of space and at the same time it supports navigation (Sholl, 1996, 157).

The ability to form and use cognitive maps is an important prerequisite for the use of tactile maps. The person with visual impairment has to have a mental representation of the environment in order to be able to map the environment as a whole (Hill & Ponder, 1976).

Tactile maps can facilitate the construction of cognitive maps by providing the reader with a more integrated and global impression of the environment. Large scale environments like neighbourhoods and cities can not be seen in their entirety and consequently a person must construct an internal spatial representation from varying visual and nonvisual information. When constructing cognitive maps, transforming information from one modality to another plays an important role because maps are by their nature multi-modal entities (Haken & Portugali, 1996, 59), at least they refer to multi-modal landscapes.

Both adults and children with visual impairment are able to create cognitive maps (Fletcher, 1980). Exploration and recognition of objects is a prerequisite for developing mental maps of the environment. Children with visual impairment learn by playing, by listening to sounds in a space, by searching for objects, and by identifying landmarks by means of auditive, tactual, visual, smell and kinaesthetic cues. Repeated experiences of travelling between landmarks build up their knowledge of the positional relationships between the landmarks, and how they change when the observation point changes during the travel.

Random movement makes it difficult to develop a clear conceptual framework into which the objects found can be slotted. Thus, children should be encouraged to create systematic exploring strategies in unfamiliar environments. A systematic pattern of exploration is helpful for remembering spatial relationships in map-type and route-type orientation. An efficient means of representing space involves the establishment of a cognitive map of the location of objects relative to one another, including distance and angle information (Morrongiello et al., 1995). Visuo-spatial experiences are important for developing the ability to code spatial information (Warren, 1994).

The construction of cognitive maps is a complex interaction between internal representations of the external environment and external representations of the mind (Portugali, 1996, 11). Vygotski (as cited in Portugali, 1996, 19) introduced the idea of a higher form of behaviour in the context of cognitive maps. Vygotski (1978) stressed the role of the external environment, emphasizing that the internal representation of the external environment 'is not just a set of objects, their pattern and spatial relations, but their interactive, mediated and mediating nature'. It is a matter of active and passive remembering, and active remembering is specifically relevant when learning a new environment.

The cognitive maps of children with visual impairment are likely to be less accurate than those of their sighted peers (Morrongiello et al., 1995). People who are congenitally blind and who can accurately integrate and coordinate the elements of a large environment are exceptional (Casey 1978), but there are some who, regardless of blindness, are capable of coding equally as well as sighted people (Juurmaa & Lehtinen – Railo, 1994).

## Tactile maps

Persons with visual impairment have the potential to acquire representations of space, and tactile maps can be an effective means of providing spatial information (Ungar et al., 1996b). The system of Braille writing for the blind persons was developed in the early nineteenth century. The earliest known tactile diagrams were published later in that century approximately at the same time that schools for blind children were established. The development of tactile teaching material began in order to offer these children a comparable curriculum (Tatham, 2003), and tactile maps were actually the earliest pictures made for the persons who were blind (Jansson, 2003, 46).

It is a challenge for the cartographer to translate the real, visual world and its concrete and abstract ideas into tactual form. The design of tactile maps generally follows the same guidelines as those used in visual maps, but technically the pictures must be simple and the basic image must be edited for tactile exploring (Eriksson, 1999; Eriksson & Wollter, 1997; Gardiner & Perkins, 2005). A tactile map cannot be a mere translation of visual information into tactual form. The production guidelines that are important in visual maps are not necessarily appropriate in tactual maps. How the maps feel is a more important aspect in a tactile map than how the maps look (Aldrich & Sheppard, 2001; Aldrich et al., 2002; Eriksson, 1997; Karentz Andrews, 1988; Sheppard & Aldrich, 2000). Each new mapping task involves questions like: who is the reader, what is the purpose of the map, what information is needed, and how should the information be portrayed (Karentz Andrews, 1988)? The important aspects to be considered when preparing tactile maps are according to Aldrich and Sheppard (2001): 'the ability to discriminate lines, textures, size, labelling, and use of colour'.

The earliest tactile maps were hand-made for a few individuals. They were like collages made of strings, buttons, and cloth placed onto a basic simple map (Dacen-Nagel & Coulson, 1990). Maps could be made of embossed paper, but hand-carved wood was the most common material. The raised, smooth, and incised surfaces of these maps represented various geographic features. One of the first tactile map users was Maria Theresia von Paradis, a famous blind musician. She performed in different parts of Europe, and tactile maps were made for her to depict her concert destinations.

Tactile maps were not produced in quantity for blind users until the late 19$^{th}$ century. In the 1890s, Martin Kunz created tactile maps that were used in schools for the blind in Europe and the United States. His paper maps were embossed in moulds. Features included raised areas to indicate landmass, with mountains prominently embossed; rows of raised horizontal lines to represent large bodies of water, and narrow unembossed areas for rivers. Raised dots and squares denoted cities, and single raised lines the geo-political boundaries. His maps often identified countries, rivers, oceans, and cities in Braille and had keys with raised symbols described in Braille (*http://www.aph.org/museum/teach/ geography.html*, 24.9.2004).

Tactile maps can be an excellent source of information about the environment for the persons with visual impairment. They can give a greater spatial understanding than either a direct experience of moving through the environment (Ochaita & Huertas, 1993) or a direct experience supplemented with verbal explanation (Dodds, 1989, Ungar & al, 1997c). The relevant information is presented clearly with relative simultaneity, and without other difficulties associated with travel in the real environment. Furthermore, if maps can compensate for the limitations in understanding spatial layout of the children with visual impairment they may form an essential component of O&M instruction (Dodds, 1989; Ungar et al., 1993; Yngström, 1999).

There is now considerable research on the strategies that people with visual impairment use to become aware of the environment, and how they differ from the processes used by sighted people (Challis & Edwards, 2000; Marek, 1997; Ungar, 2000). Producers of tactile maps tend to work independently of each other without systematic consistency in their methods. Rowell and Ungar (2003a) made an international survey gathering the main aspects regarding the production, techniques and design of tactile maps. They noted the obvious risk that people who are visually impaired could be disadvantaged in our increasingly image-oriented society if they did not have the possibility of accessing visual information in alternative ways. It is a challenge for producers of tactile graphics to keep up with an increasingly graphically literate, sighted population.

Maps for sighted users often represent a landscape using conventional symbols. Tactile maps rely much less upon conventions and they must be simplified to a much greater extent (Brambring & Laufenberger, 1979; Edman, 1992; Gardiner & Perkins, 1996; Gardiner & Perkins, 2005; James & Gill, 1974). Tactile maps typically use technology consisting of raised lines, shapes, textures and symbols.

Recent development in the production of tactile maps includes the harnessing of several sensory modalities, including the visual, auditory and tactile senses. They are produced using a number of different technologies, and it is important to reduce information complexity, to emphasize the quality of the lines, and to choose textures and colours carefully in order to distinguish them from the background.

Desirable characteristics of tactile maps are durability, sharpness of border lines, surface texture, recognizable symbols, and availability. Maps can be located and available in various places, and they should withstand abrasive use, chemical exposure, and adverse weather conditions. At the same time they should be pleasant to touch, consistent in symbol representation and they should have distinguishable lines to trace.

One of the important issues is whether tactile maps should attempt to reproduce visual maps in a tactile format, or whether they should seek to represent the environment in ways that are more compatible with the visually impaired user's sense of spatial awareness. Two main types of maps are accessible to users: maps that are readable by students with impaired vision and maps that are for blind users. It would be sensible to produce maps which are readable by both groups.

### *Types of tactile maps*

The earliest versions of tactile maps were *collage maps* made of built-up displays of string and handicraft materials glued on a substrate to create a variety of heights, textures, and shapes. This display could serve as a tactile map, or it was a master that was then thermoformed for reproduction.

*Thermoform maps* are two-and-a-half dimensional maps; they are widely used for educational purposes. A thermoform map requires a master or a model, and a thin plastic sheet that is placed over the master and vacuum shaped into a tactile map. Thermoform plastic is available in a variety of thicknesses, which makes it possible to produce varying heights. The surface varies from gloss to matt (Tatham, 2003). It can be pre-printed with colour to allow use by partially sighted persons or to enable sighted assistants to help the person with visual impairment use the product. Thermoform maps are easy to clean and are not sticky, but they do not usually have visual aspects, which are important for the readers with low vision (Turner & Sherman, 1986). In any case, thermoform maps are a one option in public places because they are durable and easy to clean.

*Microcapsule or swell paper maps* are either hand-drawn or printed figures which are copied onto heat-sensitive microcapsule paper. The paper must be heated and run through a tactile image enhancer; the marks on the paper covered by black ink raise above the paper surface, creating a raised-line drawing. The swell paper drawing can be achieved by a combination of computer drawing programs and Braille fonts, or by simply drawing a figure on a piece of white paper. The raised-line drawing obtained with this method is used directly by students; the pictures are two-dimensional and all marks are of equal height. Tactile pictures and maps made of microcapsule paper are top-rated among users although they are not as crisp as Thermoform maps (Horsfall, 1997).

*German film or Ritmuff-sheet* is a semi-transparent plastic sheet which is placed on a rubber mat. Figures can be drawn using a stylus or an ordinary pen that leaves a raised line on the sheet. The main advantage of this method is that it can be used interactively to create a graphic which children can feel at different stages of production. They can also make their own drawings. The main disadvantage of this method is that there is little variation in line height, and graphics quickly become tatty as the film is a flimsy and fragile material (Tatham, 2003).

New *inkjet technology* is the latest development. It produces raised tactile print using a printer that produces raised ink surfaces on a variety of substrates. This happens by laying down a polymer via an adapted jet head, which is then cured under ultra violet light. This process makes it possible to produce symbols of different elevations, textures and profiles; thus, it allows maximizing haptic contrast. This new technology makes it possible to print maps directly from electronic copy, and to create different tactile maps for a variety of personal needs (Petrie, 2005). The inkjet process can offer advantages and possibilities when producing tactile maps and graphics. Users also benefit from the new technology, which offers easier use and more alternatives with more details in the graphics (McCallum & Ungar, 2003). Inkjet technology, however, is not yet available for wider production.

*Embossed maps* are created from patterns of raised dots, using a computer-controlled Braille printer. The images can also be pressed on a paperboard or metal foil by using inexpensive tools (Horsfall, 1997; Tatham, 2003). This is not an efficient type of tactile map, though it is a cheap method. One development in tactile maps has been the use of the spur-wheel to create drawings on Braille paper.

*Computer graphics embossed by Braille printers* uses Braille graphics software programs with Braille graphics printers to achieve a master of printed dots. The master can be Thermoformed for multiple copy production or the Braille graphics file can be embossed multiple times for paper versions.

In some cases *small scale models* can be more realistic tools than maps or verbal explanations for introducing spatial concepts to students who have difficulty with abstractions. Models more closely represent actual three-dimensional space and therefore may be a bridge to the use of maps (Bentzen, 1997).

The quality of the substrate, such as the roughness of the paper, is significant for the reader in terms of the sensitivity and reading rate. Pike et al. (1992) found that the performance of children with visual impairment was equally good when using maps of swell paper and of thermoform. The users favour swell paper maps because of their clear visual images and tactual clarity. They are nice to touch, their texture is easy to work with, and they have black and white contrasts. People with visual impairment have expressed the opinion that mobility maps produced on swell paper or on a rough paper are easier and more satisfying to explore than maps made of aluminium or plastic (Jehoel et al., 2005, Turner & Sherman, 1986).

More important than the substrate is the map design, because it affects the exploring performance. It took less time to trace the route on the 'texture' maps than on the 'shape' maps. The explanation is that exploring and identifying a symbol by texture is more immediate than identifying a symbol by shape (Pike et al., 1992).

Unfortunately, tactile maps are not sufficiently available. There is a lack of producers and skilful tactile map readers, with the result that there is minor demand for maps of good quality and not enough instruction in map reading skills (Aldrich et al., 2002). It would be essential to create coherent guidelines for tactile map design. The guidelines should take into account the differences in age, vision and other abilities of the potential users. The design should include the map size and format, the choice of symbols and the scale (Rowell & Ungar, 2003b). If this were achieved, it would be possible to have globally standardized maps.

**Learning and use of tactile maps**

The conventional method of direct familiarization with an area by travelling through it can be time-consuming and may be disturbed by adverse weather conditions. When a child who is blind explores an unfamiliar environment he or she can study a tactile map before entering the area. It allows the child to explore the area independently, thus avoiding the situation of having all the information coming through another person. Even a brief exposure to the map is an effective and adaptable means for introducing the spatial structure of a novel area. The user can be either congenitally or adventitiously blind; the strategy and significance of using the map can vary as well (Spencer & Travis, 1985; Ungar et al. 1997c).

The benefits for travellers include: (a) becoming familiar with the spatial relationships of parts of a city, and (b) increasing one's knowledge and understanding of the parts and structure of a city and its major transportation links. Capable and motivated travellers with visual impairment can employ tactual maps to assist them in travel planning. A map user with some residual vision can utilize both the tactile and visual coding system of Visuo-tactile maps if these elements are included in the same map (Bentzen, 1977).

Although tactile maps have been proven to promote route learning, they are not in use extensively. To be able to benefit from tactile maps, the user needs to know how to encode the information and to learn encoding strategies through abundant experience. It has been thought that blind people lack the spatial skills for using tactile maps, such as the ability to appreciate the aerial perspective of a map or to apply a scale transformation necessary to relate the map to the real world (Blades et al. 1999; Dodds, 1989; Ungar et al., 1994; Ungar et al., 1996b).

The use of maps needs practice in relating the map to the environment which it represents. Tactile maps can improve spatial understanding, for instance, by encouraging the child to adopt externally based coding frameworks for structuring spatial representations of the environment. It can vicariously provide spatial information containing all the interrelationships between objects in space and presenting those relationships within one or two hand-spans.

By means of tactile maps, children who are blind can gain information that is not possible to gain in another way (Eriksson, 1997). Tactile maps help children with visual impairment to understand their environment better, although according to Piaget, preschool-age children are too young and immature for mapping behaviour because it is too early a stage to acquire Euclidean spatial concepts (Stea et. al., 1996, 352). However, recent studies have shown that complex spatial behaviour and mapping skills appear earlier than Piaget suggested.

*Children as map users*

Landau (1986) reported a 4-year-old girl Kelli. She was congenitally blind with no previous experience of maps. Kelli was able to use a simple tactile map including two symbols, by means of which she could define the location of objects using directional expressions. The use of simple maps did not require any special training; it was suggested that metric properties may be quite a basic component of early human spatial knowledge, and that young children are capable of using these important metric spatial properties even in abstract tasks such as the use of a map.

The study predicted that rudimentary use of a map might appear as soon as the child shows evidence of spatial awareness and the understanding of physical symbols. Landau (1986) did not want to make any definitive conclusions that the spatial representations underlying the use of a map would be identical in all children irrespective of whether they were blind or sighted, but he suggested that blindness need not deter the child's understanding of basic functions of spatial awareness.

Sighted children are able to understand and to use maps at the age of four (Blades & Spencer, 1986). Without previous experience they can determine their own position in space, show their position on the map, and follow a route. Young children, even at the age of three can use maps without training in order to locate places in small environments. Ungar et al. (1996b) argued that visual experience may not be a necessary requirement for the ability to form integrated, global impressions of the environment. Children's experiences of the environment may prompt the use of different strategies for coding information.

Ungar et al. (1993, 1994, 1996a, 1997b) found that children with visual impairment from 5 to 12 years of age had the potential to understand and use tactile maps. They were able to remember and reproduce the array of symbols on a pseudo map, and some children with visual impairment even outperformed sighted children of the same age. They could understand and use tactile maps, and in fact, children who were totally blind learnt the structure of the environment more accurately from maps than from direct exploration.

Effective tactile map instruction can help to compensate for limitations of visual experience. The addition of explicit instruction might result in more flexible wayfinding and general understanding of the layout. The additional memory involved in using a tactile map would not put children who are blind or with some functional vision at any particular disadvantage. Most important is to find strategies, which would contribute to an understanding of the maps as a whole (Ungar et al., 1995c; 1997a).

Thus, children with visual impairment are able to gain knowledge from tactile maps, understand simple maps, make spatial judgments, and use tactile maps to perform spatial tasks such as estimating directions and distances, and locating themselves on the map regardless of age (Ungar et al., 1993, 1994, 1996a, 1997a, 1997b). The children in these studies were either blind, or had residual vision, or they were sighted with blindfolds.

Children older than eight seemed to have better strategies, especially when tracing the routes. However, some younger children were also able to adopt effective strategies; thus it seems that appropriate procedures for exploring tactile maps can be taught even to very young children with visual impairment. In the study dealing with distance judgments, a 30 minute training session in strategy methods improved the performance of the children in both age groups.

Children who were congenitally blind were less able than children with useful vision to gain a useful representation of the environment from direct travel, but they acquired a representation of the layout from the tactile map, which formed the basis for relatively accurate estimates of directions. When investigating the ability of children with visual impairment to estimate distances from a tactile map, Ungar et al. (1997b) found that children with visual impairment did not perform as well as sighted children. They lacked an effective method for working out distances, but after brief training in determining distances their performance improved.

Ungar et al. (1997a) examined if it was possible to compensate for the difficulties in achieving a survey level representation by using tactile maps in addition to the direct experience of walking in the real environment.

Another goal was to evaluate the significance of tactile maps in O&M training, and to determine whether children with visual impairments are suitable users of tactile maps. They reasoned that if young sighted children can understand maps (Blades & Spencer, 1986) it implies that there is no conceptual barrier to the children's understanding of spatial representations. Children who were blind were least accurate when exploring a layout, but by means of the tactile map, they improved almost to the level of the children with useful vision. The information on the map also contributed to the children's performance in subsequent combinations of map and direct experience, in which they improved even further. Therefore, the conclusion may be that young children with visual impairment can understand and use a simple tactile map, and, particularly, that the performance of children who are totally blind in estimating the direction of objects is greatly facilitated by the view of the environment given by the tactile map.

These findings should affect O&M instruction of children with visual impairment. If O&M instruction focuses purely on route-learning skills, it may place a limit on the spatial competence of these children. The potential of acquiring an overall conception of the layout of their environment should be systematically nurtured from the earliest age to minimize the developmental lag that Fletcher (1980) introduced in connection with the differency theory. Training children with visual impairment to use tactile maps would not only produce immediate benefits in learning O&M skills, but the children would also be better able to understand their environments and to find their way around their schools, homes, and local areas. Repeated experience in relating maps to environments may confer enduring, generalized improvements in the children's spatial competence as they grow older.

## Synthesis of multi-dimensional skills

The mother of a four-year-old blind girl touchingly describes her worries concerning the poor availability of tactile pictures. Her daughter would not have the same opportunity as sighted children to explore pictures and to experience excitement and find fascinating information in books. She demands 'a tactile feast for the hungry fingers' of children who are blind (Norman, 2003). Children with visual impairment should have the same opportunities as their sighted peers to access all available information (Aldrich & Sheppard, 2001).

### Tactile graphics

*Graphicacy*—the ability to understand and to create graphic displays − is becoming an important portion of literacy. General information exists increasingly in visual, nonverbal, graphic formats such as signs, pictograms, diagrams, charts, graphs and maps. Pictures can be represented as picture descriptions, reliefs or small scale models; however, some type of additional verbal explanation is necessary if the picture is presented in a tactual form (Eriksson, 1999; Pring, 1989). In some cases, a verbal description can be a better option for clarifying the essential features of the picture than an embossed picture or diagram.

A revealing example of how a child who is blind depicts environmental features by drawing is Marek's (1997) description of how a young English girl who was blind drew a London double-decker bus. She chose to represent the bus by drawing only three lines: one for the step she climbed to board the bus, one for the hand rail and one for her seat. Obviously she had not experienced the other existing elements of the bus and she had a poor awareness of its main characteristics. Supplementary explanations are necessary to connect the picture with the framework of the environment and to help the child make conclusions about the object. Those three lines were the characteristic features of the bus for this girl who was blind, but three straight lines can depict several objects in the environment for some other person.

> But movement, as S. Millar strongly emphasizes, is also crucial for a blind child's understanding of spatial relations characterizing three-dimensional objects and their two-dimensional representations. For an average sighted person, it is difficult to understand that a simple drawing of a table represented by means of three lines may remain just three lines for a blind person. This will no longer be surprising, however, if we make the effort to understand a blind child's path towards acquiring the concept of a table. The small hand moves along the edges of the tabletop, then brushes over its surface and moves on to examine the four legs. With each new position of the 'comprehending hand', the rest of the table disappears and continues to exist as a memory of a series of tactile impressions, and, which is perhaps even more important, as a series of movements of the child's hands examining the object. A small model will help the child grasp the spatial relations among the different parts of the table but will not bring the child any closer towards understanding how a sighted person can recognize it in a graphic representation consisting of just three lines.
>
> (Marek, 1997).

In their early years, children who are blind have few opportunities to be in touch with tactile graphics. Sighted infants and children have practically unlimited access to pencils and paper, but the children who are blind lack appropriate materials. However, as new technical innovations and resources for producing tactile graphics become more common and available, it should be clear that also children with visual impairment should have access to graphic information and presentations.

Raised-line tactile maps, graphs, and tactual illustrations for geography, mathematics, and science are common teaching materials, but many children with visual impairment find them difficult. Aldrich & Sheppard (2001) studied the attitudes of 9-19-year-old students with visual impairment towards tactile graphics. The attitudes of the students ranged from enthusiasm to despondency, with a clear link between attitude and age. The older students were more likely to dislike tactile graphics because they had to study more complicated tactile figures than the younger students.

When producing tactile study material it is necessary to 'translate' and edit the printed material. Too many graphics are derived directly from unsuitable visual graphics. The designer of tactile material needs to be well acquainted with the domain to be described and knowledgeable about graphic formats and conventions that are especially suitable for readers who are blind (Aldrich et al., 2002).

Recognition of figures and their spatial organization are important when the child who is blind is learning to read by the sense of touch (Millar, 1997). If the child has not experienced tactile pictures and has not received instruction in picture reading, exploring, understanding and naming the figures is difficult. If children have a mental image, it helps them to infer the figure based on the information from different tactile lines.

The acquisition of skills in graphics reading depends on several prerequisites of cognitive development (Aldrich et al., 2002). Children can learn to identify shapes such as triangles, squares and rectangles at quite an early age, but shape recognition, line tracing, and recognizing congruence between a target shape and the same shape rotated by 180 degrees require well developed cognitive skills.

The view that there are a series of developmental ‘thresholds’ that determine the learner’s readiness to acquire tactile graphicacy skills clearly holds implications for teaching. There is no reason to believe that the developmental prerequisites for tactile graphicacy will be the same as for visual graphicacy. In fact, tactile graphicacy requires a greater degree of cognitive maturity than visual graphicacy.

Aldrich et al. (2002) suggested that the level of cognitive development of the child who is blind should be taken into account when beginning to teach the use of tactile graphics. According to her, tactile graphicacy in children who are blind develops later than visual graphicacy in sighted children. If the child has to study skills that rely on mental processes beyond the present level of the child's cognitive maturity, it may result in frustration and loss of confidence.

The role of the teacher is important when introducing tactile graphics. By improving the design of tactile graphics and educating the students to use tactile material it is possible to avoid the situation in which students with visual impairment regard themselves as second class citizens on the topic of graphic presentations.

What skills underlie tactile graphicacy? What is the best way for children who are blind to develop these skills? A curriculum of tactile graphics is necessary because the description that guides a child through the picture indicates what he is expected to find. Before children are able to relate tactile pictures to reality, they need instruction in order to understand forms, directions and distances (Eriksson, 1999).

The Jyväskylä School for the Visually Impaired in Finland has created a curriculum with the following guidelines for tactile picture reading and for teaching geographical maps (M. Österlund, personal communication, October 8, 2001):

1. The child explores the object by using both hands in order to clarify the exact form of the object and to perceive the entity of the object.
2. The child makes comparisons between the relationships of different parts of the objects in order to perceive details.
3. The child explores and gives a glance at the picture by sweeping the palm over the picture in order to clarify the size, texture and lines, composition, location and possible text in the picture.
4. Analytical exploration begins at the heading and continues from the upper left corner of the frame, moving from top to bottom and looking for possible instructions, continues line by line from left to right, building the whole concept of the picture. This procedure follows the same guidelines as reading a text.

*Hand-over-hand technique*

When the child who is blind is learning tactile scanning, the instructor or the teacher often uses hand-over-hand technique in guidance (the placement of an adult's hand over a child's). This approach does not allow any sensitivity to the child's reactions. Some children dislike having their hands manipulated, while some can become passive and learn to wait for the adult's hand as a prompt to initiate an action, if the sighted person regularly guides the child's hand. If the hand is guided, the child has no possibility of controlling the tactual process and the functioning of the haptic receptors involved in the perception of touch, pressure, temperature, and pain.

The information gained through the tactile sense is necessary when the child perceives the qualities of the objects to be exposed. When a sighted person guides or leads the blind child's hand, it is the sighted person's strategy for the tactile search, and it is influenced by the ability to see as well as by the degree of comprehension of how a child who is blind experiences the surroundings. In this case, the child has no possibility for independent exploration. Yet, he or she has to have the opportunity to decide which sensory elements are most important and how much time or how many repetitions are enough for exploration. For this reason, hand-over-hand assistance should be used carefully and decreased as soon as possible (Nielsen, 1996).

*Hand-under-hand technique*

Hand-under-hand method is a less intrusive approach although it is more difficult to use with children. In this method the child’s hand is placed on top of the teacher’s hand. When the teacher moves the child's fingers along the tactile surface he or she can experience the hand movements required for tracing a line. When the teacher's hand is gradually pulled out from under the child’s hand, the child will feel the line and can move his or her hand with minimal physical guidance from the adult person. This gradual fading of assistance encourages children to trace tactile lines on their own (Dote-Kwan & Chen, 1999).

## Reading by touch

> The tactual-perceptual system is the only one of the five major sense systems in which the freely roaming hand or finger determines the serial order of perceiving the distinctive features of the stimulus. In visual perception, there is a simultaneous perception of both the distinctive features and their spatial relationships. In auditory events, the serial, temporal order of the distinctive features is fixed. In both systems, there is relatively little or no room for variation in the serial perception of the distinctive features compared to what occurs in the tactual system.
>
> (Berlà & Butterfield, 1977).

The reading procedure by means of touch is different from visual reading. Braille reading is slower than reading print because the fingers of the reader explore the text character by character and information is gathered as fragments. Information about spatial relationships is obtained through the tactual-kinaesthetic sense, which is slower than vision in acquiring information (Berlà, 1981).

It is significant how a reader uses the hands. When the person with visual impairment explores a three-dimensional, real object, the identification of the object is more effective if he or she uses more than one finger. Hand movement is a very individual matter, depending on such factors as the effect of asymmetry in the brain, the relative sensitivity of each finger, and the effect of training.

All Braille readers do not use the same techniques when trying to recognize shapes. Variations exist in hand position, how the hands move from left to right, in the number of regressions, rubbing movements, and erratic movements when knowledge of the code and/or reading efficiency are insufficient (Lorimer, 2002) .

Lorimer's study paid attention to the differences in the information processing of the right and left hemispheres of the brain and how the information is relayed. Reading involves both spatial and verbal aspects that interrelate; neither should be neglected. When the nerve impulses from the fingers reach the brain, most of them cross over to the opposite side, so that information from the left side of the body is controlled by the right hemisphere and vice versa. The right hemisphere is more involved in space recognition and the left hemisphere with language.

Lorimer (2002) found that the most efficient method in Braille reading was the use of both hands working independently. The left hand starts reading, and the right hand takes over somewhere along the line. While the right hand completes the line the left finds the beginning of the next line. In map exercises it is important to start reading using both hands: one hand does the exploring while the other keeps track of the reference point. This procedure also supports the basics of Braille reading because young readers may easily lose track of the order of the lines when reading a text.

Habits in reading technique can be set as early as three years of age. Preschool teachers have the responsibility of helping young children who are blind to establish the efficient use of their hands, an important skill when these children are integrated into normal schools. Even when the habits seem to be fixed, improvement is still to be encouraged for progress is by no means automatic. Even a short period of instruction in line tracing and analysis of distinctive features have significantly improved shape recognition performance of the students with visual impairment. The best results have been achieved among the youngest students (Berlá & Butterfield, 1977).

Each individual should have the opportunity to reach her or his own maximum potential in society, and this is possible for the individual with visual impairment through appropriate interventions and qualified teaching. When progressing in Braille skills, the reader will become less aware of reading strategies. The readers seem to use 'the complementary touch, kinaesthetic and movement information automatically in a spatially organized manner' (Millar, 1997).

## Tactile map reading strategies

Adults with visual impairment are able to use tactile maps, to scan the image, to understand abstract symbols and scale, and to interpret the symbolic representation of a tactile map (Perkins & Gardiner 2003). Because children who are blind can find reading of tactile maps complicated, it is important that their teachers create positive attitudes towards tactile maps and use maps frequently in teaching.

Good tactile map readers relate the features to the frames of the maps, and advanced travellers use systematic strategies like object-to-object, perimeter- to-object, or home base- to-object strategies, both by travelling and by exploring tactual maps (Hill et al., 1993; Ungar et al.; 1995c; Ungar, 2000). Children with visual impairment should be given early experiences of different methods and possibilities of coding spatial relationships. Tactual experience must be structured so as to assure flexibility of external reference systems (Ungar et al., 1996a; Ungar et al., 1997a; Warren, 1994). Children need to be encouraged to explore spatial relations between objects and the absolute positions of objects within the frame of the map instead of exploring the sequences of the objects. Children need to become aware that they can change their exploring strategy depending on the situation and on the type of information they are searching.

The ability to read maps depends on the skills to form mental representations of the environment, the haptic-motor skills of the child, and readability of the map symbols. Additionally, an effective, systematic, and purposeful strategy of scanning and searching tactile diagrams, pictures, and maps is essential (Berlà 1981; Berlà et al. 1976; Berlà & Butterfield, 1977; Perkins& Gardiner; 2003Ungar et al. 1995c).

Delay in teaching these skills and concepts may cause children to develop inappropriate exploring skills, irrelevant habits, and distorted concepts about maps, which then may require an intensive training programme to 'relearn' a more efficient reading method. The pupils should be introduced to tactual-spatial concepts and skills early in the educational process. The ability to be analytical, systematic, and accurate is important, not only for reading maps, but also for reading and interpreting other types of tactile information.

Berlà et al. (1976) compared the performances of good and poor map readers, who were school-age Braille readers, in order to distinguish the necessary elements for effective map exploring procedures. Continuous movement in line tracing, the ability to search for shapes, recognition of shapes, comparison and differentiation of shapes, and locating distinctive features on the maps were the important factors influencing good performance, as well as the recognition and tracing of shapes which were juxtaposed to other shapes.

Good map readers searched the map completely by using one finger instead of the flat of the hand or several fingers. They also picked out a point of origin and traced around the shape in a continuous motion and returned to the point of origin; they did not search the area between the lines or contours. Ungar et al. (1995c) found that children who were good tactile map readers had strategies of the same kind as sighted children.

Generally, many of the poor readers' difficulties come from ineffective learning strategies that prevent understanding tactile maps as a coherent whole, and inefficient exploration strategies can give inexact information from the maps (McLinden, 1999).

Perkins & Gardiner (2003) videotaped the performance of 16 adults with visual impairment as they explored tactile maps. The subjects used their hands singly or together, and they could be fixed or move across the map. Sometimes, the hands were held flat, and the palm was used to gain an overview. The fingertips were clearly the most important in tactile map reading. Often one finger was used for fine discrimination of raised details and four fingers for general exploration. Subjects used their fingers constantly to move over the surface of the map; at other times the fingers repetitively traced back and forth along a symbol, or they traced a line. The most successful tactile map reading techniques were constant exploration, use of both hands and four fingers together and one finger searching details with repetitive movements. Good readers employed a mix of single finger, multiple fingers and whole hand-based techniques.

These results differ from the studies of Jansson & Monaci (2003), who studied the efficiency of blindfolded university students by having them identify the shape of a state on a two-dimensional tactile map using either one or two fingers when tracing the contours. Increasing the number of fingers from one to two on one hand did not have a significant effect. This result may be ambiguous because the subjects were sighted university students.

# Research tasks and the progress of the study

The researcher had an interest in teaching children with visual impairment to read tactile maps. Several studies demonstrated the use of tactile maps when children with visual impairment were familiarized themselves with an unfamiliar environment (Casey, 1978; Landau, 1986; Ungar et al., 1993; Ungar et al., 1995b; Ungar et al., 1995c; Ungar et al., 1996a; Ungar et al., 1996b; Ungar et al., 1997b). None of the studies specified whether the children were experienced map readers or what kind of instruction they had received in reading tactile maps before their abilities were tested. The results were not unambiguously positive for the youngest preschool age group.

The initial idea of using a simple, map-like scale model in teaching spatial layouts to preschoolers with visual impairment came up during the special O&M programme named Teddy Bear Club[5], which the Finnish Federation of the Visually Impaired organized for young children with visual impairment in 1995 (Hirn & Marila, 1996). The teachers in the programme were O&M instructors, who were not very experienced in using tactile maps with young preschool children.

The author of this study made an informal enquiry from the Finnish O&M instructors at the annual instructors' meeting in 2003, asking whether they used tactile maps in their teaching. The results were similar to the literature, revealing that O&M instructors were reluctant to teach young children with visual impairment systematic map reading skills. A common reason for limited use of the maps referred to lack of experience, and the conception that children who are blind lack spatial skills and they have difficulties in understanding the aerial perspective that tactile maps present (Dodds 1989; Espinosa et al., 1998).

## The aim of the study

The aim of this study was to produce a new educational intervention programme. It was essential to develop and create a concrete, practi-

[5] Teddy Bear club was an O&M programme that aimed to develop O&M instruction of preschool age children with visual impairment, and expand the concept of O&M training. The programme was a group activity covering the topics in O&M, daily living skills, sensory training, social skills, gross and fine motor skills.

cal method, which could be adapted and offered in any preschool to any child regardless of the degree of his or her visual impairment. The goal of the map tasks was to develop a means for these children to become aware of the world beyond their immediate experience, and to improve their spatial abilities and understanding. Other goals were to teach the concept and purpose of the map; to enrich O&M instruction of young children with visual impairment by teaching them an overall layout of a certain area instead of single routes; and to teach the use of tactile maps for understanding basic Euclidean concepts, as well as the abstract system of lines and angles which depict spatial relationships between different locations (cf. Morrongiello, 1995; Rieser et al., 1982).

## Research questions

People with visual impairment appear to have difficulties in organizing holistically the experiences they encounter in a large space; instead they often tend to organize environmental experiences in a piecemeal fashion. They exhibit varying skills in using tactile maps; they show different means of organizing their perceptions.

Generally, the studies related to tactile maps have focused largely on psychological aspects of spatial representation, the better methods of wayfinding and environmental knowledge, map reading strategies, the context in which tactile maps can be used, map design, map symbol standardization and tactile graphics production technology (Perkins, 2002). The studies have examined the ways people get to know their environment, how they solve spatial tasks, whether they use spontaneously functional strategies in spatial tasks and whether they use tactile maps to promote coping in different environments.

These issues are important, but before an assessment of a subject's abilities to use tactile maps, it is important to ascertain that the person understands the concept of a map and has the skills to read a map tactually. There were no unambiguous results regarding whether spatial awareness and mobility of children would improve by introducing map reading as a regular subject in the primary school curriculum.

This study concentrated on the following questions:

1. What are the simplest tactile maps like?
2. How can the concept of a map be introduced to a young child?

3. Has a preschool child with visual impairment the patience to work with tactile maps?
4. Can a structural programme for teaching tactile maps be connected with preschool activities?
5. Who should be involved in implementing the map training programme?

## The progress of the research

What do people with visual impairment think of research in the field of visual impairment? Duckett & Pratt (2001) found in their study that people wanted practical and action orientated research. They wanted to be contributors to the research instead of objects in clinical assessment settings. They also thought that research should deal with everyday problems, and the results should facilitate structural changes in the society.

This study has tried to respond to these opinions. The approach in this study was practical, progressing from the theory to the data via hypothesis-creating, correcting, testing, and strengthening the theory. The researcher tried to be analytic and to find verification to support the theory, and not merely replicate existing knowledge. The researcher attempted to adapt experiences gained in her role as an O&M instructor. She combined existing but scattered knowledge into a comprehensive entity.

The theory was developed through systematic research of the literature and an analysis of previous findings showing that children with visual impairment are able to extract knowledge from tactile maps. The study is a qualitative action research presenting the evidence, the goals, the objects of the research, and observations of the programme, instead of quantitative analyses with a predetermined set of variables, seeking systematic statistical relations between the variables. The purpose of the study was to observe the phenomena in a real-life context (cf. Sudweeks & Simoff, 1999; Yin, 2003).

*Curriculum development*

Theory alone cannot promote educational science. Action research is an appropriate method when a new approach must be integrated into existing educational systems. It offers a systematic approach for introducing innovations and improvements in teaching and learning, as well as for understanding the practice of the practitioners. In action research, the practising teachers are the most competent persons for identifying problems and finding solutions. By bringing their expertise into the research process it is possible to improve the practice and advance knowledge in the field (Järvinen & Järvinen, 2001; Karr & Kemmis, 1986; Riding et al., 1995).

The curriculum must provide a framework which can promote learning by providing the children with opportunities to gain proficiency, and enabling them to function in a meaningful way. It also involves commitment; it requires participation of the teachers, therapists, pupils, parents, school administrators, and others. Success depends on the improvement of actual educational practices, the greater understanding of those involved in the process, and the enhancement of conditions in which those practices are carried out.

If there is sufficient flexibility to adopt curriculum models that arise from identified needs as much as from prescribed content, it will give the opportunities to promote the individual skills necessary for children with special needs. Teachers need to establish patterns of curriculum development through which they can respect and encourage children's diversities, and find opportunities to teach functional skills within the broader prescribed subject-based curriculum instead of focusing on narrow subject content. The curriculum should be regarded as a vehicle for learning rather than an end in itself (Rose, 2007; 298).

The teacher in this study had the dual role of being the producer of the educational theory, and the user of that theory. There was no need to separate the design and delivery of teaching; instead, the process brought theory and practice closer together. The conditions of the success in the study were in the improvement of the educational process as a whole, requiring the participation of the teachers and the children. The participation of the parents would have been valuable, but in this case their role was in the background. It was a clear deficiency.

However, action research neither gives an explicit solution to the identified objectives nor produces a strictly generalizable model of learning or teaching. Action research proceeds through spiral cycles of critical planning, acting, observing, and reflecting implementations.

A traditional research design in applied science produces scientifically verified knowledge to be used to ensure that pre-established educational goals are achieved by the most effective and measurable means.

Traditional academic psychology research design requires working with an experimental study with group comparisons between the subject group and the control group as well as statistical analyses having the elements of standardization, validation, and calibration (Karr & Kemmis, 1986). Professional expertise stems from the possession of the technical skills required to apply scientific theories and principles to educational situations, seeking to optimize the efficacy of learning by utilizing scientific knowledge. Professional competence is judged by the effectiveness of practices in achieving whatever aims are being pursued.

The aim of this work was not to evaluate the measurable effectiveness of the programme. Instead, the aim was to offer children the opportunity to work with tactile pre-maps regardless of the severity of visual impairment or the external circumstances. It is not always possible to carry out a full psychological investigation. The intensive study of one single case may at times provide more meaningful information than that obtained from the traditional experimental method of an extensive study of large samples. There should be a bridge across the gap that separate practitioners and clinicians (cf. Davidson & Costello, 1969).

The researcher used curriculum-based measurement for evaluating the progress of the children. Curriculum-based measurement is a flexible and powerful tool for educators to evaluate the effectiveness of interventions. This assessment method gives the instructor the opportunity to focus on the individualized evaluation of the children, to reflect on the results, and to provide information that the educators need in order to give regular, explicit feedback to the children in relation to their curriculum objectives. The instructor/researcher was able to target the specific instructional needs of the children and she could base her instructional and pedagogical decisions on technically adequate and defensible child performance data (Alonzo et al., 2007; Rouse & McLaughlin, 2007, 94).

### *Multiple case study: requirements and implications*

A case study is an appropriate approach when trying to answer the question "what"; when the focus of the topic is on a contemporary phenomenon within a real-life context; when introducing innovations; or when exploring operational links rather than mere frequencies or incidences (Yin, 2003). The participants and direct contacts with them are the primary source of the data. In case studies, the most common data collection methods are direct participant observations and interviews instead of controlled experiments and surveys, which may separate the phenomenon from its content.

Empirical studies evolve only when it is accompanied by theory and logical inquiry, not when treated as a mechanistic or data collection attempt. The appropriately developed theory is also the level at which the generalization of the case study results will occur.

A case study can describe thorough investigation of one single person, group, activities or behaviours in different settings, and the result can be a unique, though typical history, description or interpretation from which can emerge a theory of the phenomenon. The researcher does not always have control over the research frame, and the evidence is drawn from different perspectives (Järvinen & Järvinen, 2001).

This study has an exploratory approach describing the individualized implementation processes of a new educational intervention. The researcher used a multiple-case design in the process. The aim of the report's multiple narratives was to predict similar results in a clear and comparable set of circumstances (Robson, 1993, 161; Yin 1994, 46). However, it was assumed that the results would be unpredictable because of the children's different characteristics and variable external conditions.

The study as a whole covered four cases. The intervention programme was designed by means of a pilot case, which was subsequently applied to three other children. Initially, it was not certain whether all four children would be anxious to learn about tactile maps, or whether each child would be able to complete the programme. Case studies rarely turn out exactly as planned. Thus the researcher must have a thorough knowledge of the theory in order to be able to react to unexpected incidents (Järvinen & Järvinen, 2001, 83; Robson, 1993, 163). In this study, work with three children attempted to verify the results achieved in the pilot case.

However, the aim in case study research is transferability rather than generalization. Case studies can be criticized because they can include methodological errors, they are not scientifically disciplined, and it is impossible to draw explicit conclusions or statistical generalizations (Lincoln & Cuba, 2000). This is also true for this study. In case studies, the researcher has to depict the data and describe the research plan adequately so that readers can determine whether it is possible to adapt the results to other contexts, too. In other words, whether the outcomes are useful outside the research setting, and whether the results expand and strengthen the formerly known theory (Tynjälä, 1991).

## Research design for the pre-map programme

The following features were included in the planning and the study was:

1. *A small scale intervention:* the study took place in practical circumstances in regular preschools. The aim was to evaluate the course of action and its effect on the daily activities of a child with visual impairment.
2. *Situational requiring problem solving:* The implementation of the programme was carried out task by task. The researcher visited the preschool regularly, but had to adapt her teaching to other activities in the preschool. She was not always sure about the venue available. Also, the mood of the child was unforeseeable.
3. *Empirical:* programme development was based on previous experiences in O&M instruction in two ways: task planning, and the impression that it was not common to connect orientation skills with instruction on maps when teaching young children.
4. *Collaborative*: the researcher, the assistants, and the teachers cooperated continuously by planning and testing the procedures.
5. *Participatory:* The researcher conducted the instruction, the planning of the daily tasks, and other arrangements.
6. *Self-evaluative*: the researcher evaluated the programme continuously, making changes if needed, and she developed the practice of planning further training.

The study progressed hierarchically from one task to another. It was necessary to learn to recognize the sequence of events in the progress of each child, to allow time to support development, and to understand the events occurring during the development periods.

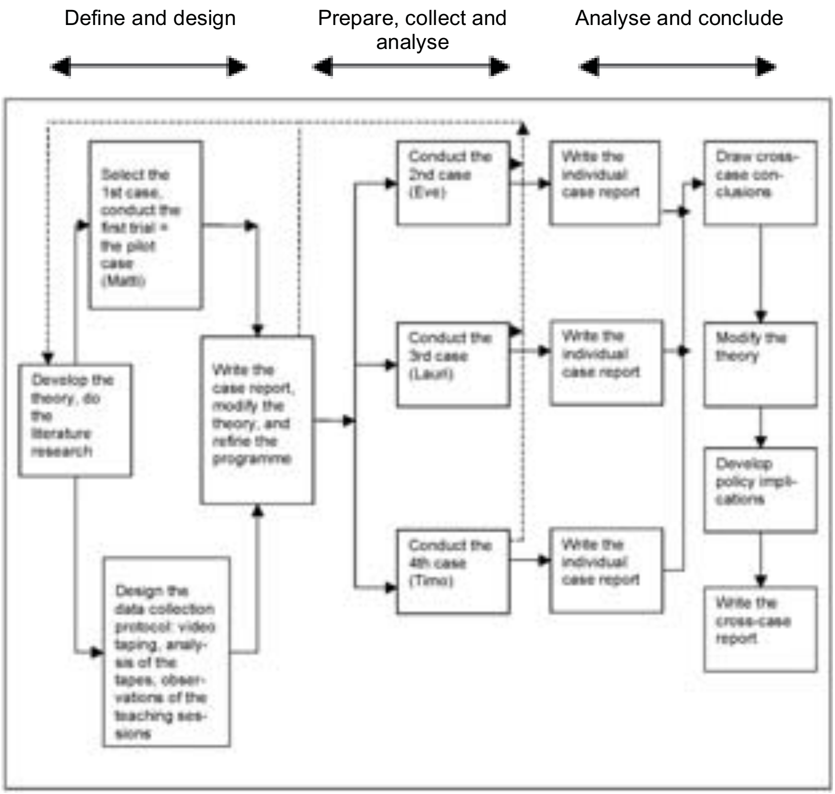
Jenkins divides the research process into eight consecutive stages (as cited in Järvinen & Järvinen, 2001). This study adopts those guidelines as follows:

**Table 1**. Study process by Jenkins

| |
|---|
| *Idea*: It is important for a child with visual impairment to learn spatial orientation and to become acquainted with the environment. The O&M instruction of young children with visual impairment should include training of spatial skills, it should be fun, and it should progress according to the potential of each child. |
| ↓ |
| *Literature research:* This study emphasized the data dealing with orientation of the children, who are visually impaired paying attention especially to the following questions: perception of space, travel skills, tactile maps and graphics, the role of tactile maps in O&M training, map reading strategies, tactile map curriculum. |
| ↓ |
| *Topic of the study*: The significance of learning to understand the concept of a map; the development of strategies when exploring maps, skills to read tactile maps, enhancement of spatial awareness, and more efficient O&M training by learning familiarization. |
| ↓ |
| *The strategy of the study*: Action research solving concrete problems in real life situations in the preschool. The study is a multiple case study with an interpretive and innovative approach that gives examples and ideas on the topic. The theories and concepts arise from the enquiry after data collection. |
| ↓ |
| *Designing the study*: The pilot programme was developed during the O&M programme of a child who was blind (Yin 1994, 74). The results of the pilot programme helped the researcher to refine the final pre-map programme. The refined programme was implemented with three other children who were visually impaired. |
| ↓ |
| *Data collection*: The theory was based on several sources. The researcher's own knowledge as an O&M expert also influenced the building of the theory. |
| ↓ |
| *Analysis of the data*: The performances of the children were documented using videotapes. The study was not so much a question of testing as generating a hypothesis (Robson, 1993, 19). The researcher had to modify the theory and the programme during the study. |
| ↓ |
| *Publication of the results*: The aim is to write a curriculum for reading tactile maps and instructions for preparing teaching materials. |

Theory development is an essential and necessary part of the case study design, although it can be time consuming, and the theory presumably needs to be redefined during the study. However, this study followed the guidelines by Yin (2003,50) regarding research design:

**Table 2**. Case study method adapted from Yin




The dotted lines depict the feedback loop when an important discovery occurred during the implementation of the pilot case, and later, when teaching the programme to three other children. For example, some tasks implemented during the pilot case were left out of the final programme. The redesign took place before proceeding further.

The results of the achievements of the children in these four cases cannot be generalized. The theory was tested by replicating the findings in the second phase. The data were based on a multiple set of experiments that have replicated the same phenomenon under different conditions. Once such direct replications have been successful, the results provide strong support for the theory, even though further replications have not been performed (Yin, 2003, 37).

## Data collection

Direct observation and qualitative case descriptions are useful in gathering evidence in areas of functioning where assessment instruments are not available. It was the case in this work.

All teaching sessions were videotaped. Generally, either the school assistant or the rehabilitation counselor videotaped the sessions. If there was no-one available, the researcher set up the video camera in the corner of the room, and the camera was on the whole session. The researcher also observed the children directly during the teaching sessions.

The researcher has collected the qualitative data by observing and interpreting these videotapes. No-one else observed the progress of the instruction extensively. The assistant or the teacher observed the sessions as often as possible for the purpose of learning the content of the instruction, not for analysing the procedure.

The researcher observed how strongly the child was motivated and how well he or she was progressing, whether the behaviour was focused on the task and self guided or more triggered by the instructor. The learning behaviour was classified as either cognitive or emotion-based functioning.

Each case has been reported separately. The researcher analysed the progress of the children during the training period, whether they learned to read a real tactile map, and whether the programme was applicable to the preschool.

The researcher observed the progress of the children as they practised in very simple mapping settings in order to: (a) perceive the relationships between the objects which they could not reach; (b) estimate directions and distances; (c) define the locations of the objects; (d) compare the locations of the objects in relation to the child’s own body as well as mutual relationships between the objects; (e) follow a prescribed route; (f) recognize symbols; (g) compare a 3-dimensional model to a 2-dimensional tactile map; and (h) read a tactile map.

The researcher had a functional participant role; she conducted all the teaching. It was valuable for her to get information from inside the process, having the opportunity to manipulate minor events and make some variations during the instruction, and to adapt teaching according to the child's functioning and needs. Without videotaping the participant role of the researcher would have been impossible because the role required too much attention, and there would have been no opportunity to write observational notes of the teaching sessions.

If the researcher can show a causal relationship between the treatment and outcome, the intervention has internal validity (Robson, 1993, 69; Yin, 2003, 36). This work did not seek causal relationships; it was exploratory and descriptive without making causal claims.

Research can be defined as generalizable when it is functional and applicable to other circumstances (Järvinen & Järvinen, 2001, 172). Case studies have been criticized because the results do not offer a strong basis for generalization, as does survey research, which relies generally on statistical generalization.

However, case studies, as experiments, rely on analytical generalization when the researcher’s aim is to apply the results to a broader theory (Yin, 2003, 37). External validity can be generalized if the procedure is not strongly dependent on a laboratory setting, and has at least partly been carried out with more than one case (Robson, 1993, 72). Thus, the findings in this study cannot be generalized widely, and they are limited only to those subjects who participated in the study.

The sample in this study was very small, and the participants were not selected randomly. One may ask how the researcher concludes that the results of this experiment are applicable to other situations. However, the theory was tested in different experiments in varying settings and circumstances, and the results were equivalent.

The findings were not controlled because the circumstances were not those of a laboratory. The data could not produce quantitative results, and it was not possible to depict the phenomena mathematically nor statistically. The theory cannot be fully verified, but preconceptions guided continuous evaluation and received corroboration during the practical work.

It is possible to speak about analytical generalization. The researcher's aim was to generalize a particular set of results to some broader theory, and a previously developed theory was used as a template with which to compare the empirical results of the study. If two or more cases are shown to support the same theory, replication may be claimed, and analytical generalization can lead to a new theory. Yet, a comprehensive replication requires matching circumstances and subject groups; therefore, this case allows only other reproductions of the programme in different settings.

### Participants

Each individual case in this study consisted of a 'whole' study, in which convergent evidence was sought regarding the facts and conclusions for the case; each case's conclusions were then considered to be the information needing replication by other individual cases (Yin, 2003, 33). All case results were the focus of a summary report. The report should indicate the extent of the replication logic for each individual case.

Only one person was totally involved in the implementation of this programme, which was not the most ideal situation. Since the researcher took the main responsibility for the instruction, the observation, and the reporting, the extent of the results was restricted because only one person was developing the practices. It would be important to engage more persons in map reading activities in future implementations.

The sample was not an extensive representation of the population of children who are visually impaired, but in this study, it was not possible nor the goal to find corresponding groups of children. In the field of blindness it is difficult to find matching and relevant subjects with predetermined requirements for group comparisons. It was impossible to make a random selection. Generally, the number of children with visual impairment in Finland is too small to warrant random selection.

Initially, the prerequisites for a child to participate in the programme were that the child had to be congenitally blind with no additional disabilities, between five and six years old, and had to attend a preschool. These criteria were difficult to achieve in 2001. There were no five- or six -year-old children who were blind without additional disabilities in the Helsinki area. The children with visual impairment living in metropolitan Helsinki either had low vision or multiple disabilities. The query was made to the rehabilitation counselors of the central hospitals (Helsinki, Päijät-Häme, Turku, Kanta-Häme, and Tampere) as well as to the children's department of the rehabilitation centre of the Finnish Federation of the Visually Impaired.

The three children who finally participated in the programme after the pilot case were chosen from the rehabilitation services of Tampere University Hospital by the recommendation of the rehabilitation counselors. Their functioning showed the typical variation of children with visual impairment. The dissimilarities of the subjects enriched the study material with different experiences. On the other hand, it made it difficult to interpret and to generalize the findings.

### *Introduction of the children*

The four participants in the study were Matti (the pilot case) from the metropolitan area, and Eve, Lauri, and Timo from the Tampere area. The real names of these children have been changed. The age of the children varied between 5.2 and 5.7 years at the time of the programme. Two children were totally blind from birth, one child was blind with some functional vision, and one child had impaired but useful vision. An assessment report of the visual acuity of the two children with some functional vision was not available at the beginning of the project.

*Matti* was five years and three months old; he was congenitally blind because of retinopathy of prematurity. Matti had a white cane for travelling; he was able to move around independently in the preschool without the white cane. He was active, curious and lively. He also communicated well with other children in the preschool class. His O&M instruction had begun when he was four years old, so the O&M instructor and Matti knew each other when the development of the pre-maps began. Matti served as the pilot case.

*Eve* was a preschooler, five years and two months old; she was nearly blind with light perception and projection. She had lost her sight at two because of retinal degeneration. The definitive diagnosis of her vision loss was not known. Eve recognized printed capital letters 6mm high from a 5cm distance in good lighting conditions and with clear contrasts between the figure and the background. She was able to guess the contents of pictures on the basis of their colour and form. It was time-consuming for her to find the target in a wider environment with several objects. Eve had a CCTV[6], a white cane, sunglasses, a tape recorder and a working stand. She attended a preschool. It located in the same building as the primary school, and she had a school assistant in her preschool group. She was also in an occupational therapy programme and had received some O&M instruction before this programme. Eve was a Braille reader, but she used both blind (tactual) and sighted (visual) techniques when performing tasks in this programme.

According to the rehabilitation report, Eve was a lively girl. The effect of her impaired vision was noticeable in her mobility, social relations and independent activities. She was able to utilize her sight

[6] A closed-circuit television is a sophisticated, optical magnifying tool. People with impaired vision use the CCTV for reading, writing, crafts, and other daily activities which require near vision.

when moving around; she travelled cautiously, and her spatial perception was limited, especially in dim lighting. She used her white cane in an unfamiliar environment or walked hand in hand with another person.

*Lauri* was an active boy, five years and two months old. He attended preschool; his preschool class was an integrated group with special needs. He was totally blind from birth because of retinopathy of prematurity. He had a prescription for a medication for epilepsy. Lauri was a self confident traveller, sometimes even reckless. He moved around independently in a familiar environment, and had no problems finding his way in the preschool.

Lauri had had some O&M instruction before the map programme began. He had a white cane, which he did not want to use in familiar places. He took part in the occupational therapy programme at the preschool. Lauri was active and cooperative. He especially liked to work with adults. Lauri was very interested in music; his own music activities sometimes disturbed his concentration. He needed special support in developing both fine and gross motor skills, as well as cognitive, social, and independent living skills.

*Timo* was a lively boy, five years and two months old. He attended preschool and was in the same integrated group with special needs as Lauri. He had low vision from birth because of retinopathy of prematurity, and he was able to work with printed materials. Timo did not have any mobility aid for travelling; he was able to move around independently in the preschool by means of his vision. The researcher made the decision that low vision was not a hindrance to being included in the study because a child with low vision can also have difficulties in spatial understanding and may be in need of training in spatial concepts and constructing maps.

Previously Timo had had eating disorders. After the programme had ended, the researcher was told by Timo's mother that he had been diagnosed with childhood autism. Nonetheless, he progressed during this map programme. Timo was a curious boy; he needed some support (mainly verbal) in daily living skills and in social skills. He was liable to throw objects during the map training, and occasionally he also used bad language when he got tired or lost his interest in the activity. Timo had occupational therapy and speech therapy; O&M training was available if needed.

*The preschool settings*

Matti and Eve were integrated in the group of the local preschool. Eve's preschool was connected with the elementary school, and Matti's preschool was a part of the normal kindergarten.

In Lauri's and Timo's preschool there were about 80 children in the kindergarten, the age of the children varying between 0 and 6 years. The kindergarten had four integrated special groups for children with special needs. The size of the group could vary between 13 or 14 children, 5-6 of which had special needs. The children with special needs could have autistic features and/or difficulties in mobility, communication, social skills, and learning. The other children were normal children from the neighbourhood. The children in this study belonged to a group in which the age varied between 3 and 5 years.

The personnel working in the group consisted of two kindergarten teachers (one had specialized to work with children with special needs), two children's nurses and an assistant. Additionally, the services of a physiotherapist and an occupational therapist were available. The multidisciplinary team was responsible for the children's care, education, and the implementation of educational rehabilitation.

## Assessment of the children

The developmental level of the children was not assessed at the beginning of the programme. There was no widely used developmental assessment tool for children with visual impairment, especially for children who are blind. However, infants and toddlers with visual impairment and with possible additional impairments would benefit from a careful assessment leading to appropriate developmental and visual intervention. The assessment process for children who are visually impaired requires specialized and skilful modification and critical interpretation.

The assessment of children who are blind is ambiguous because of the lack of assessment tools with a comprehensive set of *blind-neutral tasks*[7]. Tasks and items that have been used to assess development of the children who are blind were originally designed for testing sighted children, and later adapted for testing children without vision. Items developed in such a way are not generally blind-neutral tasks; they do not take into consideration all the aspects needed in

7 Blind-neutral tasks are those whose solution is not or only slightly dependent on sight (Brambring & Tröster, 1994).

order to accomplish a task without vision. Even if the tasks can be solved when blindfolded, they are difficult for children who are blind if they cannot concretely explore the objects for their spatial and auditory features. When blindfolded, sighted children use techniques that rely on their visual experiences to compensate for the lack of vision. Instead, in a test to be used with the blind, the norms of the assessment instrument should be derived from the population of children with visual impairment (Brambring & Tröster, 1994; Warren, 1994).

Furthermore, children who are congenitally blind should be assessed differently from children who have some functional vision, or have had sight during the first year of life. Qualitative differences in vision affect the results. Also, differences in educational settings, early intervention procedures and family support should be considered in the assessment. For instance, children who take part in longitudinal studies have in most cases received early intervention, which can affect their performance. For this reason it is unwise to draw any firm conclusions on whether a child's development is delayed (Bee, 2000; Brambring & Tröster, 1994; Dekker, 1989).

Most of the tests used to assess children with visual impairment focus on the comparative intelligence of sighted children and children who are visually impaired. Warren (1994) suggests studying adaptive functioning directly and seeking information about children's environments, because environmental variables can also produce variations on scale indicators.

### *Assessment examples*

The Reynell-Zinkin Mental Development Scale and the Wechsler Intelligence Scale for Children can be used for assessing the developmental level of children who are visually impaired. The Bielefeld Longitudinal Study has aimed to cover all relevant areas of development of children who are blind, but the assessment tool is not available in Finland. Orientation and mobility was a domain that was carefully observed when developing the observation scales of congenitally blind children from the ages of one to six (Brambring & Tröster, 1994).

Developmental assessment of children with visual impairment does not happen regularly in Finland. Children are evaluated in most cases with the La-Ku programme, which is the Finnish application of the Oregon Project for Visually Impaired and Blind Preschoolers (Brown et. al, 1991). The programme is a criterion-referenced assessment tool; it is not designed to provide precise developmental scores.

The La-Ku program consists of 640 behavioral statements organized in eight developmental areas evaluating cognitive, language, socialization, vision, compensatory, self-help, fine motor, and gross motor performance of the children. The La-Ku programme is designed to provide assessment and guidance, giving suggestions of teaching activities to the educators and parents of young children with visual impairment from infancy to six years of age.

It would have been most valuable to assess the spatial abilities of the children at the beginning of this study, but again, there was not an appropriate assessment tool. The Bielefeld Observation Scales for Blind Infants and Preschoolers (Brambring & Tröster, 1994) was not in common use during the study.

The Hill Performance Test of Selected Positional Concepts (Hill, 1981) is intended to assess spatial skills in four areas: (a) ability to identify positional relationships of body parts; (b) ability to move various body parts in relationship to each other to demonstrate positional concepts; (c) ability to move the body in relationship to objects to demonstrate positional concepts; and (d) ability to form object-to-object relationships to demonstrate positional concepts (Hill, 1981). It is a norm referenced test with 72 items. It was developed to assess children with visual impairment aged 6 to 10 years in particular, and it requires basic receptive language skills, ambulation, and body flexibility. However, the test is not widely used, although it can be used by O&M instructors, counselors, psychologists, and other professionals in the field of visual impairment. In this pre-map programme, it would not have been appropriate to use the Hill Performance Test with such young children because the prerequisites for its use would have been too demanding.

In order to briefly assess the general intellectual functioning of the children in this study, a neuropsychologist performed the Short Form Vocabulary Design of the Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R)[8] test after the programme. The following subtests of the verbal scale in WPPSI-R were used: general knowledge, vocabulary, similarities, general comprehension, and sentences.

The examination was at screening level, neither for diagnosis nor classification. The WPPSI-R test was carried out 10 months after the

[8] The WPPSI-R test was published in the USA in 1967, and the revised edition was published in Finland in 1995. It has been designed for preschoolers as a comprehensive measure of cognitive ability.

end of the programme. At that time the age of the children varied from 6 years 1month to 7 years 4 months. This assessment was carried out to determine, whether the cognitive development level of a child participating in a tactile pre-map programme could or should be assessed in order to better adapt the tasks and the procedure to meet the developmental level of each child.

The results of the assessment were neither valid nor generalizable, although the two children with the highest scores performed better than the two with the lowest scores. A formal test could be used for finding guidelines, but not as a tool for selecting the participants of the programme.

In the WPPSI-R assessment Matti's scores were equivalent to the mean performance level; his performance profile was even. Eve reached scores that were better than average especially in verbal reasoning tasks; her performance was equivalent to the performance of a seven-year-old child and in some parts even better. During the assessment she was six-years-one-month old. Lauri's performance in verbal reasoning was poorer than average and his performance generally was equivalent to the performance of children between 4.6 and 5.6 years old. Timo's scores varied and were equivalent to the performance of children between 4 and 7 years of age. The lowest score was in the item assessing concentration and memory skills. He had difficulties in concentrating on the situation because he was hungry. He did not complete any of the assignments, and the researcher interrupted the procedure. He got a second try after lunch, and performed every task.

### The development of the pre-map programme

The preliminary map learning programme was developed during the winter 2000–2001 as a part of Matti's O&M and preschool programmes. He was the child in the pilot study for data collection before the final preparation of the case study programme (cf. Yin 1994, 74). This arrangement allowed for a less structured and more prolonged relationship. The total number of lessons for using maps with Matti was 15; the total number of lessons for his O&M instruction was 55. The length of one session was not determined.

The researcher taught O&M to Matti at the preschool regularly once or twice a week. Matti's school assistant took part in all activities during the process. She collaborated with the researcher in designing map tasks, giving ideas, evaluating, and testing the learning tasks in practice as a part of the everyday preschool activities. She also gave valuable feedback regarding the functional aspects and videotaped all teaching sessions.

During the programme the researcher learned that the school assistant has an extremely important role when there is a child with special needs in the class. Later, when working with the three other children, the researcher made it a point to engage the school assistants and/or the preschool teachers in the activities of the pre-map programme (Musselwhite, 1986).

The programme began by developing very simple tactile, map-like representations, which were named pre-maps. The first pre-map represented a simple scenery (pieces of carpeting), and in the final task, the child explored a factual tactile map with several symbols depicting real scenery. The basic elements of the programme were inspired by visual maps, but the aim was to avoid too many vision-based elements (Hampson & Daly, 1989; James & Armstrong, 1976; Keates, 1982; McNeill & Renfrew, 1990; Yngström, 1999).

The tasks were cognitively demanding, requiring a variety of skills: identification and naming of the parts and edges of the map, naming of directions, judgment of dimensions, definition of the object's location, identification of the different materials, remembering the locations of the targets, the rotation of the map, viewing the map from different directions, efficient exploring strategies, identification of the elements in the scale model, comparison of the scale model with the real view, recognizing the three-dimensional object by using a two-dimensional symbol, identification of shapes of the symbols, and line tracking.

The development of the programme was based on the experiences gained by teaching Matti in the pilot project. The main focus in the pilot project was to test and develop different tasks, which could facilitate understanding tactile maps. When practising pre-map tasks, Matti also learned O&M skills such as location of lost objects, trailing the wall, taking direction and squaring off[9], auditory training, obstacle detection, and many others.

The work with the pilot case helped the researcher refine the teaching material with respect to both the content of the programme and especially the procedures to be followed, because it provided conceptual clarification for the study design (Yin, 1994, 79).

---

9 'Squaring off' means the act of aligning and positioning one's body in relation to an object for the purpose of getting a line of direction, usually perpendicular, to the object (Hill & Ponder, 1976).

The programme continued with three other children in autumn 2001. The researcher met the parents of the prospective participants, and introduced the plans. The parents were interested and gave their permission to work with their children.

## Teaching method

The instructions for all children and preschoolers must be presented as an age appropriate play, and one cannot restrict oneself to training specific skills for very young children. Additionally, the O&M instructor must teach O&M competences to the parents and preschool teachers and assistants, since they can teach O&M in everyday play situations.

Instruction in special skills helps the child with visual impairment to achieve his or her potential. Maps are not encountered by a child with visual impairment incidentally, but maps can be a logical part of O&M intervention, and they should be introduced at an early age to give the child the opportunity to develop spatial capabilities. If infants and young children, especially those who are blind, have the possibility of experiencing a rich physical environment without overprotection, they show more developmentally advanced perceptual-motor behavior and a more advanced level of conceptual development for a given age than those whose environment is restricted (Warren, 1994). Low expectations generate low outcomes.

Playing is a natural, enjoyable and important way for children to learn to adapt to a new world. For adults, learning something new means work. But for the child, learning is usually exciting and fun (Skellenger & Hill, 1994; Tröster & Brambring, 1994). Toddlers love to help sweep the floor, to wash dishes or bake. This 'help' can be fun or irritating for adults, but the toddler is learning about how things work in the world. Equally, real-world objects such as doorknobs, sponges, and household items that have tactile appeal and can be manipulated by hand are fascinating alongside recommended playthings.

Playing prepares children for adult life. Play is socially elaborated and guided by offering materials and toys, scripts and rules. Many preschool activities can be learned in play, and at the same time the play activities serve as teaching material (Hakkarainen, 1999, 236). Children's play is characterized by symbolic actions in imagined situations.

Teaching tactile graphics and maps can happen in the form of games, tasks and leisure activities, and the child with visual impairment is encouraged to explore and enjoy the exciting world 'out there'. The child needs a great deal of prompting strategies given by the instructor in an unobtrusive way and using situational sensitivity (Musselwhite, 1986, 29). Textures, outlines, solid and broken or dotted lines introduced in such activities will be invaluable in helping the blind child understand the significance and meaning of these elements in tactile maps, where they are used to represent stretches of land or water, buildings or continents, borders, roads and rivers (Marek, 1997).

Hughes et al. (1998) questions 'the heavy reliance on play-based activities in preschool programs, particularly in inclusive settings' as well the huge delays reported in play-based activities of children who are severely visually impaired. These activities are essential when children are developing various cognitive, verbal, linguistic, and social skills, but they need an adult facilitator. This questioning is justified; activities have to be developed and modified to suit the needs, strengths, and abilities of the child who is visually impaired. The facilitator can focus on bringing the child to a higher level in play activities (Skellenger et al., 1997).

The preschool teachers, parents and other adults need to consider carefully the types of play that encourage children who are blind. For example, symbolic play includes pretend play (e.g., pretend eating) and representational play (e.g., using a stick for a spoon). In comparison to sighted children, children who are blind are reported to explore less often, exhibit less spontaneous play, rarely imitate their caregiver's routine activities, and frequently engage in solitary play that is repetitive and stereotyped. They can exhibit delays in functional play because of either fine-motor difficulties or sensory restrictions or both of these (Tröster & Brambring, 1994; Wilska, 2000).

The skills of symbolic play promote performance in pre-map tasks. Apparent delays in development of symbolic play among children who are blind might be linked to language and cognitive development, or might reflect restricted opportunities for natural experiences in the world (Hughes et al. 1998; Tröster & Brambring, 1994). Instruction in adaptive play can promote several skills in class work, if and when it is conducted in a variety of settings during the day with different instructors. It can also enhance peer interactions (Musselwhite, 1986). The aim in this study was to focus on non-isolated instruction, although the training sessions took place apart from the other children. The final aim was to generalize and integrate the activities into the preschool class.

In day care, play usually takes place in a situation that is organized by adults. Motivation of play is circular: Play brings joy and satisfaction, motivating people to play (Hakkarainen, 1999, 233; Saarela, 1995). Play is a typical example of activity directed by an individual's inner motivation.

In this case, however, the object and motivation in the activity were mainly originated by an adult person, and the goal was to create something new, not really to give the opportunity for 'free playing' (Hakkarainen, 1990, 284). The children did not have a clear choice, but still they were interested in participating in the activities, possibly because they received the undivided attention of the instructor. In this map programme, imagined situations obeyed certain logic of the script, which was formed by a chain of play actions. In this case, the script limited the number and type of possible persons and objects in the play.

Hakkarainen (1999, 237) introduces two types of frames in play construction in day care settings: the practical frame and the developmental frame. In this programme, the frames were more practical-educational than developmental; the pre-map activities were actually dedicated to learning. The instructor carried out the programme, and there was no time for the children to mature at their own pace. The time perspective, which is essential for developmental frames, was not possible in this case.

# Results

This section describes the work involved in the pilot case, session by session, and how the final pre-map programme was created. The description of the final programme is extensive, and should provide ideas for implementing pre-map tasks in various early educational settings. Although the results of the study may be regarded as isolated individual cases, some factors may be the same for a larger population. This gives the option to conclude indirectly in which respects and to what extent the data are exceptions, in which respect they are comparable to other solutions, and what kind of different solutions exist (Sudweeks & Simoff, 1999).

The narratives of the participants in the programme describe the behaviour of the individual children in each task, and the observations that the researcher made to guide the teacher in redefining the programme or putting it into practice. Two subjects used blind techniques exclusively; one subject used predominantly blind techniques, but partially her vision, and one subject was able to use his vision continuously.

*Motivation, emotions and cognition*

The tables (pp. 109–124) show how each of the three children succeeded and whether the learning was cognitively or affectively controlled. Both emotions and cognition influence the learning situations, and understanding of emotions in educational settings can promote the achievement of the learning goals. When the child clearly knows the goals of the activities, he or she will be more strongly committed, and will not experience the situation as threatening. If the tasks are relevant to his or her talent and potential, the child can achieve emotional autonomy and enjoy the activities.

Learning happens when the opportunities, the challenges, and the action are in balance and match the child's abilities and skills. Children should get intrinsic rewards and enjoy the activity without signs of frustration. If they do not know or understand fully the goal of the task, the result can be frustration and uncontrolled behaviour (Csikszentmihalyi et al., 1993; Meyer & Turner, 2002; Nummenmaa, 2006).

In this study, Matti's and Eve's performances were successful. They seemed to achieve flow experiences; there was a balance between the challenges and their skills (Ainley, 2006; Csikszentmihalyi, 1993). They were motivated and enjoyed the learning situations. They were able to concentrate 30–40 minutes at a time as they progressed in the tasks; Eve sometimes happily hummed when working.

At times, Lauri and Timo could react and behave emotionally but in an uncontrolled way. They were eager to spend long periods with the tasks, but they preferred to play and do their own things in addition to the formal tasks.

One reason for their behaviour could have been that they did not fully understand the goals of the tasks. However, Timo succeeded in the final evaluation although during the training period he had difficulties in concentration. The teaching sessions with Timo might have been too long. The moment he got tired, he lost his concentration and temper, and started to throw things around. Generally, Lauri and Timo could have worked at a slower pace. They both had had difficulties earlier in their lives; the effect of those factors on the boys' performance was not known.

## From exploring four pieces of carpeting to reading a tactile swell paper map: The pilot case

1st session: What is the map?

Teaching materials: four rectangular pieces of carpets on the floor, an A 4-size map made of the same materials in a smaller size, a big and a small play duck (a mother duck and a baby duck). Matti named the four materials: the spider net (= a rubber net), a creek (a bubble plastic), velvet ice (a stretchy texture), an artificial, man-made fur.

Matti had a vivid imagination and named the different textures quickly. In the beginning, Matti examined the map from the short side; the pieces of cloth were across in front of him. As Matti explored the instructor guided his hand movement by using the hand-over-hand technique.

Next, Matti changed his position to the long side of the 'landscape'. Thus, the map was rotated to a horizontal position and the rectangular cloths were located lengthwise in front of him. Matti was able to determine his position and knew how to pick up the mother goose from the spider's cobweb on the first try after he had checked its location on the map.

Matti changed his position to the opposite side of the 'landscape',and he explored the scene from a new position. He had to decide whether the map was aligned accurately, and if the map and the scene on the floor corresponded to each other. Matti was able to align the map correctly.

2nd session: The map of the 'sun treasure'

Materials: things from the closet, playthings from the gym, different fabrics.

Ville was a preschool friend of Matti; he was sighted. The boys had made up a story about a sun treasure earlier; Ville had drawn a black and white map that was based on their story.

Matti's preschool assistant suggested that the boys could build the landscape shown by the map on the floor in the gym. The boys got along well when working together. The instructor and the assistant helped them find the necessary materials in the closet, but the boys were in charge. Ville checked now and then to see whether the map and the landscape corresponded to each other.

When the landscape on the floor was ready, the boys started to travel there by using the map and simultaneously told the story they had made up earlier. The boys wandered back and forth several times on the route between the 'cloud home' and the 'sun treasure'. In this exercise, the boys used the following materials: the sack chair was a 'cloud home'; the ropeway, a cord, led from there to the boat, a skateboard, which was located at the 'cloud pond'. There was also a crocodile lurking in the pond.

The boys reached the other shore of 'the pond' by boat, and from there to 'the grassy path' that led to the treasure chest, a plastic box, containing ’golden’ coins. The course of events was the following: 1) The boys made up the story; 2) They drew a map; 3) They built the landscape according to the map; 4) They wandered back and forth in the landscape. At the end of the session, other children from their group were allowed to come and travel the route according to the map. Matti and Ville acted as their guides. The procedure encouraged and developed social interaction in the group.

The instructor made a scale model from the landscape onto a Styrofoam board. Ville acted 'as the expert', explaining what kind of materials should be used. Matti described the different features of the scale model.

### 3rd session: The previous theme continued

Now and then, the instructor used the hand-over-hand technique in teaching, but Matti mainly explored the map independently. He asked questions regarding the symbols and materials that had been used for the map, such as sandpaper, pipe cleaner, and bubble plastic. Matti moved his hands on the map while simultaneously describing the route.

The instructor held her hand under Matti's hand while he showed the details on the map. This was a better way to show the target because now Matti was able to control how he touched the map, and the length of time taken for exploring it.

Next, a model of the landscape was built in a box, the front side of which had been cut away. The instructor drew a map depicting the landscape on a Ritmuff-sheet and guided Matti to explore it on top of the box with one hand. The other hand simultaneously examined the model inside the box. Matti explored the objects and the map very carefully and systematically, studying the correspondence between the locations of the objects in the model in the box and the symbols on the map above the model. It was difficult for him to perceive the symbols at this stage since he was using only one hand for map exploration.

### 4th session: A magnet board + three stripes

Materials: A rectangle-shaped magnet board with short and long sides served as a map. Three magnetic tapes of different lengths and different materials formed the map. Similar materials of longer length formed the landscape first on the floor and later on a table. Different toys with a big and small version were available. The small toys were glued onto the piece of magnet. Matti chose to have cars in this task.

Matti concluded that there were three tapes and identified the tape materials. He was able to distinguish which of the tapes was the longest. The instructor arranged the landscape of three tapes on the floor and formed the same view on the magnet board, which served as a map on the table.

The instructor set a little car on the map to show the location of the bigger car. Matti found it on the floor by using the map. Matti repeated the same training several times.

Matti practised this task from the short and long side of the landscape. The map was rotated when needed. Matti knew the directional concepts well, naming the directions on the table even though he was not sitting at the table. He was able to examine the landscape and the map from different sides and determine the location of objects accurately. Matti performed several tasks with the toys himself and seemed to be happy with this exercise.

5th session: A flying treasure chest

Materials: a table, a small dog house (later a plastic box) that functioned as a treasure chest, a magnet board as the map, and magnet buttons of different shapes to serve as the map symbols.

Matti explored the size and dimensions of the table. The instructor and Matti named the edges and corners of the table. The instructor guided Matti's hands on the table to show where the dog house had 'flown'. Matti explored the map, looking for the location of the box. Matti found it when he had first determined its location on the map.

Next, the instructor placed two toys on the table: a rectangular treasure chest and a round Russian puppet figure. The magnets served as symbols of the table map: one was round and the other rectangular. Matti said that the round magnet represented the Russian puppet and the rectangle was the treasure chest. Matti explored the map; he determined where the toys were and was able to find them in the correct locations.

6th session: The previous theme continued

In this session, Matti performed the previous task with three objects. Matti wanted to use his own tongs as one object; the other two toys were the treasure chest and the Russian puppet. The instructor tried to place the objects on the table very silently so that Matti could not determine their location by listening. Matti had to study the whole table in order to locate all the objects.

When Matti had determined where the objects were, he was able to pick them up at the right locations. Then, Matti placed the objects on the table himself, and showed the locations of the objects on the magnet board, assisted only slightly by the instructor.

7th session: A Lego map depicting an unfamiliar room

This task was carried out in an unfamiliar class room. Matti moved around in the room in the beginning by trailing the walls (= a perimeter method); he studied the targets he found, such as the furniture, the doors and the shelves. Matti hoped that he would find an electric cubicle. He tapped the wall looking for audible clues. Matti used his hands for examining objects. He noticed quickly that the jar containing the chewing gum was different from the jar in his own unit.

Matti’s exploration strategy corresponded somewhat to the visual exploring of a sighted child by getting similar information through touching the items or by listening. Matti, for example, identified the hallway door because he heard sounds behind it. At this stage, the instructor also helped Matti with relevant questions.

The instructor had made a map of this unfamiliar room by using Lego bricks. Matti and the instructor sat in front of the door of the map. The place was chosen to be the home base and reference point. The walls, the doors, the windows, and the pieces of furniture were marked on the Lego board. The instructor showed the Lego map to Matti, explaining how Matti had moved around in the space. Matti immediately began to explore the map and asked questions about the different targets on the map.

Matti’s hands were 'independent and active explorers' but the instructor still needed to grasp his hands now and then. This exercise showed that systematic exploration is an important skill that must be practised because Matti’s hands wandered around without a systematic strategy.

In this task it was logical to begin to study the map from the side that was closest to Matti. Matti had a play dog with him in this task. The dog was 'wandering' between different locations on the map, and Matti knew how to take it to different locations in the classroom according to the map. The instructor used the map to show where Matti and the dog sat, and then she showed the route from the home base to the window, which was the destination. Matti kidded around first by stopping a few steps ahead of the target. Then he started to laugh and the instructor realized that Matti knew where he was and where he had to go.

The next task was to pick up an Easter decoration in the bookshelf. Matti found it easily. In this task he was able to orientate himself because he heard the location of the instructor and the buzz of the camera. The sounds served as landmarks at that moment. In this exercise, the instructor was active and almost disturbed Matti’s independent exploring.

### 8th session: A Lego map depicting an outdoor space

The instructor had prepared a Lego map depicting the yard of the preschool. The main building, the storehouses and the playground equipment, an outdoor table and benches were represented on the map.

Matti said that working with maps was nice because the maps helped him to find things (for example, he had found gingerbread). Matti explored the map carefully, and he asked continuously: 'What is here? What is this?' Matti's hands explored efficiently but the movements were slightly sporadic; he did not explore the map systematically from one side to the other. With this strategy it was difficult for Matti to get the idea of how the targets were located with respect to each other.

At this stage, Matti determined the locations of the objects mainly in relation to himself. Matti travelled with his hands next to the sandbox but he did not study its location in relation to the preschool building on the map. He was in a hurry to go to the sandbox because he wanted to dig holes. The instructor tried to get Matti to practise once more. Matti explored the map while staying in the sandbox. For the first time, Matti seemed slightly unwilling to continue, but then began to study the map again.

The instructor emphasized that it is important to align the map right. When Matti started to walk, he aligned himself randomly. He travelled in this task by means of verbal assistance, turning a lot as he moved around. Matti travelled in the right direction but did not make any conclusions about the map. He practised orientating on the basis of the sounds.

### 9th session: A swell paper map

Matti got a new type of map made of microcapsule paper with embossed, black contours and a map key containing eight map symbols. The map again depicted the school yard. The instructor guided Matti’s hand to the map legend showing the symbol of a slide, which Matti explored. Then he explored the map trying to search for a similar symbol on the map.

Matti was doing rather well. Yet, his exploring technique was unsystematic. The task was rather difficult with too many map symbols. The instructor should have asked Matti to begin the examination of the map legend from the top left corner, one symbol at a time. Matti examined it, sometimes using only one hand. In any case, Matti found a storehouse on the map.

Next he looked for bushes, and simultaneously he made up a story about what was happening in the yard. The next task was to look for the sandbox. First Matti became acquainted with the symbols that depicted the sandbox, and he found the symbols on the map. Then by travelling, he also found the sandboxes in the yard.

### 10th session: A Lego map and routes

This task took place in the gym. Matti got a Lego map again, and the instructor described and showed the location of the home base. The instructor explained the different routes between the home base and separate targets and Matti travelled the routes back and forth. The training proceeded according to the story invented by Matti. When Matti used only one hand by exploring the map, the functioning was sporadic. The use of two hands made the procedure more systematic. Matti found the pond on the map, and he walked to the pond.

At the pond he studied the map again, determining his own location, and then he returned to the home base. Matti moved partly by using the skateboard which he had found in the gym. It was not a good idea because the directions changed randomly when the wheels turned and Matti lost his sense of direction.

### 11th session: A Lego map and map alignment

This session was a repetition of the previous lesson, but the focus was on how to align the map at each new target. Matti got lost on the first route and he returned to home base. The instructor showed the route on the map, but Matti got lost again.

Matti had named the targets with funny names like a 'bunny meadow', the 'top merry-go-round', and a 'fox hole'. He was allowed to choose routes by himself, which maintained his interest, and he explored the map again and again.

Matti moved from one target to another and had to align the map at each location all over again. Matti was able to read the map but moving from one target to another was more difficult. It would have been easier to travel back and forth between the home base and the new target, and not along the routes round the gym. Now the starting point changed continuously and the instructor had to align the map in the right direction. Eventually, Matti learned to examine and to determine locations between the targets. However, travelling from one target to another was not always successful.

### 12th session: The swell paper map depicting the school yard

Matti was given the task to travel a route according to the map. He wanted to find material for building a wooden bench. Matti was inspired by the thought of sawing. Matti studied the map: he had to travel a route from the front door of the preschool to the storehouse. Matti also explored the map during the travel. When the instructor asked where Matti was going, he answered: 'here' without specifying the direction.

Matti was eager to go on when he got permission to cut down the trees that he found on the way. The instructor again used the hand-over-hand technique! Matti examined the map in front of the storehouse; the instructor had rotated the map, and now it introduced the view in the right direction. The instructor tried to describe the route. It was difficult to explain new concepts while telling Matti how to go around certain targets.

Matti travelled his own routes on the map with his fingers. He knew distinctly how and where he ought to go. He explored the fence opposite him. He started to wonder how he could jump over the fence. Matti knew how to go to the swings even though a new bench had appeared in the yard and it was not marked on the map. Matti found another new feature on the map, a climbing wall. He had not noticed it earlier. This brought out new questions and concepts to be explained. Thus, by exploring the map and travelling around, new routes elicited new features in a familiar environment.

When Matti studied the map, he was able to find and perceive all the playthings in the yard, as well as to determine their location. He had not known about all of them previously because they were not on his usual routes.

### 13th session: Repetition by using the magnet board

This session was repetition with the magnet board and with the magnet toys as map signs. Matti examined the objects and compared their sizes. Matti made up a story; he wanted to place the toys on the table by himself and make a map. He set the toys near each other in the middle of the table. Thus, it was difficult to draw a map.

This time Matti was not interested; his mind was preoccupied with all the matters that had happened at his grandmother's during the previous weekend.

14 the session: An unknown outdoor environment and the collage-like map

This task was similar to the map of the 'sun treasure', but it took place outdoors. The instructor gave Matti a collage-like map depicting an activity route emphasizing the exploration strategy. Matti built the landscape together with the instructor on the lawn according to the map; Matti had studied the map earlier so he was familiar with it. He began to explore the map from the bottom, describing what he found.

The instructor gave all the materials to Matti so that he could touch and recognize them. Matti checked that all the necessary materials were present. He studied the landscape in reality and checked the map again. The instructor helped him with the directions and alignment of the map. Matti made up his own adventure story again. Matti liked this task: 'It was nice ', he commented.

15th session: A swell paper map and a new environment

Matti’s family moved to another neighbourhood. Before Matti went to familiarize himself with the new preschool, beforehand, he got a swell paper map that depicted the new premises. Matti studied the map eagerly and asked pertinent questions, for example, about the location of different rooms and the routes from one room to the other.

Now Matti explored the map in a systematic way. He studied the locations of the different rooms, how they related to each other, where the doors were located, what shape the tables were, and what kind of routes he could travel. At first Matti explored using only one hand. He learned the names of the rooms quickly. When he wanted to have more exact information, he began to operate independently, and he started to explore the map by using both hands.

Finally, Matti 'travelled' different routes on the map. Later, when he visited the new preschool he knew the premises and how they were located in relation to each other. This final map session was a great performance! Matti was only six years old and he was able to explore the map, to travel different routes on the map, and to tell stories in connection with the map. Matti no longer needed the instructor’s hands to help him explore. He examined and interpreted maps independently, and he had learned to know the premises in order to be able to travel there independently.

## The final pre-map programme

Based on these experiences, the researcher wrote the final programme with eight map tasks, which followed each other hierarchically in a logical order. It was necessary to evaluate the findings from the pilot case in order to redefine the concepts. In Matti's case, the order of tasks was not well planned. It was not always logical, sometimes as a result of the uncertainty of the researcher, sometimes because of external circumstances. During the implementation the researcher made judgments regarding: (a) the order of the task; (b) the prerequisites for the space; (c) the language to be used; and (d) the features that maintain the interest of the child.

The following text describes the results of the experimental intervention with the task-specific objectives, teaching materials, procedures, and site requirements. The researcher found the idea for each task design in the articles mentioned in parentheses. Performance was not evaluated during this programme, but it is possible to use a numerical ranking for successful performances. The suggested number of trials exists next to each task; it is a random figure intended as a measure of whether the child had learned the task, and it has no statistical significance. It is not necessary to evaluate the performances numerically. These children had one more rehearsal in autumn 2002; the results were numbered but not listed, because the programme had already ended.

### *Task 1: The concept of the map*

(Blades & Spencer, 1986; Miletic 1995; Ungar, 2000)

*Objective:*

The child learns: (a) the concept of the map in general; (b) that the map is a representation of a real view; (c) that it should be positioned according to the child’s body position relative to the environment (fig. 3).

*Teaching materials:*

a) Five pieces of carpeting (50 cm x 140 cm) made of fabrics that have different tactile qualities and different colours. The midline of each is marked with a tactile line.
b) The map, which is made of pieces of the same fabric materials as carpets glued one after another on the pasteboard.
c) Toys, pairs of the same toy creatures in big and small sizes.

*Procedure:*

In the first phase the child examines the view from the 'bottom' of the fabric line (the view's midline is vertical). The carpet pieces are put on the floor in a line with small spaces between them (Fig.3); the same arrangement of fabrics is glued on the pasteboard in the same order as the layout on the floor. Thus the same layout is to be found both on the floor and on the map. The child explores the pasteboard map in order to recognize the fabrics and compares the map with the floor layout. The instructor guides the child to start to examine the map from the upper left corner because it is the same method when beginning to read or when it is important to briefly glance over a picture and still track the reference points. During the exploration the instructor names the sides of the map: the left, right, upper, and lower sides. After the exploration the child walks or crawls on all fours over the pieces, trying to recognize the fabrics and check the order in which they are arranged on the map.

The map always has to be positioned in the same direction as the floor layout in relation to the child's body position. The instructor puts the big toy on one of the pieces of fabric on the floor, while the smaller toy is put on the corresponding location on the map. The child explores the map, tells the location of the toy and then goes to pick up the toy from the floor.

In the second phase the child moves to the other end of the fabric row where the view is thus reversed. After studying the layout the child has to turn the map 180º in order to have the equivalent view on both the floor and the map.

*Site:*

Free floor space in one room in the kindergarten

*Evaluation of task mastery:*

The child picks up the toy from the location shown on the map when he or she stands at the bottom end (short side) of the floor layout (4 / 4).

The child picks up the toy from the location shown on the map when he or she stands by the side (long side) of the floor layout (4 / 4). Trials in total, 8 / 8.

Tactile exploration of the map

The baby duck on the map...

shows the location of the mother duck on the floor.

The map does not match?

Rotation of the map ...

gives the correct alignment with the layout.

**Figure 1**. The concept of a map

***Task 2: The frames of the map and the directions (Table top picture plan)***

(James & Armstrong, 1976; Musselwhite, 1986; Ungar, 2000; Uttal, 2000; Lewis et al. 2002)

*Objective:*

The child learns to know that the map has frames, features that are referred to as the left, right, upper, or lower sides of the map. The child learns, for example, what the left or upper side of the map is and what it means when the object is said to be located, for example, in the upper right corner of the map. The child is guided to explore the map and to name the frames, sides, and the corners (fig. 4).

*Teaching materials:*

a) A rectangular table; the child has to be able to reach all the edges of the table when positioned at the middle of the table's longer edge closest to him.
b) A rectangular magnetic board, no bigger than 35cmx55cm.
c) 1–3 magnets, preferably different shapes.
d) 1–3 small toys, such as a plastic box, a car, and a teddy bear.

*Procedure:*

The child explores the table and the instructor explains that the four sides of the table form the frames of the layout. The edges and the corners of the table are named. The table represents the view and the magnetic board is the map. First the child works with one of the boxes, which is described as 'a flying treasure chest'. The instructor sets the box at a designated place on the table and shows its location to the child by putting a magnet on the map (the magnetic board) at the corresponding location. The child explores the map, verbally identifies the location of the box (the treasure chest), and attempts to locate the box on the table.

Once the child is able to use the map successfully and to locate one object, the instructor can add another object so that the child has to specify two locations. The task becomes even more demanding when the child is asked to work with three magnets and toys.

*Site:*

Any room equipped with the appropriate size rectangular table

*Evaluation of task mastery:*

Four correct accomplishments when the child is working with one object (4 / 4)
Four correct accomplishments with two objects (4 / 4)
Trials in total, 8 / 8

Determination of the vertical…

and the horizontal dimension

Location of the treasure chest on the table

Three items on the table and the magnet map

The tongs were found!

**Figure 2**. Table top picture plan

***Task 3:*** *Object localization on the map of three tapes*
(Ungar, 2000)

*Objective:*

The child learns to compare and to sort tapes of different lengths according to their materials and textures. After exploring the 'tape map' the child is able to localize the position of an object placed at the end of one tape (fig. 5).

*Teaching materials:*

a) Open space on the floor, or a rectangular table, the size at least 130 cm x 250 cm
b) Three tapes of different materials and of various lengths (e.g., 60 cm, 120 cm, 240 cm), and three shorter magnetic tapes (the lengths e.g., 7 cm, 13 cm, and 26 cm) covered with materials equivalent to the long ones
c) A magnetic board
d) 1–3 magnets
e) 1–3 toy boxes or other small toys

*Procedure:*

The child sits at the point of reference, and the tapes are arranged in front of the child either on the floor or on the big table. One 'treasure chest' (i.e., toy box, etc.) is laid at the end of one tape. The same combination is arranged on the magnetic board that functions as the tactile map. The child explores the map and compares it to the tapes lying either on the floor or on the table, and then indicates the end of the tape at which the box is located.

A more advanced version of the task asks the child to place the object at the end of one tape and then show its location on the map to the instructor.

*Site:*

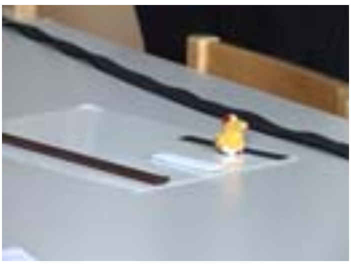
Open floor space in a peaceful room in the kindergarten

*Evaluation of task mastery:*

Determination of the object's position at the correct end of the appropriate tape. Trials in total, 4 / 4.

Tactually different tapes on the table

The duck is located at the end of one of the tapes.



Baby duck on the magnet map

Exploration of the layout

**Figure 3**. Follow the tapes

### *Task 4: The map as a multipart entity*

(James & Armstrong, 1976; Casey, 1978; Blades & Spencer, 1986; Dodds, 1989; Lewis et al. 2002)

*Objective:*

The child learns to recognize diverse elements on the model map, and to distinguish a continuous route by exploring the map and collecting information from the map. The child learns to track the route by following a line made of the different elements, and to compare the map with the actual layout (fig 6).

*Teaching materials:*

a) A model map made of different materials that form a route (e.g., four foam plates, a rope, a plastic net, a miniature hoop, four pieces of carpet)
b) The same materials in a bigger size forming a corresponding route on the floor, and small and big toys.

*Procedure:*

The map introduces a route with elements (as mentioned above) that follow each other and form a square route. The instructor can name the elements, and invents a story that describes the child's imaginary travel along the route. The child explores the map while listening to the description of the story's successive stages of travel. The map search demands comprehensive map-exploring techniques, the ability to process tactile information, and tracing skills.

Next, with the instructor's assistance, the child builds the matching route on the floor using the same materials as on the map. The starting place or 'home base' is the reference point for using the map and building the floor layout. The instructor sets a big toy at a particular location along the floor route and a small size toy on the corresponding location on the map route. The child explores the map, locates the small toy on it, and moves on the floor from the home base along the marked map route to get the toy.

*Site:* one room with empty floor space, 5m x 5m

*Evaluation of task mastery:*

The child picks up the toy from its location on the floor, which has been designated on the map.

Trials in total, 4 / 4.

An orbital route on the map

Exploration of the map

Alignment of the map

and reaching the destination on the basis of the map

**Figure 4**. Making a landscape and a map

***Task 5: The symbols***

(Fletcher, 1980; Rener, 1993; Millar, 1995; Stratton, 1996; Jehoel et. al. 2005)

*Objective:*

The child learns certain, meaningful map symbols and markings. The child learns to trace raised lines when exploring the map (fig. 7).

*Teaching materials:*

a) Ritmuff-sheet (a plastic sheet on which lines and marks, made with a pen or a stylus, produce a raised line or mark that can be felt by the fingers.)
b) 3 to 5 objects in different sizes and shapes

*Procedure:*

The instructor puts one object on the Ritmuff-sheet and draws its outline; the ratio of the drawing to the object is 1:1. The child traces the line, and tries to recognize the shape of the figure. The figure is called a symbol, and represents the three-dimensional object in a two-dimensional form. The instructor adds objects one by one and draws their outlines; the number of objects may vary from three to five. The set-up forms a simple map.

The child recognizes and describes the different symbols. The child compares the objects with the drawn symbols, and puts the correct objects on top of the matching figures.

*Site:*

Any room and a table in a kindergarten

*Evaluation of task mastery:*

The map consists of three figures drawn on the Ritmuff-sheet forming the map. The child recognizes the symbols and puts objects on the matching figures on the map (1/1).

The child gets another map with the same figures in a different order, but the child does not know that the figures are the same. He or she has to recognize the symbols. Next, the child gets five different items, and has to choose three correct ones and put them on the corresponding place on the map (1/1). Trials in total, 2/2.

Three toys on the Ritmuff-sheet

Embossed symbols

Recognition of the drawn and embossed symbol

**Figure 5**. Symbols

### *Task 6: From a 3-dimensional model to a 2-dimensional tactile map*

(Berlà & Butterfield, 1977; Fletcher, 1980; Millar, 1995; Marek, 1997; Yngström, 1999; Uttal, 2000).

*Objective:*

The child learns to: (a) explore a 3-dimensional model; (b) describe the arrangement of the objects displayed in the model; (c) compare the model with the 2-dimensional tactile map drawn according to the model; (d) describe relationships between the objects, both in the model and on the map (fig. 8).

*Teaching materials:*

a) Small models of houses, trees, lakes, sandboxes, swings, pathways, and so on, each having a piece of Velcro-strip glued to the bottom.
b) Styrofoam® board covered with soft cloth (30x40 cm).
c) Ritmuff-sheet.
d) Cardboard box (30x40 cm) having a lid and with the front side cut out.

*Procedure:*

The child builds his or her own 3-dimensional fantasy layout on the Styrofoam® board using small models. The instructor puts this layout into the cardboard box, draws a corresponding 2-dimensional tactile map on the Ritmuff-sheet, and sets the map on top of the box. Because the front side of the box is cut out, the child can simultaneously touch and explore both the layout in the box and the tactile map on the box. Thus, it is possible to make comparisons between the 3-D model and the 2-D map, and to determine spatial relationships between the objects.

*Site:*

Any quiet room and a table

*Evaluation of task mastery:*

The instructor adds one extra item to the model that is not on the map. The child should determine the difference (2/2).

After the map has been rotated 90° or 180° or 270°, the child should recognize the wrong position and align it to correspond with the map (3/3). Trials in total, 5/5.

The 3D model and the 2D Ritmuff- map

Exploring the map

Comparison between the model and the map

**Figure 6**. Transformation from 3D to 2D

### *Task 7: An unfamiliar room*

*Objective:*

The child learns to use both a small model made of Lego bricks and a Ritmuff-map to explore an unfamiliar room, and to familiarize himself or herself with the furniture arrangement. The child learns to locate different objects on the map and to describe relationships between their locations. Finally, after exploring the map, he or she is able to travel from the home base to different objects (fig. 9).

*Teaching materials:*

a) Lego bricks
b) Ritmuff-sheet
c) Usual kindergarten furniture (such as tables, chairs, a cabinet, a bookshelf)

*Procedure:*

The instructor prepares a small model of the arrangement of objects in an unfamiliar room using Lego bricks. Lego bricks are usually available in every preschool, and because all children play with them, there is an opportunity to share this activity with other children. The same layout is drawn on the Ritmuff-sheet, and the child explores and compares the model and the Ritmuff-map.

After examining both the Lego model and the Ritmuff-map, the child explores the room, and moves around to find objects that he or she locates on the map. The child travels between different designated objects. By changing the observation point, the child is encouraged to examine the layout from different positions in the room.

*Site:*

A room with simple furnishing, preferably unfamiliar to the child

Evaluation of task mastery*:*

The child travels from home base to the given destination to pick up a toy. The location of the toy is shown either on the Lego-model or on the Ritmuff-map. This task is done three times, each time with a different destination. Trials in total, 3/3.

Exploration of the unfamiliar space

Imaginary finger travel

Discovery of the table in the Lego map

and travelling in reality!

**Figure 7**. Travel in the model

***Task 8: Recognition of the map symbols on a swell paper map***
(Berlà et al. 1976; McNeill et al., 1990; Millar, 1995)

*Objective:*

The child learns what a map legend [10]is, can identify the map symbols in a map key, and can find and recognize symbols on the actual map. He or she learns to explore the entire tactile map systematically, from left to right and from top to bottom (fig. 10).

*Teaching material:*

a) A tactile map made on micro-capsule paper (the map is preferably made of the child's daily environment)
b) Four map symbols, which are chosen from the map and drawn on separate slips of paper
c) The map legend for the map symbols on the map with the explanations of the symbols written both in Braille and in print

*Procedure:*

The instructor gives the child symbol slips, one by one (four in all), and explains what each symbol represents. The child looks for each symbol on the map key. After recognizing the given symbols in the map key, the child explores the tactile map from left to right and from top to bottom, trying to find and locate these four symbols on the map. In the next stage, the child explains the relationships between the objects on the map, and travels an imagined route by exploring the tactile map with his or her fingers.

*Site:*

The table in any peaceful space in the kindergarten

*Evaluation of task mastery:*

The child gets one symbol from the map key, explores the map, and identifies the symbol on the map. Four different symbols are presented, one at a time.

---

[10] The map legend is the key for understanding the map. It contains icons to tell, for example, what a little picnic table symbol means. The meaning of map symbols is revealed only in the map legend, as the same symbols may have different meanings on various maps. A map would be useless if one did not know the meaning of the various symbols. A legend usually contains three types of symbols: point symbols (indicating e.g.. a city), line symbols (indicating e.g. a road or a river), and plane symbols (indicating e.g. areas).

Using three different symbols in the map key, the child explores the map and tries to find the three symbols (1/1). Trials in total, 5/5

The swell paper map of the playground

Identification of the symbols

Map of the of the preschool, exploration with 3 fingers

The pin shows the hiding place of the toy cat

**Figure 8**. Exploring the real tactile map

## Three case histories: Eve, Lauri and Timo

Three other children participated in the programme during the autumn of 2001; two of them succeeded in completing the whole programme; one of the children did not complete all the tasks although he enjoyed participating.

The task session had no exact time limits; the session lasted as long as the child was active and concentrated on the task, but occasionally changes in the routines of the preschool influenced the timetable. It was possible for the child to practise one task once, twice, or three times. One of the children was not able to work with all eight tasks, and he did not complete the whole programme.

The instructor had not met the children previously; she had some background information, which was not very extensive. She wanted to get to know them before starting to work with the map tasks. She started the programme by explaining the different map types to each child (a map made of swell paper, a map on the magnetic board, a collage, and a map made of Lego bricks). Except for the boy with low vision, the children were not familiar with tactile maps. He had an idea about the map, and he had drawn a map of his own for the instructor during the first meeting.

*Eve*, who had lost her vision at the age of two, used both her hands and sight for exploration from the beginning. She identified the materials of the maps, she touched and compared different objects and materials and made comments. She knew the horizontal (left and right) and vertical (up and down; further and closer) directions, but she did not have a special exploring strategy.

*Lauri*, who was totally blind, sat in the instructor's lap during the introduction of different maps. They discussed the elements of the maps; the instructor asked whether Lauri knew the concepts of left and right. He knew them fairly well. Lauri explored the maps and the materials. The instructor explained that the different materials and figures have certain designated meanings. Lauri paid more attention to the instructor's watch; the instructor had to encourage him to explore the map. The instructor used the hand-over-hand technique a great deal.

The instructor asked *Timo*, who was partially sighted, whether he knew the meaning of the maps. Timo had drawn a map of his own before the first session; he was excited about the topic, but he did not know how to explain his map. The instructor explained that the map is used when a large space has to be described in a smaller form. When the instructor showed Timo different maps, her hand directed Timo's hand movements because he wanted to tear the materials out of the map. Timo was also able to explore the map by using his vision.

*Matti and Eve* were able to complete the programme successfully; they had 'hungry fingers', but it was impossible to determine whether developmental maturation had an impact on the children's performance during the process, and what the ultimate result was. Eve's learning period was relatively short (about three months); therefore, developmental maturation obviously did not have a big effect on her performance. Matti had a longer instruction period, during which time developmental factors presumably had an impact on his performance. The researcher was not sure whether they learned to learn because they were motivated, or whether they were motivated because they were learning.

*Timo* needed assistance and he had concentration problems. His functions were in the 'zone of proximal development, which is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance' (Vygotsky, 1978, 86). Yet, he was motivated and his interest grew during the programme. Repetitions improved his performances and served as a trial for him.

*Lauri* needed a great deal of assistance. It remained unclear whether his performance would have improved if he had had more time to mature and to develop his skills. He was very motivated to participate in the programme, he enjoyed all the attention the instructor gave him, but his progress was slow. The researcher was not fully aware of how his medication affected him.

The following text describes the performance of each child in separate pre-map tasks.

### *Task 1: The concept of the map*

*Eve* performed the task independently. She named different materials and identified the edges and dimensions of the map. She studied the map and compared it with the view located on the floor. Eve learned that the directions and dimensions of the real view changed when she moved to different sides of the view. She learned to rotate the map so that it was comparable to the real view. Eve was also able to form a map of her own, and she knew how to set the fabrics on the floor in the right order in accordance with the map.

*Lauri* needed assistance in the task. He did not make spontaneous conclusions or ask questions about the map. Lauri identified right and left in terms of his own body but the transfer of these concepts to a target out of his reach was difficult. Lauri turned around continuously and changed his position haphazardly. These movements disturbed his functioning because the directions changed continuously. Without assistance Lauri did not know how to align the map comparable to the view located on the floor. He needed play breaks during the session. Lauri practised the first task twice.

*Timo* needed guiding questions and assistance in the use of the hands when studying the map. In the first task Timo had a tactile map (the instructor did not have a printed map even though Timo would have been able to work by means of his vision). It was difficult for Timo to concentrate. He practised the task twice, using his vision more the second time. Poor concentration affected Timo's working, and he tired quickly. However, he partly succeeded in the task, although he received some assistance from the instructor's verbal questions as he worked on the long side of the layout.

**Table 3**. results in task 1

| *Name* | *Accomplished* | *Cognition/emotion* |
|---|---|---|
| Eve | + | cognition |
| Lauri | + with assistance | emotion |
| Timo | + | cognition/emotion |

Remarks regarding the procedure:

- The map must contain an odd number of pieces of carpeting because one of the pieces has to be in the middle in order to formulate an exact location.
- The pieces on both the map and the layout on the floor must have a midline which the child can feel by touching.
- An exact terminology regarding the directions and the locations must be defined at the very beginning of the programme.
- The instructor must use the same vocabulary throughout the whole programme.
- A big toy selection is not necessary; if the child has too many choices, time will be lost in choosing teaching equipment. A choice between two toy figures is enough.
- t is essential to pay attention to the exploring strategy from the very beginning.
- The instructor must decide when the child should explore the pre-map from below upwards or from above downwards.
- After glancing at the pre-map the first time, the child can start exploring it from the upper left corner, which is the same reference point as in reading Braille.
- When it is a question of moving according to the map, it is logical to start from the bottom edge, which is closest to the child.

### *Task 2: The frames of the map and the directions*

*Eve* perceived the view on the table quickly. She named the edges and corners properly. She noticed that the table was large but the map was small, which gave her the emerging idea that the map was a reduced presentation of the landscape she was observing. Eve was able to use two or three objects in the task. She was able to compose her own maps according to how she had placed objects in the landscape, and she determined the locations of the objects verbally. Eve realized that when she moved to another side of the table, the object which was located at the top right corner of the table moved to the bottom left corner when she looked at the view from the opposite side of the table. Eve was able to align the map according to the view located in front of her. She used both vision and the sense of touch in the task, but when the instructor formed the view on the table, she turned her back in order to avoid using her vision.

At the beginning of this map session *Lauri* was disturbed by fantasy games of his own, and it was difficult for him to concentrate. Lauri did not want to explore the map or to name the edges of the map. He did not know how to determine the location verbally. However, he searched in the right direction for the target. He was also able to indicate both the lower edge and the upper edge of the map. When the instructor asked him whether the object was located on the lower or upper edge of the table, in the middle, or in the left or right hand corner of the table, he simply answered 'yes'. With a little help from the instructor, he progressed in naming the edges. The instructor helped Lauri move his hands when he explored the map. Lauri's hand movements were generally sudden and occasional. His exploration skills were emerging, but he was not spontaneous, and he needed breaks for playing.

When working with *Timo* the instructor emphasized the verbal expressions of directional concepts. When the instructor asked Timo the location of the treasure chest he answered: 'here', and he banged the right section of the table. Timo's actions were random; he might answer wrong verbally even though he showed the right location with his hand. Timo was not motivated to use his hands to explore the map; he was also able to perform a task by using his vision. However, the instructor did not change the mode to a totally vision-based one at this stage.

In this session the instructor showed the edges of the map to Timo using the hand-over-hand technique. She explained the meaning of the vertical and horizontal concepts, and what it meant when the object was located away from oneself. Timo learned to determine the right direction when trying to search for objects on the table after examining the map.

Timo also examined the view from different sides of the table. He occasionally gave the correct answer. Timo examined the view first from the original position when the chest was located at the top right corner of the table. When he moved to another side of the table, it was difficult for him to understand that the chest was located at the bottom left corner. At this stage Timo became tired and the instructor decided that the task was difficult and required too much concentration. Timo practised this task twice. In the second training session he also tried using three objects.

**Table 4**. results in task 2

| ***Name*** | ***Accomplished*** | ***Cognition/emotion*** |
|---|---|---|
| Eve | + | cognition |
| Lauri | + with assistance | emotion |
| Timo | + | cognition/emotion |

Remarks regarding the procedure:

- It is best to place the object in a corner or at the edge of the layout in order to get an exact location.
- It is difficult to measure and to compare the length of the perimeter by using the sense of touch if the child has not learned the strategy of measurement.
- Measurement is a skill which must be taught.
- If the table has been divided into four segments with horizontal and vertical tactual midlines, it is easier for a child with to determine the locations of the objects.

### ***Task 3:*** *Object localization on the map of three tapes*

*Eve* identified the materials and compared the lengths of the tapes made of different materials. Eve used both her vision and the sense of touch. A toy was located at the outer end of one of the tapes in the scene on the floor, and a similar miniature toy was located on the equivalent location on the map. Eve explored the map tactually; she wanted to check whether the layout on the floor corresponded with that on the map. She was excited and wanted to perform the task again and again comparing the map and the layout on the floor. Eve was able to align the map after she had compared the location of the big doggy on the floor with the corresponding location of the small doggy on the map.

*Lauri* studied the properties of the tape materials with the instructor. The instructor helped to name the tapes. Lauri was able to determine that the tapes were of different lengths. He began to explore the magnet map from the upper edge. Lauri and the instructor examined together whether the tapes on the floor were similar. Then they compared the map and the layout on the floor, and Lauri noticed that they were alike.

The instructor had to ask Lauri to explore the whole map. Lauri thought that the small teddy bear had jumped onto the map to show the location of the big teddy bear. He found the bear quite accidentally. It was difficult for Lauri to give the right answers even though the questions were direct: 'What is this? Is it a Velcro tape or sandpaper? Where is the sandpaper?' Lauri's actions were not effective; he wanted to produce 'his own voices' and not concentrate on exploring the map. However, he wanted to continue in the programme.

*Timo* identified the tape materials, and noticed that they were of different lengths. The instructor helped him find a correct strategy for examining the map with his hands. The magnets were located at the ends of the tapes on the map. Timo examined them independently. He found a magnet piece on the map, and the corresponding chest located on the floor. He studied the contents of the chest eagerly. Timo was able to use his vision, and the task was easy for him.

**Table 5**. results in task 3

| ***Name*** | ***Accomplished*** | ***Cognition/emotion*** |
|---|---|---|
| Eve | + | cognition |
| Lauri | + with assistance | emotion |
| Timo | + | cognition/emotion |

Remarks regarding the procedure:

- This task can be performed either on the table or on the floor.
- Because the measurement of lengths is difficult, it is worthwhile concentrating on identifying the materials and on comparing the tapes tactually.

### *Task 4: The map as a multipart entity*

*Eve* studied the map tactually, again naming the objects. It was easy for her to identify them and distinguish them from each other. The instructor and Eve built the corresponding layout on the floor using the same materials as on the map. Eve explored the layout on the floor and by using the map checked how the different elements were located in relation to each other.

The instructor emphasized the correct alignment of the map. Eve showed her location at home base on the map and travelled different routes. She also designed her own routes. Eve practiced directional and spatial concepts in the exercise by checking which objects were opposite each other.

Eve also did a modified exercise, in which the tactile map drawn on the Ritmuff-sheet substituted for the collage-like map from the earlier session. Eve examined the map tactually explaining what she found on the map. She counted the squares; she found a curvy rope, circles, a rectangular base, and a round ring (her home base). The same view was located on the floor. Eve distinguished the embossed figures from each other tactually. The home base was located at the lower left corner of the composition. On the map, Eve examined how the squares were located in relation to the home base. First she set the squares close to each other, but she corrected the mistake after checking the map and placed the objects in the right order in relation to each other. The instructor emphasized again the correct alignment of the map. By using the map, Eve was able to conclude which toys were opposite each other. Eve thought that the Ritmuff-map was difficult to examine for information.

*Lauri* practised this task two times. It was difficult for Lauri to concentrate because he was very worried about the tip of his white cane, which had just been broken. 'What kind of a map is this?' Lauri examined the map carefully, and the instructor explained that there were symbols representing the view on the floor. She also explained how different symbols on the map represented objects on the floor (such as stones, a path and a moss tussock).

The instructor directed the discussion. Lauri explored the map, and finally identified the round home base. The instructor asked Lauri about the shapes of the signs trying to assess whether Lauri identified the forms of the square, the rectangle and the circle. Lauri did not answer. When Lauri and the instructor travelled and studied the layout on the floor, Lauri showed the route simultaneously on the map. The instructor turned the map when the travel direction changed. Lauri knew to some extent how he had to follow the map when travelling. He occasionally gave the correct answers to questions regarding the map and the layout on the floor.

Lauri kept turning the whole time, and the turning hindered him from determining the directions. It was difficult for Lauri to give an exact indication of right and left, because his position continuously changed. He often answered questions about the direction by indicating it with his hand and saying 'here'. It was difficult for him to calculate the number of symbols, and to understand such concepts as: above, farther, outer, and backwards. Lauri's exploring skills were emerging. He needed both verbal and physical prompts; his actions were illogical and occasional. However, he liked the exercises, and he also experienced some success.

The second time, Lauri knew how to discuss the map and the floor layout. Even though he was ill, he wanted to come to preschool because he knew it was a 'map day'. He liked to build the layout on the floor according to the guidelines of the map. Lauri's preschool teacher said that Lauri had benefited from the map programme because during the trials he also got training in basic movement, gross motor skills and body concepts.

*Timo* explored the map depicting the activity track together with the instructor, and she directed Timo's hand movements although it would not have been necessary. Timo began to spontaneously examine the map, starting from the lower edge. When he built the layout on the floor, he knew that the circle representing the home base was located on the lower left edge of the map. Timo became tired so the instructor helped him build the rest of the landscape.

Timo knew the directions but he had to think of how to align the map. He succeeded in travelling right by using the map, and he could describe the route. The instructor emphasized how important it was to align the map in relation to the landscape. Timo was allowed to choose routes by himself but in the 'hiding place play' he threw the toy from the map away. Because Timo did not follow the agreed rules, this session was suspended.

Timo practised this task twice. The second time, the map was a printed map because Timo was able to see it. Timo recalled the features on the map, and he described the exercise to his preschool teacher. Timo did not want to build the landscape represented by the map on the floor but he explained how he could travel with the map.

**Table 6**. results in task 4

| *Name* | *Accomplished* | *Cognition/emotion* |
|---|---|---|
| Eve | + | cognition |
| Lauri | + - with assistance | emotion |
| Timo | + | cognition/emotion |

Remarks regarding the procedure:

- A collage type map is better than a map with raised lines, for example, on a plastic sheet. If the map has been drawn onto the Ritmuff-sheet, it is difficult to explore and find points on it.
- The layout should have a simple form without any extra paths between the different materials.

### *Task 5: The symbols*

The instructor drew pictures of Eve's and her own hands on the Ritmuff-sheet, explaining what a one-to-one ratio means. In other words, the picture of the hand that has been embossed on the plastic sheet is the same size and the same shape as the hand is in reality. The picture of the hand was called a symbol.

Next, the instructor drew the outlines of a toy car, a watering can and a die on the Ritmuff-sheet, and Eve explored them tactually. The rectangle depicted the car. The circle depicted the watering can, and it was different from the rectangular figure of the car. Eve anticipated correctly that the die would form the figure of a square. The objects were set on the corresponding locations on the Ritmuff-sheet, and the instructor explained that they are called map symbols.

*Lauri* got and counted three objects: a cup, a box and a play iron. The instructor explained the meaning of the symbol on the map. She drew a circle which depicted the cup, making the remark that she could not draw the handle of the cup. When the cup dropped on the floor, Lauri had to find it by using searching techniques used in O&M training. He was more interested in scratching the Ritmuff-sheet because it made a funny sound. He also wanted to draw by himself.

Since it is difficult to draw the outlines of objects on the sheet the instructor drew all three symbols. The Ritmuff was now the map, and the instructor asked Lauri about the locations of the objects. He could finally tell that the iron was closest and the cup was furthest from him. It was difficult for him to specify the order of the objects, or what it meant when the object was located between two other objects. It would have been a good opportunity to speak about horizontal and vertical dimensions, but Lauri lost interest occasionally. The task might have been too demanding. However, he wanted to continue. In this task the instructor used the hand-over-hand technique, which Lauri said he did not like.

*Timo* used printed material in this exercise. He could choose three objects which would be the map symbols. Timo determined which object was the nearest to him. The instructor explained how to determine the location of the teddy bear in relation to the other objects. When Timo repeated the task, he began to throw and hide objects; therefore one of the objects was omitted.

When the pictures of the Teddy bear and car were drawn again, Timo named them and put them in the right place. He also noted that the objects were located side-by-side.

**Table 7**. results in task 5

| ***Name*** | ***Accomplished*** | ***Cognition/emotion*** |
|---|---|---|
| Eve | + | cognition |
| Lauri | - with assistance | emotion |
| Timo | + | cognition/emotion |

Remarks regarding the procedure:

- The instructor should not have too many objects to choose from; the objects should be simple and clearly of a different form from each other.
- In this task, the instructor can let the child with to draw the figures on the Ritmuff-sheet depending on the skills of the child.
- The drawing introducing the locations of the objects can be used as a map.
- The instructor can emphasize searching techniques.
- t is advisable to use the hand-under-hand technique instead of the hand-over-hand technique.

### *Task 6: From 3-dimensional model to 2-dimensional tactile map*

*Eve* recalled a map from the previous lesson. She described it successfully to her assistant, who had not seen the map before. Then Eve chose six objects for preparing the model on the Styrofoam board. Next, the instructor put the model into the cardboard box with the open front wall. A Ritmuff-map was on top of the box.

The instructor drew on the plastic sheet the map depicting the landscape in the box. She created and explained the symbols for different items including a slide, a pond and a sand box. Eve used both hands simultaneously in exploring. Her left hand explored the model in the box, and her right hand read the Ritmuff-map on top of the box. Eve was able to say which objects were close to her and which objects were further away.

In the next task Eve had a model in front of her with six objects forming the layout. The instructor gave Eve the map that was turned 90 degrees anticlockwise. When Eve compared the model and the map, she noticed the error, and she aligned the map right.

Eve wanted to make several models and maps. When she studied a new version of the model and the map, she could tell whether the map corresponded with the layout in the box. When Eve explored the map from different angles, she could describe the locations of the objects in the model. She also aligned the map and the model to correspond to each other. She was proud of her achievement and stated: 'Of course I knew because I explored'.

Initially the objects in the model were colourful, and Eve could use her vision. Later the instructor used white objects on a white board in order to encourage tactual exploration. When working, Eve did not pay attention to the colours. It was difficult to say whether she was using her vision, because she used her eccentric fixation efficiently. When exploring the map she used touch and vision, but sometimes she forgot to study the map systematically from edge to edge. She preferred the model to the tactile map.

*Lauri* and the instructor prepared the model together. The instructor drew the Ritmuff-map depicting the layout for Lauri to explore. Lauri's hand movements were immature; he rushed and made random circles when exploring the model. Thus, the instructor begun to guide the procedure and Lauri's hand movements using the hand-over-hand technique. Lauri found the objects when he explored systematically. Next, the instructor put the objects of the model on top of the tactile Ritmuff-map, making the relationship between a symbol and the model very concrete.

Lauri liked this task. The instructor put the model into the cardboard box with the open front wall. The Ritmuff-map depicting the layout was on top of the box. Lauri explored the inside of the box trying to find the pond. He found it, and then checked the location of the tree. He also checked whether the map corresponded with the model. With the instructor's help Lauri used both hands systematically by exploring the model inside the box with one hand and the map on top of the box with the other hand.

*Timo* had concentration problems in the beginning. He wanted to tear down the objects which were used in the model. However, gradually he began to explore the model. When the instructor and Timo built the layout, he first set the objects one on top of the other. When the model was ready, and Timo had explored it, he was able to describe the layout. In the initial stage he considered the model as a map.

Timo could use a drawing as the map. He spent 20 minutes on the task. When the instructor drew the map, she asked Timo how the map signs should be set on the board. Timo was interested, but after 20 minutes his interest faded. When he was allowed to make his own map in between, he concentrated on the task for a moment and then began to drive a car on the map. Anyway, Timo answered correctly questions about the locations of different targets with relation to each other. Timo's skills were developing although he tried to mess up the map by drawing his own figures.

During the second lesson on this topic the objects were white, and the lighting was diminished. The contrasts were lower than before and Timo had to use his hands more. It was still difficult for him to understand the difference between a model and a map. Timo also practised the concepts of left and right. The instructor set up the model in the box, and drew the map on paper, explaining the important elements. When the map was ready, Timo correctly noted that the rock was missing.

It was important for Timo to get 'Timo's own map' to depict this view. Later he wanted to have his self-made maps. Timo was happy when explaining the contents of the map to his preschool teacher.

Timo practised the same subject for the third time. The objects were again white on a white base, but they were arranged differently. Timo was now interested in the task, and he knew to a certain extent how he had to design the layout. He was still uncertain about distinguishing and naming the left and the right corner. He preferred to tap the corner of the board saying 'this way here' instead of indicating the location verbally. He needed a great deal of confirmation regarding his description, but he used a suitable exploring strategy after being helped with guiding questions. When the instructor drew the map depicting the model on regular paper, and the picture no longer had embossed outlines, Timo could not use his hands for tactile exploring, so he explored it visually (scanning). Timo no longer threw things, and he looked happy.

**Table 8**. results in task 6

| *Name* | *Accomplished* | *Cognition/emotion* |
|---|---|---|
| Eve | + | cognition |
| Lauri | + - with assistance | emotion |
| Timo | + | emotion |

Remarks regarding the procedure:

- The scale models of the objects are more distinguishable from each other when they are of different sizes.
- If the child has some vision, it is advisable for the instructor to use low contrast items (white models on white surface) and to draw the map on the Ritmuff- sheet with a stick instead of a pen. In this way, the colour contrast will remain minimal.
- If the child still needs the instructor's hand for guidance, the hand-under-hand technique is advisable; thus the child has the opportunity to explore the target independently.

### *Task 7: An unfamiliar room made of Lego bricks*

*Eve* explored the Lego map with both hands. The map depicted the preschool library which was to some extent already familiar to Eve. She was able to tell which room was located behind the second door that she found on the map. The map exploration took place outside the library so Eve could not familiarize herself with the space by using her vision.

In the library Eve began to explore the space immediately. She checked the location of the table in the room and on the map. It was difficult for Eve to find the cabinet located opposite her. The instructor had problems finding explicit definitions for the locations. Eve tried to locate the cabinet using her vision but she needed the instructor's assistance. A Lego bird was located at the door 'of the salon'; Eve found its location easily on the map. She wanted to have a Ritmuff-map, and she set the Lego bird on the map. Then she took the bird to the correct location in the library.

In the next exercise the map was rotated 180 degrees. Eve rotated the map after one guiding question by the instructor. Then Eve was asked to set the Lego bird on the map in the place where Eve was sitting herself. The task was difficult, the instructor asked several assisting questions and Eve had to check the situation concretely. The walls were named on the map and Eve remarked that two walls having doors must be distinguished from each other in some way.

In the exercise a Lego doll was located at the door and the Lego bird was located by the window wall. When the instructor had explained the concept 'opposite' to Eve she was able to determine that the Lego bird and the Lego doll were located opposite each other.

Next, the Lego bird was in front of the bookshelf, so the door to the salon was on the right in relation to it. Because the Lego doll was in front of the wall formed by the moving library shelves, and it had to go to the door, it first had to go to the left and then to the right. In this task Eve explored the view from a different direction so Eve's performance was extremely good. She was also able to describe the objects located on the left and right side of the Lego doll.

Next, Eve worked in the preschool kitchen, which she did not know well. Eve's task was to independently prepare a Lego map representing the kitchen arrangement (the instructor had built the kitchen walls beforehand). Eve began by placing the table on the map, but it was located in the middle of the room, having no point of reference, and the instructor suggested starting by putting doors and windows on the map first. Eve had to check the relative locations of the objects and compare distances several times. Such concepts as longitudinal, transversal, vertical and horizontal were not very familiar. When the doors, windows and cupboards had been placed on the map, she added the rest of the furniture.

The task was demanding because it was not a question of recognizing the symbols and reading the map. Eve had to explore the space, make deductions, and produce a map like the model. Including this kind of task in the programme is not realistic.

Although Eve did not like the task she worked carefully. She checked the locations of the targets on the map tactually. After completing the map, she repeated the travel in the kitchen and confirmed the locations of the objects. Eve’s spatial skills were excellent, and she succeeded even though the task was extremely demanding and she did not like it.

When he began, *Lauri* had in mind the theme from the previous lesson, and he was not eager to change the subject. When exploring the Lego map Lauri wanted to tear it down. In his opinion the map represented a bear's cottage or a cow barn (the map represented the playroom of the nursery school). He identified windows on the map and started to open and close them. He was able to name the lower edge of the map but he gave no answer to the question regarding the location of the map's upper edge.

The map represented a part of the school called Nukkari; the instructor gave names that were based on the characteristics of the walls like the 'Window wall' or the 'Sandman wall'. Lauri's own definitions were unrealistic and haphazard; he called the cabinet, for example, a chimney even though he knew that the map represented the preschool classroom and there was no chimney.

Lauri tried to explore the map but his strategy was disorganized and the instructor had to grab his hands in order to direct the movement. In addition to map exploration Lauri practised directional concepts. Even though Lauri had difficulties in completing this task his skills were improving; he knew all the walls and was able to point to the area on the map where the children played house.

*Timo* explored the Lego map and was able to figure out that it represented Nukkari. He located the 'Sandman wall' as well as the other walls, but he needed repetition. Timo patted the map so the Lego bricks on the map fell off continuously. Timo called himself Paavo, a traveller on the map. Timo had difficulties in concentrating, and the instructor had to motivate him to complete the task.

The instructor showed Timo the hiding place of the treasure chest twice. Timo found it by using his vision, and it was difficult for him to explain his actions when using the map. Timo used his vision to locate targets; the map was a secondary tool for him. He did not practice determining the location from another person's perspective.

Timo practised this task twice. In the second session he immediately identified the Lego map as Nukkari. Timo did not work spontaneously; he still sometimes mixed up right and left. He finally found the top right corner of the map, and he began to explore. Timo wanted to tear down the walls; it would have been better to use the black and white map with him. He did not pay attention to the alignment of the map, and he was not able to concentrate for longer periods. This time the session was interrupted because the instructor noticed that Timo was ill.

**Table 9**. results in task 7

| *Name* | *Accomplished* | *Cognition/emotion* |
|---|---|---|
| Eve | + | cognition |
| Lauri | - | emotion |
| Timo | + with assistance | emotion |

Remarks regarding the procedure:

- The use of Lego bricks is a two-sided issue: Lego bricks are usually available to all children in the preschool. With Lego bricks, the child with visual impairment can play together with sighted children. But, the use of Lego bricks may be difficult for the child who is blind because handling them requires fine motor skills.
- The Lego map is very clear and concrete; it is like a model. It is easy to perceive but it takes time for the child to build a map or a model.
- The construction may be easily breakable and wobbly.

### *Task 8: Recognition of map symbols on swell paper map*

*Eve* had a map made of swell paper representing the premises of the preschool. She quickly found the hallway on the map; she identified it as well as the rooms next to the hallway. She also checked the alignment of the map.

The instructor had marked the hiding place of the toy cat on the map with a pin. Eve determined its location and found it on the first trial. In this task she used both vision and touch. Eve could determine the cat's location on the map, and she wanted to choose the route by herself.

In the next exercise Eve used the same map; she was in the classroom facing the hallway and aligned the map right. She defined her location by using the map; the hallway was her reference point. Again she was able to determine the cat's hiding place and how to travel there. She proudly explained: 'I cannot go through the wall; therefore I have to go around and through the hallway.'

The task was repeated starting in another classroom. Now the hallway was behind Eve. She determined the location of the hallway (she needed a few assisting questions) and aligned the map. Eve wanted to hide the cat by herself and was able to mark the cat's location on the map.

As the final map task Eve had a swell paper map representing the schoolyard of her school. She explored symbols on the map. She began to read the map from the lower edge, which was located closest to her. Eve used both hands when exploring: she examined the map key with one hand, and with the other hand searched for similar figures on the map. She found, for example, the sandbox, the wooden wall, sheds, and a gymnastic bar. Eve already had a systematic exploring strategy.

Eve was eager to explore the map of the yard. She knew many items in the yard and now she recognized their symbols on the map. She outlined the yard as a whole by exploring the objects sequentially. She had to attach new features to the known information.

When Eve had studied the map symbols, she explored the whole map. Now she began map reading from the upper left corner. The instructor assisted the movement of the exploring hand because Eve started to rub the symbols she found relatively hard.

*Lauri* did not perform this task.

*Timo* had a map drawn on paper and depicting an unfamiliar room. Timo wanted to play explorer. He moved around in the room familiarizing himself with the space. The home base was next to the door. He located the target to be found by using his vision. He identified it with the assistance of guiding questions by the instructor. Timo travelled around the space; first he explored all the walls. The numerous items alongside the walls made it difficult for him to perceive the shape of the room. Timo was able to work by using his vision but he wanted to explore the targets tactually.

Timo and the instructor began to draw the map on the table in the middle of the room. This location was inappropriate because the room had to be observed from the middle without any concrete landmark or wall. They moved to a location against the wall next to the door. Timo wanted to study the room further; he roamed around. The instructor had to persuade him to come back to the map.

The instructor drew a map on paper and asked Timo to check it and to name the locations of the visible targets. Timo partly knew how to determine the locations but he needed practice with the directional and spatial concepts. When Timo was at the home base next to the door, and the map was aligned right in front of him, he was able to show where he had hidden his play dolphin.

It was still difficult for Timo to give a verbal explanation of the location of the target. When the instructor asked Timo to show on the map where he had put the dolphin, he answered: 'Here', tapping the map.

Timo took the dolphin to the right place but he had to change the place, because there was no space for the dolphin. He knew how to accomplish this after getting some assistance, and was able to show the new location on the map. Timo got tired again; he threw the fish into the basin, wrinkled up the map and said that he did not like map work any more.

Timo's map skills were emerging but his teaching sessions should have been shorter. It was difficult for him to concentrate for long periods. Short and repeated exercises could have been better with Timo.

**Table 10**. results in task 8

| *Name* | *Accomplished* | *Cognition/emotion* |
|---|---|---|
| Eve | + | cognition |
| Lauri | - | emotion |
| Timo | + with assistance | emotion |

Remarks regarding the procedure:

- The language and the terms must be as unambiguous as possible; the same terms must be used by the instructor and the staff members.
- The symbols must be designed before symbol training.
- A databank of the symbols would be ideal; there are many different kinds of playground equipment, such as swings, sandboxes, balance beams and the ball wall, which do not have generally recognized map symbols. The instructor had to design and use them throughout the whole programme.
- When the child starts to travel according to the map, it is best to start exploring from the bottom edge of the map.
- It is important to carefully choose the location (the home base) where the child explores the map and looks at the layout. The location cannot be in the middle of the space. No landmarks should be behind the child, and the map must be aligned accurately.

### The opinions of the parents and teachers

At the end of the programme both the parents and teachers of the children were given a questionnaire of nine questions dealing with: the information they were given before the programme started, the suitability and individuality of the programme, learning, and the effect of the programme on the child's everyday life (App 1). They were asked to evaluate the significance of the map programme using a numerical scale from 1 (did not agree at all) to 5 (agreed fully). The summary of the responses given by the parents and the school personnel showed very positive results: the mean value of the scores given by the parents was 4.2, and by the preschool personnel 4.7.

The questionnaire also included five open-ended questions for feedback on expectations, learning outcomes, the effect of the intervention programme on the child's everyday life, suggestions for future map use, and the need for further information. Again, the results were positive, assuring that the programme was a very welcome addition to the preschool teaching material for children with impaired vision.

A summarized feedback of the open-ended questions:

*Did you have expectations regarding the experiments in the map programme? Did the programme correspond to your expectations?*

Parents:

Three of the parents did not have many expectations because they did not know what the programme would involve. They seemed to find the programme interesting, and ultimately, their experiences were positive. One mother expected her child, the parents and the teachers to be taught the basics of using maps, as well as what tools could be used at home and at school also since the programme ended.

Teachers:

The teachers did not have many expectations because this activity was a new concept. Nevertheless, the programme was a very positive experience. The assistants expected to get new teaching methods for helping children to move around independently. They thought that the mental images provided by the maps would help them describe the preschool building as a whole. They also expected to receive new perspectives on their work, and new tools for helping children to develop spatial understanding. Generally, the programme corresponded to their expectations.

*Can you mention special skills that your child learned during the programme?*

Parents:

The children had learnt: (a) map alignment; (b) the proportions of the objects; (c) a map can be used, for example, to describe the child's own room; (d) directional concepts (in front of, behind, on the left ); and (e) directional concepts change when turning. The programme encouraged children to move. The children's ability to localize objects improved, especially in outdoor settings, and the concept of the map became familiar and interesting.

The children began to ask about directions when the family travelled by car, they began to ask about the locations of objects and targets, and their spatial concepts and understanding became more established. They understood that the map described the environment, and the symbols depicted the real world.

Teachers:

The children began to understand directional concepts better; one child developed fine motor skills by building with Lego bricks. The ability to trace an embossed line improved and the interest in maps increased. The children had learned to 'look at the space' in miniature form. It was not always necessary to explore the whole space in a concrete way by trailing the walls for example. The children were able to introduce the room to visitors by themselves. They were keen on checking the alignment of the map and being able to correct the situation by rotating the map or turning oneself.

*Has the programme had any effect on your child's everyday life? If yes, can you describe how?*

Parents:

During the summer holiday, one child had asked his parents to make a map of the route they were travelling. He was very interested when his parents and other adults looked at maps.

One child had shown the pre-maps used at school at home; she had prepared her own Lego map that depicted her room, and her school assistant began to use tactile maps in school.

Teachers:

It was difficult to explain the effects of the programme on daily life. However, a comprehensive understanding of space and routes had become easier because of the maps. The school building was easier to introduce piece by piece with the map.

The children began to travel more independently on the preschool premises, becoming more able to move about on their own initiative. The children outlined the space, and they were able to make excursions to the other groups in the day care centre.

Spatial perception generally increased, and the teachers initiated new ways to help the children orientate in space (for example: previously the music box had been used for showing directions instead of describing the space as a whole to the child.) The staff became interested in the maps and added them to the other children's programme.

*Do you have other ideas regarding the instruction in map use?*

Parents:

Map instruction could be a part of O&M instruction, but in a playful way.

Teachers:

Map games could also be carried out with all children in the preschool; two preschools of three had implemented some map training with sighted children too.

Participating in the teaching sessions had been a good experience; the assistant and the teacher asked for teaching material for further activities.

*Do you want more information on certain matters?*

Parents:

Parents had questions regarding the programme: How could they make appropriate maps by themselves? How should they symbolize landmarks on a map? How could they continue after the programme ended?

Teachers:

How could they continue after these children transferred to another group? What are appropriate teaching materials; are models available? How often should map tasks be repeated; can tasks done previously be repeated in this programme?

# Discussion

The purpose of this work was to develop innovative and wide-ranging teaching materials related to spatial understanding for use with preschool children who are visually impaired. A child who is blind from birth has to use substitute overlapping information from the environment through other modalities that converge with the existing reference cues and means of coding.

Children need to understand the analogy between the planes and surfaces of their bodies and the planes and surfaces in the external world. That is, they need to transform the reference information from a body-centered scheme to the rational function in the external circumstances. It is not an innate ability, so children need instruction in this process. The procedure is fundamental, especially for children who are blind, but also for children with low vision, who are justified in getting instruction in these skills (Rieser et al., 1992).

Several studies have shown that children with visual impairment are able to read tactile maps. However, the results within the youngest age groups showed that proficiency in map reading was poor. Some studies (Berlá, 1981; Berlá et al., 1977; Ochaita & Huertas, 1993; Ungar et al., 1997b) showed that even a short training period improved the skills of the children when they practised estimating distances by reading a tactile map. There was no previous study on introducing a systematic programme for teaching elementary map skills; therefore, it was important to develop a simple curriculum for teaching preschool children how to read tactile maps.

A tactile map can be one tool for enhancing spatial skills. But before children can read a map, they need to understand the map-related concepts. The researcher developed a pre-map programme presuming that children with visual impairment would be able to learn to read a tactile map by means of age appropriate and playful instruction tasks.

This pre-map programme can be one instruction tool when children with visual impairment progress from body-centered orientation behaviour to more holistic strategies for travelling: that is, from immature to mature forms of thinking and from concrete to abstract functioning (Wood & Attfield, 1996). The programme combines elements from spatial awareness, fine motor skills, mobility skills, and pre-Braille.

Through this educational programme, children have an opportunity to benefit from several diverse experiences in the environment, to improve their O&M skills, and to develop a better understanding of spatial organization (Dodds, 1989; Juurmaa & Lehtinen-Railo, 1994).

The elements in the pre-maps have guidelines that are convergent with those used in teaching the sport of orienteering in primary schools (cf. McNeill & Renfrew, 1990). Thus, the teacher has an excellent opportunity to integrate a child with visual impairment into a preschool class when practising map skills.

The efficacy of the programme for improving the children's achievements in spatial skills was not tested. Efficacy measurement was not the goal of the work; instead, it was important to create and introduce a programme that could be implemented and applied in any preschool with the materials, instruments, and facilities that are generally available. The programme is addressed to any child with visual impairment regardless of visual acuity. The aim is to provide effective opportunities for individualized learning to all children with visual impairment. The materials and tasks of this study can be used in preschool, in O&M instruction, or at home.

The researcher received some previous reports regarding the visual status of the children. She did not make a functional vision assessment, nor did she receive any inclusive information on the children's developmental abilities. She did not use the O&M-related screening by Dodson-Burk & Hill (1989b) either, because that screening had not given essential information for implementing the pre-map program.

It was not possible to create an appropriate assessment tool for testing spatial understanding of the children at preschool age (see p. 75). Yet, the assessment of cognitive skills could supply an instructor with valuable information when planning tasks to meet the needs and the potential of each individual child. Thus, the researcher began working with the information she got from the hospital, as well as with the rehabilitation reports. This is generally the situation when an O&M instructor begins teaching a new student. However, more background information would be advisable in order to write a comprehensive instruction plan with individual goals.

Reflective interaction is one method involved in the development of a new programme. The researcher must adjust and modify the programme to better conform to the children's behaviour (Karr & Kemmis, 1986). When examining the children's performances, the researcher used participating observation and curriculum-based measurement instead of clinically testing the children's abilities in spatial perception. The primary goal was to observe the children's ability to develop a functional and cognitive understanding of maps.

The pre-map programme was composed of eight tasks progressing hierarchically and logically from pre-maps to the exploration of the real tactile map. The initial development of the programme took place through the two-way interaction and cooperation with Matti (the pilot case), Matti's school assistant and the researcher. The work with the pilot case was vital when thinking of the development of different map tasks. At the beginning, the instruction in map reading skills was one part teaching and learning process with Matti. His positive reactions, concentration and enjoyment with pre-maps encouraged the researcher to develop a set of map tasks, which formed the pre-map program. Subsequently, the programme was carried out with three other children who had visual impairments of different degrees and varying characteristics.

The programme is significant because it is coherent, and develops progressively skills for reading tactile maps from the basic rudiments to advanced mastery. Although the results have not been measured and they cannot be generalized, the programme gives sufficient reasons for teaching maps for preschool children with visual impairment. The programme is applicable in various external conditions, the instructors, teachers and parents of the children can adapt the tasks of the programme to different everyday situations using its separate elements. The elements are needed when the child's activities are in a novel environment, or when the map can depict the location of the objects on the child's desk.

Practice in pre-map skills supports progress in a range of instructional domains, and the programme provides methods and materials for preschool teachers. Children like the activities, being able to concentrate on one task for as long as 30-40 minutes.

*From pre-map experiments to functional map reading*

The preceding narratives described how the children progressed during the programme. In the first pre-map task the children with visual impairment worked on a predefined space, learning the general concept of the map. They learned how to align the map in relation to the layout and to recognize different objects and phenomena that could be localized by different strategies. They learned to use the tactile map when planning to travel in a space or when choosing different routes between targets. The pre-maps included special two-dimensional marks and symbols that depicted certain three-dimensional objects in the space. An interesting phase was that of evolving from an egocentric perception to a more survey type comprehension of the environment, and the greater understanding of how a small scale model could be represented by means of a two-dimensional tactile map. Finally, the children learned to read the actual tactile map. The procedure can be illustrated as an orienteering track, on which the route proceeds from start to finish (Fig. 9). The instructor may modify the transition between the control-points according to each child's abilities and progress.

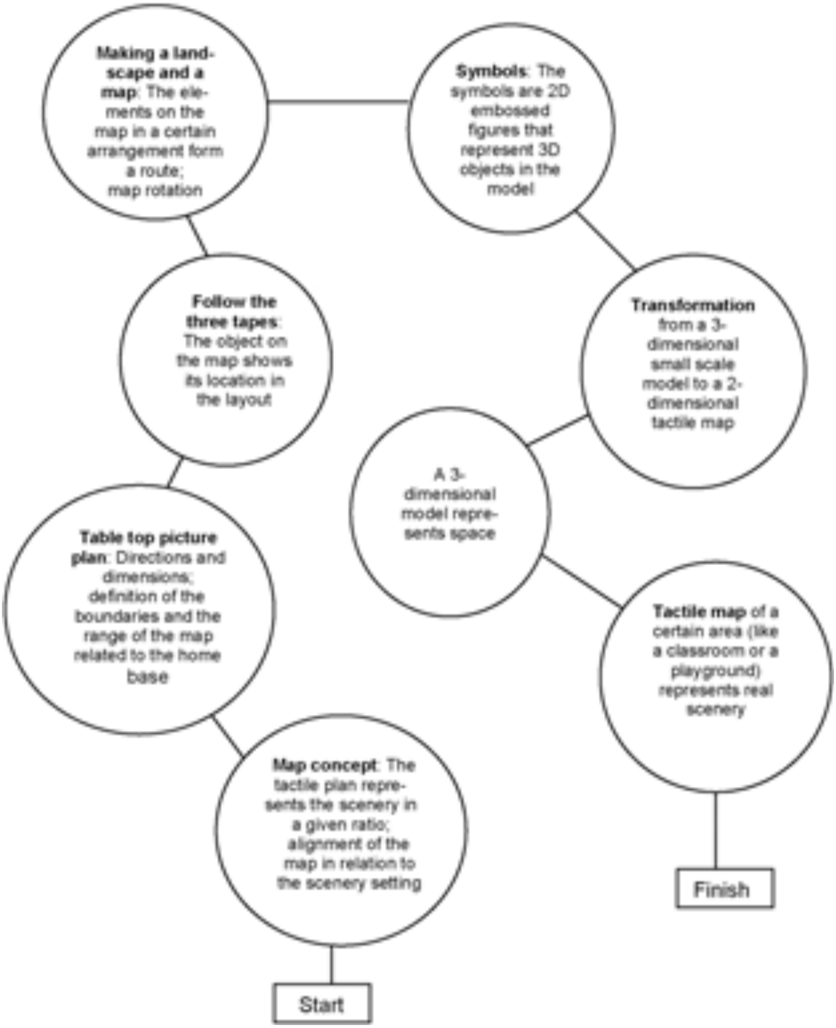



**Figure 9**. The course of the pre-map programme

The study shows that the progression of the pre-map tasks is appropriate and logical. However, the instructor needs to evaluate continuously whether the task requirements are appropriate for the specific skills of each child, and map tasks must be chosen with care in order to maintain the motivation. The parents and teachers must have the patience to wait for the maturation of the child with 'alternative developmental paths' (Brambring, 2007). Many tasks in the programme require the development of manual skills with high coordinative demands. It is important to give the child enough time for each task, and also the opportunity to repeat the tasks several times. It is possible to continue teaching the programme throughout the whole school year, but the instructor can and should modify the substance of the tasks or change the task order when needed.

*Challenges of the programme:*

Carrying out the programme sets demands on the instructor, who must adapt the programme according to the children's skills and needs: (a) Children who take part can be either blind or have impaired but useful vision; (b) If the children have some vision, black and white, printed map materials with large figures can be used; (c) The instructor may not know the level of cognitive development of a child, although this information would help the instructor to design the programme individually. It is a challenge to make clear the goals of the tasks to the child. If the child understands the goal of the procedure, it is easier for him or her to be motivated to perform the task; (d) The premises of the preschools as well the expectations of the personnel vary; and (e) The other children in the preschool group have an effect on the course of teaching events.

Initially, the researcher thought that she, together with each child separately, could make up a story related to the map task in question. This did not work. The children were not very eager to produce stories, and the procedure took too much time. It is more important to have short, clear, and imaginative instructions at the beginning of each training session. When the story is the same for all the children, it is easier for the instructor to use unambiguous terms and definitions, continuously allowing the child to concentrate on the actual learning task instead of making up a story.

If the instructor continuously uses the hand-over-hand technique, the child may adopt a passive touch because the initiative for exploring comes from another person, and the child lacks the opportunity to spontaneously control hand movements and the quality of touch (Nielsen, 1996). It is important that the child learns an effective strategy for exploring.

In this study, exploring techniques were not strongly emphasized. In most cases the child started to explore the map from its upper left corner, sweeping the hand from left to right and from the upper to the lower part of the map. The procedure can also begin from the bottom, close to the child's body. The strategies of the children varied. However, the instructor has to evaluate what is the most appropriate direction of the hand movements in each situation.

The pre-map programme and tactile maps should be available to anybody who works with a child with visual impairment. The good feedback from the teachers, assistants and the parents proved the value of the programme. The preschool teacher and/or the child's assistant can carry out the programme after receiving training and instructions from the O&M instructor; they are the key persons involved in emphasizing mapping skills in the daily routines.

The role of the school assistant is extremely important. The assistant works continuously and closely with the child, adapting and preparing learning materials. The activities should be conducted in a transdisciplinary or multidisciplinary team to assure that all persons involved in the teaching procedure know the basic guidelines on how to adapt these items in their work. Unfortunately, this is not always the case in reality (Hyvärinen, 2002).

The participation and engagement of the parents in the use of tactile maps are important if maps are to become a regular element in the child's everyday life. During this programme, the parents had no opportunity to attend the instruction sessions. This was a defect. Further actions to rectify this were not planned, and the researcher does not know to what degree tactile maps have been used with these children after the programme ended. However, it is important to make sure that the children who participate in a map programme will receive maps whenever needed in the future. At present, it may be difficult because of insufficient resources in tactile map production.

# Conclusions

This pre-map programme is a comprehensive set of learning tasks, which are appropriate to be used with preschool children with visual impairments. Its varying components cover several domains that support the development of the children.

Children with visual impairment are more often integrated in normal day-care centres and schools. The size and composition of the class can be very diverse. In a group of children with varying disabilities it is a challenge for teachers to develop teaching materials and organize daily activities for children who are visually impaired. The preschool personnel try to do their best to reach the educational goals of every child, but it can be difficult when developmental paths are not the same for each individual.

The pre-map curriculum can solve some of the problems encountered in planning educational activities by providing methods and ideas for teaching many necessary, blind-specific skills. Shared functions bring the teacher and child closer and give direct feedback of the child's behaviour and progress. This also gives the teacher an opportunity to adapt the activities and to choose the proper tasks to work with.

During the pre-map programme, the researcher noted many problems in the children's O&M skills. Map tasks give the child the possibility of developing various learning and processing methods in spatial understanding and motivate the child to explore independently. O&M instructors should be educated and encouraged to more often use tactile maps when teaching young children with visual impairment. Comprehensive instruction would assure children overlapping and unique training in various skills that develop their control of space.

The pre-map programme supports not only O&M skills. Throughout the map programme the instructor can teach children environmental, spatial and directional concepts, and the systematic use of hands when exploring tactile pictures and graphics.

Braille reading and the use of tactile graphics require fine motor skills, tactile sensitivity and the ability to trace embossed lines and recognize shapes and sizes. By exploring tactile graphic symbols and maps, children with visual impairment can learn correct finger placement and develop finger strength. All these elements for promoting a wide range of skills in the use of the hands are found in the pre-map programme. The instructor should remember, however, that a tactile map is one but not the only tool for teaching spatial awareness.

The programme can also promote integrated social activities, because the tasks are appropriate for all children with or without impairments. The sighted first graders became interested in Eve's practising with the swellpaper map. She was proud to be able to introduce the map and explain her reading techniques.

The parents of a child with visual impairment taking part in the map programme need to be kept informed of how the instruction is progressing. They might, however, experience the programme as stress, if they themselves are not confident of using the maps for orientation. In this case, it is important to offer them the possibility of participating in the project. In any case, providing the child with maps should not add to the workload of the parents. The aim should be to facilitate spatial perception in everyday situations when the child is exploring a new environment.

## Work in the future

The development of the pre-map programme was one step in teaching a young child spatial skills when learning to orientate. The sample was limited and heterogeneous, which did not allow for making definitive conclusions. Although it will be difficult to find matching cohorts, it would be a challenge to examine the effectiveness of the programme in a controlled setting with controlled groups. In addition, this work brought out the need to create an assessment tool for evaluating the spatial skills of young children with visual impairment and for planning appropriate and individual methods for early education.

Further, it would be important to determine how people who are congenitally blind could improve their perception of space in a multisensory way and how they could develop useful cognitive resources to structure an unfamiliar environment. There is still need for further development in teaching effective strategies for map reading and taking into consideration the different needs of people who are blind or partially sighted.

Previous studies have shown the advantages of tactile maps for people who are visually impaired. They should also have the possibility of choosing a tool for orientation according to their needs regardless of age or other characteristics. This pre-map programme was designed for children, but there are many adults who also want to learn to read tactile maps. They need their own, age appropriate learning programme.

Besides children with visual impairments, there are other groups, who can benefit this program. A recent study about the vision problems among the children with physical disabilities revealed problems in their functional vision and showed several difficulties when they try to and to orientate in the unfamiliar environment (Eronen et al. 2008, 128). It is worth of an experiment whether the children with different disabilities can learn better to control unfamiliar environment by learning map reading through a systematic programme.

In the future, it is important in terms of equality that people who are visually impaired have the same opportunities as sighted people to obtain tactile maps, signs and other graphics in different establishments. Tactile maps are one part of the accessible environment. Modern technology can make tactile maps available to anyone who needs them in their everyday life. Because of the ready availability of desktop mapping and GIS software in most geography departments (e.g. MapInfo, Arc View), it is not complicated to convert the representation of a standard map into a form that is more suitable for people with vision loss.

What is most important now is to promote, advocate, and advance the teaching of those skills necessary for reading tactile maps.

# References

Ahonen, T., & Viholainen H. (2006). Motorinen kehitys [Motor development]. In H. Hämäläinen, M. Laine, O. Aaltonen, & A. Revonsuo (Eds.), *Mieli ja aivot* [Mind and brains] (pp. 268–274). Turku: Turun yliopisto, Kognitiivisen neurotieteen tutkimuskeskus; Gummerus Kirjapaino Oy.

Ainley, M. (2006). Connecting with learning: Motivation, affect and cognition in interest process. *Educational Psychology Review, 18*(4), 391–405.

Alho, K., Kujala, T., Paavilainen, P., Summala, H., & Näätänen, R. (1993). Auditory processing in visual brain areas of the early blind: evidence from event-related potentials. *Electroencephalography and clinical Neurophysiology, 86,* 418–427.

Aldrich, F. K., & Sheppard, L. (2001). Tactile graphics in school education: perspectives from pupils. *The British Journal of Visual Impairment, 19*(2), 69–73.

Aldrich, F.K., Sheppard. L., & Hindle, Y. (2002). First steps towards a model of tactile graphicacy. *The British Journal of Visual Impairment. 2*(2), 62–67.

Adelson, E., & Fraiberg, S. (1974). Gross motor development in infants blind from birth. *Child Development, 45*, 114–126.

Alonzo, J., Ketterlin-Geller, L.R., & Tindal, G. (2007). Curriculum-based measurment in reading and math: providing rigorous outcomes to support learning. In L. Florian (Ed.), *The SAGE Handbook of Special education* (pp. 307–318). London: SAGE Publications.

Anthony, T. L., Bleier, H., Fazzi, D. L., Kish, D., & Pogrund, R. L. (2002). Mobility focus: Developing early skills for orientation and mobility. In R. L. Pogrund & D. L. Fazzi (Eds.), *Early focus* (2nd ed., pp. 326–404). New York: American Foundation for the Blind.

APH educational research Guidelines for design of tactile graphics. Retrieved May 30, 2007, from http://www.aph.org/edresearch/guides.htm.

Ashmead, D. H., Hill, E.W., & Talor, C. R. (1989). Obstacle perception by congenitally blind children. *Perception & Psychophysics, 46*(5), 425–433.

Ashmead, D. H., Wall, R.S., Eaton, S.B., Ebinger, K.A., Snook-Hill, M-M., Guth, D. A., & Yang, X. (1998). Echolocation reconsidered: using spatial variations in the ambient sound field to guide locomotion. *Journal of Visual Impairment & Blindness. 92*(9), 615–632.

Bee, H. (2000). Perceptual development. *The Developing Child* (9th ed., pp. 138–161). Needham Heights, MA: Allyn and Bacon.

Bentzen, B. L. (1977). Orientation maps for visually impaired persons. *Journal of Visual Impairment & Blindness. 71*(5), 193–196.

Bentzen, B. L. (1997). Orientation aids. In B. B. Blasch, W. R. Wiener, & R. L. Welsh (Eds.), *Foundations of orientation and mobility* (2nd ed., pp. 284–316). New York: American Foundation for the Blind.

Berlá E. P. (1981). Tactile scanning and memory for a spatial display by blind students. *The Journal of Special Education 15*(3), 341–350.

Berlá E. P., & Butterfield, L.H. (1977). Tactual distinctive features analysis: Training blind students in shape recognition and in locating shapes on a map. *The Journal of Special Education 11*(3), 335–346.

Berlá, E. P., Butterfield L., H., & Murr, M.J. (1976). Tactual reading of political maps by blind students: A videomatic behavioral analysis. *The Journal of Special Education 10*(3), 263–276.

Bigelow, A. (1991a). Spatial mapping of familiar locations in blind children. *Journal of Visual Impairment and Blindness, 85,* 113–117.

Bigelow, A. (1991b). The effects of distance and intervening obstacles on visual inference in blind and sighted children. *International Journal of Behavioral Development, 14*(3)*,* 273–283.

Bigelow, A. E. (1992). Blind children's ability to predict what another sees. *Journal of Visual Impairment and Blindness, 86,* 181–184.

Blades, M., & Spencer, C. (1986). Map use by young children. *Geography* ©, 47–52.

Blades, M., & Spencer, C. (1990). The development of 3- to 6-year-olds' map using ability: The relative importance of landmarks and map alignment. *Journal of Genetic psychology, 151*(2), 181–190.

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

Blades, M., Lippa, Y., Colledge, R.G., Jacobson, R.D., & Kitchin. R.M. (2002). The effect of spatial tasks on visually impaired peoples' wayfinding abilities. *Journal of Visual Impairment & Blindness, 96,* 407–19.

Bliss, I., & Hämäläinen, H. (2005). Different working memory capacity in normal young adults for visual and tactile letter recognition task. *Scandinavian Journal of Psychology, 46,* 247–251.

Bliss, I., Kujala, T., & Hämäläinen, H. (2004). Comparison of blind and sighted participants' performance in a letter recognition working memory task. *Cognitive Brain Research, 18*(3), 273–277.

Brambring, M. (1976). The structure of haptic space in the blind and sighted. *Psychological Research, 38*(3), 283–302.

Brambring, M. (1993). *„Lehrstunden" eines blinden Kindes. Entwicklung und Frühförderung in den ersten Lebensjahren.* München: Ernst Reinhardt Verlag.

Brambring, M. (1994). *Early intervention for orientation and mobility skills in young blind children*. Paper presented at the International Mobility Conference 7. Melbourne, Australia.

Brambring, M. (1998). *O&M early intervention—when to start and what to teach.* Paper presented at the International Mobility Conference 9. Atlanta, GA.

Brambring, M. (2001). Integration of children with visual impairment in regular preschools. *Child: Care, Health and Development, 27*(5), 425–438.

Brambring, M. (2005). Perceptual perspective taking in children who are bllind: The state of research and a single case study. *The British Journal of Visual Impairment, 23*(3), 122–127.

Brambring, M. (2006). Divergent development of gross motor skills in children who are blind or sighted. *Journal of Visual Impairment and Blindness, 100*(10), 620–634.

Brambring, M. (2007). Divergent Development of Manual Skills. *Journal of Visual Impairment and Blindness, 101*(4), 212–225.

Brambring, M., & Laufenberg, W. (1979). Construction and complexity of tactual maps for the blind. *Psychological Research, 40*(3), 315–327.

Brambring, M., & Tröster, H. (1994). The assessment of cognitive development in blind infants and preschoolers. *Journal of Visual Impairment and Blindness. 88*(1), 9–18.

Brown, D., Simmons, V., Methvin, J., Anderson, S., Boigon, S., & Davis, K. (1991). *Oregon project for visually impaired and blind preschoolers*. Medford, OR: Jackson County education Service District.

Buultjens, M., & Ferguson, R. (1994). Let's play together. *The British Journal of Visual Impairment, 12*(3), 87–89.

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

Challis, B.P., & Edwards, A.D.N., (2000). Weasel: A system for the non-visual presentation of music notation. *Computers helping People with Special Needs: Proceedings of ICCHP 2000* (pp. 113–120). Karlsruhe, Germany: Österreichische Computer Gesellschaft.

Chen, D. (1999). Understanding hearing loss: Implications for early intervention. In D. Chen (Ed.), *Essential Elements in Early Intervention.* New York: American Foundation for the Blind.

Cohen, L., & Manion, L. (1989). *Action research. Research methods in education (2nd ed.)*. London and New York: Routledge, (pp. 217–2241).

Csikszentmihalyi, M., Rathunde, K., & Whalen, S. (1993). *The Talented Teenagers: The Roots of Success and Failure* (pp. 37). Cambridge, England: Cambridge University Press.

Dacen-Nagel, D. L., & Coulson, M. R. C. (1990). Tactual mobility maps / a comparative study. *Cartographica: The International Journal for Geographic Information and Geovisualization, 27*(2), 47–63.

Davidson, P.O., & Costello, C.G. (1969*). N=1: Experimental Studies of Single Cases.* NY: Van Nostrand Reinhold Company.

Dekker, R. (1989). Manual to the intelligence test for the visually impaired children aged 6 to 15 (1): Theoretical background. Zeist: Bartimeus Centre.

Dodds, A.G. (1989). Tactile maps: A psychologist's perspective. *The Cartographic Journal, 26,* 3–6.

Dodds, A. G., Howarth, C. L. ,& Carter, D. C. (1982). The mental maps of the blind: The role of previous visual experience. *British Journal of Visual Impairment, 76*, 5–12.

Dodson-Burk, B., & Hill, E. W. (1989a). *An orientation and mobility primer for families and young children*. New York: American Foundation for the Blind.

Dodson-Burk, B., & Hill, E.W. (1989b). *Preschool orientation and mobility screening*. Alexandria, VA: Division IX of the Association for Education and Rehabilitation of the Blind and Visually Impaired.

Dote-Kwan, J., & Chen, D. (1999). Developing meaningful interventions. In D. Chen (Ed.), *Essential elements in early intervention. Visual impairment and multiple disabilities* (pp. 287–336). New York: American Foundation for the Blind.

Downing, J. (1999). Critical transition: educating young children in a typical preschool. In D. Chen (Ed.), *Essential Elements in Early Intervention.* New York: American Foundation for the Blind.

Duckett, P.S., & Pratt, R. (2001). The researched opinions on reserch: visually impaired people and visual impairment research. *Disability & Society, 16 (6)*, 815–835.

Easton R. D., & Bentzen, B.L. (1987). Memory for verbally presented routes: a comparison of strategies used by blind and sighted people. *Journal of Visual Impairment & Blindness,* 100–105.

Edman, P.K. (1992). Maps. *Tactile Graphics* (pp.193–321). New York: American Foundation for the Blind.

Eriksson, Y. (1997). *Att känna bilder* [To feel pictures] (pp. 84–87). Solna: Sweden: SIH Läromedel.

Eriksson, Y. (1999). How to make tactile pictures understandable to the blind reader. *65th IFLA Council and General Conference.* Paper presented at the conference conducted by International Federation of Library Associations and Institutions. Indonesia.

Eriksson, Y., & Wollter, S. (1997). *Från föremål til taktil bild* [Converting the object into a tactile picture ] (pp. 31–41). Lyckelse: Tryck Nya Tryckeriet.

Eriksson, Y., Jansson, G., & Strucel. (2003). *Tactile maps. Guidelines for the production of maps for the visually impaired*. Enskede: The Swedish Braille Authority.

Erin, J. N., Fazzi, D. L., Gordon, R. L., Isenberg, S. J., & Paysse, E. A. (2002). Vision focus. Understanding the medical and functional implications of vision loss. In R.L. Pogrund & D.L. Fazzi (Eds.), *Early focus: Working with Young Children Who are Blind or Visually Impaired and Their Families*. (2nd ed., pp. 52–106). New York: AFB Press.

Eronen, U., Heikkinen, E., Hyvärinen, L., Kiviranta, T., Miinalainen, I., & Tervo, A. (2008). Johtopäätökset ja suositukset [Conclusions and recommendations]. In T. Kiviranta, U. Eronen, E. Heikkinen, I. Miinalainen & A. Tervo (Eds.), *Näkökulmia näköpulmiin* [Viewpoints to Vision problems]. Helsinki: Erityisopetuksen ja kuntoutuksen palvelukeskus.

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

Farrenkopf C., & Davidson I. F. W. K. (1992). The development of perspective taking abilities in young blind children. *Re:View, 24*(1).

Fazzi, D. L., & Klein, M.D. (2002). Cognitive focus: Developing cognition, concepts, and language. In R. L. Pogrund & D. L. Fazzi (Eds.), *Early Focus: Working with Young Children Who Are Blind or Visually Impaired and Their Families* (2nd ed., pp. 107–153). New York: AFB Press.

Ferrel, K. A. (2000). Growth and development of young children. In M. C. Holbrook & A. J. Koenig (Eds.), *Foundations of education*. *Vol 1*: *History and theory of teaching children and youths with visual impairments* (2nd ed., pp. 111–134). New York: AFB Press.

von Fieandt, K. (1962). Näkö-kosketus-avaruuden jäsentyminen [Organisation of the Visual-Tactile Space]. *Havaitsemisen maailma* [ The world of perception] (pp. 204–230, and 273). Porvoo: WSOY.

Fletcher, J. F. (1980). Spatial representation in blind children. 1: Development compared to sighted children. *Journal of Visual Impairment and Blindness, 74*(10), 381–385.

Fogel, A. (1997). Seeing and being seen. In V. Lewis & G. M. Collis (Eds.), *Blindness and psycholocigal development in young children* (pp.86–98). Leicester: BPS Books.

Fraiberg, S. L. (1977). *Insights from the blind: Comparative studies of blind and sighted infants.* New York: Basic Books.

Gardiner, A., & Perkins, P. (1996). Teaching touch on the towpath: a tactile map for a visit to the countryside. *The Cartographic Journal, 33*(2), 111–118.

Gardiner, A., & Perkins, P. (2005). 'It's a sort of echo...': Sensory perception of the environment as an aid to tactile map design. *The British Journal of Visually Impairment, 23*(2), 84–91.

Gibson, E. J., & Spelke, E. S. (1983). The development of perception. In P. H. Mussen (Ed.), *Handbook of Child Psychology: Vol. 3. Cognitive Development* (4th ed., Es J. H. Flavell & E. M. Markman, pp. 2–76). New York: John Wiley & Sons.

Griffin, H. (1981). Motor development in congenitally blind children. *Education of the Visually Handicapped, 12,* 106–111.

Golledge, R .G., Klatzky, R. L., & Loomis, J. M. (1996). The construction of cognitive maps by visually impaired people. In J. Portugali (Ed.), *The Construction of Cognitive Maps* (pp. 215–245). Netherlands: Kluwer Academic Publishers.

Haken, H., & Portugali, J. (1996). Synergetics, inter-representation networks and cognitive maps. In J. Portugali (Ed.), *The Construction of Cognitive Maps.* (pp. 69-86). Netherlands: Kluwer Academic Publishers.

Hakkarainen, P. (1990). *Motivaatio, leikki ja toiminnan kohteellisuus* [Motivation, play and object-orientaion of activity] (284). Helsinki: Orienta-Konsultit Oy.

Hakkarainen, P. (1999). Play and motivation. In Y. Engeström, R. Miettinen, & R-L. Punamäki (Eds.), *Perspectives on Activity Theory* (pp. 231–249). Cambridge : Cambridge University Press.

Hampson P. J., & Daly, C.M. (1989). Individual variation in tactile map reading skills: Some guidelines for research. *Journal of Visual Impairment & Blindness, 83*(10), 505–509.

Hapeman, L. P. (1967). Developmental concepts of blind children between the ages of three and six as they relate to orientation and mobility. *International Journal of the Education of the Blind, 17*(2), 41–48.

Hill, E.W. (1981). *The Hill Performance Test of Selected Positional Cncepts, Instruction manual.* Chicago, IL: Stoelting Co.

Hill, E. W. (1986). Orientation and mobility. In G.T. Scholl (Ed.), *Foundations of education for blind and visually handicapped children and youth*. New York: American Foundation for the Blind.

Hill, E. W., & Ponder, P. (1976). Orientation. *Orientation and mobility techniques: A guide for the practitioners* (pp. 3–11). New York: American Foundation for the Blind.

Hill, E. W., Dodson-Burk, B., & Smith, B. A. (1989). Orientation and mobility for infants who are visually impaired. *RE:view, 21*(2), 47–60.

Hill, E. W., Guth, D. A., & Hill, M-M. (1985). Spatial concept instruction for children with low vision. *Education of the Visually Handicapped, 16*(4), 152–161.

Hill, E. W., Rosen, S., Correa, V. I., & Langley, M. B. (1984). Preschool orientation and mobility: an expanded definition. *Education of the Visually Handicapped, 16,* 58–72.

Hill, E. W., Rieser, J. J., Hill, M-M., Hill, M., Halpin, J., & Halpin, R. (1993). How persons with visual impairments explore novel spaces: Strategies of good and poor performers. *Journal of Visual Impairment & Blindness,* 295–301.

Hirn, H., & Marila, A. (1996). *Nalle-kerhosta maailmalle* [From Teddy Bear Club into the World]. Helsinki: Näkövammaisten Keskusliitto ry.

Horsfall, B. (1997). Tactile maps: new materials and improved designs. *Journal of Visual Impairment & Blindness, 1,* 61–65.

Huertas, J. A., & Ochaìta, E. (1992). The externalization of spatial representations by blind persons. *Journal of Visual Impairment & Blindness, 86*(9), 398–402.

Hughes, M., Dote-Kwan, J., & Dolendo, J. (1998). A close look at the cognitive play of preschoolers with visual impairments in the home. *Exceptional Children, 64,* 451–462.

Hyvärinen, J., Carlson, S., & Hyvärinen, L. (1978). Aivojen näköjärjestelmän muokkautuminen varhaisiässä [Plasticity of visual mechanism in early childhood]. *Duodecim, 94,* 287–298.

Hyvärinen, L. (2002). Näkövammaiset lapset [Children with visual impairment]. In M. Jahnukainen (Ed.) *Lasten Erityishuolto ja opetus Suomessa* (pp.275–283). Juva: Lastensuojelun Keskusliitto.

Hyvärinen, L. (2003). Assessment and classification of visual impairment in infants and children. Paper prepared for the WHO meeting on Classification of Visual Impairment. Retrieved October 14, 2004, from http://www.lea-test.fi.

Hyvärinen, L. (2007). Assessment of functional vision for educational purposes and early intervention. Retrieved September 23, 2007, from http://www.lea-test.fi.

*International Classification of Functioning, Disability and Health (ICF)*. (2001) Retrieved February 11, 2008, from http://www.who.int/classifications/icf/site/icftemplate.cfm.

*International Classification of Functioning, Disability and Health, Children and Youth Version (ICF-CY)* (2007), Geneva: World Health Organization.

Jacobson, W. H. (1993). *The Art and Science of Teaching Orientation and Mobility to Persons With Visual Impairments.* New York: AFB.

James, G. A., & Armstrong, J. D. (1976). *Handbook on mobility maps*. Nottingham: University of Nottingham: Blind Mobility Research Unit.

James, G. A., & Gill, J. M. (1974). Mobility maps for the visually handicapped: A study of learning and retention of raised symbols. *AFB Research Bulletin, 27,* 87–98.

Jansson, G. (2003). Tactile maps—overview of research and development. In Y. Eriksson, G. Jansson, & M. Strucel (Eds.), *Tactile maps: Guidelines for the production of maps for the visually impaired.* Kalmar: Lenanders Grafiska.

Jansson, G., & Monaci, L. (2003). Exploring tactile maps with one or two fingers. *The Cartographic Journal, 40*(3), 269–271.

Jehoel, S., Ungar, S., McCallum, D., & Rowell, J. (2005). An evaluation of substrates for tactile maps and diagrams: Scanning speed and users' preferences. *Journal of Visual Impairment & Blindness, 99*(2), 85–95.

Jokiniemi, J. (2007). *Kaupunki kaikille aisteille – moniaistisuus ja saavutettavuus rakennetussa ympäristössä* [City for All Senses—Accessibility and Cross-Modality in the Built Environment] (p. 76). Espoo: Teknillinen korkeakoulu (Helsinki university of technology).

Juurmaa, J. (1959). Intermodaalisista lahjakkuustekijöistä [Intermodal talent factors]. *Ajatus: Filosofisen yhdistyksen vuosikirja* [Conception: The Annual of the Philosophic Association] *, XXII,* (pp. 93–113), Helsinki: Suomalaisen Kirjallisuuden Kirjapaino.

Juurmaa, J. (1973). Transposition in mental spatial manipulation: A theoretical analysis. *American Foundation for the Blind Research Bulletin, 26,* 87–134.

Juurmaa, J., & Lehtinen-Railo, S. (1994). Visual experience and access to spatial knowledge. *Journal of Visual Impairment & Blindness*, 88,157–170.

Järvinen, P., & Järvinen A. (2001). Qualitative, interpretive and new theories creating research. *On research methods* (pp. 62–87). Tampere: Opinpajan kirja.

Karentz Andrews, S. (1988). Applications of a cartographic communication model to tactual map design. *The American Cartographer, 15,* 183–195.

Karr, W., & Kemmis, S. (1986). Teachers, Researchers and Curriculum. *Becoming Critical: education, knowledge and action research* (pp.7–49). London: The Falmer Press.

Keates, J.S. (1982). *Detection and discrimination. Understanding maps* (pp. 28–40). London and New York: Longman.

Knott, N. J. (2002). *Teaching orientation and mobility in schools: An instructor's companion.* New York: AFB Press

Koenig A. J., & Holbrook, M. C. (2002). Literacy focus: Developing skills and motivation for reading and writing. In R. L. Pogrund & D. L. Fazzi (Eds.*), Early Focus: Working with Young Children Who Are Blind or Visually Impaired and Their Families* (2nd ed., 154–187). New York: AFB Press.

Kujala, T. (1996). *Brain plasticity shown by the processing of auditory and somatosensory information in blind humans.* Doctoral dissertation, Helsinki University, Helsinki, Finland.

Kujala T., Alho, K., Paavilainen, P., Summala, H., & Näätänen R. (1992). Neural plasticity in processing of sound location by the early blind: An event-related potential study. *Electroencephalography and clinical Neuropsychology, 84, 469–472.*

Kujala, T., & Hämäläinen H. (2006). Neurokognitiivinen muotoutuvuus ja sen rajat [Limits of neurocognitive plasticity]. In H. Hämäläinen, M. Laine, O. Aaltonen, & A. Revonsuo (Eds.), *Mieli ja aivot* [Mind and Brains] (pp. 421–429). Turku: Turun yliopisto, Kognitiivisen neurotieteen tutkimuskeskus; Gummerus Kirjapaino Oy.

LaGrow, S., & Weessies M. (1994). *Orientation & Mobility: Techniques for Independence.* Palmerston North: The Dunmore Press Limited, New Zealand.

Lahtinen, R. (2003). *Development of the Holistic Social-Haptic Confirmation System.* Licenciate thesis. (pp.15–17). Helsinki University, Helsinki, Finland.

Landau, B. (1986). Early map use as an unlearned ability. *Cognition, 22,* 201–223.

Landau, B., Spelke, E., & Gleitman, H. (1981). Spatial knowledge and geometric representation in a child blind from birth. *Science, 213,* 1275–1278.

Landau, B., Spelke, E., & Gleitman, H. (1984). Spatial knowledge in a young blind child. *Cognition, 16,* 225–260.

Lewis, S., & Iselin, S. (2002). A comparison of the independent living skills of primary students with visual impairments and their sighted peers: A pilot study. *Journal of Visual Impairment & Blindness,96,* 335–344.

Lewis, V., Collis, G., Shadlock, R., Potts, M., & Norgate, S. (2002). New methods for studying blind children's understanding of familiar space. *The British Journal of Visual Impairment and Blindness, 96,* 335–344.

Lincoln, Y., & Cuba E. (2000). The only generalization is there is no generalization. In R. Gomm, M. Hammersley, & P. Foster (Eds.), *Case study method: key issues, key texts* (pp. 27–44). London: Sage Publications.

Long, R. G., & Hill, E.W. (1997). Establishing and maintaining orientation for mobility. In B. B. Blasch, W. R. Wiener & R. L. Welsh (Eds.), *Foundations of orientation and mobility* (2nd ed, pp. 39–59). New York: American Foundation for the Blind.

Lorimer, P. (2002). Hand techniques in reading braille; synthesis of spatial and verbal elements of reading. *The British Journal of Visual Impairment and Blindness, 20*(2), 76–79.

Lowenfeld, B. (1948). Effects of blindness on cognitive functions of children. *Nervous Child, 7,* 45–54.

Marek, B. (1997). Before a blind child can read a map: First steps in tactile graphics. *Proceedings of ICEVI's 10th World Conference. Stepping Forward Together: Families and Professionals as Partners in Achieving an Education for All.* Brazil.

Marston, J. R. (2002). *Towards an accessible city: Empirical measurement and modeling of access to urban opportunities for those with vision Impairments, using remote infrared audible signage.* Unpublished doctoral dissertation, Univeristy of California, California.

McCallum, B., & Ungar, S. (2003). An introduction to the use of inkjet for tactile diagram production. *The British Journal of Visual Impairment and Blindness, 21,* 73–77.

McLinden, M. (1999). Hands on: Haptic exploration strategies in children who are blind with multiple disabilities. *The British Journal of Visual Impairment and Blindness, 17*(1), 23–29.

McNeill, C., & Renfrew, T. (1990). *Start orienteering with 6–8 year olds*, 1–16. Doune: Harveys.

McNeill, C., Ramsden, J., & Renfrew, T. (1987). *Teaching orienteering* (1–18, 22, and 79–80). Doune: Harveys.

Meyer, D. K., & Turner, J. C. (2002). Discovering emotion in classroom motivation research. *Educational psychologist, 37*(2), 107–114.

Miletic, G. (1995). Perspective taking: Knowledge of level 1 and level 2 rules by congenitally blind, low vision, and sighted children. *Journal of Visual Impairment & Blindness, 89*, 514–523.

Millar, S. (1976). Spatial representation by blind and sighted children. *The Journal of Experimental child Psychology. 21*, 460–476.

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

Millar, S. (1994). *Understanding and representing space: theory and evidence from studies with blind and sighted children.* Oxford: Clarendon Press.

Millar, S. (1995). Understanding and representing spatial information. *The British Journal of Visual Impairment and Blindness, 13*, 8–11.

Millar, S. (1997). Reading without vision. In V. Lewis & G. M. Collis (Eds.), *Blindness and psychological development in young children* (pp. 38–52). Leicester: BPS Books.

Miller, S.A. (2004). Piagetian research. In L. Nadelman (Ed.) *Research manual in child development* (pp.111–122). Mahwah NJ: Lawrence Erlbaum Associates, Inc.

Morrongiello, B., Timney, B., Humphrey, G.K., Anderson, S., & Skory, C. (1995). Spatial knowledge in blind and sighted children. *Journal of Experimental Child Psychology, 59*(2), 211–233.

Morsley, K., Spencer, C., & Baybutt, K. (1991a). Is there any relationship between a child's body image and spatial skills? *The British Journal of Visual Impairment and Blindness, 9*(2), 41–43.

Morsley, K., Spencer, C., & Baybutt, K. (1991b). Two techniques for encouraging movement and exploration in the visually impaired child*. The British Journal of Visual Impairment, 9*(3). 75–78.

Musselwhite, C. R. (1986). General training strategies for adaptive play. *Adaptive Play for Special Needs Children: Strategies to Enhance Communication and Learning* (pp. 19–32). Taylor & Francis Books Ltd.

Newcombe, N. S., & Huttenlocher, J. (2000). *Making space: The development of spatial representation and reasoning* (pp.1–11, 133–138 and 143-177). MA: The MIT Press

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

Nielsen, L. (1996). How the approach of guiding the hands of the visually impaired child can disturb his opportunity to build up strategies for tactile orientation. *The British Journal of Visual Impairment*, *14*(1), 29–31.

Norman, J. (2003). Tactile picture books: their importance for young blind children. *The British Journal of Visual Impairment, 21,* 111–114.

Norwich, B. (1999). The connotation of special education labels for professionals in the field. *British Journal of Special Education, 26*(4), 179–183.

Nummenmaa, L. (2006). Emootiotukimuksen mentelmät [Methods in emotion research]. In H. Hämäläinen, M. Laine, O. Aaltonen, & A. Revonsuo (Eds.), *Mieli ja aivot* [Mind and brains] (pp. 71–78). Turku: Turun yliopisto, Kognitiivisen neurotieteen tutkimuskeskus; Gummerus Kirjapaino Oy.

Ochaita, E., & Huertas, J.A. (1993). Spatial representation by persons who are blind: A study of the effects of learning and development. *Journal of Visual Impairment & Blindness, 87,* 37–41.

Ojamo, M. (2002). Näkövammaisuus ja näkövammarekisteri [Visual impairment and the register of visual impairment]. *Näkövammarekisterin vuosikirja.* (pp.1–3). Finland: Stakes and Näkövammaisten Keskusliitto ry.

Pavey, S., Douglas, G., McLinden, M., & McCalls, S. (2003). An investigation into the mobility and independence needs of children with visual impairment. Part 1: The development of a mobility and independence curriculum framework. *The British Journal of Visually Impairment, 21,* 4–9.

Perkins, C. (2002). Cartography: progress in tactile mapping. *Progress in Human Geography, 26*(4), 521–530.

Perkins, C., & Gardiner, A. (2003). Real world map reading strategies. *The Cartographic Journal, 40*(3) 265–268(4).

Petrie, H. (2005). Tactile inkjet mapping project (timp): A new printing technique for tactile graphics. Retrieved March 31, 2007, from www.csun.edu/cod/conf/2005/proceedings/2212.htm

Piaget, J., & Inhälder, B. (1977). *Lapsen psykologia* (M. Rutanen, Translated in Finnish). Jyväskylä: Gummerus

Pike, E., Blades, M., & Spencer, C. (1992). A comparison of two types of tactile map for blind children. *Cartographica, 29,* 83–88.

Portugali, J. (1996). The construction of cognitive maps. In J. Portugali (Ed.), *The Construction of Cognitive Maps* (pp. 1–7). Netherlands: Kluwer Academic Publishers.

Potter, L. E. (1995). Small-scale versus large-scale spatial reasoning: educational implications for children who are visually impaired. *Journal of Visual Impairment & Blindness, 89,* 142–152.

Pring, L. (1989). Getting in touch with pictures and words: Educational strategies for the blind. *International Journal of Rehabilitation Research, 12*(1), 57–65.

Publication Manual of the American Psychological Association (5th ed). (2001), Washington D.C.: American Psychologigal Association.

Riding, P., Fowell, S.P., & Levy, P.C.M. (1995). Action research approach to curriculum development. *Information Research, 1*(1). Retrieved April 4, 2008, from http://informationr.net/ir/.

Rieser, J. J., Guth, D. A., & Hill, E. W. (1982). Mental processes mediating independent travel: Implications for orientation and mobility. *Journal of Visual Impairment & Blindness,76*(6)*,* 213–218.

Rieser, J. J., Hill, E. W., Talor, C. T., Bradfield, A., & Rosen, S. (1992). Visual experience, visual field size, and the development of nonvisual sensitivity to the spatial structure of outdoor neighborhoods explored by walking*. Journal of Experimental Psychology,121*(2), 210–221.

Roberts, R., & Wing, A. M. (2001). Making sense of active touch. *The British Journal of Visual Impairment, 19*(2), 48–56.

Robson, C. (1993). Designing case studies. *Real world research* (pp.146-169). Oxford, UK: Blackwell publishers ltd.

Rose, R. (2007). Curriculum considerations in meeting special education needs. In L. Florian (ed.), *The SAGE Handbook of Special Education* (pp. 295–306). London: SAGE Publications.

Rouse, M., & McLaughlin, J. (2007). Changing perspectives of special education in the evolving context of educational reform. In L. Florian (Ed.), *The SAGE Handbook of Special Education* (pp. 85–103). London: SAGE Publications.

Rowell, J., & Ungar, S. (2003a). The world of touch: An international survey of tactile maps. Part 1: production. *The British Journal of Visual Impairment, 21,* 98–104.

Rowell, J., & Ungar, S. (2003b). The world of touch: An international survey of tactile maps. Part 2: design. *The British Journal of Visual Impairment, 21,* 105–110.

Saarela, M. (1995). Nappuloiden tutkimisesta yhteiseen peli-iloon. *"Miten tää pelaa"? – 5–6-vuotiaan kehitysvammaisen lapsen pelaamiseen orientoituminen* ["How does it go"—Orientation towards games in mentally retarded children aged 5–6 years] (pp. 176–200). Riihimäki: Kehitysvammaliitto ry. Valtakunnallinen tutkimus- ja kokeiluyksikkö.

Schenkman, B. (1985). Human echolocation: A review of the literature and a theoretical analysis. *Human echolocation: the detection of objects by the blind* (pp. 2–33). Uppsala: Uppsala universitet.

Sheppard, L., & Aldrich, F. K. (2000). Tactile graphics: A beginner's guide to graphics for visually impaired children. *Primary Science Review, 65,* 29–30.

Sholl, M. J. (1996). From visual inforamation to cognitive maps. In J. Portugali (Ed.), *The Construction of Cognitive Maps* (pp. 157–186). Netherlands: Kluwer Academic Publishers.

Skellenger A. C., & Hill, E.W. (1994). Effects of a shared teacher-child playintervention on the play skills of three young children who are blind. *Journal of Visual Impairment & Blindness, 88,* 433–445.

Skellenger, A. C., & Hill, E. W. (1997). The preschool learner. In B. B. Blasch, W. R. Wiener & R. L. Welsh (Eds.), *Foundations of Orientation and Mobility* (2nd ed. pp. 407–438). New York: American Foundation for the Blind.

Skellenger, A. C., Rosenblum, L. P., & Jager, B. K. (1997). Behaviors of preschoolers with visual impairments in indoor play settings. *Journal of Visual Impairment & Blindness, 91*(6), 519–530.

Smith, B. S., & Hill, E.W. (1992). The development of motor curriculum for preschool children with visual impairment. *Peabody Journal of Education, 67,* 41–53.

Spencer, C., & Travis, J. (1985). Learning a new area with and without the use of tactile maps: a comparative study. *The British Journal of Visual Impairment, 3*(1), 5–7.

Sonksen, P. (1993). Effect of severe visual impairment on development. In A.R. Fielder, A.B. Best & M.C.O. Bax (Eds.), The *Management of Visual Impairment in Childhood* (pp. 78–90). GB, Suffolk: Mac Keith Press.27

Stea, D., Blaut, J. M., & Stephens J. (1996). Mapping as a cultural universal. In J. Portugali (Ed.), *The Construction of Cognitive Maps* (pp. 345–360). Netherlands: Kluwer Academic Publishers.

Stratton, J. M. (1996). Emergent Literacy: A New Perspective. *Journal of Visual Impairment & Blindness, 90*(3) 177–183.

Strickling, C. A., & Pogrund, R. L. (2002). Motor focus: Promoting movement experiences and motor development. In R. L. Pogrund & D. L. Fazzi (Eds.), *Early Focus* (2nd ed, pp. 287–325). New York: American Foundation for the Blind.

Sudweeks, F., & Simoff, S.J. (1999). Complementary explorative data analysis: The Reconciliation of quantitative and qualitative principles. In S. Jones (Ed.), *Doing Internet Research. Critical Issues and Methods for examining the Net* (pp. 29–55). CA: Sage Publications.

Tatham, A. F. (2003). Tactile mapping: yesterday, today and tomorrow. *The Cartographic Journal, 40*(3). 255–258.

Tellevik, J. M. (1992). Influence of spatial exploration patterns on cognitive mapping by blindfolded sighted persons. *Journal of Visual Impairment & Blindness, 86*(5), 221–224.

Tellevik, J. M., & Martinsen, H. (1991). *Wayfinding and learning of spatial relations, the effects of different mobility and orientation strategies.* Paper presented at the International Mobility Conference 6, Madrid, Spain.

Thorndyke P. W., & Hayes-Roth B. (1982). Difference in spatial knowledge acquired from maps and navigation. *Cognitivie psychology, 14,* 560–589.

Thrower, N. (1996). *Maps and civilization: cartography in society* (245). Chicago: University of Chicago Press.

Tobin, M. J., Bozic, N., Douglas, G., Greaney, J., & Ross, S. (1997). Visually impaired children: development and implications for education. *European Journal of Psychology of Education, 12*(4), 431–447.

Tröster, H., & Brambring, M. (1994). The play behavior and play materials of blind and sighted infants and preschoolers. *Journal of Visual Impairment & Blindness, 88,* 421–432.

Turner, E. J., & Sherman, J. C. (1986). Construction of tactual maps. *American Cartographer, 13*(3), 199–218.

Tynjälä, P. (1991). Kvalitatiivisten tutkimusmenetelmien luotettavuudesta [Reliability in qualitative research]. *Suomen kasvatustieteellinen aikakauskirja: Kasvatus* [The Finnish pedagogical journal: Education]*, 22*(5–6), 387–398.

Ungar, S. (2000). Cognitive mapping without visual experience. In R. Kitchin, & S. Freundscuch (Eds.), *Cognitive mapping: Past present and future* (221–248). London: Routledge.

Ungar, S., Blades, M., & Spencer, C. (1993). The role of tactile maps in mobility training. *The British Journal of Visual Impairment, 11,* 59–61.

Ungar, S., Blades, M., & Spencer, C. (1995a). Can visually impaired people use tactile maps to navigate? *Proceedings of the 17th International Cartographic Conference,* Barcelona: International Cartographic Association, 2849–2853.

Ungar, S., Blades, M., & Spencer, C. (1995b). Mental rotation of a tactile layout by young visually impaired children. *Perception, 24*(8), 891–900.

Ungar, S., Blades, M., & Spencer, C. (1995c). Visually impaired children's strategies for memorizing a map. *The British Journal of Visual Impairment, 3*(1), 27–32.

Ungar, S., Blades, M., & Spencer, C. (1996a). The ability of visually impaired children to locate themselves on a tactile map. *Journal of Visual Impairment & Blindness, 90*(6), 526–535.

Ungar, S., Blades, M., & Spencer, C. (1996b). The construction of cognitive maps by children with visual impairment. In J. Portugali (Ed.), *The Construction of Cognitive Maps.* (pp. 247–273). Netherlands: Kluwer Academic Publishers.

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

Ungar, S., Blades, M., & Spencer, C. (1997b). Teaching visually impaired children to make distance judgements from a tactile map. *Journal of Visual Impairment & Blindness, 91,* 526–535.

Ungar, S., Blades, M., & Spencer, C. (1997c). The use of tactile maps to aid navigation by blind and visually impaired people in unfamiliar urban environments. *Proceedings of the Royal Institute of Navigation, Orientation and Navigation Conference 1997*. Oxford: Royal Institute of Navigation.

Ungar, S., Simpson, A., & Blades, M. (2004). Strategies for organising information while learning a map by blind and sighted people. In M. Heller & S. Ballasteros (Eds.), *Touch, Blindness and Neuroscience*. Madrid: Universidad Nacional de Educacion a Distancia.

Ungar, S., Blades, M., Spencer, C., & Morsley, K. (1994). Can visually impaired children use tactile maps to estimate directions. *Journal of Visual Impairment & Blindness, 88,* 221–233.

Ungar, S., Bayal, A. E., Blades, M., Ochaita, E., & Spencer, C. (1997). Blind and visual imapaired people using tactile maps. *Cartographic Percepectives, 28,* 4–12.

Uttal, D. H. (2000). Seeing the big picture: map use and the development of spatial cognition. *Developmental Science, 3*(3), 247–286.

Vygotsky, L. S. (1978). Interaction between learning and development. *Mind in Society* (pp. 79–91). Cambridge, Mass: Harvard University Press.

Warren, D. H. (1996). Coping with the environment. *Proceedings of the Eighth International Mobility Conference* (pp.133–147). Norway, Trondheim

Warren, D. H. (1994). *Blindness and children.* New York: Cambridge University Press.

Webster, R. (1976). A concept development programme for future mobility training. *The New Outlook*, 195–197.

Wheeler, L., Floyd, K., & Griffin, H.C. (1997). Spatial Organization in blind children. *Re:view Rehabilitation and Education for Blindness and Visual Impairment, 28*, 177–181.

*WHO/PBL/93.27. Management of low vision in children*. (1992). Retrieved February 9, 2009, from http://whqlibdoc.who.int/hq/1993/WHO_PBL_93.27.pdf.

Wilska, P. (2000). *Sokean lapsen leikki* [Play of the blind child]. Pro gradu-thesis. Helsinki University, Helsinki, Finland.

Wiener, W. R., & Lawson, G. D. (1997). Audition fort the visually impaired traveler. In B. B. Blash, W. R. Wiener, & R. L. Welsh (Eds.), *Foundations of Orientation and Mobility* (2nd ed., pp. 104–169). New York: American Foundation for the Blind.

Wood, E., & Attfield, J. (1996). The problems with play. *Play, learning and the Early Childhood Curriculum* (pp.1–15). London: Paul Chapman Publishing Ltd.

Yin, R. K. (1994). Designing case studies. *Case Study Research: Design and Methods* (pp.18–53), London: Sage publications.

Yin, R. K. (2003). *Case study research design and methods.* (3rd ed.). London: Sage Publications.

Yngström, A. (1999). *Orienteringskartor för synskadade*. Örebro: Tryckta Ark AB

# Appendix 1

PARENTS' QUESTIONNAIRE

YOUR OPINION REGARDING THE MAP PROGRAM
I would appreciate your feedback on the tactile map programme which I have practised with your child. Please evaluate the significance of the map programme using a numerical scale from 1 to 5 in the following way: 1 = not at all; 2 = somewhat; 3 = I cannot say; 4 = I agree somewhat; 5 = I fully agree. Circle the most suitable alternative in your opinion.

| | | Not at all | | | | Very much |
|---|---|---|---|---|---|---|
| 1. | The instructor informed me sufficiently | 1 | 2 | 3 | 4 | 5 |
| 2. | The programme included important tasks/items | 1 | 2 | 3 | 4 | 5 |
| 3. | The programme corresponded to the child's individual needs | 1 | 2 | 3 | 4 | 5 |
| 4. | The child learned new skills | 1 | 2 | 3 | 4 | 5 |
| 5. | I was content with my child's progress during the instruction | 1 | 2 | 3 | 4 | 5 |
| 6. | The map programme has affected everyday activities | 1 | 2 | 3 | 4 | 5 |
| 7. | The instructor gave sufficient information on the objectives of the child; it was possible to influence the objectives | 1 | 2 | 3 | 4 | 5 |
| 8. | The map programme can be used as a part of the preschool programme for a child with visual impairment | 1 | 2 | 3 | 4 | 5 |
| 9. | The number of lessons was adequate and with suitable intervals | 1 | 2 | 3 | 4 | 5 |

Additionally, you can answer the following five open-ended questions regarding the map programme (optional):

1. Did you have any expectations regarding the experiments in the map programme? Did the programme correspond to your expectations?

2. Can you name special skills that your child learned during the programme?

3. If the programme had an effect on your child's everyday life, can you describe how?

4. Do you have other ideas regarding the instruction in map use?

5. Do you want more information on certain matters?

## Appendix 2

The results of the questionnaire

| Form | Respon-dent | Name | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | home | Matti | 4 | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 4 | 4.33 |
| 2 | preschool | Matti | 4 | 5 | 5 | 4 | 4 | 5 | 5 | 5 | 5 | 4.67 |
| 3 | home | Eve | 4 | 5 | 4 | 4 | 5 | 3 | 4 | 5 | 5 | 4.33 |
| 4 | preschool | Eve | 4 | 5 | 5 | 5 | 5 | 4 | 4 | 5 | 5 | 4.67 |
| 5 | home | Lauri | 3 | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 4 | 4.22 |
| 6 | preschool | Lauri | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 4.67 |
| 7 | home | Timo | 4 | 4 | 5 | 4 | 3 | 2 | 4 | 5 | 4 | 3.89 |
| 8 | preschool | Timo | 5 | 5 | 5 | 4 | 4 | 4 | 5 | 5 | 5 | 4.67 |

The summary of the numerical scale

### OPEN QUESTIONS AND ANSWERS IN THE QUESTIONNAIRE

In the questionnaire, there were five open-ended questions regarding their opinions about the map programme. Answering was not obligatory, but all answered at least some of the questions.

1. *Did you have expectations regarding the experiments in the map programme? Did the program correspond to your expectations?*

Parents:
Three of the parents did not have many expectations because they did not know what the programme would involve. They seemed to find the programme interesting and the experiences were positive. One mother expected that the child, the parents and the teachers would have been given basic information on the maps, and on the tools to be used at home and at school after the programme ended.

Teachers:
Not so many expectations, because this activity was such a new concept. Nevertheless, the programme was a very positive experience.

The assistants expected to learn new teaching methods to help the children move around independently. Mental images by means of the maps would help to explain the preschool building as a whole. They also expected to get new points of view on their work, and new tools for helping children develop spatial understanding.
The programme corresponded to their expectations.

2. *Can you name special matters that your child learned during the programme?*

Parents:
The children learned map alignment, the proportions of objects, that a map can be used to describe the child's own room, directional concepts (in front of, behind, on the left), the changes in directional concepts when the child turns, and increased courage to move. The localisation of objects, especially in outdoor settings, improved, and the concept of the map became familiar and interesting.

The child began to ask about directions and about the features of the scenery when the family travelled by car. The child also began to feel more secure about spatial concepts.

The child began to understand that the map described the environment, and that the symbols depicted the real world.

Teachers:
Understanding about directional concepts increased, the child developed fine motor skills by building with Legos. The ability to track the embossed line developed and the interest in maps increased.

The child learned to 'look at the space' in a miniature, so it was not always necessary to explore the whole space concretely by trailing the walls, for example. The child was able to introduce the room to visitors by him/herself.

The child was keen on checking the alignment of the map and was able to correct the situation by rotating the map or turning him/herself.

*3. If the programme had an effect on your child's everyday life, can you describe how?*

Parents:
On the summer holiday, the child asked the parents to make a map of the route they were travelling. He/she was very interested if adults were talking and looking at maps.

The child brought home maps that were used at school; he/she made their own Lego map that depicted their room, and the teaching assistant in the school began to use tactile maps. The other staff in the preschool became interested in the maps and added them to the other children's programmes.

Teachers:
It was difficult to explain the effects on daily life but a comprehensive understanding about space and routes had become easier because of the maps. The school building was easier to introduce piece by piece by means of the map.

Independent travel on different preschool premises increased and the children became more able to execute their own ideas of moving around. The children outlined the space and were able to make excursions to visit other groups of children in day care.

Spatial perception generally increased. The teachers got new ideas about how to help children orientate in space (for example: previously the music box had been used for pointing directions instead of explaining the space as a whole to the children...)

*4. Do you have other ideas regarding the instruction in map use?*

Parents:
Map instruction could be a part of O&M instruction in a playful way.

Teachers:
Map games could also be carried out with all children in the preschool. This was done in two of the preschools that participated in the programme.

It was a good experience to take part in the teaching sessions, and the assistant and the teacher asked for teaching materials for further activities.

*5. Do you want more information on some particular matters?*

Parents:
Parents wanted more information on how they could make appropriate maps by themselves, how landmarks should be symbolized on the map, how parents could continue after the programme had ended.

Teachers:
Teachers wanted more information on how they should continue when the children changed groups, what would be appropriate teaching materials, how they could get models, how often map tasks should be repeated, and whether they could repeat the tasks used in the programme.

## LIST OF FIGURES