CAN VISUALLY IMPAIRED PEOPLE USE TACTILE MAPS TO NAVIGATE?

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Abstract
Tactile maps are a very useful way for visually impaired people to learn about their environment. However, psychological aspects of their use have been neglected in tactile map research. We report a series of studies in which visually impaired children performed various tasks using tactile maps. It was found that even quite young children can use tactile maps to navigate, but that certain strategies for exploring a tactile map and for organizing map information mentally were associated with better map reading performance. The implications of these findings for the education and rehabilitation of visually impaired people are discussed.

1 Introduction

Most research on tactile maps has focused on design and construction aspects such as legibility and discriminability of symbols and the relative merits of different tactile media. Much less attention has been paid to the psychological factors involved in the actual use of tactile maps. The ways in which information is acquired from maps and the processes for transforming this information action in the environment will certainly differ for visually impaired people relative to sighted people. Such factors are vital to anyone considering the provision of tactile cartographic materials for visually impaired people.

Previous research indicates that visually impaired people are severely impaired in their ability to gain an integrated representation of space from direct experience in large scale environments [1-6]. However, it is also clear that visually impaired people have the potential to acquire representations of space which are at least functionally equivalent to those of sighted people if they are provided with the appropriate kinds of experience. We argue that tactile maps are an extremely effective means of providing visually impaired people with information about the structure of space [4, 7, 8].

We argue for at least two main applications of tactile maps in the rehabilitation of visually impaired people. Firstly, tactile maps are an excellent means of familiarising visually impaired people with specific environments in which they have to navigate, such as a local urban area or a new building [9, 10]. Furthermore, tactile maps can be used in the education of young visually impaired children in order to improve their concept of space in more general terms. Despite these potential benefits, maps are used very little in the education of young children as it has widely been thought that the ability to understand maps as representations of the environment does not develop until about seven or eight years of age.

In a series of studies we have shown that young children, both sighted and visually impaired, can understand and use simple maps to estimate directions and distances and to locate themselves in the environment. It was also found that the strategies spontaneously used by participants while reading tactile maps played a decisive role in their ability to acquire accurate and flexible information from the maps.

2 Estimates of Direction

One important factor in the flexible use of maps is the ability to judge the bearing of a target location from the starting point of travel. It has been shown that visually impaired people have great difficulty in making such judgements when a large-scale space has been learned by direct locomotor experience (Rieser et al., 1986). We hypothesised that by using a tactile map, which directly presents information about the relative positions of locations, to learn about an environment, visually impaired children should be able to compensate for this difficulty.

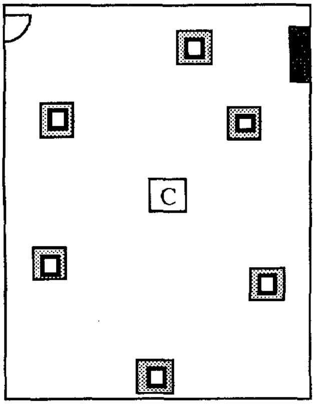

Figure 1: Example of a layout used in the direction estimation study.

In an experiment, 15 congenitally totally blind children and 23 children who had some residual vision in two age groups (4:10 to 7:11 and 8:2 to 12:3) were introduced to two large-scale environments either by direct locomotor experience or with a tactile map. The environments were constructed in a large school hall and consisted of large boxes each of which contained a unique toy (see Figure 1). In the first layout, children were initially led by the experimenter from the centre of the layout (C in Figure 1) to each of the landmarks in random order (Exploration Condition). The children were then asked to make direction estimates to each of the landmarks using a specially constructed pointer. Next, the children were given a tactile map of the same layout and allowed to explore it until they claimed to be familiar with it (Map -after Exploration- Condition). After this, the children were again asked to make distance estimates. About a week later, the procedure was repeated in the second, different layout, but this time the children were given the map first (Map Condition) and locomotor experience second (Exploration -after Map- Condition).

When they were introduced to a novel environment by direct experience, the totally blind children performed very poorly relative to the residual vision group. However the accuracy of their direction estimates improved dramatically when they were shown a tactile map of the same environment. Their performance was about the same when they saw a tactile map of the second environment and did it not deteriorate after they had received locomotor experience of the same environment. In contrast, the residual vision group tended to perform more poorly with the map than with direct experience.

The results indicate that congenitally totally blind children are less able than children with residual vision to gain a useful and coherent representation of an environment from direct locomotion. In contrast, however, it is clear that the totally blind children acquired a representation of the layout from the tactile map which formed the basis for relatively accurate direction estimates.

3 Estimates of Distance

Unlike sighted map users who can 'home in' on a landmark even from a substantial distance, visually impaired people rely on a range of strategies to keep them on course between two familiar landmarks. One of the most important of these is the ability to judge with some degree of accuracy the expected distance between two landmarks in the environment. It is therefore especially important that users of tactile maps can accurately establish distances from a map.

Figure 2: Example of one of the strip maps used in the Distance estimation study.

We carried out a study to examine the way in which blind children would approach the problem of estimating distances in the real world from a tactile map. Ten totally blind children and 16 children with some residual vision were divided into two age groups (5 to 7 years and 8 to 11 years). The children were shown a strip map representing three objects at different points along wall (see Figure 2). Once the child had studied the map carefully, she was led to the actual wall (15 metres long) and shown the first two objects, which were attached to the wall, and was encouraged to find the distance between them. Then the child returned to the map and was asked to work out or estimate the distance between the second and third objects, considering the relationships on the map and the actual distance walked between the first and second objects. Finally, the child was given the third object and asked to walk along the wall and to place the object in the correct relation to the first and second objects. The scale of the maps and the relative distances between the objects was systematically varied across sixteen trials.

Although there was no overall difference in the accuracy of distance estimates between the two sight groups, we found that the younger children were considerably less accurate than the older children. Therefore we considered the possibility of improving the children's performance through a simple training session. From video recordings of the children performing the task, we rated several strategies used by the children in solving the distance estimation problem, and from the most effective of these we formulated a single strategy which was used to train the children.

The children were asked to examine the map, comparing the distance between the first and second landmark with the distance between the second and third landmark. This was done by counting the number of fingers which could be fitted into these two spaces, and establishing how much longer or shorter the second part was than the first part. The older children were generally able to calculate the ratio mathematically while the younger children tended to characterise this difference in such terms as 'a bit longer' or 'much shorter'.

Next the children were asked to walk along the fence between the first and second objects, taking careful note of the distance they walked. The children were then shown how to use this information and the previous ratio calculation to establish how much further they should walk before placing the third object. This procedure was repeated until the children fully understood what was expected of them. The training session lasted about thirty minutes. Following the training, the children were tested as before, and it was found that training improved the performance of the younger children to the level of the older children.

4 Strategies for Knowledge Acquisition from Tactile Maps

When a print map is viewed by a sighted person, a great deal of information such as the relative and absolute positions of locations, the relative orientations of roads and the divisions between regions is instantly available. But the visually impaired map reader must discover this information by constructing it from sequential scanning of the map, forming reference frameworks and gradually establishing an overall, integrated impression of the map. For this reason it is important that a visually impaired map user has effective strategies for learning information from a tactile map.

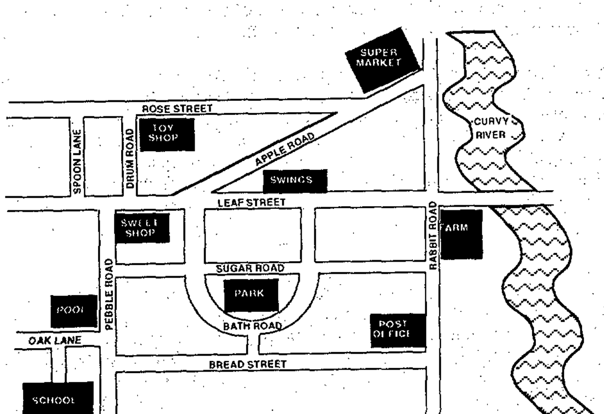

Figure 3: The map which the children learned. The tactile version was identical except that all the lines were raised and the labels were in braille.

In a further study, we examined the relationship between map reading strategies and the ability of map readers to acquire information from a tactile map. Nineteen children with visual impairments (VI) took part in the study; of these children seven were totally blind and twelve had limited residual vision. All usually read braille. Twenty-two sighted children also took part in the study so that comparisons could be made between the performance of the children with visual impairments and the performance of children with sight. The children were divided into three age groups: a young group (6 and 7 year olds), a middle group (8 and 9 year olds) and an older group (10 to 13 year olds).

A map of an imaginary town centre (30cm x 42cm) was constructed in tactile and print forms (see Figure 3). It included thirteen named roads, nine labelled places and a river. The materials also included a metal board (30cm x 42cm) and a box of magnetic pieces used for map reconstruction (see below). Pieces were provided to represent roads, places and the river - there were more than three times the number of magnetic pieces required to reconstruct the map.

The participants were shown the map for seven minutes and asked to learn it as accurately as possible. During this learning period they were asked to talk aloud about everything they noticed on the map and everything they thought about while they were trying to remember it (cf. 11, 12]. At the end of the learning period the map was removed and the participants were given the metal board and magnetic pieces and were asked to reconstruct the map from memory. Map elements were labelled for the participants, with braille and print labels, after they had named and placed each piece on the board.

After they had completed their first reconstruction, the metal board was photographed and the magnetic pieces removed from it. The participants were given the original map and asked to learn it again. They had a further seven minutes to learn the map (thinking out loud as they did so), then the map was removed and they were asked to reconstruct the map once more.

The participants learnt the same map for a third time and reconstructed it from memory on a blank board. All three learning and reconstruction periods were videotaped to provide a complete record of the participants' commentaries and performance. Each participant's third reconstruction was assessed in two ways - by measuring how accurately the features had been placed in their correct positions on the board, and by having independent judges score the reconstructions for how well they resembled the original map. In these ways it was possible to rate the participants' final reconstructions in terms of their accuracy and quality.

An analysis of the accuracy of the maps showed that there were no differences between the performance of the different groups of children with visual impairments, though these children were less accurate in reconstructing the map than the children with sight. There were no age differences in performance. However, there was a great variety of individual performance across sight groups.

The participants' commentaries were analysed for statements which referred to aspects of the map; methods of learning the map; intentions to use particular techniques; and comments about their own performance. There were ten categories of map learning including the use of mnemonics (e.g. rehearsing a list of names), making associations with map features (e.g. "this is like my school"), counting items on the map, repeatedly reading out names from the map, following a route through the map, looking for patterns of features (e.g. finding geometric shapes and other figures), and relating features to the map frame (e.g. by identifying an item as the one at the top of the map, or in the corner). Further sets of categories were used to classify the other aspects of the participants' performance.

A comparison of the learning strategies used by the VI children and the children with sight revealed that the children with visual impairments spent more time reading out names or tracing routes around the map, they also tended to describe shapes on the map without interpreting them as features, and they were more likely to bring in general knowledge which was not directly relevant (e.g. by making comments like "there should be a roundabout in the park"). In contrast, the children with sight more frequently mentioned the position of features on the map with reference to the frame of the map or relative to the position of other features, and they made more frequent comments about patterns formed by groups of roads or features on the map. These strategies were ones which emphasized the spatial relationships on the map, and may account for the greater accuracy of the children with sight.

A second analysis focused on just the VI children who read braille. A comparison was made between the strategies used by the seven VI children who produced the most accurate maps and the strategies of the seven VI children who produced the poorest maps. There were two significant differences in the way that these two groups of children learnt the map - the more accurate children more frequently related features to the frame of the maps and more frequently mentioned the relationships between features. In other words, the strategies of VI children who produced the most accurate maps paralleled the choice of strategies used by the other successful children in the experiment.

These results have important implications for teaching children the best ways to encode information from a tactile map. Strategies such as those used by good map learners could, in principle, be used to train children to interpret tactile maps (and other tactile graphics) more effectively.

5 Conclusions

In summary, visually impaired children are able to use tactile maps to perform simple spatial tasks such as estimating directions and distances in a large-scale environment. Furthermore, children's map using performance can be improved by training in a more effective strategy. Children differ greatly, both across and within sight groups, in their ability to acquire a faithful representation of a map. These differences can largely be accounted for by differences in the strategies children use to explore the map and to organize information from it.

These and other studies [9, 10] indicate that tactile maps are an extremely effective means of familiarizing visually impaired people with their spatial environment and of introducing visually impaired children to the structure of space in general. We propose that instruction in the use of tactile maps should form an integral part of the school curriculum for visually impaired children, and that they should be encouraged to relate maps of different areas to the spaces they represent (from their classroom to their home town).

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