

SURVEY

REFEREED PAPER

Real World Map Reading Strategies

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INTRODUCTION

This paper reports an ongoing series of investigations into the nature of tactile map reading and use. There is general agreement that reading maps for sighted or visually impaired people involves a three stage process in which visual or tactile signs need to be detected and discriminated prior to being interpreted (Perkins, 2002). Researchers also concur that the tactile reading process is less precise than sight and it has been suggested that tactile map reading is best theorized as a serial process, in which the fingers follow raised symbols and gradually build up an overview of spatial relationships (Tatham, 1991). In contrast sight allows information to be processed as whole rather than the sums of parts. There has however been little investigation into the 'ecology of reading' or detailed observational studies of the strategies involved in real world use of tactile maps. Advice about the best techniques to use is general and often not backed up by systematic empirical evidence. Nolan and Morris (1971) suggest that tactile map reading should start from the edges of the image and with a gross scan of the map, to be followed by using both hands to trace map detail. In contrast studies by Berlà and his associates recommend the use of just the index finger (Berlà & Murr, 1976a and b; Berlà, Butterfield & Murr, 1976). Bentzen (1980) encourages the use of free exploration of the map's detail, whilst Kikuza (1989) suggests gaining an overview, with systematic investigation using two hands, followed up by more detailed investigation. Best (1992) also suggests using two hands.

One reason for this contradictory advice is likely to be insufficient attention given to the wider context of map reading, in other words how, when, and where the map is used, and who is using it. Table 1 shows that there are diverse influences, reasons and contexts for use that impact upon reading. By 'placing' the reading process we might be able to gain a more informed understanding of which strategies work best.

This paper is concerned with documenting how tactile maps are read in a real world context and offers a framework for deciding on the 'best' methods of reading a tactile map. It implicitly adopts a cultural and ecological stance informed by observing how visually impaired individuals relate to tactile maps, rather than one derived from con-

Table 1. Factors influencing reading strategies

Timing	Prior During After
Sighted guidance	Assisted Unaided
Context of use	Free Constrained Rule bound
Reading environment	Real world
Complexity of image	Lab Real maps Simplified

trolled and simplified experiment. We are concerned with a number of possible strategies. For example should both hands be used and in the context of our work is index finger alone best? We are also concerned with the similarities between map use for visually impaired and sighted people and the potential uses that visually impaired people might make of maps. What 'real' difference does sight make? Broadly these questions might be reduced to an investigation of how reading and use are linked, whether universal recommendations are possible and perhaps crucially what the implications might be for education and training.

CASE STUDY METHODOLOGIES

The research reported here is drawn from a series of investigations of recreational and educational map use involving a mix of directed and free reading, guided and unaided, before during and after a number of activities in areas of managed countryside in the North West of England. Case studies were carried out during golf tournaments, and in country parks. Vacuum form-based maps were designed to serve as working representations with differing complexities following practices detailed in Gardiner and Perkins (2002). More information about the case studies is given in Gardiner (2001).

Multiple methods were employed in the case studies for the collection and analysis of data. For the reading case study reported here 16 visually impaired map readers used

the maps to plan routes across a country park. Video recordings were made of individual map reading, complemented by still photography. Map readers were encouraged to talk aloud about their reading during the process. In some contexts a more extensive questionnaire was used to generalize results.

From the video and audio evidence types of reading were identified and coded. The time sequences and frequency of links between categories were analysed and follow up interviews were used to tease out explanations for reading behaviour that could be related to use. A number of different indices were used to judge the 'best' reading strategies and in the main these were derived from spoken comments. For example success might involve identifying a symbol and relating it to an environmental feature, or it might involve more complex route planning activities.

RESULTS

There are many different ways of reading a tactile map (see Figure 1). The hands may be employed singly or together and may be fixed or move across the map. They

may be held flat, with the palm used to gain an overview. The fingertips are clearly, however the most important sense organs in tactile map reading. Our readers used a single finger for fine discrimination of raised detail, with up to four fingers for exploration. A pincer movement of a single finger with the thumb was sometimes used for sensing point symbols.

The use of fingers or hands seemed to be directed towards a number of functional activities. Distances were estimated by using the width of one, two, three or sometimes four fingers in combination, or sometimes a span between a finger and thumb or between two fingers. For gross exploration of the layout of the map the whole hand seemed to be employed, with palms as well as fingers gathering information. Sometimes people used their fingers constantly to move over the surface of the map, whereas at other times fingertips repetitively tracked back and forward along a symbol. Tracing a line was a common approach, and some visually impaired readers used the fingertips to walk across the image. Figure 1 illustrates some of these techniques.

Tables 2 and 3 show the frequency of reading strategies and also indicate whether the technique appeared to be a

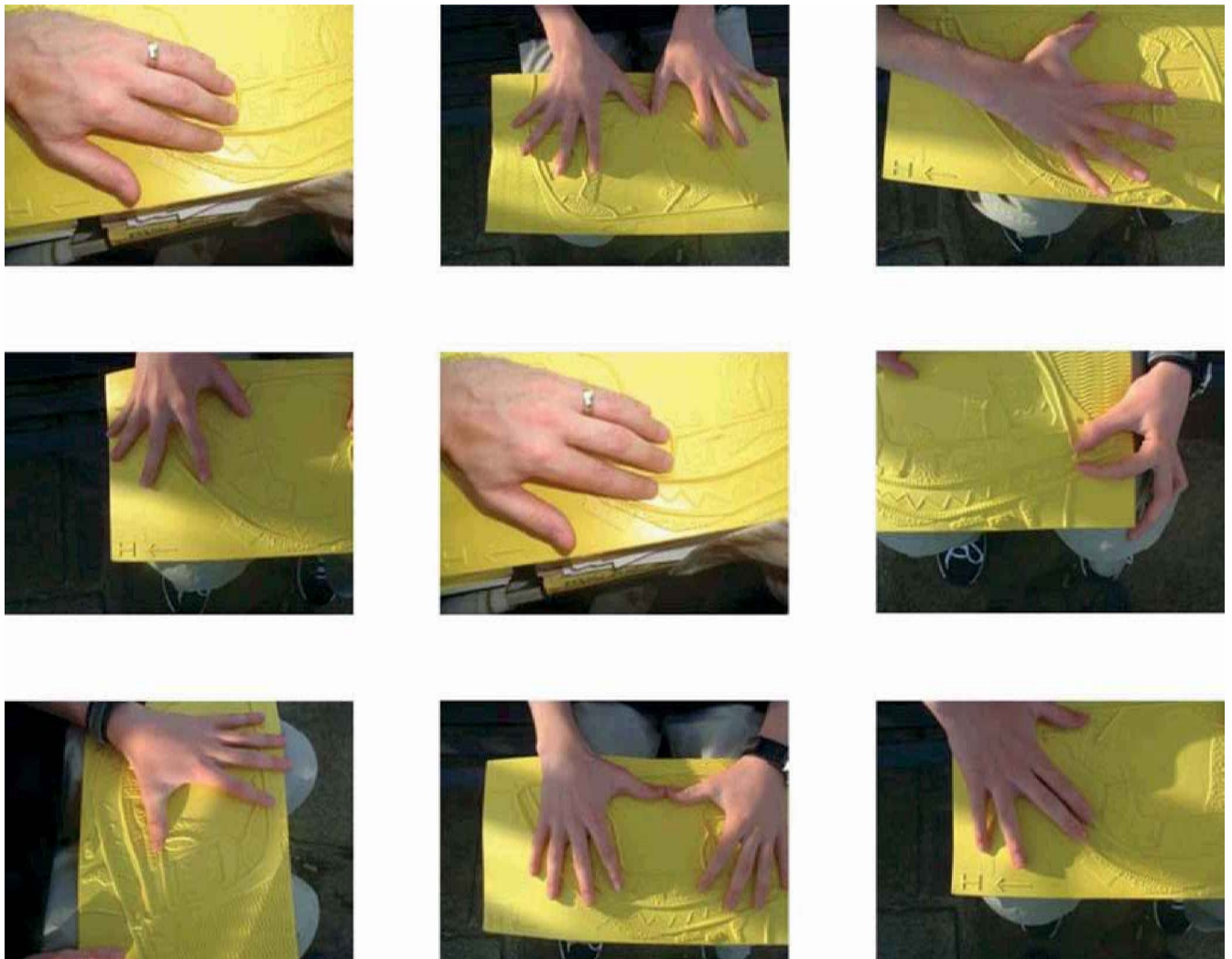


Figure 1. Map reading strategies

Table 2. Successful tactile map reading techniques

Technique	Success	Frequency of use
Constant exploration	✓	Most frequently used
Both hands	✓	
4 fingers together	✓	
1 finger for detail	✓	
Whole hand flat	✓	
1 fixed other moves	✓	
1 hand	✓	
Repetitive movements	✓	Least frequently used

Table 3. Other less frequently used techniques

	Success
Span for shape	✓
Span for distance	✓
Pincer	?
Finger width for distance	X
Thumb fixed	X
Thumb explores	X
Walking fingers	X
Thumb to trace	X

successful approach for our readers. Children, who were sometimes playing with the map rather than reading it in a functional way, demonstrated the least successful strategies in the sample.

IMPLICATIONS FOR READING STRATEGIES

An interesting result in our study was the common use of both hands and of more than one finger. There are significant advantages in terms of the amount of information that can be processed if more than one finger is used to read. Our results imply that the amount of information provided and processed by readers does indeed depend upon the number of fingers used. In our studies four fingers seem to be more effective for some reading tasks than just index finger, an interesting contrast to Berlà's (1976a and b) results. Perhaps there is a more obvious analogy with eye movement studies than has been suggested in the past? Sight may appear to offer synoptic possibilities, but in practice is still a serial perceptual process. The precision and speed that come with sight create the difference and make it *appear* that sight offers a synoptic reading, unlike the very slow and coarse tactile sensing of information.

Our map readers processed tactile edges early and these received most attention in the reading process. Paths and land use boundaries were examined in detail, large areas of consistent textures received less attention. It might be argued that the importance of edge processing is a function of the production technology employed. Vacuum formed maps support multiple levels and clearly discriminated textures: perhaps edges become more important simply because they may be read more easily (Gardiner, 2001)? However research suggests edge processing plays an important cognitive role in sighted map reading (MacEachren, 1995) and these arguments would equally apply to the tactile process. So its significance is likely to be independent of the production system and design.

These results imply that tactile designers ought to pay particular attention to the representation of textural contrast and to how levels interact in the tactile map. Perhaps too much attention has been given to the design of individual symbols and too little to the interaction between symbols?

Some obvious associations were clearly observed, notably that when two hands were used, one was often fixed as an anchor, but in general there were no clear associations between type of reading and articulated reason for employing that method. The maps were complex representations and the unstructured tasks carried out in real world map reading meant it was difficult to draw firm conclusions in this area. We were also unable to identify the better overall map reading strategies.

We suggest a pragmatic approach rather than a single best method.

1. Methods should follow context rather than being prescribed. For example the question of whether one or two hands should be used is clearly a function of whether the map has to be held, whether it is to be used indoors or outdoors, in warm, cold, wet or dry weather. Children have different expectations and responses to adults. A simple map may be successfully read with a single hand, whilst a larger more complex image might best be read with two hands.
2. If context matters then the views of the visually impaired map reader matter too: design, reading and use ought to empower them, to enable rather than impose standards (Perkins and Gardiner 1997).
3. In the contexts we explored (free and unaided use with complex maps in the field) the best map readers employed a mix of single finger, multiple fingers and whole hand-based techniques, but explored in a systematic manner, investigating the whole image first, then processing the edges and finishing by filling in the detail.
4. A number of other important factors influenced the strategy used. Knowledge of the area or of the map design alters the reading strategy and prior training clearly also influences readers to adopt differing approaches. Differing abilities in map reading seem to be related to the strategy. Readers who articulated most links were also the most effective readers. The least systematic found it hardest to achieve task success.

This focus upon the nature of the connections between map reading tasks mirrors the results of a study of orienteers using maps to articulate navigational decisions (Crampton 1992). His conclusions about differences in map use between sighted experts novices strike a chord in our tactile reading research and prompt questions about the supposed differences between tactile and sighted perception.

IMPLICATIONS FOR USING TACTILE MAPS

So far as the similarities between tactile and sighted map use are concerned our research offers optimistic conclusions. The tasks involved in reading and using tactile maps are similar to those employed by sighted people. The uses to which maps may be put also seem similar for visually

Table 4. Comments on the use of tactile maps made by users in the field

Explore
Search
Locate symbol
Follow line
Trace route
Recall route
Locate self on route
Relate self to land feature
Relate land feature to land feature
Relate map to land in the field
NSEW
Scale
Direction egocentric
Comparison
Anticipation
Interpretation
Route visualization
Layout visualization
Enhancement
Independence
Emotion
Imagination

impaired and sighted people. Both groups are able to choose appropriate maps, use short term memory to scan the image, understand abstract symbols and the ways in which maps generalize data. Both sighted and visually impaired users can interpret scale and understand orientation and direction. Both can distinguish land cover and interpret the symbolic representation of the tactile or conventional map. Both are able to use the map as a way of updating existing knowledge about the world.

Table 4 shows some of the kinds of observed use that we videoed in our case studies: clearly these do not differ significantly from the kinds of use of sighted maps documented by researchers such as Catling (1980).

We would argue therefore, that the well documented differences between tactile and sighted map use are more a function of social than perceptual or cognitive factors. As a result of limited tactile map availability and many poor designs, negative views prevail about the potential of tactile maps. Visually impaired people have low expectations of tactile maps and only rarely have much experience of relevant training in reading skills.

CONCLUSIONS

Our research has drawn attention to the need for complex and individual strategies to be employed by individual readers of tactile maps. We suggest that the most successful readers make most links and articulate a more strategic approach, and that the best approaches are likely to vary according to context and product. We believe the similarities between *potential* uses by visually impaired and sighted people are a reason to be optimistic, but caution that the social context of tactile map use remains a significant limit-

ing factor. Universal training solutions are just as unlikely to be appropriate as universal map design solutions: the context matters and more real world research involving the opinions of visually impaired people is needed to determine the best approaches for different groups, different representations and different user tasks.

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