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Progress reports

Cartography: progress in tactile mapping

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For this first of three progress reports on cartography, I am going to focus upon research into tactile mapping for visually impaired people, published since Fleming's (1990) review. This specialist field is often perceived as marginal to more mainstream cartography; production is often informal and receives no attention in Parry and Perkins (2000), the latest benchmark survey of the state of world mapping. Key themes in the tactile mapping community, however, reflect current concerns in the wider worlds of cartographic research. Six topics are reviewed here. How might spatial understanding differ among visually impaired people, and how might this be linked to map use? How does the 'real-world' practice of tactile map design vary according to context? To what extent has the increasing emphasis on standardization also applied to tactile mapping? How is technological change affecting tactile map production? Are hard-copy tactile representations still relevant in the digital and multimedia age? Finally, given the cultural turn in geography and more critical emphases among historians of cartography, how relevant are ethical issues in tactile map research?

I Cognitive research and map use

In the last decade, one of the most important topics of tactile mapping research has focused on psychological investigations of spatial representation (Millar, 1994) and wayfinding abilities (Golledge, 1999) of visually impaired children and adults (for reviews in this area see Kitchin *et al*., 1997; Ungar, 2000; Jansson, 2000). Most of the work carried out has been laboratory-based and has investigated small-scale and artificial environments. These experiments have tended to confirm the view that blind people have the same cognitive spatial abilities as sighted people, but that their configurational knowledge is less complex owing to differing access to information and past experiences (Golledge, 1993). It has been suggested that use of tactile mapping can significantly improve visually impaired people's cognitive maps and can help their wayfinding and environmental knowledge (Blades *et al*., 2000).

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More recently, an increasing emphasis has been placed upon larger-scale and real-world environments (for example, Golledge *et al*., 1999; Kitchin *et al*., 1998) and the role that tactile maps might play in their understanding (Ungar *et al*.,1994). Visually impaired children and their mapping skills have been the focus of many of these studies. Research has addressed distance estimation using maps (Ungar *et al*. 1994; 1997a), map-memorizing strategies (Ungar *et al*., 1995a), the recall of symbol layout and alignment (Ungar *et al*., 1995b), self-location (Ungar *et al*., 1996) and the role of mapping in informing route knowledge (Edwards *et al*., 1998). Real-world investigation of visually impaired adults has focused upon wayfinding and map-reading strategies. Investigations have compared the success of direct experience and tactile mapping in route learning in Sheffield and Madrid (Espinosa *et al*., 1998; Ungar *et al*., 1998), and have documented spontaneous strategies used by blind map-readers (Ungar *et al*., 1997b). The wider context of map use by visually impaired adults is discussed by Blades *et al*. (2000). Other work has investigated the context in which a tactile map might be used, comparing use before and during travel (Bringhammar *et al*., 1997) and addressed different ways of assessing cognitive map knowledge (Jacobson, 1998). Many of these studies conclude with an educational justification for the research: more informed knowledge of cognitive issues should lead to better mobility training in particular during school years (Ungar *et al*., 1993; Blades *et al*., 2000).

II Map design

Descriptions of map design and construction predominated in the early years of research into tactile mapping and there is a continuing emphasis upon different designs, contexts and uses. A common feature of research continues to be state-of-the-art overviews of national progress. In the last five years, for example, papers have contrasted the state of the art of mapping in Tanzania (Mtaroni, 1999), India (Kumar, 1999), Japan (Ohtsuka *et al*., 1997), Slovenia (Rener, 1996) and Argentina (Amenguel and Cuppi, 1997), in addition to the wealth of reported western European, North American and Australasian research.

The context in which tactile maps are produced is clearly relevant, and while it varies from nation to nation is almost always significantly different from conventional mapping practice (see, for example, Perkins and Parry, 1996, on the UK). Tactile mapping is characterized by limited print runs, with design and production often strongly influenced by national blind charities, and almost no conventional market mechanism influencing practice. As a consequence there is almost no 'commercial' production. 'Enabling' legislation facilitating access, and the existence of a mobility training infrastructure are also powerful influences (see Blasch *et al*., 1997, for the definitive guide to mobility issues in an American context).

Tactile mapping is also much more likely to be available for public urban space and to focus upon mobility. Recent examples of research have emphasized university campuses (Golledge *et al*., 1991; Hudson, 1998; Jacobson, 1992; Koch and Liebmann, 1995; Perkins, 1999), shopping centres (Tatham, 1990) and public-transport mapping (Landau, 1999; Luxton *et al*., 1994). A recent innovation in this area has been to extend mobility maps to the inside of buildings, including research on whether a path- or wall-based symbology is most appropriate (Holmes and Arditi, 1998). The very different requirements of route-based mapping, as against maps of areas, have also received attention (Golledge, 1991).

There has been very little research into appropriate designs for thematic tactile mapping; Blok (1993) is one of the few papers in this area. A series of papers have recently, however, begun to suggest a wider diversity of tactile designs, extending tactile mapping to orienteering (Gardiner, 1998b), canal towpaths (Gardiner and Perkins, 1996a), golf courses (Gardiner and Perkins, 1996b) and country parks (Gardiner, 1997). The wider context of designing reference maps for use in education has been explored by Wild *et al*. (1997), and Gardiner (1998a) discusses the role of tactile maps in environmental education.

III Standardization

Work on tactile standards falls into two rather different strands, but neither has yet led to the kinds of international agreement increasingly found in the design of digital map databases used for visualization by sighted people.

On the one hand there are those who wish to encourage the use of standardized tactile symbols, usually linked to a specific production technology. Such approaches have a long research history, dating from pioneering work carried out in Britain at the University of Nottingham (James and Armstrong, 1976). The Nottingham kit continues to be widely used in urban contexts, and was enhanced in 1988 by the European-wide acceptance of the Euro Town Kit, of 28 tactile symbols appropriate for urban tactile mapping (Laufenberg, 1988). Other de facto standardization has been encouraged by the increasing acceptance of standard works on design, such as Edman (1992).

A number of recent initiatives are exploring ways of developing this work. Tatham (2001) discusses recent progress in these fields. There are, for example, plans for an international Database of Tactile Symbols, that would be disseminated across the world wide web to include information about dimensions, context of use and the most appropriate production technology for each symbol (Tasker, 2000).

A second strand of research into standardization has emphasized presentation of mapping and seeks to codify good practice in the wider issue of map design, rather than focusing upon individual symbols (Law, 1988). It has been argued that guidelines for design are needed that are independent of production technology, since resources and infrastructural support are likely to vary greatly (Tatham, 1999). National organizations for visually impaired people have published guidelines for the design of graphics, notably American Printing House (1997) and the American National Library Service for the Blind (Corcoran, 2000). Other national initiatives in this area include the establishment in 1999 of the National Centre for Tactile Diagrams at the University of Hertfordshire, which offers advice to designers of mapping and other tactile diagrams (NCTD, 2001). Attempts are being made to bring together some of these national examples of good practice, notably in the Tactile Graphics Project, established in 2000 by the International Council on English Braille to coordinate research in tactile graphics design and write production guidelines at an international level (ICEB, 2000). The debate on the need for standards looks set to continue.

IV Production technology

The technology used for the production of tactile maps is significant because it profoundly affects use and is closely linked to symbol design. Gardiner (2001) highlights the advantages and problems of four main 'families' of production technologies: multitextural, etching, embossing (hand, machine and print based) and vacuum-forming. The vast majority of hard-copy tactile graphics are still produced using vacuum-forming and microcapsule or foam ink-based systems. These continue to predominate, despite significant progress with electronic mobility aids. Few papers have been published in the last decade about the application of these technologies and little systematic comparative evaluation has been carried out (see Perkins, 2001, for a review of the limited literature in this field). Contradictory results from comparative trials reflect research context and design. For example, the often-quoted comparative analysis by Nagel and Coulson (1990) cites significant preferences for the use of microcapsule paper, whereas Gardiner (2001) reports multilevel graphics generated in thermoform offering significant advantages.

A number of recent papers highlight innovations and applications. One of the major problems with mass production of thermoform-based mapping lies in the time to create master moulds. Dahlberg (1997) comments upon the potential of machine routing of masters, in conjunction with a GIS application, and Gardner (1996) reviews American progress in this area. Another key problem with graphical information lies in the difficulty of merging braille with raised graphics. Two rather different solutions address this issue. Lange and Reeves (1999) describe a new type of inkjet printer developed with EU funding and in collaboration with a commercial vendor. This PRINT project deposits raised dots and graphics onto the same page. In contrast the TIGER system is a new Windows-based graphics embosser, commercially available through Viewplus technologies (Walsh and Gardner, 2001). Other new technologies under investigation in 2001 include systems capable of generating multilevel symbols of PVC gel applied to a substrate using computer-driven printing equipment; CAD-driven wax printing systems and new printers capable of raising microcapsule line work in a single pass (Gardiner, 2001). Innovation is likely to continue.

V Dispensing with, or enhancing, the map: technological fixes

The lack of appropriate map data, and the need to generalize existing digital data to create discriminable symbols, are major barriers to the mass production of tactile mapping (Tatham, 1991). At the start of the 1990s drawing and mapping software came to be widely used for the design of tactile map masters (see, for example, Theissen, 1999), and the first attempts were made to generate appropriate symbols from GIS (Coulson, 1991). Since then a number of research projects have sought automatic derivation of tactile mapping from digital map data (for example, Sheppard, 1996, on Ordnance Survey data; Ohtsuka *et al.*, 1997, on Geographical Survey Institute data in Japan; and Michel, 1997, on German ALK data). Others have focused upon the use of GIS to support mobility (Jacobson and Kitchin, 1997; Clark, 1997; Golledge *et al.*, 1991).

The most revolutionary changes, however, lie with the development of Personal Guidance Systems, that combine GIS, digital mapping and GPS-based locating technology with multimedia user interfaces comprising, for example, synthesized voice output, virtual auditory displays or tactile route output (Jacobson, 1994). Pilot systems continue to be developed, notably by Golledge and his colleagues at the Santa Barbara campus of the University of California (Golledge *et al*., 1998; Loomis *et al*., 2001). Other guidance systems also incorporate audio output, GIS and GPS technology, notably Atlas Speaks and Strider, developed by Arkenstone in the mid-1990s (Lapierre, 1998) and currently available through Sendeco (May, 2001). Meanwhile European collaboration in the mid-1990s saw the development of GPS and GIS technologies with auditory output in the MOBIC project, incorporating pre-journey and outdoor systems (MOBIC Consortium, 1997). Alternatives to GPS-based wayfinding rely upon radio beacon-based local information systems. A recent example is the Auditory Location Finder system described by Hine *et al*. (2000).

A rather different strand of technology-led development has used touch tablets to integrate sound and tactile displays, but without navigational support. The NOMAD system was the first of a number of applications in this area (Parkes, 1988). Numerous NOMAD maps have been developed across the world (see Hudson, 1998, for a recent application). Other multimedia developments include the TACIS project, which focused upon touch, tone landscapes and voice overlays (Lange, 1999). This technology has been used in a multimedia information system for blind people in European cities, with the first pilot prepared for Dublin (Gallagher and Frasch, 1997). Other systems of talking kiosks are already operable in the USA and use similar combinations of touch and audio output (Landau, 1999).

Integrating multimedia displays with virtual-reality technologies is the latest research focus. The potential of using these technologies in teaching mobility skills is explored by Krueger and Gilden (1999) and by Jacobson and Kitchin (2002), and its possible use for improving the design of conventional tactile mapping has also received attention (Cheesman and Perkins, 2002).

VI Ethics

In 1999 John Gill, Chief Scientist at the RNIB, and strongly influential in the development of technology-led initiatives, recognized that ‘although numerous electronic mobility aids have been developed over the last twenty five years, none have proved popular with more than a handful of users’ (Gill, 1999: 1). Despite the research emphasis upon high-technology solutions, most blind people do not use them. In addition most are not even aware of the potential of simpler and more traditional hard-copy tactile maps. It has been suggested that the ethics and practice of research into tactile mapping can explain this lack of real-world application (Perkins and Gardiner, 1997).

Almost all research on tactile mapping is carried out by sighted people, and largely in a western and urban context. Most takes place in the academy, rather than outside in the community. Research quality is judged by academic criteria, not by the contribution to quality of life. It has been argued that this emphasis is implicitly positivist and technocratic, and based on an inappropriate medical model of disability, that ignores the wider social constructions of visual impairment (Gleeson, 1999). The positionality of the researcher has recently been problematized, and it has been argued that the blind subject's view of the world should be given greater emphasis (Butler and Bowlby, 1997; Kitchin, 1999). Reflecting this change of emphasis, recent work has sought to discuss with visually impaired people how they 'see' the world (Golledge, 1997; Johnson and Petrie, 1998; Kitchin *et al*., 1998; Pow, 2000).

Practical ways of involving visually impaired people in the design of mapping have also been described (Perkins and Gardiner, 1997; Gardiner, 2001), and bottom-up approaches to mobility mapping have been developed (Matthews and Vujakovic, 1995). However, most reported initiatives are from the developed world and fail to address the needs of visually impaired people living in villages in developing countries (Mtaroni, 1999). A more relevant and practical approach in a poor third-world context may be to use whatever materials are available for the production of mapping and mobility aids, rather than impose western notions of design standardization or technology (Tatham, 1999).

Perhaps, as Gardiner (2001) suggests, researchers should focus more on the social context of map use, and let that drive design decisions, instead of spending large research grants on often inappropriate technological solutions.

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