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On the theoretical basis of tactile cartography for the haptic transformation of historic maps

Keywords: Tactile maps; haptic perception; Ptolemy map.

Summary

The theoretical basis on which historic cartography transformed in tactile form can be used for the educational and cultural improvement of visually impaired people, especially from the younger generation, is reviewed in this paper offering the grounds for the production and testing of some experimental tactile maps representing in generalised form some of the milestones of the history of map-making. It is presented a Ptolemy-type map of Greece, which is produced in tactile form in order to test the validity of relevant theoretical references composing and encouraging the usefulness testing of such maps.

Introduction

The majority of people have used a map to collect information, find the position of selected information, orientate, map out routes, calculate distances between places, and help themselves become familiar with a region. People with visual impairment are unable to collect the external visual stimuli from the environment or to use conventional maps. So, the importance of tactile maps as informational, orientation and educational means is undoubted (Papadopoulos 2004). This last attribute of tactile maps emerges more strongly in the teaching of history and geography courses.

In recent years, there has been an effort to give the blind access to all the cognitive media that sighted people have access to, starting from their school education. Maps are undoubtedly such a medium. Historic tactile maps can be used as a teaching aid, since their introduction into the education of the blind can significantly improve their knowledge of *historic space* and create new standards for their education. The teaching of history also includes an understanding of the natural and socio-cultural environment. Thus, the map is currently a necessary tool for teaching practice. According to Leontsinis (1995), the role of the historic map is directly related to basic historic information that provides the student with a solid foundation for his/her knowledge, since the map is a medium for the schematic presentation of the historic material. The main help historic maps provide in the teaching of history is instructive and efficient communication, compared to that offered by everyday words and concepts.

In this domain, another fold of using historic maps can be also used for the enrichment of the cultural formation of people with visual impairment. This is related to the possibility to give the blind the opportunity to feel how geography was displayed in early maps and

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what was the technological level of representing cartographically the geographic features of the earth's surface with respect to the actual representations. In this paper we demonstrate a relevant example carried out in order to give the blind an access to 'see' the coastline of Greece as it is represented in an early depiction of Ptolemy's *Geographia*, giving first some fundamentals from the theory of haptic perception and tactile graphics.

Haptic perception and tactile graphics

A major mean of enabling a blind person to communicate with the surrounding space is the tactile map. Tactile map has raised graphic patterns that are recognizable by touch. The blind user perceives the information graphed on the map by feeling the elements of the map with the fingertips. For the education of visually impaired people and for their space comprehension, 'touch' is considered as basic modality for selecting information. Recognition through touch is not direct, as in the case with sight. First, we see the whole, and then we observe its parts. However, in the sense of touch, the construction of the whole is a mental process that takes place after the perception of the parts (Revesz 1950). Several writers, Piaget among them, have noted that the development in haptic exploratory characteristics is similar to that in visual exploration, with haptic development following a timetable that is comparatively delayed. Much of this delay may be related to the characteristics of the receptors for the two modalities (Piaget 1953). Two important differences are obvious (Warren 1982): The first is related with incapability of hands comparing them with eye movements. Hand and its fingers are more cumbersome than the eye, making explicit that visual system is better and earlier prepared to make the fine muscular adjustments needed for regular and rapid exploration of stimuli. Second difference related with spatial distribution of receptors in the eye - that is more conducive than that on the hand to the simultaneous registry of spatially distributed stimulus arrays. Peripheral field of vision allows the synchronised import of spatial relationships, in contradiction with the attribute of 'sequence of actions', that is characteristic for haptic exploration.

Unlike a print map, from which spatial and other information can be read off almost simultaneously, a tactile map must be explored sequentially. There are two important consequences of this. Firstly, acquiring spatial information from a tactile map may place greater demands on memory, as the information will have to be integrated from successive hand movements. Secondly, it is likely that different tactile scanning strategies will be differentially effective for gathering the relevant spatial information (Ungar, Blades and Spencer 1993).

Strategies that are in use during the haptic exploration, affect strongly the haptic perception (Warren 1982). There are research results (Abravanel 1968, 1973, Davidson 1972a, Berla and Butterfield 1977) supporting this opinion. However, a number of studies have demonstrated significant improvement in haptic performance with experience (Davidson 1972b, Simmons and Locher 1979, Davidson, Appelle and Pezzmenti 1981). Ungar, Blades and Spencer (1993) noted that visually impaired children could remember and reproduce the array of tactile map symbols. Therefore, the additional use of memory involved in employing a tactile map would not put visually impaired children at any particular disadvantage.

The educated blind person is capable of fine perceptual performance with the sense of touch. A number of blind people are interested in art and study at museums. For example, blind individuals study art history at the 'Whitney Museum' in New York. An organization called *Art Education for the Blind* is dedicated to the development of methods for the communication of art history to blind people (Morton and Heller 1991).

The production of tactile maps

The importance of tactile maps means first that they should be accessible to the visually impaired, and second that they should be correctly interpreted. There has been considerable research into the design of these maps over recent decades, providing answers to most of the questions which have arisen concerning their intelligibility – the use of symbols, for example, and the implementation of uniform standards to make the maps generally accessible (Papadopoulos 2005).

For the production of tactile maps a number of methods have been developed worldwide (see, e.g., Edman 1992, Papadopoulos 2000), the most frequently used being the stereo-copying method, thermoform method, silk screen with foam ink method and the method using a milling machine. Tactile maps are produced using a variety of substrates (background materials), depending on the production method that is used (Horsfall 1997). For example, the stereo-copying process uses microcapsule paper that contains heat-activated microcapsules, embossed graphics are produced using paper, thermoform uses thermo-plastic polymers, and screen-printing is done on a wax-based paper (Jehoel et al. 2005).

Previous studies have attempted to measure differences in map-reading performance for maps that have been produced using various methods. Dacen-Nagel and Coulson (1990) studied map-reading performance on maps of several levels of complexity that were produced by four methods. They found that microcapsule maps were explored the fastest and received the most favorable comments, followed by multitextural maps and maps that were produced by letterpress plates, whereas thermo form maps yielded the slowest response times and the most unfavorable comments. According to Pike, Blades and Spencer (1992) there are no significant differences in map-reading performance of children with visual impairments using microcapsule and thermoform maps.

The introduction of new technologies, mainly in the last ten years, has contributed to the design and production of tactile maps, following procedures appropriate to the special needs of tactile mapping, with automatic cartography (Papadopoulos 2005). During the procedure of implementing a tactile map with the use of a personal computer, a basic stage is the construction of a digital map. However, it is well known today, especially to those involved with cartography, that many digital maps are available as a result of the creation of conventional maps. Based on this heritage we can create easier tactile maps, avoiding the task of digitising a map and concentrating on the generalization of graphical forms and on the writing of the braille labels. Taking into consideration the above situation, we can say that the procedure for the construction of the digital map includes the following stages (Papadopoulos 2000, Papadopoulos, Livieratos and Boutoura 2001): The construction of the *geometrical content* of the digital map; the *generalisation* of the graphic forms; the choice of *tactile symbols*, their construction and placement; the placement of *labels* in braille; the construction of a proper *legend*.

The generalisation process is more necessary when the development of a digital tactile map is based upon a digital map for the visually people. Then is possible that an amount of information must be generalized to be more comprehensible in accordance with the scale of the two different maps. The generalization of linear information is the most frequent during the generalization process.

For the placement of braille labels in digital map, some braille fonts are used. These braille fonts come from the country where the map is constructed. However, citizens of other countries will transcribe tactile maps in order to be readable. For the conversion of this braille labels into English braille code, the transcription of braille labels is required. For decades now there has been considerable discussion of – and research into – the transcription of conventional maps; various ‘romanisation’ systems are now widely accepted and used. In Greece, designed a tool for the automated transcription of Greek tactile maps into the Roman alphabet. That can be also used for the conversion of Greek tactile maps into English braille (Papadopoulou 2005).

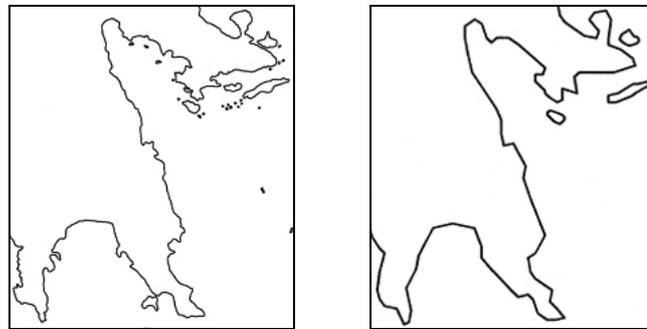


Figure 1. In left, a coastline representation before generalisation and in right after generalisation.

A Ptolemy map of Greece in tactile form

Based on the theory reported above, the construction of a Ptolemaic tactile map is not only a good example of how drawings and graphics, in general, can be transformed into a form that can be readable by the blind, but also a step forward in giving the blind the possibility to discover a fundamental chapter in the history of geography and map-making.

This possibility deepens the blind’s understanding of the early representation patterns of the geographical space and enriches considerably his/her cultural background in the field of the representation history of spatial environment. In other words this type of maps, transformed in haptic form, can be characterized as a useful teaching and cultural medium strengthening the blind’s conception on how geography was cartographically represented in the early times offering thus, the possibility for mental comparisons with the actual geographical patterns available in modern tactile maps.

The concept of *comparison* of early maps, transformed into tactile form, with modern tactile counterparts opens, as such, another dimension in the overall perception abilities of the blind, because in general the concept and practice of ‘haptic comparisons’ is not so common in the educational and cultural experience of the blind.

The origin of the idea is also based on the contemporary approaches that have fortunately prevailed wanting the blind to have access to all those media that improve and complete their

educational and cultural formation getting full use of all relevant historical documents, not only textual but also graphic, giving emphasis to the latter due to their particularities and complexities which are inherent in the graphic representation.

Through feeling this tactile Ptolemaic map, the blind reader discovers a different, 'historic' representation of an actual part of the Greek territory. Through comparisons s/he is able to draw with the respective contemporary tactile map of Greece, s/he realizes the differences in the mapping approaches between the two periods. By reading the place-names listed on the map and by identifying their position s/he can collect useful historic information, and in a way s/he can 'see' important geographic representations highly referenced in the history of spatial mapping as it is, e.g., Ptolemy's *Geographia*.

In order to study the impact of this type of maps in the spatial perception of young blind students, the tactile of a Ptolemy-type representation of Greece was produced (Fig. 2). The map was obtained by digitising a copy of the Ptolemaic map of Greece, Tabula X – Graecia (Strasburg 1525, Gruninjer & Kuberger) and then it was transformed into tactile form in A3 format (42x29.7 cm) with place names in Greek braille. The printing is in microcapsule paper.

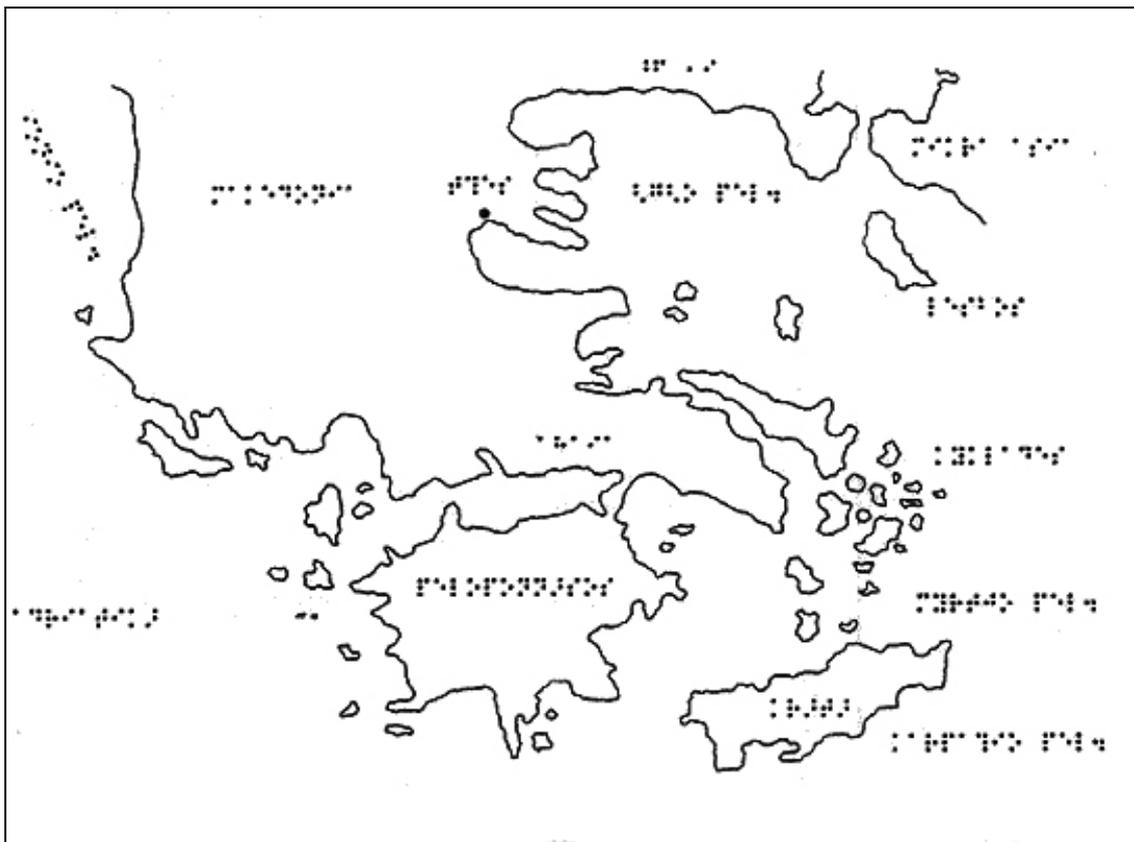


Figure 2. A tactile map of Ptolemy's Greece printed in microcapsule paper, Tabula X (Graecia), Strasburg 1525, Gruninjer & Koberger.

This type of tactile map, the first ever produced in Greece by the National Centre for Maps and Cartographic Heritage (1999), was experimentally used in order to study the reactions of a group of young students in the Thessaloniki School for the Blind. The result

was surprisingly positive and very interesting because the majority of the students recognized the coastline differences from the actual modern coastline reacting with highly divertive mood because they perceived the deformations as a surprising geographic game. This was explained mainly because of the age of the students (teenagers) who focused their haptic comparative interest on the details of the maps, i.e. the strait of Corinth, the place names as appeared in Ptolemy map etc. It is expected that an extended experiment with other age groups of different educational and cultural background could offer more data in evaluating the impact of such geographic representations to the spatial historic perception of the blind.

Acknowledgement

The tactile Ptolemy map presented here was produced in microcapsule paper using facilities and instrumentation of the Hellenic National Centre for Maps and Cartographic Heritage. In its map collection belongs the original Ptolemy map of Greece (Gruninjer & Koberger, Tabula X – Graecia, Strasburg 1525) from a facsimile copy of which the tactile map was derived.

References

- Abravanel, E. (1968). The development of intersensory patterning with regard to selected spatial dimensions. *Monographs of the Society for Research in Child Development*, 33, 1-52.
- Abravanel, E. (1973). Division of labor between hand and eye when perceiving shape. *Neuropsychologia*, 11, 207-211.
- Berla, E. P. and Butterfield, L. H. (1977). Tactual distinctive features analysis: training blind students in shape recognition and in locating shapes on a map. *Journal of Special Education*, 11, 335-346.
- Dacen-Nagel, D. L., and Coulson, M. R. C. (1990). Tactual mobility maps - A comparative study. *Cartographica*, 27(2), 47-63.
- Davidson, P. W. (1972a). The role of exploratory activity in haptic perception: some issues, data, and hypotheses. *Research Bulletin of the American Foundation for the Blind*, 24, 21-27.
- Davidson, P. W. (1972b). Haptic judgments of curvature by blind and sighted humans. *Journal of Experimental Psychology*, 93, 43-55.
- Davidson, P. W., Appelle, S., and Pezzmenti, F. (1981). Haptic equivalence matching of curvature by nonretarded and mentally retarded blind and sighted person. *American Journal of Mental Deficiency*, 86, 295-299.
- Edman P.K. 1992: *Tactile graphics*. New York: American Foundation for the Blind.
- Horsfall, B. (1997). Tactile maps: New materials and improved designs. *Journal of Visual Impairment & Blindness*, 91, 61-65.

- Jehoel, S., Ungar, S., McCallum, D. and 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.
- Leontsinis, G. N. (1995). The historical map in teaching general and local history. In *Cartographic education and the culture of maps*, Proceedings of the 2nd National Cartographic Conference, 25-30 (in Greek), Thessaloniki: Hellenic Cartographic Society.
- Morton A. & Heller, M. A. (1991). Haptic Perception in Blind People. In M. A. Heller & W. Schiff (Eds.), *Psychology of Touch* (chapter 10). Lawrence Erlbaum Associates, Inc.
- Papadopoulos, K. S. (2000). Tactile cartography and tactile maps. Doctoral dissertation, Department of Cadastre, Photogrammetry and Cartography (in Greek). Thessaloniki: Aristotle University of Thessaloniki.
- Papadopoulos, K., Livieratos, E. and Boutoura, C. (2001). A large scale city atlas for the blind. In *Mapping the 21st century*, Proceedings of the 20th International Cartographic Conference, Beijing: State Bureau of Surveying and Mapping.
- Papadopoulos, K. (2004). A school program contributes to the environmental knowledge of blind. *The British Journal of Visual Impairment*, 22(3), 101-104.
- Papadopoulos, K. S. (2005) Automatic Transcription of Tactile Maps. *Journal of Visual Impairment and Blindness*, 99(4), 242-245.
- Piaget, J. (1953). *The origin of intelligence in the child*. London: Routledge & Kegan Paul.
- Pike, E., Blades, M., and Spencer, C. (1992). A comparison of two types of tactile maps for blind children. *Cartographica*, 29(3-4), 83-88.
- Revesz, G. (1950). *The psychology and art of the blind*. London: Longmans Green.
- Simmons, R. W., and Locher, P. J. (1979). Role of extended perceptual experience upon haptic perception of nonrepresentational shapes. *Perceptual and Motor Skills*, 48, 987-991.
- Ungar, S., Blades, M. and Spencer, C. (1993). The role of tactile maps in mobility training. *British Journal of Visual Impairment*, 11, 59-62.
- Warren (1982). The development of haptic perception. In W. Schiff & E. Foulke (Eds.), *Tactual perception: A sourcebook* (chapter 3). New York: Cambridge University Press.