THE CHALLENGE OF MAPS FOR THE VISUALLY HANDICAPPED

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INTRODUCTION

It is a pleasure for me to participate in and hopefully make some contribution to this Symposium on Computer-Assisted Cartography. While I am interested in and involved in various ways with the broad spectrum of subjects with which all of you are concerned I should like to confine my remarks to two special groups of potential users of the graphic communication products in which we are all interested. Those two groups include: 1) persons who have very low levels of visual ability, sometimes referred to as partially seeing; and 2) persons who are legally or totally blind, including both adventitiously and congenitally blind individuals.

I do this for two reasons: 1) the functions of maps and graphics for these two groups is, in essence, exactly the same as for all human beings. These functions relate primarily to the process of learning and understanding the static and dynamic characteristics of spatial data sets distributed above, upon and beneath the terrestrial surface as well as, increasingly, those related to extra-terrestrial phenomena; and 2) the philosophy, methodology and technology of cartography, with some special modifications, is directly applicable to the creation of graphic products to serve the needs of these two groups.

The range and variety of activities in which those who must adjust to severe visual malfunctions or blindness are participating is steadily increasing. Whether these activities involve sports, such as skiing, hiking, fishing and, whether they are related to employment in industry or the professions, or involve the daily problems of learning to operate in and gain understanding about an unseen or dimly seen environment, maps could serve as useful communicative devices. As one blind person commented, "I have acquired various tactual maps and atlases, and am astounded by their uselessness. They are merely base maps." And further, "...disturb me because of the lack of thematic maps."1/ Despite the fact that the need has existed for many years the cartographic profession, with a few exceptions, has not recognized it and has not contributed very significantly to the knowledge and techniques needed to create effective maps for these people. I am sure that you all recognize the fact that the graphic mode of data presentation is not necessarily the most effective device for conveying information to all sighted individuals, neither can it be assumed to be best for those with severely restricted or no sight. Furthermore, the lack of a variety of easily available maps designed for different learning tasks has been so severe that many visually handicapped people have never seen a map designed for their use and thus have never acquired any training or experience in reading and interpreting them. Thus the increasing range of activities in which they participate has not generated an increase in demand for maps that could be useful tools in those new learning situations. We thus face an historical vicious circle--the visually handicapped do not use maps therefore there is no reason to create maps. The circle must be broken, but as is apparent to all of you this entails solutions to many psycho-physical, design and technical problems as well as an educational program for teaching the visually handicapped to read and interpret maps and to convey ideas of the possible multiple functions which maps could serve for them.

RESEARCH NEEDS

In my view there are three broad, closely interrelated areas or stages which require research and experimentation if we are ever to become competent in providing for the map needs of the visually handicapped. The first relate to a technology for creating tactual graphics which is flexible, inexpensive and as compatible as possible with current systems for production of maps for the sighted. A production system must be available or other phases of research will be sharply constrained. The second area relates to the host of problems which are largely psycho-physical in character. These include the question of tactual perception and discriminable symbol design as well as fundamental knowledge about spatial orientation and environmental data needs for independent mobility of the blind. For those with severely impaired sight we need to broaden our research on visual parameters to yield better data on figure to background contrasts achievable in black and white as well as in color.

Studies related to optimal symbol (data) loading or complexity are badly needed in the applied design of graphics for both groups. We very much need to know more about the potential for and the parameters of symbol scaling particularly in an ordinal and possibly an interval sense for both groups. The third area has to do with the application of knowledge, gained through the first two stages of research, in developing a methodology for communicating or transmitting information and especially spatial concept understanding to the visually handicapped. I am curious as to how I could get across Ullman's concept of spatial interaction, intervening opportunity, etc. to a blind student through use of audio and tactual methods. Would map-like tactual diagrams be effective and how should they be structured and used? I have never seen a tactually readable map of population distribution even though hundreds have been produced and are used in teaching sighted students. What about the enormous variety of special purpose thematic maps which have been prepared for the sighted--are any of them (assuming they could successfully be transformed to a tactually readable version) useful in teaching the blind. I believe that progress in all three of these areas might eventually put use in the position of creating and using maps as one type of aid for imparting the same range of knowledge to the blind and partially seeing as we now attempt to do for those with no significant visual impairment. In my view this is a very legitimate objective.

RECENTLY COMPLETED AND ON-GOING RESEARCH

During the last year we have undertaken anew a literature search and correspondence with agencies and individuals around the world to assess the state of current research which has been completed or is underway, on maps for the visually handicapped.2/ To date I have not identified any significant studies having to do with the design and production of maps for those with severe visual impairment, the partially seeing. Only Greenberg's study3/and a joint paper by Greenberg and Sherman4/ are directly related to these problems. For the blind, some very significant progress has been accomplished chiefly in England, Sweden and the United States. Space and time do not allow for a full description here but certainly the recent work of Gill, James and Armstrong in England, Jansson in Sweden, Morris, Nolan and Berla from the American Printing House for the Blind and Wiedel and Groves as well as

Gilligan and Amendola here in the United States all have contributed significantly to the body of knowledge needed in creating maps for the blind. There are many others who have or are undertaking significant work but in many cases it is not as directly related to map design problems as those cited.

The work of Gill and James has pertained to all three areas of research already identified. Gill[5] has developed a computer-assisted method of routing, in negative form, combined with a computer program for transposing to braille with which he has produced a number of effective mobility maps. Gill and James[6] have performed controlled testing which has both confirmed and expanded our knowledge of symbols and their discriminability. Armstrong[7] has written thoughtfully about results of research at the University of Nottingham. While most of this activity is related to large-scale mobility map function and design, it has contributed knowledge and experience pertinent to the broader frames of reference discussed in this paper. Nolan and Morris[8] of the American Printing House for the Blind have been major contributors to our knowledge of tactual symbols and their discriminability. Franks[9] and Berla[10] have and are working with problems associated with the third area of research related to strategies and uses of maps for communication of concept understanding to children. Wiedel and Groves[11] have also been major contributors to our knowledge in all three areas of research. I wish time permitted a more complete review and a further range of citations, but it is obvious that within the last five years or so many have contributed to a substantial amount of knowledge upon which others (hopefully including cartographers) can build. There is of course a moral obligation to do our best in providing for the needs of the visually handicapped; increasingly there is a growing legal obligation as Federal and State laws relating to equal access to information develop and are enforced.

RESEARCH PROGRESS AT THE UNIVERSITY OF WASHINGTON

Under a research contract funded by the U.S. Geological Survey we are exploring the rationale and methods of converting standard USGS map products into forms useable by both the partially seeing and the blind. As the range of activities of the visually handicapped expands, it seems probable that a selected range of map types, published by this agency, could and should be published as special editions. We have begun with the objective of creating two experimental maps as part of the Bicentennial program. The first is of Metropolitan Washington, D.C., all the area within the Beltway, at a scale of 1:24 000 or one inch to two thousand feet. Basically this involves conversion of all or portions of twelve seven-and-a-half minute quadrangles into a visual image designed for those with very restricted vision as well as one which is tactually readable. This map for wall display will be published in two dual-use editions in molded plastic; one with the multi-color normal visual image with tactual symbols in relief and the other with a large type reverse image combined with tactual symbols. The pre-printing on plastic and the vacuum forming of the final products will be carried out by the Defense Mapping Agency Topographic Center, which is cooperating on this project. The second map will be of the Mall in Washington to function as a personal mobility map at a scale of one inch to three hundred feet. One dual-use edition will be produced combining a large print visual image and raised tactual symbols. Entirely new data are required for this map which have only now been acquired, thus completion will be delayed until the end of the year.

The metropolitan map will be unique for I cannot identify a single map of a whole major city that has been produced anywhere in the world for use by the visually handicapped. In fact the support and encouragement of USGS is unique, the first case in the world in which a national mapping agency has ever attempted to produce maps for the visually handicapped. The map scale eliminates its use as a mobility map; its function will be as a tool to learn about the gross morphology of the city and the major transportation linkages within it.

As for any map, our first concern was analysis of the functions the map should be designed to serve. We knew from our own and others work and experience that the physical restrictions on possible symbology (size, spacing and general discriminability) reduce the permissible information load to about 25% of that for a normal vision map of comparable scale. I questioned many blind and partially sighted about function and content of such a map in hopes they would be able to help. Unfortunately I met with the statement, "I have never seen such a map, never thought about such a map even of my home city--I don't know the purpose for which I would use it and thus I am not sure of what information it should contain," over and over. We produced three versions of a test sample of downtown Washington, had blind individuals examine it and then discussed content. We reviewed the content of the only other nearly comparable map, that of Central London first published by the Royal National Institute for the Blind in England in 1961 at a scale of four and a quarter inches to the mile. The review of existing literature gave us very little more enlightenment. Thus we have selected and symbolized information on this map to the best of our ability; we have eliminated far more content from the original quadrangle source maps than we have preserved. The validity of our decisions will have to be determined by user reactions once the map is available for their use. We plan an evaluative study at a later date.

We know that the larger percentage of blind in the United States does not read braille. For this reason the map will be restricted to use by those who can read braille or large print. At a later date we shall try to structure and create an audio-tape cassette to go with the map although this will be more difficult than Blasch's[12/] specific route descriptions recorded on tape. These problems also relate to the dual-use (visual-tactual) character of the final products with which a normally sighted or partially seeing person could help a non-braille reading blind individual use the map. In fact our experience indicates that unless it is absolutely impossible a tactual map for the blind should never be produced without at least a large print visual image combined with it.

Almost simultaneously with our investigations of functional design problems was our development of a photomechanical system of transforming a two dimensional image into a three dimensional one. I will not detail all the products we have experimented with, in the end and for the moment we have found the Dyna Flex[13/] printing plate system least expensive and as effective as any other. These polymer plates[14/] are exposed through a high contrast line negative and when processed an image is formed whose height is .025[15/] of an inch. Completed plates cost approximately eight dollars per square foot, but are tough and durable such that they can be used directly as tactual graphics or as masters for vacuum-forming additional copies in plastic. Our experiments also indicate that the plates may be used in blind embossing of paper copies at much lower unit prices. This photomechanical process makes possible pre-separated manuscript copy in hand drawn, scribed or plotter output form and the use of conventional contact techniques for producing composite negatives from which the plates can be made. Separation made feasible could allow several subject-specific maps to be produced on the same base at relatively low cost. This last capability is of utmost importance for tactual and low vision maps since the information load is so much lower than on maps for those with unimpaired sight. As a result the visually handicapped will be better served by several isolated subject maps than one composite which is so complex that it cannot be read or requires so much effort that it is not used.

The polymer plates which are quite satisfactory for many tactual communicative products suffer from one major limitation. They are manufactured for printing, thus requiring all image elements to be on the same plane. We are aware of the tactual functional values of more than one height for all symbols. Variation in symbol z values increases the discriminability of categories of symbols. Greater relief for certain symbols seems to also give them greater tactual emphasis much as thicker line weights, color allocations or varying of figure to ground contrasts create in maps for those with normal sight. Therefore, as part of our continuing research Carl Youngmann is undertaking work with a numerically-controlled router system, similar to that of Gill's and we are also looking into a new experimental digitally controlled twin-laser system which is being developed by Formigraphics Engineering in California. Using either, we may be able to control the vertical heights of each type of symbol at will, thus making it feasible, through testing, to establish the desirable ranges of relief for symbols which should be used for tactual maps.

Design and production of the Metro map, which is virtually complete, has involved the creation of braille in black and white form (not raised) to be compatible with our photomechanical conversion system. Thanks to information obtained from Mr. Gilligan we have used Chartpak transfer braille sheets[16] for this composition. To accurately set up braille for map labelling, legend and key, one must have the editorial help and advice of a sighted person who is expert with braille and its use. Lack of an existing automated system with output in visual, not embossed, form to transpose names, descriptive phrases and text to braille equivalents makes this process very time consuming and increases the likelihood of human error. The bulk of braille, as a general rule, makes it impossible to incorporate full names on a map at any scale. We are using abbreviations of names rather than abstract alpha or numeric braille symbols to reduce as much as possible the necessity for referring to the key. We have also departed from standard braille placement procedure in aligning it close to symbols dictated by the alignment of the symbol. As a consequence the legend content must be more redundant than for a sighted map to incorporate samples explaining the symbol to braille relationships and particularly the orientation rules that have been developed for the map. The key giving full identity to the abbreviations on the map has to be prepared in two cross-referenced forms. The first gives full names by categories for each abbreviation and a locational description. The second is organized by abbreviations in alphabetical order independent of the category each identifies. We hope this will facilitate quicker and more accurate reference from the map to the key and reduce confusion in reading the braille.

Type for the partially seeing image is in 18 point Helevetica in capitals and lower case letters. Very minimal data on type specifications for large type, for those with highly restricted vision, are available. We had, consequently, to establish our own rules for photo-type setting. We hope our decisions will retain a high level of legibility and readability for this image.

I wish I could say, "Here is the final product, please help us in any way you can to evaluate its characteristics and functional effectiveness." This I cannot do for final stages of reproduction will not take place until late this autumn. What I have said must be regarded as an interim report of our research progress. I hope by spring, during the ACSM meetings, to be able to make a more complete report accompanied by samples of the completed maps. At that time we should also have completed the map of the Mall which in itself poses a number of special problems. I have ordered the new Map Making Kit and Map Makers Handbook[17] which is being marketed in England. Among other objectives, this unit is intended to stimulate and help develop use of standard tested symbols for mobility maps. I am very sympathetic to this objective and after analysis we may attempt to utilize the same symbols for the Mall map. Very few attempts have been made, anywhere in the world, to standardize tactual symbols for such maps, those that presently exist vary greatly in their design and symbol use. This diversity severely constrains training programs for the blind intended to train them in the use of such maps.

CONCLUSION

I believe, at this point in time, it is reasonable to conclude with the following statements.

1. The map resources designed in an effective manner and form for those with visual handicaps, the blind and partially seeing, is extremely limited and in many respects non-existent.

2. We cannot, however, assume a large pent-up demand for maps from these two groups. Most, never having had a variety of maps easily accessible to them, do not think of them as a useful device and, often, would not know how to use them for gaining access to knowledge.

3. Demand will grow slowly and then only after the resources are expanded and made available at modest cost.

4. The real hope for demonstrating the utility of maps as a communicative device for the visually handicapped and teaching them how and for what purposes they could and should be used lies in educational programs of our schools.

5. There is a substantial body of research findings and general knowledge which can be applied by the cartographic profession in creating new and useful map products for these persons.

6. New technology and materials make it possible to incorporate an expanded range of cartographic methods including computer-assisted methods, to significantly decrease the cost and increase the flexibility with which we can create maps for the visually handicapped.

7. If, finally, we can aid in the utilization of such products as communication devices to help convey concept and process understanding to those with severe visual handicaps we will have at least partially closed the loop in the cartographic process. We will then be able to apply user and experiential feedback to create a still broader range of functional maps for the two groups of people identified at the beginning of this paper.

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12. Blasch, B.B., R.L. Welsh and T. Davidson, "Auditory Maps: An Orientation Aid for Visually Handicapped Persons, The New Outlook, 67 (1973), pp. 145-158.

13. Manufactured as a letter-press and dry-offset printing plate by Dyna-Flex Corporation, Salt Lake City, Utah.

14. There are several other similar plates manufactured, of which the Nyloprint plate manufactured by BASF in Wyandotte, Michigan, is fully as effective for this purpose and only slightly more expensive.

15. Standard braille calls for a height of from .017 to .022 of an inch.

16. While we have made the Chartpak V.T. 736 transfer sheets work, the present product should not be used for it has serious inadequacies in alignment, cell size and spacing and dot size. We will shortly have produced a new version which should become available in a few months.

17. Both produced by and available from the Blind Mobility Research Unit, University of Nottingham. Price is $5.50, prepaid. Address orders to Dr. G. A. James, Blind Mobility Research Unit, University of Nottingham NG7 2RD.