Spatial Cognition Through Tactile Mapping

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Abstract
This paper describes an experiment **to determine whether a tactile map of the University College of Swansea campus increases** the spatial awareness of visually handicapped subjects.

Introduction

We all have an awareness of our surroundings that has been gathered through our sensing of environments, or from representations of those environments (e.g. photographs). From these physical sensations an understanding of that environment is formed through cognitive processes, giving rise to a spatial awareness. Unfortunately for some these senses are limited, such as those who are visually handicapped. For blind people, vision, often thought of as the most accurate source of spatial information, is not available. Nevertheless, they too are able to orientate themselves within an environment and to hold spatial concepts (Worchel, 1951; Fischer, 1944). They have to base their spatial judgments on their remaining senses. The touching of a tactile map is one method which can help improve the awareness of visually handicapped people (Andrews, 1983).

This 'spatial awareness' is held within the mind as some kind of mental imagery. This imagery may range from a pictorial scene such as a remembered face, to an artificial and complex scene such as a dream (Robinson *et al.,* 1978). Within this mental imagery there is a high degree of spatial arrangement, with concepts ranging from simple ones such as near and far, to more complex and well developed ideas, such as objects being positioned in a conceptualised geometric space. Knowledge of these locations and relationships shape our cognitive images of the environment and- effect our spatial decision making and behaviour. The images stored in our head form cognitive or mental maps, and the...

> 'drawn representation of geographical space is what we commonly and loosely mean by the noun 'map'.' (Robinson *et al.*, 1978, p.1)

A map may take many forms, scales, shapes and purposes. Complicated spatial arrangements can be shown, ideas and concepts conveyed. Just as the visual map is a vital tool for understanding and education so is the tactile map, defined as:

> 'a map which is designed and constructed to be read by the sense of touch, requiring that portions be elevated in the third dimension.' (Walter and Robinson, 1987, p.70)

Imagine a world of darkness where tactile maps exist and consider the following questions. How would certain information, especially that of a spatial nature in geography or history books be conveyed? How would people find their way around an unexplored new town? How would someone learn the shapes and locations of countries of the world? How would we analyze the distribution of rainfall or population? (Andrews, 1988). For the visually handicapped tactile maps may be the only means of acquiring the structural knowledge to organise spaces and places.

Cognitive **maps**

A cognitive map:

> '... is a process composed of a series of psychological transformations by which an individual acquires, codes, stores, recalls and decodes information about the relative locations and attributes of phenomena in his/her everyday spatial environment.' (Downs and Stea, 1973, p.9)

The cognitive maps of the blind and the sighted will differ due to the different sensory inputs forming the mental image. Accuracy of these images is hard to assess due to the differing inputs. A map may be considered accurate from a different criteria than purely planimetric accuracy.

Clearly, utility is more important than completeness or precision. Shemyakin (1962) had a young school girl, blind from birth, draw a sketch map of her house. It was a near perfect drawing, but omitted the windows. She was not being inaccurate, it was a true sensory picture of the house as she saw it.

The blind have to rely on non-visual clues to form their mental maps. They use sound, touch, taste and smell, as well as time and kinaesthetic feedback. This is very different from the sighted and their visual perception. Consider yourself in a familiar but dark room, the sighted have the ability to walk about their own homes in the dark. They will use such clues as, the number of steps and the time it takes to reach a door, and the height of the door knob against the body. It is clues similar to these that the blind will use.

Due to necessity the blind relate a route in far more detail than the sighted, showing by their lack of vision a greater use of their inherent cognitive mapping skills. Sight is compensated for by the remaining senses.

Learning an Environment

In conceptualising small scale places, the blind and the sighted are able to perceive their nearby surroundings in a simple way with the minimum use of memory. During cognitive mapping WC 'perceive' at local scales and use 'cognition' at larger ones. However, this scale boundary is very fuzzy and is different for the blind and sighted. The areal thresholds of our senses differ, and the visual sense has a greater areal threshold than any other. Obviously one can see further that one can touch or smell. So the blind are forced to sequentially perceive large spaces through non-visual sources and, therefore, their internal imagery is of a conceptual nature and has to be committed to memory. Their 'window' on the world is much smaller than that for the sighted.

At a larger environmental scale, the visual sense resembles the methods of image integration used by the blind in smaller environments. Typically, the blind build up a non-spatial route orientated view which is similar to the sighted at this scale. However, the sighted person is then able to build up a better mental map by uniting several intersecting routes. For the visually handicapped this is much more difficult, as landmark recognition is much harder due to their limited senses. Their routes are often less diverse, and their auditory, tactual and olfactory senses provide only the most basic elements for comprehending space. Despite this the blind are often competent wayfinders, and with tactual maps are able-to orientate themselves around obstacles (Leonard and Newman, 1967).

Gaining an awareness of the campus of University College of Swansea

An experiment was conducted in order to test the hypothesis that tactile maps can improve the cognitive mapping skills of people with the absence of vision. The experiment fell into three parts. In part one the visually handicapped were asked to draw sketch maps of the campus. These images were to be their cognitive mental maps acquired through senses other than vision. Step two was to design and construct a tactile map of the campus. This was in essence a cartographic design exercise bounded by the limits of tactual perception. The third part involved familiarising the blind with the map and then asking them to redraw their cognitive map of the campus. This was done in the hope of showing that tactile maps can fill some of the gaps in their spatial learning of an environment. Comparisons between the initial and final map drawings were made.

study **Area**

The campus of the University College of Swansea was used as the study area. Three congenitally blind people were the subjects of the experiment and all were familiar with the environment of the campus. All the subjects lived in the halls of residence located on campus and travelled around the campus to attend lectures and carry out a range of academic and social activities.

Initial procedure

Each person was tested individually and in random order. They were asked to draw as accurately as possible their impressions, *i.e.* their working cognitive mental map of the campus. 'Their graphical results with added labels are shown in Figures la and 2a. **A raised line** drawing board was used to allow them to feel as they drew.

Results and Discussion

No quantitative study of the maps is to be made since a measure of 'accuracy' is not relatively important to the utility of the map. Clearly, these maps were working cognitive models. They were the conceptual scheme with which the subjects travelled. The three congenitally blind did not appear to have any difficulty in conceptualising and structuring this large environment, even after their initial apprehensions ('Oh no!' and 'Draw a map?' were common responses). They ordered and conceptualised the elements of the environment in a holistic and interdependent framework, in contrast to the results found by Casey (1978). Their approach was very methodological following their mobility routes - lines of knowledge in 'no-mans land'.

There is evidence to suggest that the blind are unable to sense a curved line on a map, which may explain the straightness of the walkway from Mary Williams Hall to Union House (Figures la and lb). More importantly, when walking on a shallow curve the blind may be unable to detect this, and when attempting to walk in a straight line they may actually veer from their path in a curved manner.

Duncan (1934) noted that blind individuals experience problems when representing right angles. This was common to all three maps. Subjects 1 and 2 drew the routes from halls to Fulton House and Fulton House to the Abbey as parallel, when in fact they are separated by an angle of 90°. However, major turns were integrated on their maps (Figures la and 2a).

These sketch maps are a reflection of their utility. The most important finding was that, with some minor conceptual problems, the congenitally blind are quite

Subject #1

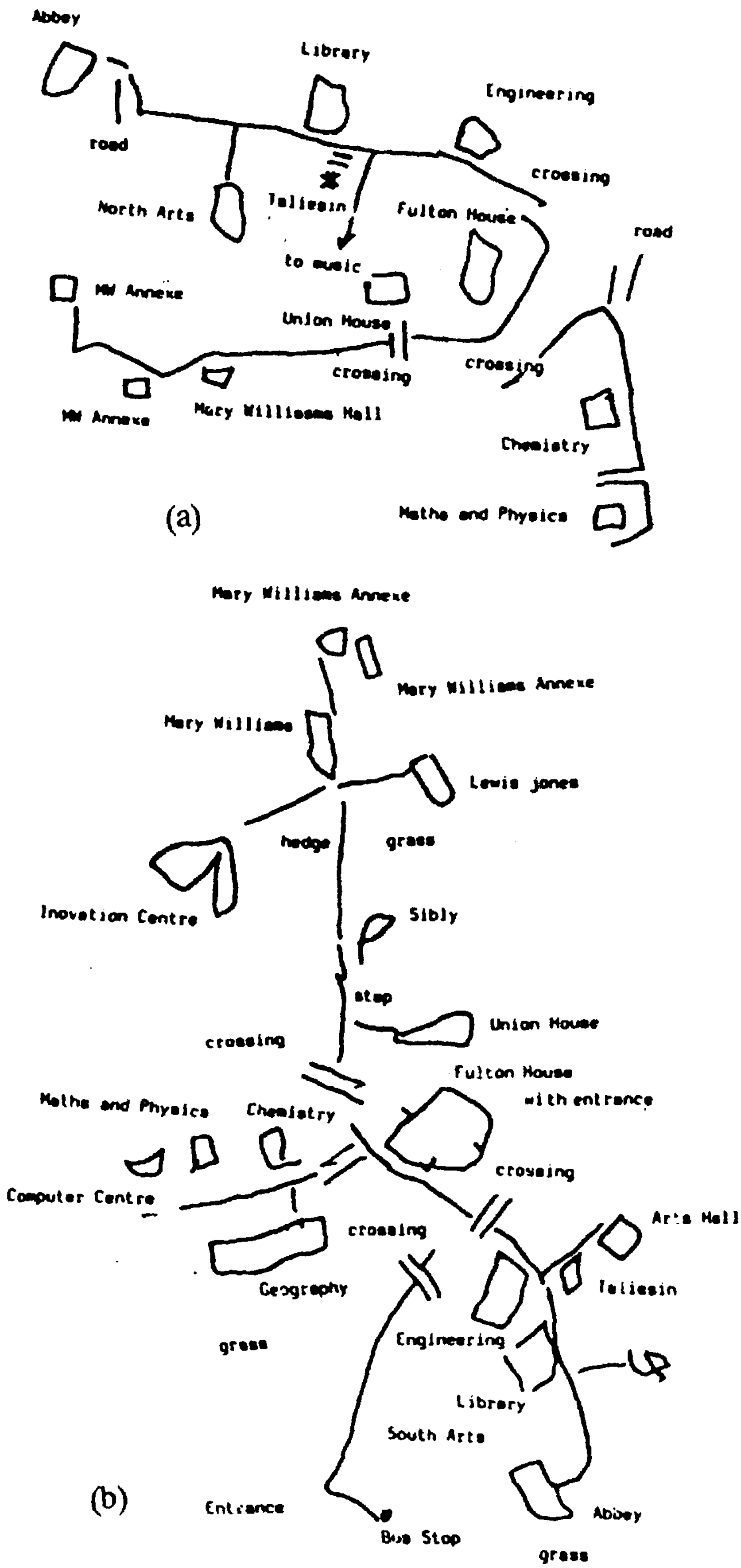

Figure 1. (a) Mental map prior to tactual map and (b) Mental map after tactual map familiarisation.

Subject #2

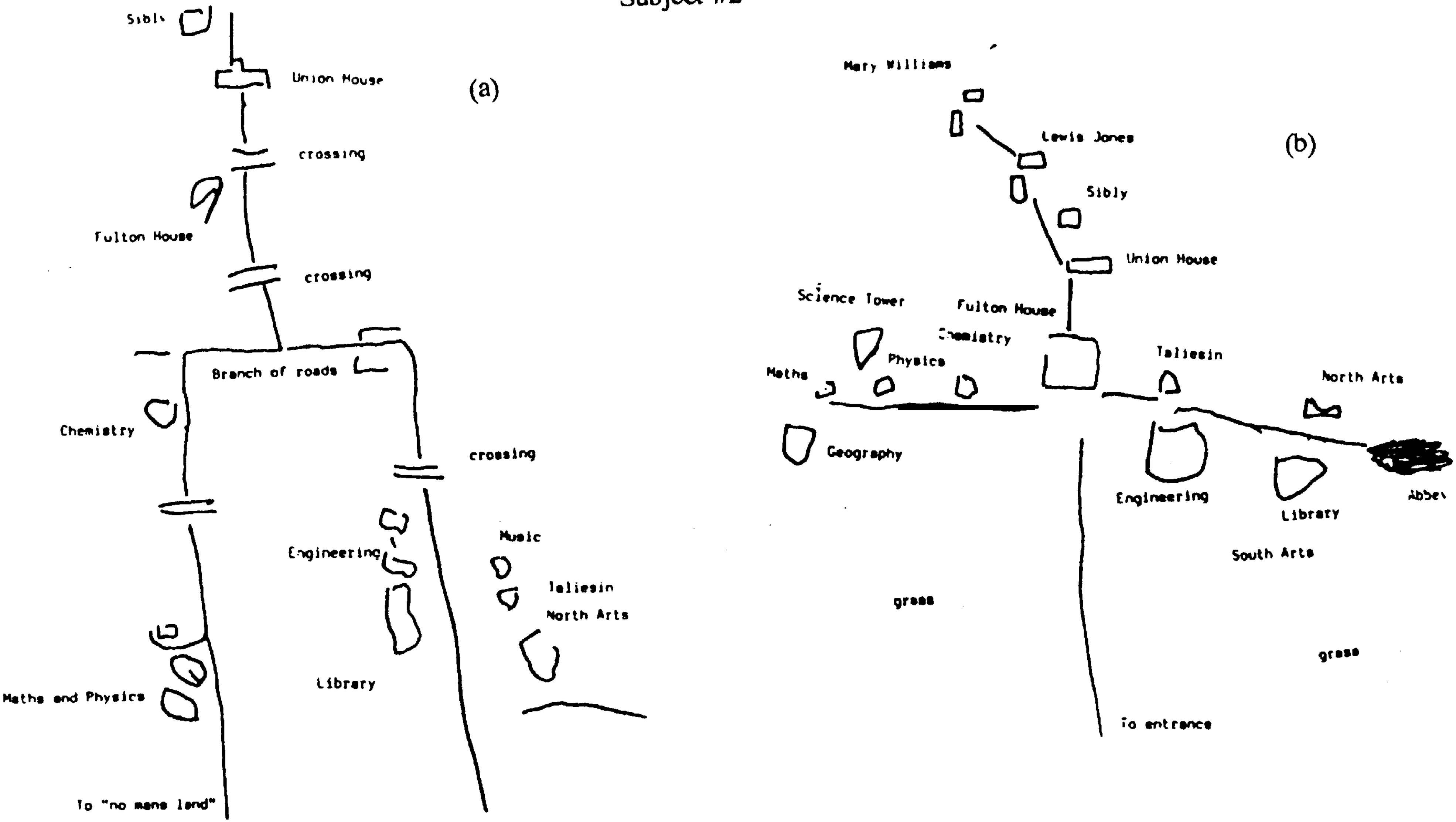

Figure 2. (a) Mental map prior to tactual map and (b) Mental map after tactual map familiarisation.

capable of producing accurate and well ordered maps of a familiar environment.

Campus recognition after tactile mapping

A 1:2000 scale tactile map was designed within the limits imposed by tactual perception ie. data presentation has to be unambiguously apparent to the user. A two dimensional original map of the campus (Figure 3) was photocopied and passed onto the Royal National Institute for the Blind. Here the image was transferred to microcapsule paper, and when heated the dark areas of the image were raised up giving a three dimensional tactual map,

Using the raised line drawing board the subjects were asked to sketch the campus, without reference to anything other than their cognitive maps. Their impressions are shown in Figures lb and 2b. These images, their newly acquired cognitive mental maps, had arisen from both their tactual scanning of the campus map and their learning of the campus environment through their own mobility.

The post map images included far more campus description and detail. Some of this information was acquired directly and only from the tactile map, such as the map of subject 2 showing areas of grass beyond the paths. Any geographic inconsistencies, or topographic anomalies, such as orientating parts of the campus 90° askew were rectified. The final maps looked far more like the visual map of the campus. Differential building sizes and some entrances were introduced.

As the pictorial evidence suggests tactile maps have provided a key role in @proving the cognitive schemes of the visually handicapped. 'This was obviously dependent on their map 'reading' abilities. Those with a poor initial cognitive map now have the potential to upgrade their working imagery to a much higher level of integration. Maps may therefore serve as a levelling process, removing some of the disparities in mobility between subjects.

Conclusion

The visually handicapped have to rely on their mental constructs far more heavily than the sighted when forming cognitive imagery of space. When space (either an environment they are familiar or unfamiliar with) is represented in a tactile form it offers a wealth of opportunity for understanding that space. Maps may range from large to small scales, and at the scale used in this experiment (1:2000) able to improve the cognitive working imagery and schemes of the blind. It would not be unreasonable to hypothesise that this could happen over a wide range of scales. Clearly improvements in mental imagery will be related to the design quality of the maps concerned.

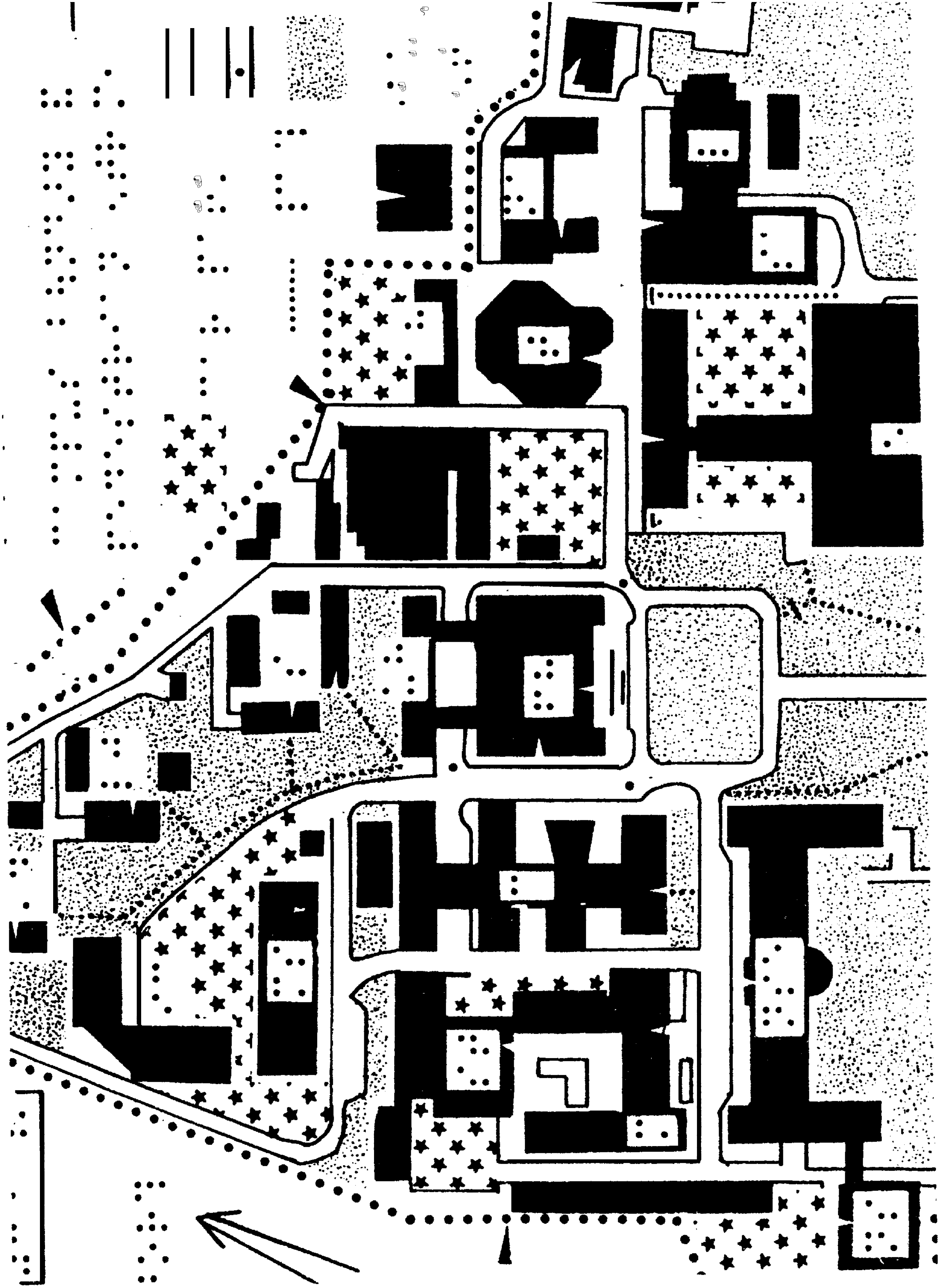

Figure 3 Dra orgin at % scale o map.

The cognitive imagery represented in the final campus recognition test was certainly accurate. A map drawn by a sighted individual is shown as a control map for sketch map planimetric accuracy. The maps by the visually handicapped are no less accurate than that drawn by the sighted person. If anything they are more 'accurate' by the level of detail integration. 'Accuracy' is best described by the term 'utility'. Maps for the blind have a very high use factor since they are the sole reference frame within which they navigate. The congenitally blind are able to use tactile graphics as well as the adventitiously blind and the blindfolded partially sighted. This is borne out by their ability to read braille, for example, and the level of accuracy and integration in their cognitive imagery. The congenitally blind do have a tactile awareness of space. 'This may be unclear at first due to a lack of experience with tactile graphics, however with training they are clearly able to form map like images from sequentially perceived information. Whether from a tactual map or a large scale environment, this is no less efficient than the use of a visual sense.

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