Two Recommendations for Tactile/Haptic Displays: One for All Kinds of Presentations and One for the Development of Haptic Displays

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ABSTRACT
Two recommendations are suggested. The first is general for all kinds of tactile/haptic presentations when vision is not available and concerns the need of an overview of the scene. The suggestion is that efforts to facilitate overview should be made in all kinds of tactile/haptic presentations. The second concerns the development of haptic displays. It is suggested that the efforts for improvement should be concentrated to develop displays that present stimulation more similar to the natural one, especially by providing an extended contact area.

Keywords
Tactile pictures, Haptic displays, Overview, Natural haptics

1. THE NEED OF OVERVIEW
It is well known that haptics alone, in contrast to vision, usually does not provide an immediate overview of a scene. There are at least two main disadvantages of the lack of such an overview: (1) The general content of the scene is not apparent at once. (2) When detailed examination is needed, it is not easy to find the locations to be specifically explored.

1.1 Methods of Facilitating an Overview with Touch/Haptics
Even if it is sometimes possible to get a rapid overview also via haptics [10], a laborious and time-consuming exploration is very common. It is a number one recommendation always to consider how to facilitate an overview of a scene to be perceived haptically. The methods may concern adaptation of tactile properties, verbal descriptions and instructions for exploration.

1.1.1 Adaptation of Tactile Properties
Several ways of facilitating an overview by adapting the tactile properties have been suggested. By Edman [3, pp. 113-128] listed a number of (partly overlapping) recommendations for the production of tactile pictures, among others the following:

- Keep the pictures simple by portraying only the most important element(s)
- Do not use unnecessary details
- Keep forms simple and without ornate decoration
- Brake down a too complex figure into a step-by-step series of pictures (four different methods suggested)
- Stress the most characteristic element of the objects / animals / humans
- Make characteristic details noticeable
- Portray objects/animals/humans in their entirety
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Another feature of tactile stimulation is related to the perception of figure and ground. In visual pictures there is, in most cases, not much trouble of distinguishing between these aspects of a scene. Contours are usually easily identified as belonging to an object in front or as belonging to the background. This is not as evident in touch/haptics [9]. Brambring and Laufenberg [2] discussed the difference in performance with two types of tactile maps as depending on differences between them in figure-ground relations. One way of making a perceptual separation easier is to vary the height of what is figure, for instance by making point and line symbols higher elevated than area symbols [3, pp. 218 f. and 233].

1.1.2 Verbal Descriptions
A suitable verbal description may function as a vehicle for an overview [16]. Comprehension of the scene is increased when the reader is told what to expect. The description can be made in

Braille or in speech. It is especially useful when the reader is unaided [3, pp. 142-143].

If a reader has earlier acquired knowledge of what is depicted, the understanding may be considerably facilitated by verbal information. For instance, if they know that the form of Italy is similar to a high boot and then get the information that the map content is Italy, they can explore the map more efficiently.

1.1.3 Instructions for Exploration

Touch has a large repertoire of exploratory movements [13]. Such movements may be differently facilitating an overview. The number of available such movements is restricted when information is picked up by movements over a two-dimensional display, but also under these conditions there are several options, and some exploratory movements are more efficient than others.

Berlá [1] found that scanning to and fro the body is more efficient than scanning left and right. When the movements are performed left and right the fingertips come successively to the same area of the display and the risk of skipping parts of it is large. The risk of a similar skipping is not as great when the fingers are moved to and fro the body. This means also that the amount of information is larger in the latter case than in the case when they are moved left and right. The difference is related to the construction of the arms and hands. You can orient your fingers in a left and right sweep such that you get the same information as in a to and fro sweep, but then you must hold your hands in very awkward orientations.

A verbal description may contain general instructions about how to read the display. Such "picture guidance" can be quite elaborate and may be critical for the usefulness of the presentation [4, pp. 54–73], especially when a reader has less advance knowledge. The instructions may, for instance, be of the following kind: start in the upper left corner, follow the slightly oblique contour downwards, and so on.

1.2 Application to All Kinds of Displays

Many of the advices above have been considered for two-dimensional displays, such as tactile pictures and maps. However, they are applicable also to three-dimensional displays. During the development of a haptic display for exploration of statues at museums it was expected that it would be especially useful for visually impaired museum visitors for whom visual experience was not available [6]. Even if an evaluation of the haptic display demonstrated its potential for enhancing the experience for its users, it was indicated that the expectation of its special usefulness for visually impaired people was not demonstrated. There were increased potentials of perception of three-dimensional aspects, but the problem with overview was still there. Arrangements compensating for the spontaneous lack of overview, for instance verbal descriptions, are still a necessity for maximum usefulness also of such a device [5].

There are many different ways to facilitate overview and they may differ between situations. The important point is that it should always be considered how to do it.

1.3 Recommendation

Efforts to facilitate overview should always be made in all kinds of tactual/haptic presentations.

2. THE NEED FOR DEVELOPMENT OF HAPTIC DISPLAYS THAT PROVIDE INFORMATION MORE SIMILAR TO NATURAL HAPTICS

Haptic perception is very efficient in identifying real objects with bare hands [11], but the same cannot be stated when it concerns haptic displays. The main reason is that the information obtained via haptic displays is much restricted compared with what is obtained under natural conditions. Especially, most displays allow only one contact area at a time and this area is in nearly all cases only a tiny point. For instance, information about a larger form can be obtained only after exploration over time.

The information provided is far from the richness of natural haptics. The situation for exploration with a haptic display is often similar to what it would be for visual exploration if we were allowed to see only through small holes in a cover moving over the scene. The problem for touch is to get an integrated perception of an object that is at each time only partially perceptible. These restrictions have considerable effects on the efficiency of the display. Decreasing the number of fingers exploring real objects from five to one impairs performance in identifying objects [12]. The largest effect is obtained between the use of two fingers and one finger [7]. Constraining the amount of information by applying a rigid plastic sheath on a fingertip also impairs the performance considerably [14, 15].

By simulation of technical development by different amounts of restriction of different kinds of information Jansson and Monaci [8] demonstrated that the most important improvement of haptic displays for identification of objects would be to increase the amount of information at each contact area, even if number of contact areas also may have some importance. A study using up to three contact areas of a haptic device got a related result of no improvement for shape perception with number of points [Frisoli, Barbagli, Wu, Ruffaldi, Bergamasco & Salisbury, Personal communication, 2004].

2.1 Recommendation

Efforts for improvement of haptic displays should be concentrated to develop displays that present stimulation more similar to the natural one, especially by providing an extended contact area.

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