Comprehensible Tactile Graphics

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Abstract

Tactile graphics (TGs) have been integral to education for the blind and visually impaired for many years. However, for a long time they have been mere raised line translations of pictorial diagrams and little research has been done to investigate the strengths of tactile perception to design better TGs. This work explores and evaluates perception and retention of tactile graphical and spatial information through several experiments. The observations would help in development of better design of tactile graphics and related educational pedagogies.

Author Keywords

Tactile graphics; assistive technology; tactile perception; tactile spatial information; tactile memory; special education; learning through touch

Introduction

Tactile graphics (TGs) are raised-line and/or textured designs on paper that offer blind and visually-impaired (BVI) students a tactual equivalent to the textbook illustrations, diagrams, etc. used by the sighted [2]. Although TGs have been used for nearly two centuries, there is ongoing debate among educators and researchers whether traditional, pictorial TG designs are pedagogically effective [6]. This debate can be avoided (but not resolved) by considering non-pictorial or abstract strategies for designing TGs. Although some basic research in this area took place almost 50 years ago [1], to our knowledge there have been no recent studies or attempts to expand such design strategies.

Our current research explores such strategies. It is based on seminal work by Nolan and Morris [5] which identified small sets (~ 10 per set) of abstract, semantically neutral TG elements (points, lines and areal textures) that function as perceptual primitives, i.e. tactual stimuli that are irreducible, easily identified, discriminable from similar stimuli, and easily remembered. James and Gill [4] enlarged these sets and identified other characteristics that contribute to tactual salience (e.g. dotted vs. continuous lines). Our current work investigates the perception of TG shapes (defined by a contour), and the perception of configurations of a few TG elements. Such configurations may lack contours but are perceived as distinct because they are surrounded by sufficient empty space, or because they are presented on separate sheets or tiles. Our initial research goal was to define a small number of elements that offered the greatest tactual salience, perhaps editing the known set of primitives [3].

Thus, our second goal was to define strategies to configure as many combinations of elements as possible while maintaining optimum tactual salience: i.e. to generate many multi-element TG designs that can be recognized practically "at first touch" (just as sighted students identify at first glance a blue square, a blue square with a yellow dot, a red triangle, etc.). In this approach, tactual salience outweighs the value of resemblance to visual images of a subject. Because many educational concepts have no specific tangible evidence (e.g. gravity, multiplication, nitrogen), no resemblance is required. Our recent research demonstrated that abstract TGs function well as symbols that are easy to discriminate, remember and correlate to semantic content. To forego resemblance also allows us to forego pictorial composition as an organizing principle, but leaves the open question: How best to position or organize multiple TGs to achieve both perceptual salience and semantic meaning? Our recent research explores this. The specific experiments discussed in this abstract focus on the perceptual-cognitive abilities of students with learning disabilities, in comparison to students without learning disabilities.

Experiments

Several experiments were conducted which tested discrimination and memory for abstract TG designs based on perceptual primitives, and also tested students' positional memory. The stimuli used were 25 different tactile symbols embossed on paper squares and mounted on plastic tiles measuring 5x5 cm (see Figure 1 for examples). In some experiments we also employed a 20-square grid (4 x 5 cells) on stiff boards with prominent ridges to hold these tiles. Four students at the Indiana School for the Blind and Visually Impaired, with cognitive disabilities, participated.

The experiments took the form of task-completion games based on tactual-positional memory.
Task 1 – Two tiles (similar or different) were presented to the participant and he/she was asked to simultaneously touch both tiles and say whether they are different or the same.
•Task 2 – Task 1 was repeated with three tiles, of which none or two were the same.
•Task 3 – Participants were given three (or more) tiles in a left-right sequence and asked to touch the tiles and memorize the sequence. The tiles were then jumbled with other tiles, and participants asked to reorganize them in the original sequence. The number of tiles in the sequence was increased with every correct answer.
•Task 4 – Three (or more) tiles were presented randomly in a 20-cell grid and participants were asked to memorize their positions. The tiles were then taken out of the grid and jumbled with other tiles, and the participants had to replace them in the same positions on the grid. The number of tiles in the grid was increased with every correct answer.
The researchers also asked the participants about their thought process while attempting the different tasks.

These experiments only addressed short-term memory (under 20 minutes).

Figure 1: Some sample symbols used in the experiments

Discussion and Conclusion

All Participants were able to remember the symbols and their positions with ease. However, they sometimes got confused between some similar shapes (e.g. 1st and 3rd shape in Fig. 1) and misplaced them in the order or grid. It was also observed that tiles in some particular positions were retained better than others, for example, the first and last tile in a sequence and the corner tiles in the grid were almost always (97%) correctly replaced. Additionally, it was observed that participants enjoyed the game/testing process with 3, 4 or 5 tiles, but were often frustrated by tasks with 5+ tiles, and made more mistakes.

In comparison, students without learning disabilities were sometimes capable of remembering sequences or grid arrangements of 10+ tiles with 80-90+% accuracy. This suggests that tactual-positional memory might be correlated with general intellectual ability. At the same time, the ability to remember sequences and grid arrangements of 10+ tiles seem sufficiently impressive that it is tempting to speculate that tactual-positional memory among the BVI is a well-developed cognitive resource, perhaps superior to the same memory mode among sighted subjects. More testing is needed, including comparisons of tactual-positional vs. visual-positional memory among the sighted.

Similarly, these limited findings cannot be extrapolated to tactile-to-semantic correlations (i.e. subject learning). It is intriguing to speculate that tactual-to-semantic correlations may strengthen tactual-positional memory, both for the learning disabled and more academically gifted students.

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