COMPREHENSION OF 3D OBJECTS FROM 2D TACTILE DIAGRAMS

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Abstract

This thesis addresses the critical challenge of designing effective tactile diagrams for people with visual impairment (PVI) by investigating how spatial object information is comprehended, represented, and recognized through touch. Existing tactile graphics often borrow visual design conventions which are often based on perspective and isometric projection, and do not align with the perceptual strategies of PVI, particularly those without visual memory. Spanning five empirical studies, this research combines qualitative and quantitative methods to explore intuitive tactile drawing strategies in congenitally blind children, recognition patterns across different representation styles, and the influence of diagram size on spatio-temporal integration.

One of the first studies of this thesis explores how congenitally blind children intuitively draw without prior training in visual representation. The objective is to understand how they internally encode spatial configurations and whether features such as genus and proportional differences of similar topological forms are reflected in their drawings. The work evaluates the alignment between verbal object descriptions and drawn outputs, forming a baseline for understanding intuitive untrained tactile representation.

Secondly, four distinct tactile representation styles: lofting, surface development, orthographic, and isometric are studied for their effectiveness in conveying 3D geometric objects to blind, late blind, and blindfolded users. The goal is to assess which configurations best support recognition across different participant groups. The findings emphasize that tactile layouts preserving geometric primitives and surface connectivity are more effective for PVI than visual-centric projections, thereby challenging conventional representation practices. Third study carried out as a part of this thesis focuses on determining which features or factors support successful object identification in conventional tactile graphics. Using a diverse set of tactile representations of commonly used everyday objects, the study involves exploration by blind participants to describe cues that aid recognition.

Next, two sets of studies are carried out to evaluate the role of diagram size in tactile recognition. Challenging the classic theory that ‘Bigger is better’ in tactile representation, two sets of data consisting of both discrete (dot-based) and continuous (outline-based) patterns are used in this study. The goal is to determine if there exists an optimal "Goldilocks" scale range that maximizes perceptual clarity while minimizing cognitive overload. This study carried out with three sets of participants, blind, late blind, and blindfolded has found

that the Goldilocks exists for discrete dot patterns. However, the preference of sizes varies with different participant groups for line drawings.

Towards the end, empirically grounded recommendations for tactile representation TacTales, are proposed offering actionable insights for educators, designers, and assistive technology developers aiming to make STEM content more accessible to blind learners. Furthermore, it lays out important scientific avenues for investigation ahead.