Variation in Intuitive Geometric Construct of Spatial Perception during Navigation

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I. EXTENDED ABSTRACT

I.1. Background

Geometry (Stanislas Dehaene 2006) and non-perceptible Euclidean geometry (Veronique Izard 2011) constitute core set of intuitions understanding environments. Psychology researchers identified patterns of comparison and spatial inference in visual problem-solving (Andrew Lovett 2012) (Charles E. Bethel-Fox 1984) which could play key role in spatial perception and navigation. We propose to study how intuitive geometric constructs can enhance human environment interaction by capturing behaviourally relevant aspects. We start from (Peponis J 1997) space partitioning to axial lines, isovists, and (Turner A 2001) isovist of regular tessellation with grid centroids, defining visibility graphs (Batty 2001) to understand how humans can construct space syntax models describing features of spatial relations. Graph-based spatial-mental-representation explains way-finding behaviour, and methods in architecture have gained plausibility by complementing these cognitive methods (Gerald Franz 2005).

I.2. Methodology / Procedure

A cohort (N=10) aged 19 years were studied through three experiments. (1) Participants choose from given options that complies an outline shape previously shown, (2) Outline of geometric/freeform shapes are shown to construct shapes within, (3) Similar outline of complex geometric shapes are marked with two points blue (start-point) and green (end-point) and participants construct a path.

I.3. Outcome / Discussion

Results: In the first experiment analysis, mode of choice show overall performance of 62% (68%-53%; simple to complex), indicating derived-constructs (Intuitive) vary from constructs through geometric principles (determined-constructs). Subsequent experiment on relations of determined-constructs to derived-constructs shows negative correlation, participants using minimal derived-constructs while opting for determined-constructs and vice-versa. It appears that the participants perhaps divided shapes into parts using nodes, edge and mid-points. In the third experiment (way-finding) the ratio of determined-constructs used is 0.5 that of derived-constructs of which, significant 81% constructs are segments and resultant-references (fusion of derived & determined).

I.4. Conclusion

Spatial perception widely varies from simple to complex forms and during navigation features are convoluted. Derived-geometry dominate determined-constructs in simple forms with egocentric behaviour while in complex there seems to be shift towards allocentric, observed in second experiment participants. In third experiment, participants are dominated by egocentric behaviour constructing convoluting features maintaining allocentric using determined-constructs. We also find variation in intuitive geometric constructs of spatial perception through resultant-references during navigation.

Keywords: Intuitive geometric constructs, Human environment interaction, Navigation, Allocentric and Egocentric

2. REFERENCES

Andrew Lovett, Kenneth Forbus. 2012. "Modeling Multiple Strategies for Solving Geometric Analogy Problems." *Proceedings of the 34th Annual Conference of the Cognitive Science Society*. Sapporo, Japan.

Batty, Michael. 2001. "Exploring isovist fields: space and shape in architectural and urban morphology." *Environmental and Planning B: Planning and Design* [28] 123-150.

Charles E. Bethel-Fox, David F. Lohman, Richard E. Snow. 1984. "Adaptive Reasoning: Componential and Eye Movement Analysis of Geometric Analogy Performance." *Intelligence* [8] 205-238.

Gerald Franz, Hanspeter A. Mallot & Jan M. Wiener. 2005. "Graph-based models of space in architecture and cognitive science - a comparative analysis." *17th International Conference on Systems Research - Special focus in Architecture, Engineering and Construction of Built Environment*. Baden, Germany: INTERSYMP-2005.

Peponis J, Wineman J, Rashid M, Kim S H, Bafna s. 1997. "On the description of shape and spatial configuration inside buildings: convex partitions and their local properties." *Environment and Planning B: Planning and Design [24]* 761-781.

Stanislas Dehaene, Veronique Izard, Pierre Pica, Elizabeth Spelke. 2006. "Core Knowledge of Geometry in an Amazonia Indigene Group." *Science [311]* 381-384.

Turner A, Doxa M, O'Sullivan D, Penn A. 2001. "From isovists to visibility graphs: a methodology for the analysis of architectural space." *Environmental and Planning B: Planning and Design [28]* 103-122.

Veronique Izard, Pierre Pica, Elizabeth S. Spelke, Stanislas Dehaene. 2011. "Flexible intuitions of Euclidean geometry in an Amazonian indigene group." *www.pnas.org*. April 25. www.pnas.org/cgi/doi/10.1073/pnas.1016686108.

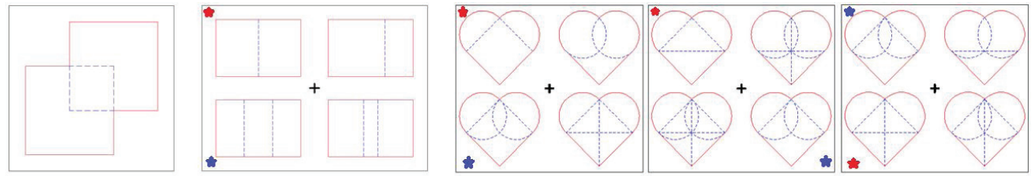

Figure 1: Geometric shapes used in first experiment. Central black cross indicate fixation point. (a) Response of most subjects and complies geometric construct (b & c) Red star is the participants' choice, whereas the blue star is geometric construct.

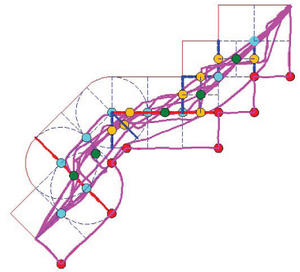

Figure 2: Typical example used in third experiment. Magenta colour lines represent the subject's path. The blue circles are determined constructs, orange - segments of geometric shapes, green - resultant references and red are edges.

3. AUTHOR BIO

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Faculty in Department of Architecture, Andhra University, Visakhapatnam, India. Research interest is, human performance in built environment applying cognitive neuroscience principles in the areas of working memory, attention and decision making relevant to intelligent spatial design for performing daily activities, in particular navigation.

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Centre of Behavioural and Cognitive Sciences (CBCS), University of Allahabad, Allahabad, India worked at several research institutes, viz., Max Plank Institute for Biological Cybernetics, Tuebingen, Germany, Emory University, Atlanta, USA and ATR Labs, Kyoto, Japan on application of functional magnetic resonance imaging (fMRI) technique to understand different cognitive processes. Current research involves investigating interactions of emotion, attention and motivation with the process of decision making and cross-modal skill learning.