UC Merced

Proceedings of the Annual Meeting of the Cognitive Science Society

Title

From Egocentric to Object-Centered Reference Frames: Grounding Visuo-Spatial Cognition in the World

Permalink

https://escholarship.org/uc/item/7cd6v67q

Journal

Proceedings of the Annual Meeting of the Cognitive Science Society, 29(29)

ISSN

1069-7977

Authors

Simmering, Vanessa R.
Spencer, John P.
Schoner, Gregor

Publication Date

2007

Peer reviewed

eScholarship.org Powered by the California Digital Library
University of California

From Egocentric to Object-Centered Reference Frames: Grounding Visuo-Spatial Cognition in the World

Vanessa R. Simmering (vanessa-simmering@uiowa.edu)
John P. Spencer (john-spencer@uiowa.edu)
Department of Psychology, University of Iowa
Iowa City, IA 52242 USA

Gregor Schöner (gregor.schoener@neuroinformatik.ruhr-uni-bochum.de)
Institut für Neuroinformatik, Ruhr-University
44780 Bochum, Germany

Keywords: spatial cognition; visual reference frames; dynamic field model

Research in spatial cognition has established that people anchor memories of object locations in a local task space to an object-centered reference frame. Although a number of models of spatial memory capture systematic biases near such reference frames, no previous models have captured the processes that transform spatial information from an initially egocentric (e.g., retinal) frame into an object-centered frame. This paper focuses on one model of spatial cognition that has shown promise in this regard, the Dynamic Field Theory (DFT; see Spencer, Simmering, Schutte, & Schöner, 2007, for review). Our previous work offered an initial account of how reference frames are established and maintained. Here we provide a more complete account that is fully grounded in neural principles.

The DFT is a process-based theory of spatial cognition implemented in a neural network model (for a complete description, see Spencer et al, 2007). The full model consists of seven layers of spatially-tuned neurons. Here we focus on interactions of the top four layers: a retinal or egocentric perceptual field (PF_{ego}), a field that translates activation to an object-centered frame of reference (Shift), an object-centered perceptual field (PF_{obj}), and a long-term memory field associated with PF_{obj} (LTM_{PFobj}).

To understand how the model aligns reference frames, consider a typical spatial recall task (e.g., Spencer & Hund, 2002). The participant sits at a large, homogeneous tabletop, and a target is presented at the to-be-remembered location. Adults' performance suggests that the edges and midline symmetry axis of the table serve as reference frames for remembering target locations. In the model, we present these inputs as Gaussian activation profiles corresponding to the relevant spatial locations. These inputs are presented to PF_{ego} within a retinal reference frame; therefore, movements of the head and eyes will change where these inputs are in the field. To use these inputs to remember a location relative to the table, information must be transformed from this retinal frame into an object-centered reference frame.

This transformation occurs in the Shift field, where activation in PF_{ego} is effectively compared to activation in PF_{obj} to find the shift value with the highest overlap in activation (i.e., greatest spatial correlation). For example, in the recall task described above, the edges and symmetry axis of the table provide constant inputs at three locations. These inputs can be initially mapped into the object-centered frame at arbitrary values. When the input to the retina shifts (e.g., due to an eye movement), however, the input to the object-centered frame must be shifted accordingly so the three peaks at new locations in PF_{ego} are correctly mapped to the three peaks at the original locations in PF_{obj}. To achieve this transformation, we use a two-dimensional Shift field that maps input from PF_{ego} onto all possible shifts of PF_{obj} (which we achieve by pre-structuring the weight matrix in the 2D Shift field). The best match in the Shift field always occurs along a particular diagonal axis. Moreover, the amount the selected diagonal axis is shifted relative to the "no shift" axis (i.e., the diagonal axis that maps input one-to-one from the retinal to the object-centered frame) specifies the shift amount.

The model can also re-align reference frames after longer delays, by using LTM_{PFobj}. In this case, the peaks in PF_{obj} are built from activation sent from LTM_{PFobj}, rather than being established online in the task. In this case, the alignment process functions exactly the same; the only difference is the source of the initial activation in PF_{obj}. This feature of the model allows for previous experience with a given object-centered frame of reference to influence behavior over multiple encounters, rather than only within a given session.

Acknowledgments

This work was funded by NIMH RO1 MH62480, NSF BCS 00-91757, and NSF HSD 0527698, awarded to JPS.

References

Spencer, J.P. & Hund, A.M. (2002). Prototypes and particulars: Geometric and experience-dependent spatial categories. *Journal of Experimental psychology: General, 131*, 16-37.

Spencer, J. P., Simmering, V. R., Schutte, A. R., & Schöner, G. (2007). What does theoretical neuroscience have to offer the study of behavioral development? Insights from dynamic field theory. In J. M. Plumert & J. P. Spencer (Eds.) *The emerging spatial mind.* New York: Oxford.