

The Spatial Foundations of Language and Cognition

Edited by
Kelly S. Mix, Linda B. Smith,
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Foreword: Space as Mechanism

Spatial cognition has long been a central topic of study in cognitive science. Researchers have asked how space is perceived, represented, processed, and talked about, all in an effort to understand how spatial cognition itself works. But there is another reason to ask about the relations among space, cognition, and language. There is mounting evidence that cognition is deeply embodied, built in a physical world and retaining the signature of that physical world in many fundamental processes. The physical world is a spatial world. Thus, there is not only thinking *about* space, but also thinking *through* space—using space to index memories, selectively attend to, and ground word meanings that are not explicitly about space. These two aspects of space—as content and as medium—have emerged as separate areas of research and discourse. However, there is much to be gained by considering the interplay between them, particularly how the state of the art in each literature impacts the other.

Toward that end, we have assembled chapters from a diverse group of scientists and scholars who represent a range of perspectives on space and language. They include experimental psychologists, computer scientists, roboticists, linguists, and philosophers. The book is divided into three sections. In the first, we address the notion of space as the grounding for abstract thought. This idea solves a number of problems. It explains how complex concepts without clear physical referents can be understood. It specifies how ‘here-and-now’ perception can interact with cognition to produce better problem solving or language comprehension. For example, Clark provides many excellent examples of ways that people co-opt both language and space to scaffold complex behavior. Due to this similarity in function, he contends, language and space are naturally coupled in human cognition. Ramscar, Matlock, and Boroditsky summarize a series of elegant experiments demonstrating that people ground their concepts of time in their own bodily movements. Likewise, Spivey, Richardson, and Zednik present research showing how people scan space as a way to improve recall. Together, these two chapters provide strong support for the basic idea of embodiment in cognition and, more specifically, the way movement through space is recruited by seemingly abstract cognitive processes. Mix’s chapter looks forward—asking whether, if these ideas about human cognition are correct, they can be used to improve instruction in mathematics. She focuses on the role of concrete models, in particular, and

asks whether they might engage a natural predisposition to ground abstract concepts in space and action.

Although spatial grounding provides a plausible explanation for higher-level processing, where does this conceptualization of cognition leave us with respect to spatial cognition in particular? As for many areas within cognitive psychology, spatial cognition was traditionally characterized in terms of logical abstractions. Research with adults has emphasized the use of propositions and linguistic frames for representing space. Developmental research has focused on how children move from concrete, egocentric views of space toward the abstract mental maps supposedly used by adults. In light of this, the claim that abstract cognition is anchored by space has a certain irony to it. Still, the same movement that questioned the grounding of other thought processes has led experts on spatial cognition to consider the role of embodiment there, too. The chapters in Section II address this issue head-on. Each grapples with the tension between established frameworks for spatial thought and mounting evidence for embodiment. Although all the authors admit a role for bodily experience, they differ in the extent to which they are willing to jettison, or even modify, traditional descriptions. But the debate itself raises critical questions about what representations are, what constitutes embodiment, and whether we need both to explain human behavior.

For example, Carlson focuses on the acquisition of spatial terminology, arguing that distance comes along for the ride as children learn a variety of spatial words—even those that are not about distance (e.g. ‘above’). Distance, she posits, is part of the reference frame used for all spatial terms, and thus becomes incorporated incidentally. Similarly, Huttenlocher, Lourenco, and Vasilyeva argue that the way children encode spatial information varies depending on whether they are moving through space as they track a target. Thus, both accounts identify a role for movement in spatial cognition, but also contend that it contributes to some form of mental representation. Landau, O’Hearn, and Hoffman make an even stronger, explicit case that abstract representations are needed to complete spatial tasks, such as block design, based on their study of spatial deficits in children with Williams syndrome. In contrast, Lipinski, Spencer, and Samuelson question the need for such mental structures. They present a dynamic field model that shows how spatial language and memory for location could be connected without an intervening representation.

In Section III, we consider space as a mechanism for language acquisition—as the medium through which many words are learned, not just terms for space. Smith and Samuelson’s chapter points out that spatial contiguity between word and sensory experience is likely just as powerful as temporal

contiguity in promoting word learning, perhaps even more so because spatial contiguity can persist through time. However, for this mechanism to work, children would have to notice and encode spatial location along with other sensory information, like the sounds of a spoken word. Smith and Samuelson argue that research on the A-not-B error demonstrates that children do connect space and action, and this same process could become activated in word learning. Similarly, Yu and Ballard consider the way space unites word and referent, but instead of short-term memory, they focus on the role of attention. They present a series of experiments in which a robot is taught the names of objects in a picture book. This appears to hinge on joint attention between the robot and its teacher, such that spoken words co-occur with visual perception of their referents (i.e., the appropriate book illustrations), more frequently than not. Cannon and Cohen also consider the role of space in word learning, but focus on the extent to which bodily experiences (i.e., movements through space) support the acquisition of verb meanings. They make the critical point that language is grounded in space, even when the particular words are not about space.

List of Plates

- 1 A simulation of the Dynamic Field Theory performing a single spatial recall trial
- 2 Copies of models (row 1) made by children with Williams syndrome (rows 2 and 3) and by one mental age-matched normally developing child (row 4)
- 3 Manipulate and Anchor conditions
- 4 An overview of the dynamic field model of the A-not-B error
- 5 The time evolution of activation in the planning field
- 6 Illustration of how sensorimotor fields feed into an association field that maps words to objects
- 7 The snapshots when the speaker uttered 'The cow is looking at the little boy' in Mandarin
- 8 Overview of the system
- 9 Overview of the method

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Abbreviations

| | |
|------|---------------------------------------|
| AVS | Attentional Vector Sum model |
| CA | Category Adjustment |
| CCD | charge-coupled device (camera) |
| DFT | Dynamic Field Theory |
| fMRI | functional magnetic resonance imaging |
| HMM | Hidden Markov Model |
| MA | mental age |
| MOT | multiple object tracking task |
| PF | perceptual field |
| PSS | Perceptual symbol system |
| SES | socioeconomic status |
| SWM | working memory field |
| TOM | theory of mind |
| VOT | Voice onset time |
| VR | Virtual reality |
| WS | Williams syndrome |

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