Spatial cognition and spatial language: What do we need to know to talk about space?

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Like all mobile species, humans have the capacity to perceive and understand important aspects of the spatial world, such as the structure of objects and layouts, and to use this knowledge to guide motor tasks such as reaching, grasping, throwing, and walking. Unlike other species, however, humans also can talk about space. The language of space is apparently so fundamental to human cognition that we see it emerge as one of the earliest aspects of language learning: Under normal developmental conditions, spatial language — the encoding of objects, their motions, locations, and properties — emerges early and easily, with no formal tutoring. The question of how this easy relationship between spatial cognition and spatial language emerges in development has considerable implications for how we think about the interface and interactivity between different cognitive systems — in this case, the systems comprising our spatial knowledge on the one hand, and language on the other.

In this paper, I will consider several possible hypotheses about the relationship between these two systems as they might interact in the development and mature use of spatial terminology. In particular, I will lay out some hypotheses that suggest different degrees of interactivity, and will begin to evaluate them in the context of recent evidence from individuals with Williams Syndrome (WS). This genetically-based syndrome presents a highly unusual cognitive profile: Individuals with WS exhibit profound spatial deficits but relatively spared language. Given this pattern of distinctive compromise and sparing, intriguiging questions arise about how these individuals learn to talk about space. If the spatial representations normally thought to underlie spatial language are disrupted or impaired, can the learner nevertheless acquire part or all of the semantics of spatial terms, and if so, are the implicated mechanisms different from those underlying normal development?

The following hypotheses will be considered:

(1) The Modularity Hypothesis suggests that non-linguistic representations of space and linguistic representations of space are modular and separate, and do not interact in development or in the mature use of spatial language. In this framework, learners do not ground their semantic representations of spatial terms in non-linguistic representations of the spatial world. A priori, this hypothesis seems unlikely because some interface between spatial cognition and the linguistic system would seem necessary in order to talk about space. However, preliminary observations of spontaneous language in WS individuals as well as performance on certain tasks engaging spatial terms suggest that certain aspects of spatial language may indeed be acquired without strong input (if any) from non-linguistic representations of space. These observations are also consistent with previous evidence demonstrating that congenitally blind children can acquire some of the semantics of color terms and that congenitally blind adults exhibit some rough spectral structure in their judgments of similarities among color terms.

(2) The Partial Homomorphism Hypothesis (cf. Landau & Jackendoff, 1993) suggests that there is interactivity between non-linguistic and linguistic representations of space. Specifically, it suggests that non-linguistic representations of space undergo filtering en route to the linguistic system, such that only certain spatial properties are represented in language. In this framework, learners acquire spatial terms by grounding their semantic representations of spatial terms in those properties of non-linguistic representations that are visible to language. This hypothesis is supported by observations about the universal semantic properties of spatial terms, which only encode a subset of the spatial properties preserved by other spatial systems (cf. Talmy), supporting the idea of a filter in the space-language interface. This type of interactivity predicts that impairment in the non-linguistic spatial system will give rise to corresponding impairments in spatial language. Preliminary observations of performance by WS children in non-linguistic and corresponding lin-

guistic tasks suggests that at least some disruptions in spatial cognition give rise to corresponding disruptions in the acquisition and use of spatial language.

The fact that different kinds of evidence support each hypothesis suggests several challenges. First, we should consider the possibility that different semantic properties of spatial language may arise through different learning mechanisms — some requiring grounding in non-linguistic spatial knowledge and others not. Second, we need to refine our ideas of what aspects of spatial cognition might, in principle, give rise to interaction effects. Given that spatial cogntion is not one global system (but rather, comprised of several distinct systems including object recognition, locational representation, reaching, navigation, etc.), it is likely that properties redundant across systems may be the ones specially engaged by language. If so, what might this say about the nature of the language-space interface?