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Attention Unites Form and Function in Spatial Language

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Introduction

Traditionally, the processing of spatial terms has been explained independently of more general cognitive processes, operating upon strictly geometric representations of the objects being spatially related. Challenges to this idea have focused on either process or representation. Research on process has linked spatial language with attention, but has assumed only abstract representations of the objects; research on representation has shown that both geometric and functional information about the objects and their interaction influence spatial language – but the process by which this is accomplished is left largely unspecified. We bring together process and representation, and offer an extension of the Attention Vector-Sum (AVS) model (Regier & Carlson, 2001) in which geometric and functional information is integrated via the process of attention.

Two Assumptions

Carlson-Radvansky, Covey & Lattanzi (1999) observed that spatial terms are defined on the basis of both geometric and functional information. For example, given the instruction: *Place the tube of toothpaste above the toothbrush*, participants were biased to place the toothpaste away from the center toward the bristles of the toothbrush. This functional bias was mediated by the typicality of the relationship between the objects (i.e., a smaller bias with a tube of oil paint). The explanation of the functional bias relies on two critical assumptions: 1) attention can be allocated to a particular functional part of an object (Lin & Murphy, 1997), with a consequent bias to define spatial terms with respect to space around that part; and 2) that the amount of attention allocated to the part is mediated by the typicality of the interaction between the objects.

Empirical support

Empirical support for the first assumption was obtained by manipulating the location of attention within the reference object, and assessing whether there was a bias to define spatial terms around this locus of attention. In Experiment 1, we used an exogenous cueing task to anchor attention at various locations within a rectangle, and then presented a circle as the located object either at the attended location or elsewhere. In Experiment 2, we used a watering can as the reference object, and a plant as the located object; with attention presumably allocated to the spout. In both experiments, response times for verifying that the located object was above/below the reference object were faster when the placement of the located object coincided with attention. Empirical support for the second assumption was obtained by collecting ratings of the functional importance of the parts of the reference objects used by Carlson-Radvansky et. al. (1999) in the context of functionally typical located objects, functionally atypical located objects, or in isolation. Ratings of the functional part were greater in the context of the functionally typical located objects, and were significantly correlated with the linguistic functional bias, suggesting that the typicality of the interaction mediated the strength of the functional information.

Computational support

The Attentional Vector Sum (AVS) model of spatial language involves an attentional beam that is focused on the reference object, and extends outward toward the located object (Regier & Carlson, 2001). There is a vector-sum representation of the direction of the located object relative to the reference object, with vectors anchored at points within the reference object and pointing toward the located object, weighted by the amount of attention paid to the point on the reference object. In order to incorporate functional information about the reference object, the attentional weight in AVS was modified such that functionally important object parts receive greater attention (Lin & Murphy, 1997). With this change, AVS captures the two critical assumptions, and simulations successfully account for the functional bias effect (Carlson-Radvansky et al., 1999) and its dependence on the typicality of the interaction between the objects.

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