Vagueness and competition in the understanding of spatial prepositions

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Spatial language has long fascinated cognitive scientists because it provides a window into the interplay between spatial cognition and linguistic capacity. An example of one specific challenge that has attracted attention from various sub-fields of cognitive science is to give an explanation of the vagueness observed in the use and understanding of spatial prepositions, as studied experimentally using, e.g., picture rating tasks. One way to explain this vagueness is by recourse to cognitive limitations, e.g. regarding the allocation of visual attention [1, henceforth RC] or regarding representations of spatial configurations in working memory [2]. This type of approach is effectively an application of Anderson’s rational analysis [3]. Although RC and related approaches have come a long way in predicting experimental data, RC suspected themselves that their account is still incomplete. They proposed that an additional factor may be at play, producing, e.g., unexpectedly steep decreases in acceptability of the preposition ‘above’ as the position of the so-called located object (LO) approaches horizontal alignment with the reference object (RO). Specifically, they hypothesized that lexical competition (LexComp) between alternative prepositions, e.g. ‘above’ vs. ‘beside’, may cause such decreasing acceptability. Recent computational probabilistic pragmatic models such as the rational speech act (RSA) model [4] lend themselves to formalize the LexComp hypothesis and integrate it with RC’s original approach.

I present experimental data supporting LexComp and propose such an integrated RSA model to account for the data. Participants provided truth-value judgments for sentences like ‘the dot is above the square’ presented together with pictures showing a small dot (=LO) near a larger square (=RO). The relative angular position of LO was manipulated (0° and 180° encode complete horizontal alignment). An additional between-subjects manipulation varied whether participants saw only the preposition ‘above’ (exp. 1, N = 18, 36 trials, positions: 0°-180°) or did also judge sentences containing the alternatives ‘left of’, ‘under’ and ‘right of’ (exp. 2, N = 21, 144 trials, 0°-360°). Based on previous studies on implicatures [5], I reasoned that explicit mention of lexical alternatives would increase their salience and thus strengthen potential competition effects. As predicted by LexComp, logistic mixed effects models revealed significantly lower endorsement rates in exp. 2 vs. exp. 1 if angular position was near horizontal alignment (0°-45°: \( \chi^2(1) = 11.3, p < .001 \); 135°-180°: \( \chi^2(1) = 9.9, p = .002 \)) whereas no difference was found for medium angles (45°-135°: \( \chi^2(1) = 0.9, p = .33 \)). In the computational model, a Gaussian distribution centered at the LO’s true position is used to integrate noisy working memory representations. Moreover, reduced production costs of recently encountered lexical alternatives model their increased salience. This integrated RSA model thus combines a noisy semantics with informativity-based lexical competition [cf. 6]. I argue that both components are essential to account for the data.