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SHORT REPORT

Spatial language and the psychological reality of schematization

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Abstract Although the representations underlying spatial language are often assumed to be schematic in nature, empirical evidence for a schematic format of representation is lacking. In this research, we investigate the psychological reality of such a format, using simulated motion during scene processing—previously linked to schematization—as a diagnostic. One group of participants wrote a verbal description of a scene and then completed a change detection task assessing simulated motion, while another group completed only the latter task. We expected that effects of simulated motion would be stronger following language use than not, and specifically following the use of spatial, relative to non-spatial, language. Both predictions were supported. Further, the effect of language was scene independent, suggesting that language may encourage a general mode of schematic construal. The study and its findings illustrate a novel approach to examining the perceptual properties of mental representations.

Keywords Spatial language · Schematization · Mental simulation · Language–thought interface

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Introduction

What is the nature of the representations underlying word meanings? Some recent research suggests that these representations may be relatively detailed, given evidence that language comprehension engages sensorimotor processes (Zwaan and Madden 2005). Work in lexical semantics, in contrast, has long held that the representations underlying word meanings, especially spatial terms, are highly schematic (Landau and Jackendoff 1993; Talmy 1983). Describing an object's location, for example, is said to involve conceptualizing the object as a "dimensionless speck" (Pinker 2007, p. 48) or a "simple lump or blob" (Landau and Jackendoff 1993, p. 228). The view from lexical semantics, while compelling, has not, however, been empirically tested. In the present research, we offer such a test. Specifically, we investigate whether words encoding spatial relations lead to the schematization of space.

A method for examining the representations associated with spatial language is suggested by research on mental simulation. In a study by Freyd et al. (1988), participants viewed a series of schematic line drawings in which a pedestal supporting a plant suddenly disappeared. The main finding was that participants spontaneously simulated the effects of gravity, indicated by greater insensitivity to downward relative to upward changes in the plant's position. More recently, Holmes and Wolff (2010, 2013) replicated Freyd et al.'s findings across a wider range of scenes, but found that simulated motion was much more pronounced for line drawings than photorealistic materials. This schematic advantage highlights simulated motion as a diagnostic of schematization. If spatial language is represented schematically, describing a scene using spatial language should be more likely to elicit simulated motion than describing the same scene using non-spatial language.

To test this possibility, we had one group of participants write a verbal description of a photorealistic scene, followed by a change detection task assessing simulated motion. Another group completed only the latter task. Given the relative coarseness with which word meanings encode experience in general (Gleitman and Papafragou 2005; Wolff and Malt 2010), we expected that simulated motion would be more pronounced following language use than not. We also expected, however, that simulated motion would be stronger specifically after the use of spatial, relative to non-spatial, language. Of additional interest was whether any effect of language use on simulated motion would depend on the particular scene described. If simulated motion effects for a given scene are observed only after describing the very same scene, they could be viewed as a kind of *thinking for speaking* (Slobin 1996), with language modulating simulation processes online. However, if such effects are not scene dependent, this would imply a more lingering influence of language on scene construal (Wolff and Holmes 2011). To address this issue, we examined simulated motion in participants who described the same scene used in the change detection task compared to those who described a different scene.

Method

Sixty-three undergraduates participated for course credit or payment.[1] In the language condition, participants spent 5 min writing a detailed description of the scene in Fig. 1a ($N = 18$) or Fig. 1b ($N = 18$) and then completed a change detection task. In this task, each trial began with the scene in Fig. 1a, showing a potted plant atop a pedestal. A blank screen appeared next, followed by a scene with the plant in the same position, but without the pedestal. Another blank screen preceded the final scene, which showed the plant in the same position, slightly raised, or slightly lowered (0.15 cm). Participants indicated whether the plant was in the same or different position compared to the previous scene by pressing one of two computer keys. Each display appeared for 250 ms, except the final scene, which remained onscreen until participants responded. There were 60 randomly ordered trials (20 for each plant position). In the no-language condition ($N = 27$), participants completed only the change detection task.

[1] All participants were Emory University students. Eight additional participants were excluded for making one kind of response (either *same* or *different*) on more than 75 % of trials.

Results

As predicted, simulated motion was more pronounced following language use than not. A 2 (condition) × 2 (position: up vs. down) ANOVA for accuracy yielded a main effect of position, $F(1,61) = 5.20$, $p = .03$, and an interaction, $F(1,61) = 3.97$, $p = .05$. Only participants in the language condition simulated downward motion, indicated by lower accuracy on down than up trials (see Fig. 1c).[2]

To examine whether simulated motion was stronger following spatial relative to non-spatial language use, we coded participants' descriptions for spatial relational (e.g., *against*, *supporting*) and descriptive (e.g., *leafy*, *marble*) terms. The simulated motion effect in the language condition was positively correlated with the relative frequency of spatial relational (see Fig. 1d), but not descriptive, terms ($p > .3$), indicating that participants who used more spatial language showed greater simulated motion.[3]

Finally, we compared simulated motion in participants who described the change detection scene versus a different scene. Simulated motion was evident in both groups [same: $t(17) = 2.22$, $p = .04$; different: $t(17) = 2.16$, $p = .05$], indicating that the effect of language was not scene dependent.

Discussion

Using language to describe a scene, especially spatial language, led people to simulate motion during subsequent scene processing, but no such effect occurred in the absence of verbalization. Given previous research linking simulated motion to schematization (Holmes and Wolff 2010, 2013), these results suggest that the representations generated during language use may be relatively lacking in detail. Our findings are consistent with research showing that children are better able to align relational structures when presented with relatively sparse stimuli (Gentner and

[2] An analogous ANOVA on correct reaction times (RTs) yielded main effects of condition, $F(1,61) = 5.08$, $p = .03$, and position, $F(1,61) = 15.40$, $p < .001$, but no interaction, $p > .3$. Slower responses occurred in the language condition ($M = 1161$ ms, $SD = 282$) compared to the no-language condition ($M = 1002$ ms, $SD = 295$), and when the target object was shifted down ($M = 1160$ ms, $SD = 377$) versus up ($M = 1003$ ms, $SD = 260$), suggesting that there was no speed-accuracy trade-off. Although the interaction did not reach significance, the asymmetry in sensitivity to downward versus upward changes was descriptively larger in the language condition ($M = 202$ ms; $d = .68$) compared to the no-language condition ($M = 118$ ms; $d = .46$).

[3] The correlation was also positive, though not significantly so, $r(34) = .16$, $p = .35$, when the degree of simulated motion was defined in terms of accuracy (i.e., accuracy on up trials minus accuracy on down trials).

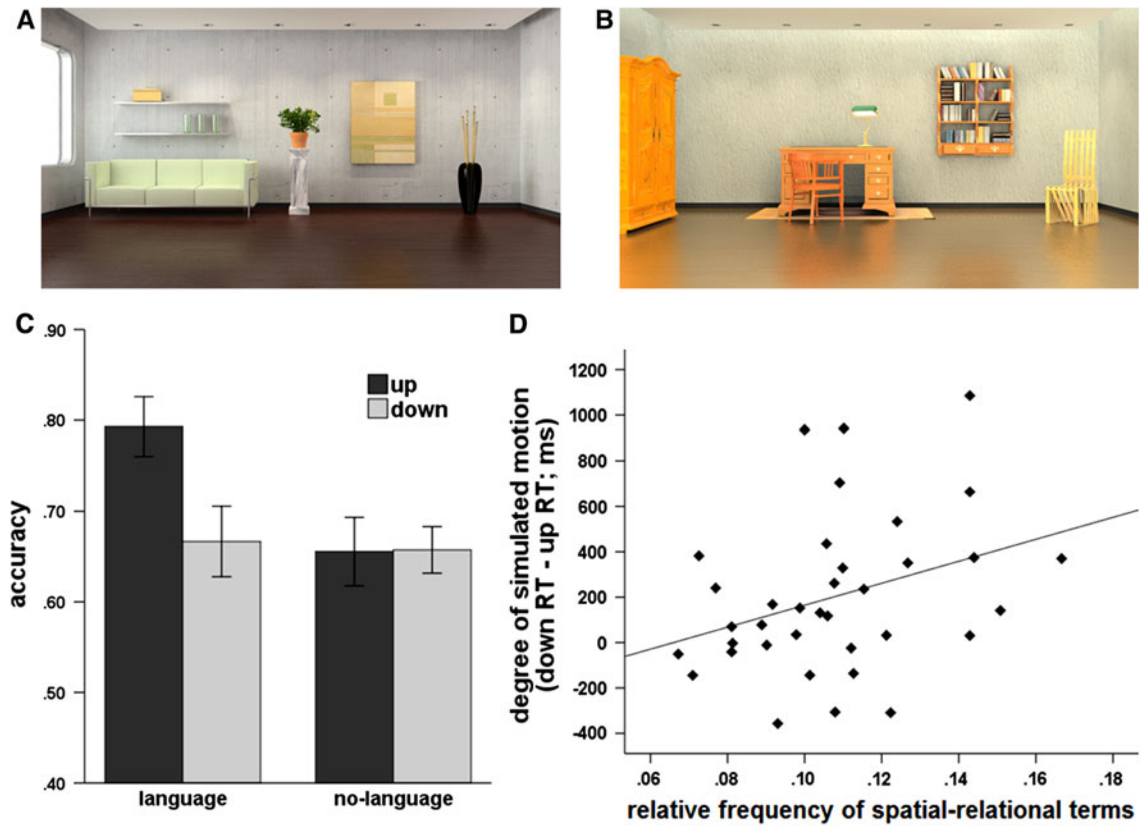

Fig. 1 **a**, **b** Displays described in the language condition. **c** Accuracy was significantly lower on down than up trials in the language condition, $t(35) = 3.14$, $p = .003$, $d = .53$, but not the no-language condition, $t(26) = .20$, $p > .8$ (*error bars*: ±1 SEM). **d** Significant positive correlation between the relative frequency of spatial–relational terms in participants' descriptions and the degree of simulated motion, $r(34) = .34$, $p = .05$

Rattermann 1991) or when exposed to spatial language (Loewenstein and Gentner 2005), but they go beyond such work in using simulated motion to gain insight into the perceptual properties of the representations supporting such abilities.

Further, we observed simulated motion effects even for scenes different from those just described, implying that schematization is not the product of specific words, but rather spatial language more generally. We suggest that spatial language may encourage a particular mental set, leading people to construe experience schematically even after language use. How long such effects of language persist is an intriguing question for future research.

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