Spatial Cognition 2016

Conference Proceedings

August 2-5, 2016 in Philadelphia, USA

ORGANIZERS
Mary Hegarty, UC-Santa Barbara
Christoph Hölscher, ETH-Zurich
Dan Montello, UC-Santa Barbara
Nora S. Newcombe, Temple University

Categorical Perception of Spatial Relations: A Cross-Linguistic Difference

Kevin J. Holmes[1], Kelsey Moty[2], and Terry Regier[3]

[1] Colorado College, Colorado Springs, CO
kjholmes@coloradocollege.edu
[2] Lehigh University, Bethlehem, PA
moty@lehigh.edu
[3] University of California, Berkeley, CA
terry.regier@berkeley.edu

Abstract. Observations of semantic diversity in spatial terms across languages have prompted a search for corresponding differences in nonlinguistic spatial cognition. While memory paradigms have failed to find cross-linguistic differences, research on categorical perception (CP) suggests that such differences might be observed in perceptual tasks. We tested for CP in English and Korean speakers for the distinction between support and non-support relations, marked obligatorily in English but not in Korean. The results showed CP in English but not Korean speakers for the support/non-support distinction, and the effect for English speakers was lateralized to the right visual field, consistent with previous research. Our findings suggest that the basic spatial terms of one's native language can affect the perceptual discrimination of spatial relations.

Keywords. categorical perception, space, language and thought, lateralization.

1 Introduction

The world's languages partition the spatial world differently. Consider, for example, the scenes shown in Fig. 1. In English, the relation of the figure object to the reference object is naturally expressed by the terms "on" and "above" in the support and non-support scenes, respectively. In Korean and Japanese, however, the distinction between support and non-support is not obligatorily encoded; the same term can be used to describe both types of relations [1].

Such semantic diversity suggests the possibility that speakers of different languages may represent the spatial world differently in nonlinguistic cognition—consistent with the Whorfian hypothesis that linguistic differences cause cognitive differences more generally [2]. However, previous research in the spatial domain challenges this possibility. In a study by Munnich, Landau, and Dosher [1], English speakers differed from Korean and Japanese speakers in their naming of support and non-support scenes, yet showed comparable memory for such scenes. These results converge with those obtained from memory paradigms in other domains [e.g., 3], and

have been interpreted as evidence for a dissociation between spatial language and spatial cognition [1].

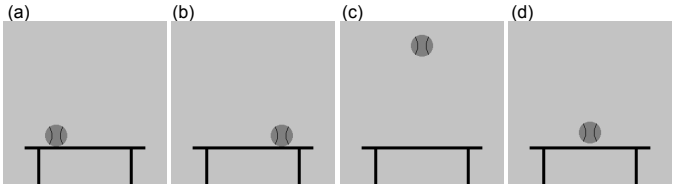

Fig. 1. Support (a, b) and non-support (c, d) scenes.

Research using non-memory perceptual paradigms suggests a different picture. Several studies in the color domain have shown that *categorical perception* (CP), or enhanced discrimination at category boundaries, differs across languages in a manner that aligns with color lexicons [e.g., 4]. Moreover, CP is often found to be stronger in the right visual field (RVF) than the left (LVF)—consistent with the language dominance of the left hemisphere, to which the RVF projects [e.g., 5; but see 6]—and such lateralized CP also appears to differ across languages, at least in fast-responding participants [7]. Such findings suggest that cross-linguistic differences in spatial cognition, not observed in Munnich et al.'s [1] memory paradigm, might be found in a paradigm testing for CP.

We investigated this possibility by having native English and native Korean speakers complete a visual search task with no memory component, consisting of scenes depicting support and non-support relations. If spatial language affects the perceptual discrimination of spatial relations, only the English speakers should show lateralized CP for the support/non-support distinction in this task.

2 Method

2.1 Participants

Participants were 37 right-handed UC Berkeley students (19 native English and 18 native Korean speakers). None of the English speakers had been exposed to Korean, and none of the Korean speakers had been exposed to English before age 12, as in Munnich et al. [1]. One English speaker was excluded for chance-level accuracy.

2.2 Stimuli and Procedure

The stimuli were four scenes of a ball and a table, each showing a support or non-support relation (see Fig. 1). The experiment was conducted entirely in participants' native language. Participants sat in a darkened room with the center of the computer

screen at eye level. On each trial of the visual search task, a fixation marker appeared for 1000 ms, followed by a four-scene display for 200 ms (an interval that discouraged eye movements). Three of the scenes were identical (distractors) and differed from the fourth (target); see Fig. 2. The target and distractors depicted relations from either the same category (e.g., all support) or different categories (e.g., support target, non-support distractors). Participants indicated as quickly as possible the side containing the target by pressing left- or right-side keys. The next trial began 250 ms after participants responded.

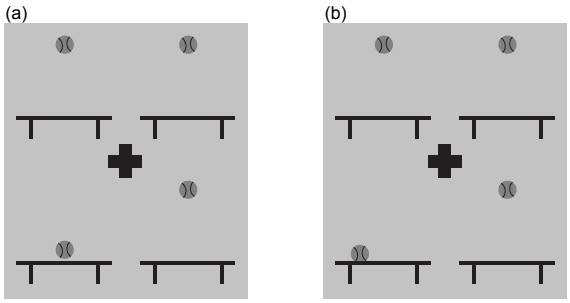

Fig. 2. Sample visual search displays, with the target in the lower left position of each: (a) within-category trial; (b) between-category trial.

There were 32 practice trials and 224 test trials, half within-category and half between-category, presented in random order. On the between-category trials, one of the support scenes was always paired with the non-support scene depicting the ball in the higher position (Fig. 1c). Across trials, each scene served as target and distractor at all four display positions.

After the visual search task, the Korean speakers were shown the four support/non-support scenes sequentially and, for each, filled in the blank in the Korean translation of the sentence, "The ball is _____ the table." A separate group of 14 native English speakers completed the same naming task in English. This task served as a manipulation check to ensure that the stimuli captured the cross-linguistic difference of interest.

3 Results

Mean accuracy was 79.9% (*SD* = 10.6), with no significant difference between English and Korean speakers. Trials in which participants responded incorrectly or RT exceeded 2.5 SDs from individual means (2.5%) were excluded. We conducted a mixed ANOVA on the remaining RTs, with visual field (LVF/RVF) and categorical relationship (within-/between-category) as within-participants factors and language

(English/Korean) as a between-participants factor. This analysis yielded a three-way interaction, $F(1, 34) = 6.47$, $p = .02$, but no other significant effects ($ps > .1$).

To unpack the three-way interaction, separate repeated-measures ANOVAs were conducted on the RT data from each language group. Whereas the English speakers showed an interaction between visual field and categorical relationship, $F(1, 17) = 5.32$, $p = .03$, indicating lateralized CP, the Korean speakers did not, $p > .1$. English speakers responded faster to RVF targets on between-category than within-category trials, $t(17) = 2.40$, $p = .03$, but showed no such between-category advantage for LVF targets, $p > .6$. In contrast, for Korean speakers, no significant between-category advantage was observed in *either* visual field ($ps > .1$); see Fig. 3.

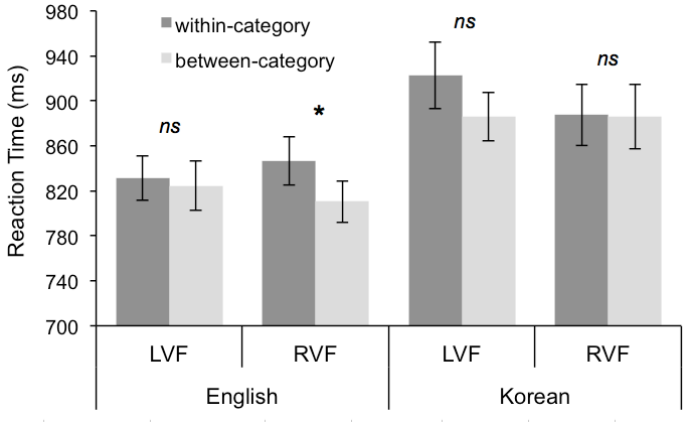

Fig. 3. Mean RT by visual field and categorical relationship for English and Korean speakers. Whereas the English speakers showed CP in the RVF but not the LVF (i.e., lateralized CP), the Korean speakers showed CP in neither visual field. Error bars are 95% within-participants CIs.

An analogous mixed ANOVA for accuracy yielded an interaction between visual field and language, $F(1, 34) = 5.17$, $p = .03$, with greater accuracy in the LVF for English speakers and the RVF for Korean speakers. Importantly, these factors did not interact with categorical relationship and no other effects were significant, suggesting that there was no speed-accuracy tradeoff.

The results of the naming task confirmed that the stimuli were readily distinguished by support/non-support terms in English, but not in Korean. Whereas only one of the 18 Korean participants used such terms to describe the spatial relations depicted, all of the English speakers who completed the naming task did so.

4 Discussion

Our results provide evidence that spatial language affects spatial cognition. English, but not Korean, obligatorily marks the support/non-support distinction, and English speakers, but not Korean speakers, showed lateralized CP for this distinction. Our findings add to the literature showing lateralized CP for basic-level categories [e.g., 5, 7; but see 6], extending the phenomenon to the domain of spatial relations. Moreover, our findings suggest that, when not marked by basic spatial terms in one's native language, the support/non-support distinction is not sufficiently salient to affect perceptual discrimination. While there is evidence that certain categories can yield lateralized CP even in the absence of overt linguistic marking [8, 9], such effects have been observed only for superordinate-level categories proposed to be evolutionarily primary (e.g., "warm"/"cool" colors) or categories for which participants received explicit training—neither of which holds for the support/non-support distinction in Korean speakers.

Our findings stand in contrast to those of Munnich et al. [1], who found comparable memory for the support/non-support distinction in English and Korean speakers. Thus, at least in the spatial domain, perceptual tasks may be more sensitive than memory tasks to Whorfian effects of language on nonlinguistic cognition. It is not entirely clear what accounts for this difference. One possibility is that if spatial language (e.g., the terms "on" and "above") is spontaneously accessed during the initial perceptual processing of spatial relations, as suggested by our finding of lateralized CP, such linguistic representations may, in some cases, be attenuated over a delay. Future research is needed to evaluate this possibility and the conditions under which it operates.

Acknowledgments. We thank Edward Munnich for guidance, and Caitlyn Brady, Alex Carstensen, and Seul Lee for assistance with stimulus preparation and data collection. This material is based upon work supported by the National Science Foundation under Grant Number 1206361.

5 References

1. Munnich, E., Landau, B., Dosher, B.A.: Spatial Language and Spatial Representation: A Cross-Linguistic Comparison. Cognition 81, 171–208 (2001)
2. Wolff, P., Holmes, K.J.: Linguistic Relativity. Wiley Interdiscip. Rev. Cogn. Sci. 2, 253–265 (2011)
3. Wright, O., Davies, I.R.L., Franklin, A.: Whorfian Effects on Colour Memory Are Not Reliable. Q. J. Exp. Psychol. 68, 745–758 (2015)
4. Winawer, J., Witthoft, N., Frank, M.C., Wu, L., Wade, A.R., Boroditsky, L.: Russian Blues Reveal Effects of Language on Color Discrimination. Proc. Natl. Acad. Sci. U.S.A. 104, 7780–7785 (2007)

5. Gilbert, A., Regier, T., Kay, P., Ivry, R.B.: Whorf Hypothesis Is Supported in the Right Visual Field but Not the Left. Proc. Natl. Acad. Sci. U.S.A. 103, 489–494 (2006)
6. Witzel, C., Gegenfurtner, K.R.: Is There a Lateralized Category Effect for Color? J. Vis. 11 (2011)
7. Roberson, D., Pak, H., Hanley, J.R.: Categorical Perception of Colour in the Left and Right Visual Field Is Verbally Mediated: Evidence from Korean. Cognition 107, 752–762 (2008)
8. Holmes, K.J., Wolff, P.: Does Categorical Perception in the Left Hemisphere Depend on Language? J. Exp. Psychol. Gen. 141, 439–443 (2012)
9. Holmes, K.J., Regier, T.: Categorical Perception Beyond the Basic Level: The Case of Warm and Cool Colors. Cogn. Sci. (2016, in press)