Spatial Reference: Studying the Interplay of Language, Culture and the Environment

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Introduction—Recent advances in the availability of affordable computational power have made it possible to subject large-scale crosslinguistic and crosscultural data samples to sophisticated statistical analyses that can isolate the effects of language, culture, and the environment in spatial cognition. The use of spatial reference frames in discourse and nonlinguistic cognition offers an ideal test case for such studies.

Background—One of the oldest and most persistent questions in the history of science is that of nature vs. nurture, or the respective role of genetics and personal experience in shaping the individual’s behavior. The latter in turn presumably reflects influences of the environment, some of which may be mediated by culture. Two widespread assumptions in the cognitive sciences (especially artificial intelligence, psychology, and linguistics) are, first, that the study of the mind should focus on those aspects of cognition that are determined by nature, i.e., are innate, and secondly, that variation in cognitive traits across human populations largely responds to environmental and cultural factors and therefore falls outside the study of “cognition proper.” As a result, comparatively little empirical research into population-specific cognitive traits has been conducted. More specifically, we know a great deal about certain pieces of the larger puzzle of the role of biology, culture, and the environment in human cognition. But these pieces have been studied in isolation, and no studies have been carried out that examine the interaction of all of them. In addition, much of this research has proceeded qualitatively, arguing for example for effects of physiography on dialect differentiation on the basis of the pronunciation of individual words and sounds, rather than quantitatively.

Recently, two collaborative projects under my direction, funded by the National Science Foundation (NSF awards BCS-0723694 and BCS-1053123) and collectively known under the acronym MesoSpace, have been investigating for the first time how a single aspect of cognition—the use of spatial reference frames (Carlson, Radvansky & Irwin 1992; Gallistel 1990; Levelt 1990; Levinson 1996)—is shaped by language, literacy, education, and two environmental variables, topography and population density. The research of the MesoSpace team for the first time presents a fine-grained picture of how these variables interact in influencing human behavior. The results point to a far more powerful role of culture in the mind than most cognitive scientists have assumed.

Spatial reference frame use as a cognitive anthropology laboratory—What makes reference frames so suitable for studying the interplay of biology, culture, and the environment in cognition is a combination of four properties: (i) they are indispensable in identifying
nontopological regions of space and thus can be assumed to be evolutionarily ancient and to have a biological basis (Gallistel 1990); (ii) yet, there is considerable variation across human populations in the types of frames customarily used for reference at the small scale; (iii) a given population’s linguistic preferences fairly narrowly predict its preferences in nonverbal tasks, including in inferences and memory (Pederson et al 1998; Levinson 2003; Mishra et al 2003; Majid et al 2004; Haun et al 2011; Le Guen 2011; Bohnemeyer et al 2014); and (iv) geocentric frames are sensitive to the environment in that their axes are defined with respect to landmarks or gradients of the environment (with varying levels of abstraction; Wassman & Dasen 1998; Levinson 2003; Polian & Bohnemeyer 2011; Bohnemeyer & O’Meara 2012; Palmer 2015). It was in the context of research probing the covariation between frame selection in discourse and nonverbal cognition (property (iii)) that the question of the factors driving frame use across populations first came up. Pederson et al (1998) hypothesized that this covariation was the result of different languages influencing the nonverbal cognition of their speakers in different ways—a language-on-thought effect in line with the Linguistic Relativity Hypothesis (Whorf 1957). In contrast, Li & Gleitman (2002) argued that the alignment between frame use in language and nonverbal cognition was epiphenomenal: participants’ behavior in both types of tasks was driven by the same set of nonlinguistic variables, including education and literacy, but also topography and population density.

The MesoSpace studies—Bohnemeyer et al (2014, 2015, under revision) investigate how speakers of eight indigenous languages of Mexico and Nicaragua and L1-speakers of the dominant contact language, Spanish, in Mexico, Nicaragua, and Spain talk about and memorize the location and orientation of objects in space. These studies have for the first time demonstrated quantitatively the impact of topography and population density on frame use. The statistical models employed by the group (mixed effects logistic regression models) also showed that the role of the first language cannot be reduced to any combination of the other factors. Furthermore, the indigenous participants proved to be more likely to use the “relative” subtype of egocentric frames (Levinson 1996) in their native languages the more frequently they use Spanish as a second language. This points to Spanish serving as a conduit for the diffusion of egocentrism in the area.

In unpublished work, the MesoSpace team has extended this investigation to a population sample that includes speakers of English, Vietnamese, and two Mesoamerican languages (Isthmus Zapotec and Yucatec Maya), as well as members of two Taiwanese populations (monolingual Mandarin speakers and Mandarin-Taiwanese bilinguals) and four Japanese populations (rural vs. urban speakers from Honshu vs. Okinawa). This is the largest and most diverse study of the use of reference frames in language to date. Preliminary results confirm the non-epiphenomenal role of language. The linguistic study also showed effects of literacy and population density, while the recall memory study showed in addition to language topography as a significant factor, but this apparent effect is at present still being probed.
Evidence of a pan-simian geocentrism bias and the rise of the small scale—Several of the MesoSpace studies produced evidence of a cognitive geocentrism bias in populations that show no clear preference in linguistic tasks. This surprising finding is consistent with the hypothesis of an innate pan-simian geocentrism bias that can be reshaped through the effect of language and other observable cultural practices (Haun et al 2006). In the context of the other MesoSpace findings, a possible scenario for the cultural evolution of egocentrism emerges. According to this scenario, egocentrism has been culturally “selected for” by an ever-expanding importance of control of the small scale in human behavior with the advent of tool use, manufactured walled-off spaces, and eventually manufactured visual representations, especially writing. Observable cultural practices such as speech, gesture, and writing serve as transmission systems that allow the members of a community to converge on the non-innate practice of egocentric frame use.

Selected references
