Universal Mechanisms, Variable Parameterization

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It seems generally accepted that spatial reference frames are crucially involved in spatial referencing (Levinson, 2003; Logan & Sadler, 1996). Reference frames are means to mentally organize space and they enable distinguishing and labeling different parts of space as well as apprehending and distinguishing different spatial relations. As such, reference frames are indispensable prerequisites for spatial referencing in all cultures and languages. Previous research has distinguished a variety of reference frames that natural cognitive agents are assumed to draw on. In the spatial language domain an influential distinction of reference frames into relative, absolute, and intrinsic frames has been proposed by Levinson (2003, but see also Pederson, 2003) and much research in linguistics has focused on how languages and cultures differ regarding their proclivity to employ these different frames.

I argue

• that differences in which reference frame is selected need not be indicative of differences in how selection is achieved,
• that the mechanisms underlying reference frame selection in English are universal as mechanisms for reference frame selection across languages and cultures,
• more generally, that certain processing steps involved in spatial referencing and the mechanisms realizing them are universal, but that the parameterization or tuning of these universal mechanisms vary across languages and cultures.

Studies on English spatial language use have shown (e.g., Carlson & van Deman, 2008; Carlson, 1999) that spatial referencing requires selecting one of the available reference frames. A recent in-depth study of the mechanisms underlying reference frame selection has identified the leaky competing accumulator (LCA, Usher & McClelland, 2001) model as an accurate account of this subprocess of spatial referencing (Schultheis & Carlson, in press). LCA is a connectionist model with a single layer of units. Each of the units represents one possible reference frame. Each unit receives input from those available sources of information that support the frame represented by the unit. Unit activation increases by accumulating the received input, and decreases due to decay and lateral inhibition between units. Activation is furthermore influenced by unsystematic fluctuations (white noise). Once any unit’s activation grows beyond a prespecified threshold, reference frame selection stops. The selected frame is assumed to be the one represented by the winning unit.

I propose that—insofar as the LCA is an accurate account of reference frame selection for English—the LCA’s structure and workings are universal as a mechanism for reference frame selection across languages and cultures. Given that (a) reference frames are crucial prerequisites for spatial referencing and that (b) all natural cognitive agents have access to a multitude of reference frames, the necessity to select a reference frame for spatial referencing will, arguably,
be of little debate. But what of the more specific claim that reference frame selection is governed by mechanisms as implemented in the LCA? Obviously, there are differences in reference frame selection across languages and cultures. As, for example, the seminal work of Stephen Levinson and his colleagues has shown, there are many languages in which frames are selected for spatial referencing that would rarely be used in English (Levinson, 2003).

However, the observed differences are differences in which frame is usually selected and they need not be indicative of differences in how selection is achieved. Even if the mechanisms are the same, differences can easily arise by different parameterizations of the LCA such as, for example, different inhibitory strength, different rates of decay, and, most notably, different salience/strength of available competing frames. Accordingly, the mechanism underlying reference frame selection may be universal across languages and cultures, while the observed variation across languages arises from adaptations of the universal mechanism.

Are there any reasons to believe that the LCA constitutes a universal mechanism? I think there are, though a more direct test and corroboration certainly seems desirable (see below). One reason is the non-deterministic nature of the selection outcome. Even when strong preferences have been found for one particular frame, alternative frames are also selected for a (small) proportion of trials. This is true not only for English (Li & Gleitman, 2002), but also for languages that exhibit a preference for an absolute frame (Levinson, 2003). Such a pattern of selection outcomes is well in line with the type of competitive, noisy process realized by the LCA. The second reason is that reference frame selection is an important process not only in spatial referencing but also in spatial cognition abilities such as mental image reinterpretation (Peterson, Kihlstrom, Rose, & Glisky, 1992) and perspective taking (May, 2004): In fact, an LCA-like process has been successfully employed to model perspective taking (Schultheis, 2007). Accordingly, the LCA captures an aspect of spatial cognition that is not tightly tied to language and it seems natural to suppose that a mechanism not specifically deployed for language is universal across languages. It is worth noting that the applicability of the mechanisms realized in the LCA to both spatial referencing and spatial reasoning also suggests a new view on the question of linguistic relativity. While many proponents in the debate either argue for (some form of) the SapirWhorf hypothesis (Majid, Bowerman, Kita, Haun, & Levinson, 2004; Levinson, 2003) or the opposite (Gallistel, 2002; Li & Gleitman, 2002) the general applicability of the LCA indicates that observed correlations between language and thought may arise from common mechanisms and not from a causal influence of language on thought or vice versa.

As already stated above, it is desirable to more directly test the proposition put forth here by investigating the universality of mechanisms involved in spatial referencing in more detail in various languages and cultures. Questions of particular interest are, for example: (a) How well does the LCA account for selection in other languages and cultures? (b) How well do other mechanisms (e.g., the AVS, Regier & Carlson, 2001) transfer from English to other languages? (c) Is the way in which mechanisms of subprocesses of spatial referencing combine (e.g., LCA and AVS) also universal? (d) How do observed variations in spatial referencing map onto changes in parameterizations?
References