The TEC as a theory of embodied cognition

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Abstract: We argue that the strengths of the Theory of Event Coding (TEC) can usefully be applied to a wider scope of cognitive tasks, and tested by more diverse methodologies. When allied with a theory of conceptual representation such as Barsalou's (1999a) perceptual symbol systems, and extended to data from eye-movement studies, the TEC has the potential to address the larger goals of an *embodied* view of cognition.

The two main claims of the Theory of Event Coding (TEC), as we see it, are the nature of perception-action relations and the role of distal coding. The former claim is supported with data from experiments that require overt behaviours, such as button presses, in rapid response to reasonably simple stimuli. Yet if it is the case that event codes are an important level of representation, then we might expect them to contribute to more complex, conceptual representations as well. Also, if common coding is indeed a key principle of mental representation, then we should find evidence of motor systems participating in a wide range of cognitive tasks. Following these assumptions, we propose that the TEC should be allied to broader theories of cognition such as Barsalou's (1999a) Perceptual Symbols Systems, and present several examples of how the TEC can be extended into methodologies that use richer stimuli and more complex responses. We argue further that problems associated with **Hommel et al.**'s second claim, regarding distal coding, are alleviated by adopting an embodied view of the mind.

Barsalou's (1999a) Perceptual Symbol Systems theory proposes an account of conceptual representation as perceptual simulation, or combinations of "perceptual symbols." Although motor systems are proposed to contribute to perceptual simulations, most of the empirical evidence so far focuses on the modal, perceptual quality of conceptual representations. For example, Stanfield and Zwaan (2001) showed that if a narrative implicitly describes an object in a certain orientation (e.g., a nail hammered into the floor versus the wall), an image of that object presented later will be identified more quickly if it is in the same orientation. This suggests that subjects construct a mental model or "perceptual simulation" of the narrative that is specific to the level of object orientation.

Recent work in our laboratory uses the framework of the TEC to show that perceptual simulations of a spoken narrative may also include "action codes" for potential motor interactions. In Experiment 2 of Richardson et al. (2001), subjects heard a story which mentioned an object with a one-sided affordance (e.g., a milk jug). The orientation of the object was implied (e.g., "the milk jug points towards the egg cup"). When subjects made a later judgment about a different property of the object (e.g., "Is the jug in the center of the table?"), there were interactions between the left/right hand used to make the response, and the left/right affordance of the imagined object. Thus, the mental representation of the scene seems to evoke action codes for object affordances, which then interact with manual responses. Moreover, the time course of these interactions followed the pattern suggested by TEC (sect. 3.2.2) such that early responses show stimulus-response compatibility effects, and later responses show incompatibility effects (Stoet & Hommel 1999; Tucker & Ellis 1998).

However, the speed of a button press is only one, rather limited, way to investigate the interaction between motor and cognitive systems. **Hommel et al.** frequently allude to eye movements as a concrete example of action continuously guiding perception, yet they do not discuss the literature on eye movements and cognition (e.g., Ballard et al. 1997). Work in our laboratory has shown how oculomotor systems participate in the comprehension of spoken scene descriptions (Spivey & Geng, in press; Spivey et al. 2000), and the spatial indexing of linguistic information (Richardson & Spivey 2000). In the latter work, we presented adults with auditory semantic facts that co-occurred with visual events in four locations. When answering a question about one of the facts, subjects made saccades to the (now empty) region of space associated with that fact. Although location was task-irrelevant, adults tagged auditory information with a spatial index (cf. Pylyshyn 2001). In this way, even though they may be looking at a blank display, subjects' eye movements reveal a degree of oculomotor participation in what is essentially a distal encoding of linguistic information.

Placing the TEC within the context of the embodied cognition framework not only widens the scope of this promising theory, it also alleviates the metatheoretical concerns that **Hommel et al.** raise in their Epilogue about the source of distal coding. From an embodied perspective, the reason we do not see spikes traveling along our nerves when we look at a flower is because those spikes *are* the seeing. An embodied mind is one in which the entire system, from sensors to effectors, participates in mental experience. There is no subset region that one can point at and call "the mind within the body." Thus, when the TEC is combined with an embodied view of cognition, the question of why coding is distal instead of proximal fades away.

In conclusion, we see an increasing body of research that reveals a very tight coupling between perception and action. Within the domain of reasonably simple, stimulus-response tasks, **Hommel et al.** replace the idea of a perception-action arc with the elegant notion of event codes. We argue that this common coding structure may also be employed in conceptual or linguistic representation. If one views cognition from an embodied or situated perspective (Barsalou 1999b; Clark 1997; Glenberg 1999; Lakoff 1999), then language comprehension is a matter of "preparation for situated action." In this framework, conceptual representations are contiguous with the representational forms of perception and action. Therefore, with a broader perspective on cognition and a wider set of empirical methodologies, the TEC provides the theoretical mechanics for investigating the embodied nature of cognition.

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