

## Multiple Object-states Represent Events: A new account of event representation

Events cause change. Even simple organisms like amoebae<sup>1</sup> react to change (e.g. Westendorf, Negrete, Bae, Sandmann, Bodenschatz, & Beta, 2013). Our own (human) ability to notice, track, represent, recall, and communicate change is at the heart of human function; from our most peripheral sensory systems to the highest levels of cognitive representation and processing. Here, we consider the implications of representing change for theories of event cognition and event representation. Our intention is to account for the *content* of event representations – or rather, the minimum content that is required to represent an event as might be experienced by an onlooker or conveyed by that onlooker via language. We introduce a new account of event representation based on those aspects of object representations that convey the distinct states that an object has experienced – minimally reflecting the *before* and *after* of whatever changes the object undergoes as an event unfolds: For an event that can be described as “*the chef chopped the onion*”, the initial state is an intact onion, and the resultant state is the chopped onion.

Research on event cognition has most recently tended to focus on how we segment the continuous input stream into discrete events (Event Segmentation Theory; Zacks, Speer, Swallow, Braver, & Reynolds, 1997), how information is maintained/recalled within and across event boundaries (e.g. The Event Horizon Model; e.g. Radvansky, 2012), and how to best characterize *generalized event knowledge* – “semantic” knowledge of how, in general, the world changes as a function of typical protagonist interactions (e.g. McRae, Hare, Elman, & Ferretti, 2005; Metusalem, Kutas, Urbach, Hare, McRae, & Elman, 2012). Accounts of event structure and lexical semantics from within the linguistic tradition (e.g. Dowty, 1979; Rappaport Hovav & Levin, 1998; Vendler, 1957; Warglien et al. 2012) posit that the meanings of verbs include reference to objects’ changes of state as entailed by the actions denoted by the verb. In all these cases, there is an assumption (tacit or explicit) that actions, participants (objects), space, time (and possibly causality) are primitives of event representation. Embodiment theories of action and object representation (e.g. Barsalou, 1999) likewise appear founded on the principle that action is a primitive, that objects are represented in terms of the perceptions and *interactions* they afford (Gibson, 1979; Glenberg, 1997), and that more broadly, language itself is grounded in action (e.g. Glenberg & Kaschak, 2002). We contend, however, that action representations are not in fact *primitives* of event representation, but rather are *emergent representations* abstracted across the distinct changes in state that objects undergo in the company of other (changing) objects.

We shall propose the primacy of object-state representations on the basis of a series of studies, from eye-tracking to fMRI, which suggest that when an event is described to have occurred such that an object has changed state, the representations of these distinct states are *simultaneously* activated when that object is subsequently referred to again (cf. homophony, in which a single lexical label can have multiple meanings). Thus, on hearing that the woman chopped the onion, and then hearing “*And then she weighed the onion*”, both the initial and resultant states are activated at “*the onion*” (e.g. Solomon, Hindy, Altmann, & Thompson-Schill, 2015). We shall argue for the *action-as-abstraction* approach to event structure on grounds of parsimony: if, as the evidence suggests (and theory requires), the cognitive system represents

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<sup>1</sup> Fortuitously, the word *amoeba* is derived from the Ancient Greek for *change*.

the spatiotemporal properties of object states, and does so in the context of other objects' spatiotemporally defined states, what more is required, representationally speaking, to encode action? (We shall confront head-on the challenge of explaining how we reconcile action-as-abstraction with the existence of brain mechanisms that appear specialized for planning and executing motoric action, but space precludes discussion here).

Our account of event representation, that multiple object-states represent events, requires not just the distinction between object types (onions in general) and object tokens (a specific onion in the possession of the woman), but also between tokens and token-states (i.e. the states through which individual tokens pass; the onion in its different, intact and chopped, states). This type/token/token-state distinction places language (and event) comprehension at the interface between semantic memory (e.g. knowledge about onions in general) and episodic memory (e.g. knowledge about a specific onion in a specific state at a particular moment in event-time). We shall describe new evidence that the brain mechanisms implicated in episodic memory (specifically hippocampus; see e.g. Burgess, Maguire, & O'Keefe, 2002, for review) do indeed play a central role in language comprehension; instantiating the tokens and token-states described by the language.

An integral part of event understanding is knowing that an event has occurred, and that the world was in one state but now is in another. The representation of such change, grounded in the interface between semantic and episodic memory, is a fundamental ingredient of language and event comprehension, and indeed, of *cognition* more generally. A fuller understanding of event representation will necessarily require that we cross that semantic/episodic interface.

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