Global and Incremental Updating of Event Representations in Discourse

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Event Models in Comprehension

People spend an impressive amount of time exchanging stories—written fiction, spoken anecdotes, instructions, explanations of scientific processes, and news reports. Stories come in written and spoken language, and also in movies and picture stories. The comprehension of narrative structure is important for coordinating behavior, for teaching and learning, and for entertainment.

A central feature of narrative comprehension is that readers, listeners and viewers construct and update internal representations of the events depicted or described in the story; these have been called *situation models* or *event models* (Zwaan & Radvansky, 1998). A crucial question for theories of narrative comprehension is: How are event models updated?

One potential updating mechanism is *incremental*. In incremental updating, new features are mapped into a currently-maintained event model as the comprehender experiences changes in the narrative situation. Information that conflicts with the new features is susceptible to updating but representations of other aspects of the situation are not affected. For example, if one reads about a new character being introduced ("Lucy strolled onto the field."), incremental updating of this character information could affect the representations of other characters in the event model but should not affect the representation of the spatial layout or the objects in the scene. Theories such as the Event Indexing model propose an incremental updating mechanism (Zwaan, Langston, & Graesser, 1995).

An alternative updating mechanism is *global*. In global updating, a current event model is abandoned and replaced by a new event model when new features are introduced. If reading that Lucy strolled onto the field led to globally updating of an event model, this could affect not only the representation of other characters, but also the representation of other dimensions of the situation. Event Segmentation Theory, a comprehension model that we have proposed, includes only global updating (Zacks, Speer, Swallow, Braver, & Reynolds, 2007).

Incremental and global updating are not mutually exclusive. One theory that includes both mechanisms is Gernsbacher's Structure Building Framework (Gernsbacher, 1990). In this theory, new information is mapped into an event model as a comprehender encounters the information—incremental updating. However, if the discrepancy between new information and the current model is too great, the current model is abandoned and a new model is constructed—global updating.

Surprisingly, there is been almost no empirical research directly testing for incremental and global event model updating in text comprehension. Movie viewing studies indicate that viewers perceive event boundaries more often when more situational features are changing (Huff, Meitz, & Papenmeier, 2014; Magliano, Miller, & Zwaan, 2001). However, this could reflect a shift in the probability of global updating rather than incremental updating.

Do global and incremental updating both routinely occur during reading? Do some groups lean more on one than the other? Here, we will review a recent line of research that begins to answer these questions for the comprehension of written narratives. The data come from functional neuroimaging, think-aloud protocols, and response time measures of working memory accessibility. The results support both incremental and global updating mechanisms, consistent with the Structure Building Framework.

Neurophysiological Evidence

Our first hint that both incremental and global updating figure importantly in discourse comprehension came from a functional MRI study of reading (Yarkoni, Speer, & Zacks, 2008). In this experiment, participants read paragraphs that either described coherent narratives, or paragraphs composed by scrambling sentences from multiple narrative into one paragraph. We analyzed activation in brain regions whose time-course was different for the intact and scrambled paragraphs. Regions in the posterior parietal cortex showed a pattern of activity that was consistent with global updating: During intact paragraphs, activation in these regions initially rose but then quickly declined until the end of the paragraph, consistent with a role in establishing a new event model. During scrambled paragraphs, activation rose and remained

high across sentences, consistent with having to establish a new model for each new sentence because the information could not be integrated into a common model. Regions in the right superior temporal sulcus and temporal pole showed a pattern consistent with incremental updating: During intact paragraphs their activity rose steadily, consistent with mapping new information into a common model. However, during scrambled paragraphs, for which incremental mapping was not possible, they showed little increase.

Think-aloud Protocol Evidence

Direct evidence for global updating came from a think-aloud study, in which participants read narratives one clause at a time and then described what they were thinking about after each narrative (Kurby & Zacks, 2012). In such a paradigm, one would expect that readers would mention features of the activity when changes in those features were described in the narrative. This could reflect global updating, but it also could reflect incremental updating. However, if readers mentioned dimensions of the situation that had *not* changed and were *not* recently mentioned, this would be evidence for global updating. To test these proposals, we asked readers to complete the think-aloud protocol, and then to segment each narrative into meaningful events. We hypothesized that global updating would be more likely at event boundaries, consistent with Event Segmentation Theory (Zacks et al., 2007). Trained coders then recorded which of five narrative dimensions were mentioned in each entry of the think-aloud protocols. (The dimensions were cause, character, objects, space, and time.) As expected, readers mentioned dimensions more when they changed. Further, they were more likely to mention *unchanged* dimensions of the situation at event boundaries. The pattern was consistent with both incremental and global updating occurring, with incremental updating occurring when new information was introduced within an event and global updating occurring at event boundaries.

Memory Probe Evidence

In the final series of studies, we used speeded memory probes to assay the consequences of updating (Bailey, Kurby, Sargent, & Zacks, 2017; Bailey & Zacks, 2015). In these studies, participants read stories that included changes in characters or spatial location. A first experiment confirmed that the readers perceived these changes as event boundaries. Further, the impact of the changes was modulated by orienting instructions: When participants were encouraged to focus on space, by being told that they would have to draw a map of the story environment, they were more likely to mark spatial changes as event boundaries. (Instructions to focus on characters had little effect on segmentation suggesting that readers were already tracking this dimension of the situation.) In a second experiment, we asked participants to recognize recently-presented phrases describing a character or a spatial location throughout the stories. Recognition of phrases was slower after a shift. Probes of the shifted dimension were slowed more than probes related to the unshifted dimension, consistent with a mix of incremental and global updating. Whereas all of the studies described so far focused on younger adults, a final study compared performance between younger and older adults. As before, younger adults showed a mix of incremental and global updating. However, older adults' responses to memory probes were consistent with purely global updating. One possibility is that this reflects an unconscious strategy shift to compensate for reduced ability to manipulate information in working memory.

Conclusion

These results establish roles for both incremental and global updating during narrative comprehension. Going forward, a challenge is to work out the computational mechanisms by which event models are represented and updated.

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