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Across the Event Horizon

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Abstract

The stream of action in life, virtual environments, film, and narratives is parsed into events. This parsing has consequences for memory. The transition from one event to another can impede memory in some ways but improve it in others. Whether impairment or improvement occurs depends on the nature of the information and how it is later remembered. The Event Horizon Model of comprehension and memory goes beyond more traditional accounts of the influence of context on cognition to explain these phenomena.

Keywords

event cognition, memory, cognition

Life is just one thing after another. We entertain ourselves with various approximations of life—video games, books, films, theater, and so on—more things, one after another. These things consist of events. How we break up all of these streams of action into events influences how we think about things and what we remember later. These memories then help guide us through the flow of experience, allowing us to develop expectations of what will happen and what to do next. Memory and cognition are deeply influenced by events and how people structure them. In my laboratory, we have been studying aspects of event structure that can impair or improve memory.

For one thing, we have found that crossing an event boundary, such as by moving from one location to another, can disrupt memory, even memory for information that continues to be relevant. That is, walking through doorways causes forgetting. However, we have also found that crossing an event boundary provides structure for information, which in turn can improve memory. That is, walking through doorways can enhance memory. In this article, I review evidence for both of these effects and outline the Event Horizon Model, a theoretical account that provides a framework for these findings and allows for better predictions about how people remember information.

My colleagues and I conceive of information about events as being mentally represented by *event models* (Radvansky & Zacks, 2011). Event models, which are mental simulations of events, are a subtype of more general *mental models* (e.g., Johnson-Laird, 1983; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998), which are mental simulations of experienced or described states of affairs. More specifically, event models capture the contents and structure of the events that people experience.

Our recent work has concerned the influence of *event boundaries*, the transitions from one event to another, on cognition. Such transitions can manifest as a change in location, a causal break, the introduction of a new activity, and so on, so long as they involve a shift from one event to another. My focus in this article is on changes in spatial locations (i.e., spatial shifts), such as walking through a doorway, and the consequences these spatial shifts have on later memory, both in terms of how they may hinder memory and how they may improve it.

Walking Through Doorways Causes Forgetting

Under some conditions, event boundaries disrupt memory. In narrative comprehension, when people encounter event boundaries, they mentally update their models (e.g., Zwaan, Magliano, & Graesser, 1995). This updating may be marked by an increase in reading time for sentences in which event shifts occur; this increased reading time may reflect increased effort needed for updating. It should be noted that although this increase in reading time is not always observed, other measures may indicate that an event shift has occurred (Radvansky & Copeland, 2010). Of more central concern is a decline in memory after an event boundary for information from prior to the boundary. For example, people respond more slowly to memory probes about what a character in a story was doing if the text has shifted to a new event than if that event is still ongoing (Radvansky & Copeland, 2010; Zwaan, 1996).

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In a series of studies we had done (Radvansky & Copeland, 2006b; Radvansky, Krawietz, & Tamplin, 2011; Radvansky, Tamplin, & Krawietz, 2010), people moved through virtual or real spaces, picking up an object on a table, moving to the next table, setting the object down, picking up the next object, moving to the next table, and so on. During this process, we probed people's memory for the objects as a function of whether there was a location shift. In the *no-shift* condition, the room people walked through was twice as long to allow for a change in distance but not location. In the *shift* condition, people moved from one room to another, travelling a similar distance but changing locations. People indicated whether each probed-for object was currently being carried, had just been set down (positives), or was some other object (negatives). We found that people took longer and made more errors when there was an event shift than when there was not. In other words, walking through doorways caused forgetting. This finding has even been replicated when the probes were not objects in the environment but word pairs presented at various points in an interactive environment (Radvansky et al., 2010). Thus, event boundaries imperil a broad range of memories.

To some, this finding may seem like a demonstration of context-dependent memory (e.g., Smith & Vela, 2001)—difficulty remembering information when the context at retrieval does not match the context at encoding. Does an event boundary only demarcate a change in context? We think not. First, context-dependent memory effects often involve much longer delays over which some ordinary forgetting has occurred, allowing the original context to serve as a memory cue. Our work, however, involves assessing information that is still likely to be in working memory. More to the point, we (Radvansky et al., 2011) found that if people returned to the original room before being probed, their memory did not improve. Moreover, that study also showed that if people travelled through two doorways, they were more likely to forget than if they had travelled through only one. So, memory is disrupted by the number of event boundaries, not just a simple change in context.

The explanation for this phenomenon is that when information is encountered across multiple events, different event models are created for each one. The presentation of a memory probe causes both models to be activated, and this co-activation produces competition and interference, which slows down response times and increases error rates. This is why returning to a previous room does not improve memory for objects that were encountered there, and why passing through two doorways makes memory even worse than does passing through one. In a sense, this is an extension of the explanation for what is known in memory research as the *fan effect*, whereby interference reflects a competition at retrieval among elements stored in multiple event representations of sentences, (Radvansky, 1999, 2009; Radvansky, Spieler, & Zacks, 1993; Radvansky & Zacks, 1991), pictures (Radvansky & Copeland, 2006a), or information learned from a map (Bower & Rinck, 2001).

Walking Through Doorways Causes Remembering

Event boundaries not only can reduce the accessibility of some information but also can increase the accessibility of other information. One memory boost comes from the increase in processing that occurs at the event boundary itself. Specifically, people show superior memory for content information about elements, such as objects, that are present during an event boundary (Swallow, Zacks, & Abrams, 2009). This enhancement of memory may be due to a general increase in processing activity when event shifts occur.

In addition to work demonstrating superior memory for the event boundary itself, there is an earlier line of work on retroactive interference that spawned later work on context-dependent memory retrieval (e.g., Smith & Vela, 2001). However, rather than focusing on how returning to a prior location facilitates retrieval, this early work focused on how moving from one location to another decreased retroactive interference (e.g., Bilodeau & Schlossberg, 1951; Nagge, 1935; Strand, 1970). In these studies, people were given two lists of items—the first list while they were in one room and the second list while they were in either the same room or a different room. There was less retroactive interference on the first list after a spatial shift between rooms (i.e., an event boundary) than when all learning occurred in the same room.

Similar to this, in a recent study we (Pettijohn & Radvansky, 2012) had people listen to two lists of 20 words, each of which was divided into sublists of 10 words. The primary manipulation was whether there was a shift from one room to another between list halves. The first half of one of the lists was read in both conditions at a rate of one word per second. People then moved to another spot, either across a large room (no-shift condition) or from one room to another (shift condition). Euclidean distance and time travelled were the same across conditions. In the second location, the second half of the list was read. After a 2-minute distractor task, people tried to recall the entire list of 20 words. Results showed that people's memory was better when there was an event boundary in the middle of a list than when there was not. In other words, an event boundary improved whole-list recall. In another study (Thompson & Radvansky, 2012), people read narrative texts with critical sentences that either conveyed an event boundary or did not. After reading, they were asked to recall the story. We found that their memory was better when there was an event boundary in the text than when there was not.

The Event Horizon Model

Under different conditions, event boundaries can either impair or improve memory. How can these seemingly opposite effects both be true? To resolve this issue and provide an explanatory account for thinking about such issues, the *Event Horizon Model* was developed. This is a relatively simple framework based on five principles: (a) the segmentation of streams of activity into event units; (b) the superior availability of information in the working event model; (c) the construction of a causal network that can then influence retrieval; (d) the superiority of memory for information stored across multiple events in noncompetitive attribute retrieval; and (e) the occurrence of retrieval interference for information stored across multiple events in competitive event retrieval.

Events are dynamic and change over time. The first principle draws from Event Segmentation Theory (Kurby & Zacks, 2008; Swallow et al., 2009). During the experience of an event, when event boundaries are identified, people segregate information into event models that are stored in memory. For example, if a person walks from one room to another, this is often a new event. When event boundaries are encountered during text comprehension, there is an increase in reading time and neural activity (Speer, Zacks, & Reynolds, 2007). Moreover, event segmentation segregates information in memory so that when one event is cued, it does not strongly activate information about other, adjacent events (Ezzyat & Davachi, 2011).

According to the second principle, the working event model has a privileged status. The information in this model is more available and reflects the structure of the current event. Support for this principle has come from a study by Glenberg, Meyer, and Lindem (1987; see also Radvansky & Copeland, 2001). In this study, people read short narratives in which a critical object was either associated with or dissociated from a protagonist. Performance was assessed in terms of the reading times for sentences that referred back to the critical object or responses to memory probes. In general, reading times were slower and responses were longer and less accurate when the object had been dissociated from the protagonist. That is, when the object was moved out of the current event model, its level of activation was diminished.

The third principle of the Event Horizon Model is that people track the causal structure of events. From this causal structure, people can often derive temporal sequences, which is more difficult when causal structure is absent. The importance of causality to cognition is observed in even the most basic mental processes, such as classical conditioning. If there is a causal break in a text, reading times increase (e.g., Zwaan et al., 1995). Additional mental effort is needed to determine a plausible cause, which separates the new situation from the previous one, triggering a new event model. Thus, part of the role of causality is to help segment events.

In addition, causal connectivity has an influence on memory retrieval. Information that is more causally connected is more important and better remembered (e.g., Radvansky & Copeland, 2000; Trabasso, Secco, & van den Broek, 1984). People exploit causal connections by using them as retrieval pathways to access information in memory. Thus, with greater causal connectivity, there is greater memorability. For example, in a study of memory for a novel and for autobiographical memories, the speed with which individual details were remembered was related to the number of causal connections (Radvansky, Copeland, & Zwaan, 2005).

The fourth principle is that when attributes are represented across multiple event models and the aim of the task is to produce as much information as possible, people can use this segmentation to improve performance. In other words, the segregation of different information into multiple event models serves to organize knowledge about that information, thereby improving memory. Thus, different memory traces act in concert—when an item is represented in more than one event, successful retrieval of the item is more likely (Pettijohn & Radvansky, 2012; Thompson & Radvansky, 2012). For example, as the study discussed earlier demonstrated, if people are given two halves of a list of words in two rooms rather than in the same room, they can better structure that information and will remember more of the list. This is further illustrated by the other studies described earlier in which event boundaries improved memories (e.g., Nagge, 1935), perhaps by reducing the amount of experienced interference.

The final principle of the Event Horizon Model is that when there are multiple event models in memory but a task requires the retrieval of only a single model, retrieval interference occurs. For example, if a person tries to retrieve a single event memory of where he or she last used a credit card, the various event models of different circumstances of using the card will compete with one another, producing interference and thus impairing memory. This retrieval interference can manifest itself as an increase in retrieval time and/or in the number of errors committed. Interference in event cognition is clearly observed in studies of the fan effect for materials that can be organized based on collections of individual, isolated sentences that describe situations (Radvansky, 1999, 2009; Radvansky & Copeland, 2006a; Radvansky et al., 1993; Radvansky & Zacks, 1991), as well as in the studies described earlier that showed that walking through doorways causes forgetting (e.g., Radvansky & Copeland, 2006b).

Current Directions

Currently, we are continuing to explore the influence of event cognition on memory and to extend the findings discussed here. For example, we are trying to understand the influence of event boundaries on memory duration, beyond the current event, as well as the influence of the number of event boundaries on memory. This is being explored in terms of both laboratory-based materials and real-world information, such as schoolwork. We are also exploring the changes in event structure and representation that come about as a function of the neural consolidation processes that occur during sleep, including the mental organization of information based on event boundaries and the segregation and integration of such information. Finally, we are interested in how event boundaries influence memory as a function of whether a person is actively involved in an unfolding event or just passively experiencing it, as well as the consequences of event boundaries on emotions and memory for emotions. As should be clear, the area of event cognition is in a formative stage, but it has a rich potential to illuminate a wide range of human experience.

Recommended Reading

Radvansky, G. A., & Zacks, J. M. (2011). (See References). An overview and review of event cognition theory.

Zacks, J. M., Speer, N. K., Swallow, K. M., Braver, T. S., & Reynolds, J. R. (2007). Event perception: A mind/brain perspective. *Psychological Bulletin, 133*, 273–293. An overview and review of event-perception findings and theory.

Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin, 123*, 162–185. An overview and review of situation model theory.

Declaration of Conflicting Interests

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References

Bilodeau, I. M., & Schlosberg, H. (1951). Similarity in stimulating conditions as a variable in retroactive inhibition. *Journal of Experimental Psychology, 41*, 199–204.

Bower, G. H., & Rinck, M. (2001). Selecting one among many referents in spatial situation models. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27*, 81–98.

Ezzyat, Y., & Davachi, L. (2011). What constitutes an episode in episodic memory? *Psychological Science, 22*, 243–252.

Glenberg, A. M., Meyer, M., & Lindem, K. (1987). Situation models contribute to foregrounding during text comprehension. *Journal of Memory and Language, 26*, 69–83.

Johnson-Laird, P. N. (1983). *Mental models: Towards a cognitive science of language, inference, and consciousness*. Cambridge, MA: Harvard University Press.

Kurby, C. A., & Zacks, J. M. (2008). Segmentation in the perception and memory of events. *Trends in Cognitive Sciences, 12*, 72–79.

Nagge, J. W. (1935). An experimental test of the theory of associative interference. *Journal of Experimental Psychology, 18*, 663–682.

Pettijohn, K. A., & Radvansky, G. A. (2012, May 3). *Walking through doorways causes remembering*. Paper presented at the meeting of the Midwestern Psychological Association, Chicago, IL.

Radvansky, G. A. (1999). The fan effect: A tale of two theories. *Journal of Experimental Psychology: General, 128*, 198–206.

Radvansky, G. A. (2009). Spatial directions and situation model organization. *Memory & Cognition, 37*, 796–806.

Radvansky, G. A., & Copeland, D. E. (2000). Functionality and spatial relations in situation models. *Memory & Cognition, 28*, 987–992.

Radvansky, G. A., & Copeland, D. E. (2001). Working memory and situation model updating. *Memory & Cognition, 29*, 1073–1080.

Radvansky, G. A., & Copeland, D. E. (2006a). Situation models and retrieval interference: Pictures and words. *Memory, 14*, 614–623.

Radvansky, G. A., & Copeland, D. E. (2006b). Walking through doorways causes forgetting. *Memory & Cognition, 34*, 1150–1156.

Radvansky, G. A., & Copeland, D. E. (2010). Reading times and the detection of event shift processing. *Journal of Experimental Psychology, Learning, Memory, and Cognition, 36*, 210–216.

Radvansky, G. A., Copeland, D. E., & Zwaan, R. A. (2005). A novel study: The mental organization of events. *Memory, 13*, 796–814.

Radvansky, G. A., Krawietz, S. A., & Tamplin, A. K. (2011). Walking through doorways causes forgetting: Further explorations. *Quarterly Journal of Experimental Psychology, 64*, 1632–1645.

Radvansky, G. A., Spieler, D. H., & Zacks, R. T. (1993). Mental model organization. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19*, 95–114.

Radvansky, G. A., Tamplin, A. K., & Krawietz, S. A. (2010). Walking through doorways causes forgetting: Environmental integration. *Psychonomic Bulletin & Review, 17*, 900–904.

Radvansky, G. A., & Zacks, J. M. (2011). Event perception. *Wiley Interdisciplinary Reviews: Cognitive Science, 2*, 608–620.

Radvansky, G. A., & Zacks, R. T. (1991). Mental models and the fan effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17*, 940–953.

Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic Bulletin & Review, 8*, 203–220.

Speer, N. K., Zacks, J. M., & Reynolds, J. R. (2007). Human brain activity time-locked to narrative event boundaries. *Psychological Science, 18*, 449–455.

Strand, B. Z. (1970). Change of context and retroactive inhibition. *Journal of Verbal Learning and Verbal Behavior, 9*, 202–206.

Swallow, K. M., Zacks, J. M., & Abrams, R. A. (2009). Event boundaries in perception affect memory encoding and updating. *Journal of Experimental Psychology: General, 138*, 236–257.

Thompson, A. N., & Radvansky, G. A. (2012 May 3). *Aging and memory for event boundaries*. Paper presented at the meeting of the Midwestern Psychological Association, Chicago, IL.

Trabasso, T., Secco, T., & van den Broek, P. (1984). Causal cohesion and story coherence. In H. Mandl, N. L. Stein, & T. Trabasso (Eds.), *Learning and comprehension of text* (pp. 83–111). Hillsdale, NJ: Erlbaum.

van Dijk, T. A., & Kintsch, W. (1983). *Strategies in discourse comprehension*. New York, NY: Academic Press.

Zwaan, R. A. (1996). Processing narrative time shifts. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22*, 1196–1207.

Zwaan, R. A., Magliano, J. P., & Graesser, A. C. (1995). Dimensions of situation model construction in narrative comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*, 386–397.

Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin, 123*, 162–185.