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Event boundaries and memory improvement

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ABSTRACT

The structure of events can influence later memory for information that is embedded in them, with evidence indicating that event boundaries can both impair and enhance memory. The current study explored whether the presence of event boundaries during encoding can structure information to improve memory. In Experiment 1, memory for a list of words was tested in which event structure was manipulated by having participants walk through a doorway, or not, halfway through the word list. In Experiment 2, memory for lists of words was tested in which event structure was manipulated using computer windows. Finally, in Experiments 3 and 4, event structure was manipulated by having event shifts described in narrative texts. The consistent finding across all of these methods and materials was that memory was better when the information was distributed across two events rather than combined into a single event. Moreover, Experiment 4 demonstrated that increasing the number of event boundaries from one to two increased the memory benefit. These results are interpreted in the context of the Event Horizon Model of event cognition.

1. Introduction

Daily life is a continuous stream of information. This stream is parsed into more manageable units through a process of event segmentation. These segments are then stored in memory. One of the consequences of segmentation is its influence on later memory, including better memory for information occurring *at* event boundaries (e.g., Swallow, Zacks, & Abrams, 2009), a disruption of memory for information that is carried *across* event boundaries (e.g., Radvansky & Copeland, 2006; Swallow et al., 2009), and better memory for information that can be *separated* by event boundaries, allowing people to capitalize on event structure to chunk and organize information (e.g., Zacks & Tversky, 2001). The aim of this study is to further explore the last of these processes.

According to theories of event cognition, when people process, comprehend, and remember information about events, they use mental representations called *event models* (e.g., Radvansky & Zacks, 2014). These event models serve as mental simulations of ongoing events, similar to the concept of situation models (van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998) and mental models (Johnson-Laird, 1983). For event cognition, experience and language are two ways to acquire information about events. The current experiments use both experience and language to look at how segmenting information into separate events affects memory.

1.1. Event boundaries and memory

The organization of information into event models helps a person structure the information that is being experienced or read about. One role of this structuring of information into event models is to often aid comprehension and memory by putting those elements that are more likely to belong together into a single representation and keeping elements from an irrelevant event from intruding. This is consistent with the general principle in memory research that structuring information often improves performance. One of the aims of the current study is to explore how event structure and the segregation of information into different event models plays this role.

The Event Horizon Model (Radvansky, 2012; Radvansky & Zacks, 2011, 2014) provides a framework for understanding how and when information is remembered as a function of event structure, and how this structure can influence the availability of information that is either integrated into a common event or distributed across events. The Event Horizon Model has five components: (1) events can be *segmented* and the different event models are stored as separate traces in memory, (2) information in the current working event model is being actively processed in working memory, (3) there is the storage of the causal relations among

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events (4) there is retrieval facilitation for noncompetitive attribute retrieval, and (5) there is retrieval interference for competitive event model retrieval. The work reported involves the operation of the first and fourth components.

The first principle is based on research in event cognition that has found that people actively parse the stream of incoming information, particularly at points when there were changes in the ongoing stream of action (e.g., Newtson, 1973; Newtson, Engquist, & Bois, 1976; Swallow et al., 2009; Zacks & Tversky, 2001; Zacks, Speer, Swallow, Braver, & Reynolds, 2007). When there are changes in event components, such as a change in space, these changes serve as event boundaries. This first principle can be thought of as embodying many of the principles of Event Segmentation Theory (Swallow et al., 2009; Zacks & Tversky, 2001; Zacks et al., 2007). In this way, the Event Horizon Model, subsumes Event Segmentation Theory. These event boundaries can be marked perceptually (e.g., Hard, Tversky, & Lang, 2006; Newtson et al., 1976; Zacks, 2004), inferred based an actor's location, intentions, or goals (Speer, Zacks, & Reynolds, 2007) or linguistically (Magliano, Miller, & Zwaan, 2001; Speer et al., 2007; Zwaan, Magliano, & Graesser, 1995; Zwaan & Radvansky, 1998). The current study does not assess this principle, per se, but relies on it in the sense that when an event boundary is encountered, people close off one event model and create another.

The fourth principle is the focus of the current studies. It is the idea that the distribution of event attributes across event models results in memory facilitation. One source of evidence consistent with this idea is a line of work on retroactive interference that later spawned work on environment-dependent memory retrieval. However, rather than focusing on how returning to a prior location facilitates retrieval, this earlier work focused on how moving from one location to another decreases retroactive interference (Bilodeau & Schlosberg, 1951; Greenspoon & Ranyard, 1957; Jensen, Dibble, & Anderson, 1971; Smith, Glenberg, & Bjork, 1978; Strand, 1970). In these studies, people were presented with two lists of items, one list in one room and a second in either the same or a different room. What was consistently found was that there is less retroactive interference for the first list after a spatial shift (an event boundary) compared to when learning was all done in the same room. Moreover, Strand (1970) suggests that other nonspatial factors also reduce retroactive interference, such as task disruption. In these studies, people were presented with two lists of items, again, one in one room and a second in either the same or a different room. Less retroactive interference was found for the first list after a spatial shift (an event boundary) and also when people left and then returned to the same room between lists.

More to the point of the current study, a number of studies by Smith (1982, 1984; Smith & Rothkopf, 1984) demonstrated an overall improvement in recall memory for word lists or lecture material when people memorized information across multiple spatial locations. One possible explanation is that recall is improved because people are associating information with the locations where the information was learned. However, this does not appear to be the case because providing the different locations as retrieval cues does not provide any retrieval benefit (Smith, 1984). The current work goes beyond these prior studies by exploring the influence of event structure on memory along with the physical environmental context that was assessed in that work. In the following studies we explore whether this improvement is a result of environmental context shifts or a more general principle of event structure. This event boundary benefit extends beyond the paradigm of word lists learned in physically different locations to events defined by computer windows as well as the context of narrative events with linguistically conveyed event boundaries. Thus, the events are experienced as changes in the location in which the information is encountered, as well as changes that were mentally simulated as part of narrative comprehension. These findings can now be assessed in the context of the Event Horizon Model of event cognition, as well as recent findings on the role of event structure on later memory. As information is distributed across multiple events, this provides structure for the information, leading to multiple event models, each containing fewer elements, as compared to a case where all elements would be part of one larger model. This organization and structure of information into small subunits can then facilitate the later retrieval of information.

In comparison to the Event Horizon Model account, there are alternative explanations for why memory would be improved in the presence of event boundaries. The first is that people will use the different events as mental categories. The idea that structure and organization can aid memory for word lists is well known (e.g., Bower, Clark, Lesgold, & Winzenz, 1969). By categorizing the items into two sub-lists rather than one long list, people could use list half as a cue to retrieve information. The prediction from this view would be that memory will be better when there is an event boundary present.

With an event boundary, people would be more likely to recall together (cluster) information from the same event and not alternate between information that is distributed across two events. This is because either event could serve as a memory cue, activating all of the information from it more so than that from the other event, or because information learned in the same event would be more likely to prime each other. This is consistent with other work in event cognition assessing event structure and memory. For example, in a study by Ezzyat and Davachi (2011) people were given narratives to read that contained event boundaries. Afterward, they were given a cue recall test in which people were provided with a sentence from the narrative and the task was to recall the next sentence. What was observed was that people were better able to recall the next sentence if there was not an event boundary between the two as compared to if there was. In other words, people were better able to retrieve information if it was part of the same event than if it were part of separate events. Thus, the expectation would be that events are acting like categories to structure retrieval.

Regardless of the precise mechanism, there would be increased event-based recall organization when there is an event boundary present. This idea is supported by the fact that Smith (1982, 1984) found that there was increased clustering with multiple learning environments. That said, the measure of clustering used did not correct for chance which we do in our experiments. To assess clustering, we used Adjusted Ratio of Clustering (ARC) scores (Roenker, Thompson, & Brown, 1971). ARC scores are calculated as follows:

$$\text{ARC} = \frac{(R - E(R))}{(maxR - E(R))} \quad (1)$$

The expected number of repetitions, $E(R)$ is calculated as follows:

$$E(R) = \frac{\sum_i n^2}{N} - 1 \quad (2)$$

where n represents the number of items recalled from a category i, and N represents the total number of items recalled. They convey the ratio of repetitions in recall from a particular category to the maximum number of possible repetitions ($maxR$), accounting for both the number of items recalled by a person and the number of repetitions expected by chance. An ARC score of 1 would indicate perfect categorization and an ARC score of 0 would indicate random organization. For example, if a person were to recall six items clustered perfectly (i.e., three items from list 1 followed by three items from list 2), $N = 6$, $n = 3$ for each category, and the maximum number of repetitions is four (six items recalled minus two categories). The number of repetitions in this case is four (the second and third