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Commentary

Similarity and Deviation in Event Segmentation and Memory Integration: Commentary on Richmond, Gold, & Zacks

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In this commentary on Richmond, Gold, and Zacks (2017), we focus on two complementary processes that play critical roles in event segmentation theory, and thus figure prominently in the arguments of the authors. We argue that the processes of *similarity* and *deviation* are important not only to event segmentation, but to a process that may seem its polar opposite, namely, integration of separate episodes of experience. In event segmentation theory, the perception of similarity in the ongoing flow of activity is fundamental to behavioral control such that as long as elements of an activity are similar, the event is the "same" and the controlling schema continues to be valid. Equally important in the model is the complement of similarity—deviation is critical in that (a) within an episode, as long as there is no deviation, the current schema can control behavior; and (b) when predictions are violated (a deviation), event boundaries are imposed and the event model is updated. We illustrate these processes in the context of the ERISS model (Encoding, Reactivation, Integration, Selection, and Self-derivation), which was developed to understand derivation of new knowledge through integration of separate episodes, and is here extended to event segmentation.

Keywords: Encoding, Event segmentation, Integration, Reactivation, Selection, Self-derivation

In their target article, Richmond, Gold, and Zacks (2017) emphasize the importance of accurate perception of the boundaries of events. The ability to perceive when one event ends and another begins is fundamental to comprehension of *who* is doing *what* to whom, *where*, *when*, and even *why*. In turn, accurate perception fundamentally influences memory for events. Individuals who carve events at their seemingly natural boundaries have better memory for them (e.g., Bailey, Kurby, Giovannetti, & Zacks, 2013; Kurby & Zacks, 2011; Zacks, Speer, Vettel, & Jacoby, 2006). They also execute the actions of events more efficiently (Bailey et al., 2013). In their target article, Richmond and colleagues explore this critically important phenomenon for its possible implications for memory in individuals who struggle to remember to the degree that it impairs their everyday lives. They provide evidence that steps to facilitate canonical event segregation contribute to more accurate memory, even in individuals with neurodegenerative conditions such as Alzheimer's disease (Bailey et al., 2013; Zacks et al., 2006). This is an exciting finding that promises a low-risk and potentially high-payoff intervention for a rapidly growing population. We applaud their efforts at application and translation. We also appreciate the insights that the work provides into basic cognitive processing.

In this commentary, we focus on two complementary processes that play critical roles in event segmentation theory (Radvansky & Zacks, 2014; Zacks, Speer, Swallow, Braver, & Reynolds, 2007; Zacks & Tversky, 2001), and thus figure prominently in the arguments of Richmond et al. We make the argument that the complementary processes are important not only to event segmentation, as emphasized by the authors, but to a process that may seem its polar opposite, namely, integration of separate episodes of experience. The twin processes are *similarity* and *deviation*. The first of these processes is the perception of similarity in the ongoing flow of activity. Perception of similarity is fundamental to behavioral control such that as long as current elements of an activity are similar to previous elements, the event is the "same" and whatever schema is controlling prediction and behavior for the activity continues to be valid. Equally important in the model is the flip side of similarity—deviation.

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Detection of deviation is critical to the authors' model in two ways. First, as just noted, within an episode, as long as there is similarity (i.e., no deviation), the current schema can control behavior. Second, when one's predictions are violated (i.e., a deviation), it is important to impose an event boundary and then update the event model with the unexpected sequence of actions. Thus the deployment of schemas during event segmentation enables identification of instances when prediction error is high, thereby serving as a mechanism through which new experiences are incorporated into existing models.

The complementary processes of detection of similarity and of deviation are critical not only to event segmentation and memory, but to accrual of semantic knowledge as well. For example, in Gentner's structure-mapping theory of comparison (1983, 1989; Markman & Gentner, 1993), similarity and deviation are stepping-stones for the construction of new knowledge through comparison, for children and adults alike (for review see Gentner & Medina, 1998). In this conceptualization the act of aligning two items or conceptual representations promotes the abstraction of commonalities. As an illustration, when 4-year-olds hear an unfamiliar word for an object (e.g., "blicket" for an apple) and are asked to select another "blicket," they more often select a conceptual match (e.g., a banana) if the original object had been presented along with a perceptually similar comparison object (an orange) than if the original object was presented alone (Gentner & Namy, 1999). Thus the opportunity for comparison invites structural alignment and the abstraction of non-perceptual commonalities, a key mechanism for self-derivation of new semantic knowledge and understandings.

Importantly, whereas similarity-based comparison facilitates identification of commonalities within events and among conceptual attributes, detection of deviation supports differentiation and further fine-tuning of knowledge. For example, research on infant categorization suggests that initial concepts are global in nature (e.g., animals vs. vehicles) and that basic-level distinctions within conceptual domains (e.g., dogs vs. cats; cars vs. trucks) develop later (e.g., Mandler & Bauer, 1988; Mandler, Bauer, & McDonough, 1991), presumably as infants begin to recognize that not all animals are the same as one another, and likewise, that the attributes of some vehicles deviate from those of others. Critically, detection of deviation is maximally facilitative of the updating of knowledge when it occurs *after* commonalities have been identified. For example, when 4-year-old children are prompted to compare two category items (e.g., bicycle and tricycle) and then given the opportunity to contrast an item with a perceptually similar item that is not a member of the category (e.g., a set of barbells), conceptual responding is more robust than when contrast precedes comparison (Namy & Clepper, 2010). Thus as in event segmentation theory, identification of similarity and deviation make differing contributions, with detection of deviation supporting the subsequent updating of representations initially comprehended based on their similarity.

The complementary roles of detection of similarity and of deviation in accumulation of semantic knowledge are especially obvious when abstraction and updating occur across—rather than within—episodes of experience. In a laboratory version of this real-world task, children are taught novel facts (i.e., stem facts) that can be combined to generate new knowledge (e.g., Bauer, King, Larkina, Varga, & White, 2012; Bauer & San Souci, 2010; Bauer, Varga, King, Nolen, & White, 2015; Varga & Bauer, 2013). For instance, two facts about dolphins (e.g., *dolphins talk by clicking and squeaking; dolphins travel in groups called pods*), can be integrated to produce new knowledge that was never directly learned (e.g., *pods talk by clicking and squeaking*). Much like real-world event segmentation, children are required to extract the facts from dynamic episodes. Specifically, each fact is embedded within a separate story passage. To mirror standard episodes (see Tulving, 2002, for review), each passage contains the uniquely defining elements of "what" (actions of main characters), "where" (story setting), and "when" (temporal connections throughout the ongoing narrative). To ensure that children encode each passage as a separate, bound episode (e.g., Ezzyat & Davachi, 2011), clear event boundaries are incorporated into the narrative (i.e., a beginning, middle, and end). Furthermore, episodes are temporally separated by unrelated tasks between the story passages. To generate the new knowledge, children must integrate the otherwise distinct events.

There is clear developmental improvement in how readily children integrate across separate episodes. When children are asked open-ended questions that can only be answered through cross-episode integration (i.e., "how does a pod talk?"), 4-, 6-, and 8-year-olds self-derive the novel integration facts on 13%, 50%, and 75% of the trials, respectively (Bauer & Larkina, 2016). Further, evidence that similarity-based comparison factors into knowledge extension via cross-episode integration comes from studies that have directly manipulated the surface similarity between paired event passages. When the character in the paired passages is the same (e.g., a ladybug in each episode), knowledge extension is more robust than when the characters in the paired passages are different (e.g., a ladybug and a rabbit; 67% vs. 37%, respectively; Bauer et al., 2012). The decrement in performance is not absolute, however. A "hint" to think about the passages before the test for cross-episode knowledge extension has a strong facilitating effect (performance increases from 37% to 78%). Together, the results of studies of this process in children 4–8 years of age suggest that even the youngest children are adept at segmenting the boundaries between events. Age-related improvements in knowledge extension seemingly stem from challenges in integrating and updating across events. Consequently, increasing or decreasing the contextual similarity (e.g., story characters, explicit hints) between separate yet related learning episodes can greatly enhance or inhibit recognition of the opportunity for integration across boundaries.

The steps of the process of integration of separate episodes of experience and derivation of new semantic knowledge from them are captured in a process model, presented here for the first time. The proposed processes are Encoding, Reactivation, Integration, Selection, and Self-derivation—represented in the acronym ERISS. The processes are illustrated in Figure 1. As will become apparent, both theoretically and empirically, the twin processes of *similarity* and *deviation* play particularly important roles in the early phases of the process of self-derivation of new semantic knowledge through integration.