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The concept of a goal critically separates dynamic events involving humans from other events. Human behaviours are motivated by goals, which are known to the actor but typically inferred on the part of the observer. Goals can be hierarchical in nature, such that a collection of sub-goals (e.g., getting a mug, boiling water) can be nested under a higher-level goal (e.g., making tea), which can be further nested under an even higher-level goal (e.g., making breakfast).

The diverse set of talks in this symposia all highlight the foundational role that goals play in action processing and representation. Eisenberg et al. detail how online prediction of others' goals shapes observers' sampling of information during action observation. Howard and Woodward provide evidence that children's memory for non-human events can be facilitated by priming children with their own goal-directed actions. Loucks and Meltzoff highlight the importance of goal structure in children's memory for complex action sequences. Finally, Cooper presents a computational model to explain the emergence of goal-directed action hierarchies.

Eisenberg, Zacks, & Flores: Prediction Around Event Boundaries During Continuous Viewing of Naturalistic Activity

The ability to break down ongoing activity into meaningful events is integral for comprehension and memory. We propose that this ability is driven by monitoring prediction error during perception. As people view ongoing activity, they maintain a model of the current event and use it to make predictions about what is going to happen next. When these predictions fail, viewers must update their event model to better capture the ongoing activity; this is experienced as a boundary between events. This proposed mechanism entails that prediction performance is worse at event boundaries than during the middles of events.

Previous research has supported this hypothesis using an explicit prediction judgment task. Here, we tested the hypothesis that perceptual prediction fails at event boundaries using an implicit eye tracking measure. In a series of two studies, participants passively watched movies of actors completing everyday activities while their eyes were tracked using an eye-tracker. Participants then watched the movies again and identified the boundaries between meaningful units of activity. We hypothesized that participants would predictively look at the objects that the actor was about to touch during the few seconds before the actor contacted the objects. In addition, we hypothesized that participants would begin making predictive eye movements later in time when the object contact occurred close to an event boundary compared to when the object contact occurred within an event. The results provided support for both hypotheses. These results provide further evidence that prediction failures drive the subjective experience of an event boundary and suggest a novel and naturalistic method for studying prediction during comprehension of ongoing activity.

Howard & Woodward: The Effect of Action Priming on Children's Event Memory

Research has demonstrated that the mere inclusion of a person in an event boosts children's memory (Howard & Woodward, under review). However, the mechanism underlying this effect has yet to be explored. One possibility is that the presence of a person primes children to think of discrete sequential steps as part of a higher-level goal, providing a structure that increases later recall. In fact, we know that even infants spontaneously segment events according to goals, and in adults segmentation according to goals relates to better event memory.

We explored whether priming children to think of goal-directed actions before encoding an event can improve sequential memory. Three-year-old children played either an action game (Action Priming) or sticker game (Control Priming) with a series of novel toys. Participants then watched two picture sequences on a Tobii eye-tracking monitor, each culminating in the creation of an object. Half of the children saw object pieces assembled by a person (Person condition) while half saw the pieces assembled without a person present (No-person condition). After a delay, children were given the pieces and asked to reconstruct the sequence from memory. Our hypotheses were that only action priming would facilitate recall in the No-person condition, and that there would be no benefit of either priming in the Person condition.

Results demonstrated that children in the Person condition remembered the same number of event steps regardless of priming. In contrast, children in the No-Person/Action group remembered significantly more steps than those in the No-Person/Control group, suggesting that action priming can increase memory for non-social events. These results suggest that early learning is strengthened by the goal structures inherently provided by social partners, and that framing even non-social events in terms of higher-level goals can increase later recall.

Loucks & Meltzoff: Higher-Level Goals Structure Children's Action Memory

Multitasking is a common occurrence in action. For example, one might be preparing breakfast at the same time as packing one's briefcase, flitting between these higher-level goals with the completion of individual sub-goals. Such events pose an unexplored representational problem for the observer: should the representation prioritize veridical sequential structure, at the cost of representing higher-level goals, or should it prioritize goals, at a similar cost to sequential structure? This representational problem may be significant for young observers, who are rapidly acquiring action goals. We previously used a deferred imitation task to demonstrate that three-year-old children's memory for familiar interleaved goals prioritizes goal organization over sequential organization (Loucks & Meltzoff, 2013).

In the current research, we more directly observed goal organization by manipulating children's exposure to higher-level goal information in two studies. In Study 1, children in the experimental group learned about a novel goal A on day 1, while children in the control group learned an unrelated novel goal (B). On day 2, all children were shown an interleaved event involving two goals – goal A and goal X – and then given a chance to imitate. Only experimental children organized their imitation according to higher-level goals, and also remembered significantly more actions overall. Study 2 demonstrated that prior goal knowledge also structures children's memory when it is gained in the form of a picture book on day 1.

We believe these results highlight both the early emergence and the benefit of goal prioritization in children's memory for others' action, and underscore the importance of this representation problem for theories of action representation.

Cooper: On the Acquisition of Goal Hierarchies: A Computational Model

Methods based on reinforcement learning, and in particular temporal difference learning, have proven to be highly effective in developing agents that can learn to perform goal-directed sequential behaviors. The direct application of such methods, however, can learn to achieve only one goal, and that goal must be known in advance (so that reinforcement can be provided when it is achieved). Thus, the classical approach does not address the questions of where goals come from or how goals inter-relate. I will consider these questions from the perspective of the contention scheduling model of routine action selection (Cooper & Shallice, 2000), which assumes that action sequences reflect the selection and execution of hierarchically organized goal-directed action schemas.

I will extend the existing model to action acquisition, showing how a set of action primitives may become associated with feature-based object representations through exploration, exploitation and habituation. Representations of action primitives and of objects form separate but connected interactive activation networks. Through experience, objects with similar action-related features come to trigger actions appropriate to those objects, and vice versa. It is further assumed that actions with "interesting" consequences (i.e., that lead to reliable changes to the world) are reified into schemas, which may themselves be invoked to achieve specific ends. Successive application of this approach results, after sufficient toying within a domain, in the emergence of hierarchically-structured goal-directed action schemas.

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