Received: 29 March 2018 | Revised: 21 September 2018 | Accepted: 10 October 2018
DOI: 10.1002/dev.21804

SPECIAL ISSUE

WILEY Developmental Psychobiology

Finding events in a continuous world: A developmental account

Dani Levine[1] | Daphna Buchsbaum[2] | Kathy Hirsh-Pasek[1] | Roberta M. Golinkoff[3]

[1]Temple University, Philadelphia, Pennsylvania
[2]University of Toronto, Toronto, Ontario, Canada
[3]University of Delaware, Newark, Delaware

Correspondence
Dani Levine, Temple University, Philadelphia, PA.
Email: Dani.F.Levine@gmail.com

Abstract

Event segmentation is a fundamental process of human cognition that organizes the continuous flux of activity into discrete, hierarchical units. The mechanism of event segmentation in infants seems to parallel the mechanism studied in adults, which centers on action predictability. Statistical learning appears to bootstrap infants' event segmentation by generating action predictions without relying on prior knowledge. Infants' first-hand experiences with goal-directed actions further enhance their prediction of others' actions. Scaffolds for event segmentation are available in the input, with caregivers providing redundant cues to event boundaries through the use of motionese and acoustic packaging. Research points to the importance of developing event segmentation skills for development in other areas of cognition, including memory, social competence, and language, though more work is needed to capture the directionality of effects. Although event segmentation is a relatively new area of focus in cognition, this process illuminates how children make sense of an ever-changing world.

KEYWORDS
action prediction, child development, event segmentation, infant-directed action, statistical learning

1 | INTRODUCTION

Events populate our world, and we take for granted that we can find where they begin and end. We take this for granted likely because as adults we are adept at recognizing boundaries in continuous streams of activity that signal meaningful changes, such as changes in actors' goals (Levine, Hirsh-Pasek, Pace, & Golinkoff, 2017; Zacks, Speer, & Reynolds, 2009; Zacks, Speer, Swallow, & Maley, 2010). Segmenting events is necessary in order to *understand* what is happening in the world around us (e.g., what other people are doing and why; Zacks, Tversky, & Iyer, 2001), to *remember* what has happened (Flores, Bailey, Eisenberg, & Zacks, 2017; Sargent et al., 2013; Swallow, Zacks, & Abrams, 2009; Zacks, Speer, Vettel, & Jacoby, 2006), and to *plan* for what will happen next (Bailey, Kurby, Giovannetti, & Zacks, 2013). Moreover, event segmentation is implicated in many aspects of children's development; the process of finding reliable and significant units of events is fundamental to how children's event memories are structured (Meyer, Baldwin, & Sage, 2011), how children uncover the world's social fabric (Zalla, Labruyère, & Georgieff, 2013), and how children acquire language (Levine, 2017).

This paper aimed to answer four questions regarding the development of event segmentation. First, what is the mechanism of event segmentation in adults (i.e., the end state of the developing system)? To this end, we will provide an overview of the adult literature, which largely supports the theory that event segmentation is the result of predictive mechanisms operating during event observation (Richmond & Zacks, 2017). Second, how do infants begin to segment events? We will discuss how children track structural regularities in physical actions (Roseberry, Richie, Hirsh-Pasek, Golinkoff, & Shipley, 2011) and leverage their growing knowledge of others' goals (Kanakogi & Itakura, 2011) to parse events. Third, how might caregivers scaffold infants' event segmentation? We will consider aspects of parent–child interaction which highlight event boundaries and help children make predictions about upcoming event units (Brand, Hollenbeck, & Kominsky, 2013). Finally, how are event segmentation skills linked to developmental achievements in other areas? We will present evidence for the impact of event segmentation on several developmental cognitive processes.

2 | ADULTS: LEVERAGING EVENT PREDICTIONS FOR SEGMENTATION

As defined by Zacks and Tversky (2001), an event is "a segment of time at a given location that is conceived by an observer to have a beginning and an end" (p. 17). Most of the events of everyday human experience are comprised of goal-directed actions (e.g., getting dressed, preparing a meal, washing dishes), which involve a series of intentional movements aimed at attaining some goal. Research examining adults' segmentation of goal-directed action events has found that adults are consistent in their perception of boundaries in these events, with comparable behavioral and neural responses to event boundaries even when viewings are separated by a period of over a year (Speer, Swallow, & Zacks, 2003). Additionally, adults are skilled at considering the *hierarchy* of events occurring at different timescales (Zacks & Tversky, 2001; Zacks, Tversky, et al., 2001), from the repetitive fine movements and subgoals involved in dishwashing (lasting minutes), to the coarser, more complex behaviors and more abstract goals involved in completing a graduate degree (lasting years). Adults' parsing of events into discrete, hierarchical action units is typically an unconscious and spontaneous process; indeed, evidence from functional magnetic resonance imaging suggests that even under passive viewing conditions, event boundaries evoke transient neural responses in the hippocampus and a distributed network of cortical regions (Ben-Yakov & Henson, 2018; Zacks, Braver, et al., 2001; Zacks et al., 2010; for a review, see Brunec, Moscovitch, & Barense, 2018).

2.1 | Event prediction: Theorized mechanism of event segmentation

A theorized mechanism for adults' event segmentation during their perception of everyday action is that segmentation emerges from the comparison of event predictions, generated from one's internal working model of the event, with actual event experience (Event Segmentation Theory; Zacks, Kurby, Eisenberg, & Haroutunian, 2011; Zacks, Speer, Swallow, Braver, & Reynolds, 2007). Our brains, and indeed the brains of many species, attempt to predict the world around us to adaptively guide behavior; we rely on these predictions for everything from avoiding dangerous situations to communicating with others (Zacks et al., 2007). Intuitively, our model of what is unfolding within an event allows us to readily predict what is likely to come next. When a child in a playground runs up to the ladder of a slide, we know that the child is very likely to climb the ladder. Predictions are often imperfect, however (the child is likely, but not guaranteed, to slide down the sliding board once she has climbed to the top of the ladder). Further, predictions generally become more uncertain *between* versus *within* events. When the child starts to slide down, there is a predictable series of steps (following the path of the slide and landing at the bottom) that must follow, but it is less predictable what will happen once the child is back on the ground.

For this reason, drops in predictability may be a particularly good cue to the location of event boundaries. It is theorized that whenever an event prediction fails, the working model and corresponding predictions are updated, leading to heightened attention (i.e., increased information processing) and often the perception of an event boundary (Hard, Recchia, & Tversky, 2011; Zacks et al., 2007). Thus, when an event is cohesive and predictable, it is perceived as a single discrete unit, but when a less predictable change occurs in an event, multiple, disparate event units are perceived. In the playground example, if a child climbs the ladder and goes down the slide twice, we might predict she will continue this pattern and go on the slide a third time. If our prediction is confirmed, we would perceive the three instances of sliding as a single unit; if the child unexpectedly runs over to the swings after the second time down the slide, we would likely perceive an event boundary at this shift in the child's goal-directed actions.

Research with adults largely supports this theorized mechanism. Directly testing this theory, Zacks et al. (2011) presented adults with videos of everyday events and paused the videos at distinct event locations (at event boundaries and within events) based on boundary judgments from a separate group of participants. Each time the video was paused, adults were asked to make predictions about what would occur 5 s later in the event. Predictions *within* event boundaries were significantly more accurate relative to predictions made *across* event boundaries, suggesting that prediction errors may explain the perception of event boundaries (Zacks et al., 2011; a compatible but distinct theory is that people are finding units with the most internal predictability, e.g., Buchsbaum, Griffiths, Plunkett, Gopnik, & Baldwin, 2015). Additional evidence for this theorized mechanism comes from research demonstrating that the perception of event boundaries is influenced by predictions derived from *action regularities* and predictions based on actors' *goals*.

2.2 | Predictions based on action regularities contribute to event segmentation

The role of predictability in event segmentation is suggested by research evaluating how adults segment novel, arbitrarily ordered action sequences (in which there is no hierarchical goal structure), so that the only cues to event boundaries are predictable structural regularities between actions. In a series of studies modeled on classic work on statistical language segmentation (e.g., Saffran, Aslin, & Newport, 1996), Baldwin, Andersson, Saffran, and Meyer (2008) presented adults with a training video containing multiple repetitions of 12 distinct object-directed actions (e.g., pouring from a bottle, clinking the bottle to a glass) randomly grouped into four three-action combinations; each combination always appeared as a triadic unit in the training video, with within-unit transitional probabilities (TPs) of 1.0. TPs between "units" in the training video were substantially lower (averaging 0.33). The result of this structure was that, once the first action in a unit was seen, the next two were perfectly predictable, but what followed after the final unit was much less so. However, there were no cues to event structure other than these randomly determined statistical regularities between actions. Following adults' exposure to the training corpus, they were tested on pairs of three-action units, with the task of selecting which unit they remembered seeing in the training video. Adults were successful at this statistical learning task—they accurately selected action units (i.e., TPs of 1.0) over nonunits (i.e., TPs of 0.0) and part-units which crossed a triad unit boundary (i.e., TPs of 0.33 and 1.0), suggesting adults extract action units on the basis of regularities between actions.

Moreover, there is evidence that statistical learning of action regularities influences adults' event segmentation, and also evidence that this influence may be the result of adults learning to anticipate actions that are predictable. Buchsbaum et al. (2015) provided a similar training video, in which TPs imparted cues to action boundaries, followed by an online action segmentation task. Participants had to press a button whenever they perceived an event boundary based on the training video. Results showed that adults' perceived event boundaries aligned with the endings of statistically intact three-action units (Buchsbaum et al., 2015). Additionally, a study by Monroy, Gerson, and Hunnius (2018) demonstrated that adults made predictive eye movements to upcoming events based on learned action regularities, with similar visual predictions whether a human agent was involved in creating those regularities by acting on objects or whether those regularities existed in the context of self-propelled object movements. Together, this research suggests that statistical learning of regularities in action may be a powerful process for segmenting events via event predictability.

2.3 | Predictions serving event segmentation are informed by goals

While adults are adept at using action regularities to segment events (Baldwin et al., 2008; Buchsbaum et al., 2015; Meyer & Baldwin, 2011), events typically also contain a wealth of other contextual information that affects predictability, such as an actor's goals. If event segmentation was operating optimally, adults would segment events based not on a single factor but on the totality of information available in the event in combination with their prior knowledge. Indeed, the evidence suggests this is the case. When viewing a narrative film, for example, adults' event boundaries and their corresponding transiently evoked brain responses align not only with physical changes in characters, objects, and spatial locations, but also with more conceptual changes in goals, causes, and interactions between characters (Zacks et al., 2010). Similarly, actors' movements are assumed to be directed toward achieving some goal (Schachner & Carey, 2013), and actions that appear to lead to causal outcomes are more likely to be perceived as coherent events than other statistically equivalent action patterns (Buchsbaum et al., 2015). Several studies also show that adults' eye gaze anticipates the goals of human action in advance of the completion of those actions (Adam, Reitenbach, & Elsner, 2017; Eshuis, Coventry, & Vulchanova, 2009; Falck-Ytter, Gredebäck, & von Hofsten, 2006; Kanakogi & Itakura, 2011). Adults may even interpret the actions of nonhuman actors (e.g., objects, machines, robots) as goal-directed, and their visual predictions of nonagentive goals are indistinguishable from their predictions of comparable goals of human agents (Adam et al., 2017; Kanakogi & Itakura, 2011). In this way, adults make goal attributions when parsing events, thereby maximizing event predictions.

The top-down goal structure of events plays a particularly strong role in adults' event segmentation. For everyday events such as folding laundry or object assembly, segmentation based on the totality of information available often results in largely the same event boundaries as segmentation based only on movement information (Zacks, Kumar, Abrams, & Mehta, 2009; see also Baldwin, Baird, Saylor, & Clark, 2001). This is likely because changes in motion align with changes in goals (and therefore predictions based on motion align with predictions based on goals; Baldwin & Baird, 2001). However, in cases where they conflict, adults' boundary judgments are uniquely informed by the goals of the action.

For example, correlations between perceived event boundaries and low-level movement features (e.g., object acceleration) are significantly weaker for animations generated from goal-directed human activity than for randomly generated animations (though correlations are significant in the former case as well; Zacks, 2004). Similarly, computational models that detect event boundaries in videos of human action using movement features select boundaries that correlate strongly with adult judgments in videos of arbitrary movement events (such as those in Baldwin et al., 2008), but are less accurate for judgments of event boundaries during videos of complex goal-directed actions, such as assembling a saxophone or making a bed (Buchsbaum, Canini, & Griffiths, 2011). These computational models are also less accurate at more abstract, higher levels of segmentation (e.g., writing on the whiteboard) versus lower levels of segmentation (e.g., taking a step). These findings suggest that movement information has less influence on adults' segmentation boundary judgments for events involving goal structures than events lacking those higher-level structures. Further, for a skilled motion event such as figure skating, experts' segmentations are more sensitive to the goal structure of the event than novices' segmentations (Levine et al., 2017; see also Bläsing, 2015). That is, having more top-down information about actors' goals alters adults' interpretation of low-level perceptual cues.

Research on adult event segmentation mechanisms provides hints about how these mechanisms may develop in children. Infants could use statistical learning of action regularities to bootstrap event segmentation, similar to adults (Buchsbaum et al., 2015) and similar to infants' use of statistical learning to bootstrap speech segmentation (see Saffran & Kirkham, 2018, for a review). Moreover, given the redundancy between movement features and goal structures in events (Zacks et al., 2009)—particularly for everyday events—one possibility is that infants may initially be sensitive to low-level event structure (i.e., action regularities, movement features), and may gradually learn about the goal structure of events through the overlap of these structures (Baldwin et al., 2001). Additionally, infants' burgeoning understanding of actors' goals may facilitate infants' ability to segment events, and infants' event segmentation may become more sophisticated as their understanding of goal-directed action matures through event experience, just as expertise in adults leads to greater alignment of segmentation patterns with event goal structure (Levine et al., 2017). These possibilities are explored as we turn to the evidence for mechanisms of event segmentation in children.

3 | CHILDREN: PREDICTING ACTIONS SELECTIVELY AND SLOWLY

As early as 9–11 months, infants segment a variety of goal-directed action events into units that align with actors' goals (Baldwin et al., 2001; Friend & Pace, 2016; Pace et al., 2014; Saylor, Baldwin, Baird, & LaBounty, 2007; Sharon & Wynn, 1998; Wynn, 1996). For example, Baldwin et al. (2001) familiarized infants with videos of everyday actions such as cleaning a kitchen, and in the following test phase, infants were presented with versions of these videos containing pauses inserted in the motion either at the completion of a goal-directed action or in the midst of (i.e., interrupting) the execution of a goal-directed action. Infants' visual attention was increased only when the videos were interrupted in the middle, suggesting infants detected a violation to the event's goal structure (Baldwin et al., 2001). This precocious ability to segment continuous action is remarkable, but could be explained by a number of possible mechanisms.

3.1 | Predictions based on action regularities

Statistical learning—the process of extracting predictably structured patterns from continuous streams of information in the environment—has the potential to bootstrap event segmentation in infants. All that is needed is "mere exposure" to structural regularities, without assuming prior knowledge (Aslin, 2017). Research examining infants' statistical learning of actions provides important insights into the ways in which infants uncover event units for the following reason. The process of statistical learning enables infants to find (or segment out) larger, higher-level action units that are comprised of smaller lower-level action units, in which the only cues to the structure of the larger units are statistical regularities between the smaller units. Thus, to the extent that infants succeed at learning regularities between actions, we can say they have formed representations of event units on the basis of expectations built-up from experience.

Indeed, research indicates that infants extract event units on the basis of structural regularities between actions as early as 7–9 months (Roseberry et al., 2011; Stahl, Romberg, Roseberry, Golinkoff, & Hirsh-Pasek, 2014). In two studies structured similarly to the adult experiments discussed earlier (Baldwin et al., 2008; Buchsbaum et al., 2015), infants viewed a video sequence of an actor (either a person or an animated starfish) performing 12 distinct physical actions (e.g., clapping, jumping jack) that were grouped into triadic units. These triadic units, with within-unit TPs of 1.0, appeared in variable positions in the sequence; this ordering created triadic part-units which crossed triadic unit boundaries such that they had lower TPs (i.e., TPs of 0.5 and 1.0). After familiarization with this sequence, infants viewed triadic units and part-units at test, and in both studies, infants' visual attention discriminated these two unit types (Roseberry et al., 2011; Stahl et al., 2014).

These studies provide evidence that infants recognize action units on the basis of expectations built-up from prior visual experience. Are these expectations also predictive? While these studies assessed infants' classification or recognition (Uithol & Paulus, 2014) of already segmented action units, the findings are consistent with a study that explored whether infants make anticipatory action predictions grounded in statistical learning of relations between actions (Monroy, Gerson, & Hunnius, 2017a). Monroy et al. (2017a) presented 19-month-olds with a novel, statistically structured event sequence involving the manipulation of six unique objects. The sequence contained two linked action pairs—in which the manipulation of one object always preceded the manipulation of a second object—with other unpaired actions interspersed randomly in the sequence. The infants learned to make visual predictions for both linked action pairs, providing additional support for the theory that infants' extraction of action units is linked to their built-up predictions of how the actions are connected to one another. In addition, Buchsbaum et al. (2015) found that adults' online judgments of boundary locations within a continuous action stream were aligned with their recognition judgments when presented with consistent and inconsistent action units in isolation, suggesting that, at least in adults, both online segmentation and post hoc recognition were the result of the same segmentation process. Nonetheless, future work on the extent to which infants' predict action (rather than responding post hoc to its predictability) would be informative.

Importantly, unlike adults (Monroy et al., 2018), children may only succeed at learning action regularities in the context of a goal-directed, acting agent (Monroy et al., 2017a). Monroy et al. (2017a) found that children learned to predict actions when viewing an action sequence performed by an agent (i.e., an actor's hand), but not when viewing an identical self-propelled action sequence, in which the hand was replaced by a spotlight. Further, this disparity was not explained by general visual attention, which was comparable across the two conditions. This finding suggests a period of selectivity that is unique to the developing system: Infants make event predictions based on structural regularities only when those regularities occur through the actions of an unambiguous agent. While the potential reasons for this phenomenon are speculative (e.g., social cues act as a filter for selecting relevant information; infants' neurophysiological motor systems were activated by the agent's hand movement) and while infants can likely learn to attribute agency to nonagentive items through additional exposure, the implication is that infants may initially analyze structural regularities across a smaller set of events than adults. Specifically, this smaller set seems to focus on goal-directed agentive action events. Thus, while goal attribution *informs* adults' event predictions, goal attribution may *constrain* infants' event predictions.

3.2 | Predictions are constrained by goals

Infants as young as 6 months can predict others' goal-directed actions, such as anticipating the goal of a reaching hand (Cannon & Woodward, 2012; Kim & Song, 2015). Additionally, like adults, children's prediction of goal-directed actions prioritizes tracking regularities in actions that produce perceivable effects when the actor's goal is achieved, such as the sound of a bell when it is rung (Monroy, et al., 2017; see also Buchsbaum, Gopnik, Griffiths, & Shafto, 2011 for evidence from children's action imitation). Furthermore, research shows that infants attend preferentially to the goal of agents' actions over the starting point or source of the action (Lakusta & Carey, 2015), suggesting that the end point of goal-directed action is particularly salient for children.

However, as with infants' predictions based on structural regularities, infants' predictions based on goals are also restricted to agentive action. Eleven-month-olds fail to predict the goal of a mechanical claw reaching for an object unless the claw exhibits behavioral cue indicative of agency, such as self-propelled movement and equifinality of goal achievement (Adam et al., 2017). Similarly, 15-month-olds fail to predict the goal when adults move the back of their hand toward the goal object, further indicating the importance of goal-directed contexts for infants' action predictions (Krogh-Jespersen & Woodward, 2014; see also Kanakogi & Itakura, 2011). Thus, while the ability to make event predictions seems to develop early, it is initially constrained to agentive goal-directed actions, particularly those that produce action effects at goal completion.[1] That infants' event predictions are constrained to unambiguous goal-directed action suggests that it may be the inherent redundancy of structural regularities and goal-based cues (because a particular pattern of movements is what brings about a particular goal; Baldwin & Baird, 2001)—that facilitates infants' ability to segment events.

3.3 | Developmental change in action predictions

How do infants' event segmentation abilities advance with development? Given infants' robust statistical action segmentation abilities and their constrained (i.e., relative to adults) knowledge of event goals, one possibility is that event segmentation improves due to experience-dependent advances in children's ability to predict the goals of others. Indeed, research reveals developmental differences both in the *ability* to proactively predict goal-directed actions and in the *breadth* of action goals that can be predicted. When observing an individual reaching for an object—a goal-directed action that is highly familiar to infants and is in their motor repertoire by 6 months—infants, like adults, predictively gaze toward the goal object prior to goal completion (Ambrosini et al., 2013; Kanakogi & Itakura, 2011). The ability to predict these goals, rather than reactively gazing at goals following goal completion, emerges during the first year of life (Kanakogi & Itakura, 2011). Moreover, the emergence of predictive looking toward familiar action goals is not simply a function of improved oculomotor skill, as it is highly specific to the goal-directed action of a human agent. That is, while 6- to 10-month-olds proactively predicted the goals of others' hand grasps, they only reactively gazed toward the same object when it was the goal of an inanimate mechanical claw or when it was the end point of a nongoal-directed "back-of-hand" movement (Kanakogi & Itakura, 2011; see also Cannon & Woodward, 2012, for evidence that infants viewing a mechanical claw predicted the familiarized location of the claw's movement rather than the familiarized goal object). In contrast, adults proactively predicted the goal object under all three conditions (albeit more slowly in the back-of-hand condition), and 4-month-olds failed to predict the goal object under all three conditions. The ability to predict rather than react to an action suggests that action expectations have been formed based on prior experience, and, functionally, these expectations may enable infants to prepare to act and interact with others more efficiently.

Beyond the *ability* to predict goals, there are developmental improvements in the *breadth* of actions that infants can successfully predict. Keitel, Prinz, and Daum (2014) demonstrated that while adults' predictions of manual action goals in a block stacking event are comparable whether one actor is stacking blocks or two actors are taking turns stacking the blocks, infants' predictions are slower for the goals of joint, coordinated action relative to individual action, and this asymmetry is more robust for 9-month-olds than 12-month-olds. Infants' ability to predict the goal of one agent's actions may precede their ability to predict the overarching goal of two agents' actions (i.e., also referred to as *super-ordinate action prediction*; Uithol & Paulus, 2014) because most of the infants' actions until this point have been directed toward individual goals rather than higher-level joint goals coordinated with others.

Additionally, researchers have identified links between action production and perception that are informative about the developing event segmentation system. Infants' prediction of others' action goals is linked to their developing ability to perform that same goal-directed action (Ambrosini et al., 2013; Filippi & Woodward, 2016; Kanakogi & Itakura, 2011; Monroy, Gerson, & Hunnius, 2017b; Sommerville, Woodward, & Needham, 2005; van Elk, van Schie, Hunnius, Vesper, & Bekkering, 2008; but see Gampe, Keitel, & Daum, 2015). Further, as indexed by suppression or attenuation of EEG alpha rhythms over sensorimotor cortical regions of the brain, infants' motor systems are activated when making predictions about others' goal-directed actions; this motor response does not apply broadly to tracking movements and is instead specific to actions for which a likely goal can be anticipated (Southgate, Johnson, Karoui, & Csibra, 2010). That is, the same neural circuits used for the production of goal-directed action are harnessed in the service of predicting action goals.

Thus, infants' direct experience with goal-directed events seems to support infants' goal predictions becoming faster and less constrained in terms of event type across development. Infants' knowledge of the goals of events may first start in the everyday events in which they are participants, such as bringing food to the mouth while eating (Green, Li, Lockman, & Gredebäck, 2016; Reid et al., 2009) and navigating obstacles while crawling (Brand, Escobar, Baranès, & Albu, 2015). Predicting the outcomes of these repeated, familiar events may then expand to include the less familiar goals of others. While more research is needed, these improvements in goal prediction likely support the development of event segmentation mechanisms.

How might adults, who structure the activities of infants through daily routines (e.g., feeding, diaper changing) and play, contribute to infants' learning about events and goal structure? The next section explores the facilitative role of adults in scaffolding infants' event segmentation.

4 | SCAFFOLDS FOR EVENT SEGMENTATION

Adults, in possession of much experience with events, can readily make predictions about upcoming actions, and this enables effective and efficient interaction with other adults. However, given the limits of infants' event segmentation abilities due to their limited knowledge of goal structures, researchers have asked whether adults modify their behaviors when interacting with infants to support them in finding the units of events (Brand, Baldwin, & Ashburn, 2002). Indeed, there is evidence for a number of behavioral modifications made by adults which highlight the boundaries of goal-directed action events—analogous to how infant-directed speech highlights language constituents in sentences spoken to babies (Fernald et al., 1989; Kemler-Nelson, Hirsh-Pasek, Jusczyk, & Cassidy, 1989; Ma, Golinkoff, Houston, & Hirsh-Pasek, 2011; Thiessen, Hill, & Saffran, 2005).

4.1 | Motionese: Tailoring action demonstrations for infants

Parents interacting with their infants spontaneously modify their actions in specific ways, relative to how they interact with other adults (Brand et al., 2002, 2013, 2009; Brand, Shallcross, Sabatos, & Massie, 2007; Rohlfing, Fritsch, Wrede, & Jungmann, 2006). These behavioral modifications, termed infant-directed action (IDA) or motionese, seem to have a pedagogical component: Adults tailor their actions in particular ways to mark things they want infants to learn, such as how to carry out a goal-directed action (Brand et al., 2009; Csibra & Gergely, 2009). Brand et al. (2002, 2007) explored these modifications by providing mothers of infants with novel objects and having these mothers demonstrate actions on the objects either to their infant (age 6–8 months or 11–13 months) or to a close relative or friend. Compared to adult-directed action (ADA), motionese was coded as involving more repetition of actions, more exaggerated, expansive movements, and production of simpler, shorter action units rather than complex, longer sequences with multiple action components (Brand et al., 2002). Repetition of exaggerated, simple action units likely highlights the boundaries of those actions by affording infants the opportunities to track structural regularities in the actions and providing opportunities to learn the goals of the actions, in addition to effects of the repetition itself on highlighting the boundaries of repeating action units. Further, Rohlfing et al. (2006) compared IDA and ADA using a 3-D body-tracking system, finding that IDA (with 8- to 11-month-olds) contained more pauses between movements. These additional pauses may serve as direct indicators to infants of meaningful action boundaries. Overall, the numerous unique characteristics of IDA provide redundant signals to the boundaries of goal-directed action.

In accompaniment to these distinct characteristics of IDA, adults demonstrating actions to infants engage the infants in the action experience more than adults demonstrating actions to other adults (Brand et al., 2002, 2007). Specifically, adults more frequently take part in object exchanges or turn-taking with infants relative to adult partners and demonstrate fewer action types per turn with infants (Brand et al., 2007). These behaviors likely serve not only to increase infants' engagement and agency when experiencing new goal-directed actions, but also highlight meaningful breakpoints in the action. Adults' demonstrations of actions to infants also involve higher levels of enthusiasm than demonstrations to adults, such as emphatic smiles when an action is completed and expressions of disappointment when an object is dropped and the intended action or outcome is impeded (Brand et al., 2002). These emotional reactions provide additional cues to the intended goal structure of the actions.

Importantly, IDA has a significant impact on infants' and toddlers attention to and learning from the actions they observe. An experimental manipulation that varied the amplitude and repetition of caregivers' action demonstrations to their infants suggested these factors enhance infants' attention to the actions (Koterba & Iverson, 2009). Indeed, given the choice to observe IDA or ADA, infants (both 6- to 8- and 11- to 13-month-olds) show an attentional preference toward IDA even when infants are simply viewing videos of action demonstrations, which omit all interactive features including facial expressions (i.e., through digital blurring of adults' faces; Brand & Shallcross, 2008). Additionally, 2-year-olds' imitation of actions is higher after observing IDA relative to ADA, even when both types of action demonstrations were experienced in an interactive context (i.e., with eye contact) with an adult (Williamson & Brand, 2014). Thus, even the bare-bones structural aspects of IDA such as action simplification are enough to increase (or mitigate decreases in) infants' attention and promote observational learning of actions. These features of motionese may hold infants' attention by making actions easier for infants to parse and by providing a pedagogical signal from the adult that there is something for the infant to learn (Gergely & Csibra, 2005). The more infants' attention is engaged, the more opportunities are available for infants to learn about event structure.

Beyond these broad measures revealing adults' highlighting of action boundaries when using IDA, and the effects of IDA on infants' attention and learning, there is evidence that using IDA specifically facilitates the predictability of the adult's actions (a key component to event segmentation) in two ways. First, the TPs of adults' IDA are informative regarding the goal structure of actions (Brand et al., 2009). For example, when adults demonstrate unrelated standalone actions on a given object (e.g., rolling, shaping, and squeezing an object) to infants (6- to 8- and 11- to 13-month-olds), they spontaneously tend to repeat those individual actions, and TPs between different actions are relatively low. In contrast, adults perform differently when demonstrating "enabling actions" on a given object—actions that carry out a goal (e.g., opening a lockbox). Adults tend to repeat the sequence rather than repeating individual actions, and TPs between the different actions of the enabling sequence are high (Brand et al., 2009). Thus, adults' action demonstrations to infants provide information about hierarchical goal structure, and infants might track these structural regularities to segment novel actions.

A second way that IDA could scaffold action prediction is through the tight alignment of eye gaze bouts (i.e., shifts of adults' gaze from the action to the infant) with action boundaries (Brand et al., 2013, 2007). Adults' infant-directed gaze reliably precedes action initiation, likely proactively preparing infants for the upcoming action (Brand et al., 2013). Infant-directed gaze also consistently follows action completion, except for the final action of an enabling sequence, in which case adults engage the gaze of infants immediately prior to the completion of the sequence's overarching goal (Brand et al., 2013). This alignment of eye gaze with action boundaries may or may not be intentional and pedagogical. For example, the action demonstration itself may consistently require adults' visual attention at particular moments. However, adults' shifting eye gaze may nevertheless have the effect of providing reliable cues that can facilitate infants' action predictions.

4.2 | Acoustic packaging and multimodal scaffolding

Adults typically do not interact with infants in silence, and there appears to be regularity in the language they provide over events. Adults increase their punctuation of actions with synchronous linguistic utterances when interacting with infants relative to adults (Schillingmann, Wrede, & Rohlfing, 2009). This "acoustic packaging" could assist infants in parsing continuous events into meaningful units, by guiding attention to particular actions, and providing acoustic signals indicating those actions' beginnings and endings (Hirsh-Pasek & Golinkoff, 1996). For example, during feeding, if a parent lifts the spoon and then moves it toward the baby's mouth while saying, "Here comes the choochoo!" this event is signaled to be a unit distinct from filling the spoon in the bowl or retracting the spoon from the mouth.

Testing this possibility, Brand and Tapscott (2007) familiarized infants with a video containing novel action sequences, in which the only cue to action boundaries was narration that was reliably coupled to particular actions. At test, actions from the familiarization video were presented in silence to determine whether infants could distinguish actions based on prior acoustic packaging. Indeed, by 9.5 months, infants' visual attention discriminated acoustically packaged actions from nonpackaged actions (Brand & Tapscott, 2007). This finding suggests that the language overlay on events may assist infants in determining which elements in actions form a unit.

Adults may specifically narrate the events in which the infant is engaged, marking actions with their respective verbs. That is, the informativeness of adults' spontaneous acoustic packaging likely goes beyond bottom-up punctuation of actions. Indeed, a fine-grained analysis of spontaneous maternal speech during mothers' action demonstrations to their infants (6- to 13-month-olds) indicated that adults' coupling of narration with actions provides not only general acoustic boundaries to the action (i.e., synchrony of speech with action onset, action occurrence, and action offset), but also verbalizes semantic descriptions of the specific action being performed (e.g., "blue goes inside"; Meyer, Hard, Brand, McGarvey, & Baldwin, 2011). Additionally, Nomikou, Koke, and Rohlfing (2017) examined videos of mother–infant dyads at home engaged in a naturalistic routine (i.e., diaper changing), to evaluate acoustic packaging of verbs with actions in 6-month-olds' everyday experience. They found that 69% of the verbs uttered by mothers in these interactions occurred within 2 s of the actions to which they referred (Nomikou, Koke, et al., 2017). The majority of these verbs actually referred to actions performed by the infants (e.g., "It tastes good, doesn't it?" in response to the infant putting a container into his mouth), and the remainder referred to actions the mother performed on objects or on the infant's body (e.g., "Shall we put your shoes back on?"). Thus, acoustic packaging provides tightly aligned, redundant cues—acoustics and semantics—to meaningful action boundaries and is prevalent in parent–child interaction.

Moreover, beyond the broad effects of semantic and acoustic alignment, there is evidence that adults spontaneously provide multimodal scaffolding *in advance* of upcoming action, which would be important for facilitating action predictions. In one study, Tomasello and Kruger (1992) found that over 60% of the verbs modeled by mothers engaging with their 2-year-olds referred to *impending* (rather than ongoing or completed) actions. The mothers typically referred to an action that they anticipated their child was about to perform or an action that they were encouraging their child to perform. Children's responses to the mothers' verb use indicated that successful comprehension occurred most often when verbs referred to impending actions, relative to children's comprehension of verbs referring to ongoing or completed actions (Tomasello & Kruger, 1992). Hearing language describing an event prior to the event's occurrence may be most effective for comprehension because it proactively prepares the child for the upcoming action unit, rather than trying to concurrently or retroactively describe a transient series of motions.

In a second study, Nomikou, Leonardi, Radkowska, Rączaszek-Leonardi, and Rohlfing (2017) filmed mother–infant dyads playing peekaboo when infants were 4 months old and again at 6 months. The researchers explored whether mothers used scaffolding to help their infants predict upcoming actions so that infants would know when it was their turn to act, and also explored relations between maternal scaffolding at 4 months and infant action at 4 and 6 months. Indeed, while there was little variation in the obligatory phases of the peekaboo game (covering, uncovering, and acknowledgement following uncovering), there was substantial variation in the optional phases of the game, particularly the preparation phase that preceded covering and uncovering (Nomikou, Leonardi, et al., 2017).

In this preparation phase, mothers explicitly announced the action that was coming next (e.g., "now mommy will be gone"). Greater use by mothers of this optional preparation phase at 4 months was associated with more attempts by the infant to uncover at both 4 and 6 months (Nomikou, Leonardi, et al., 2017). This suggests that multimodal scaffolding, specifically preparing infants to anticipate the action, shapes current and future infant behavior and enables more fluid and meaningful dyadic interaction. The many behavioral modifications adults make spontaneously, through their use of motionese and acoustic packaging when interacting with infants, suggest that adults may play a substantial role in infants' learning of event structure and in infants' developing abilities to segment events.

5 | SIGNIFICANCE OF EVENT SEGMENTATION FOR OTHER DEVELOPMENTAL PROCESSES

The research presented in the prior two sections discussed mechanisms of event segmentation in infants and ways in which adults spontaneously scaffold infants' parsing of events. Throughout those processes, it is clear that event segmentation is influenced by memory (e.g., statistical learning of actions), emerging social knowledge (e.g., predicting goals), and language (e.g., acoustic packaging). However, growing research indicates that effects do not occur only in a single direction—that is, event memory, social knowledge, and language learning rely on children's event segmentation skills.

5.1 | Memory: Chunking action goals and preserving goal hierarchies

The area of cognition that is perhaps most directly impacted by event segmentation is memory. Extensive research with adults suggests that event memory is functionally dependent on how the event was segmented (Flores et al., 2017; Sargent et al., 2013; Swallow et al., 2009; Zacks et al., 2006), and research with children provides further insights into how memory preserves event structure that is created during event segmentation. Imitation research reveals that 3-year-olds' memories for observed action events, both familiar and novel, are organized based on hierarchical goal structure rather than the temporal order in which the actions were observed (Loucks & Meltzoff, 2013; Loucks, Mutschler, & Meltzoff, 2017), suggesting children segment events according to goal hierarchies and preserve this segmentation in their memory for the events.

The link between event segmentation and subsequent event memory has been demonstrated in infants as early as 16 months (Bauer & Mandler, 1989). Bauer and Mandler (1989) tested 16- and 20-month-olds' recall for novel event sequences, both enabling (i.e., hierarchically linked actions that accomplish a goal) and arbitrary (i.e., nonhierarchically linked actions), using elicited imitation. For example, the overarching goal of one enabling sequence was to create a rattle, which involved the actions of placing a ball in a large cup, moving an inverted smaller cup into the large cup containing the ball, and then shaking the cups. This particular ordering of actions was necessary to accomplish the overarching goal. In contrast, an arbitrary sequence with the goal of making a picture involved the actions of placing a sticker on a chalkboard, leaning the board against an easel, and then drawing on the board with chalk. These actions were not hierarchically linked, and their ordering was arbitrary. The immediate recall of 16- and 20-month-olds revealed superior memory for enabling sequences, which children segmented as chunks, relative to arbitrary sequences which they segmented as individual units (Bauer & Mandler, 1989; see also Bauer, 1992). By 20 months, infants exhibited long-term, 2-week delayed recall for these sequences as well, with the same pattern favoring enabling sequences (Bauer & Mandler, 1989). These results suggest that the way an event is first segmented—as a hierarchical chunk or as individual units—determines the ease with which the sequence can be remembered.

More direct evidence linking event segmentation with subsequent event memory comes from research with 3- and 4-year-olds using a modified event segmentation paradigm (Meyer, Baldwin, et al., 2011). In this paradigm, a videotaped event is transformed into a slideshow of still-frames, which children (or adults) can click through to simulate the continuous event (Hard et al., 2011; Meyer, Baldwin, et al., 2011). The amount of time individuals dwell on each slide provides a measure of attention, with surges of attention indicating perceived boundaries. Meyer, Baldwin, et al. (2011) had children click through an event portraying an individual interacting with various toys and then complete a forced-choice memory task. They found that children with strong memory of the event had exhibited surges of attention primarily at coarse event boundaries (i.e., higher-level goals), and to a lesser extent at fine-grained boundaries (i.e., lower-level goals), suggesting a hierarchical segmentation. In contrast, children with low memory of the event did not show any consistent pattern of attention at event boundaries relative to within-events (Meyer, Baldwin, et al., 2011). These results suggest that children's memory for events is dependent on their online parsing of those events.

Thus, the evidence from infancy through adulthood suggests that online event segmentation processes lead to the detection of event boundaries that prioritize goal hierarchies, thereby facilitating event memory. Given research with adults suggesting facilitative effects of cueing coarse event boundaries on event memory (Gold, Zacks, & Flores, 2017), future research should evaluate how cueing boundaries aligned with action goals in infants (as with motionese and acoustic packaging) could bolster event memory and memory development.

5.2 | From predicting action to engaging in social interaction

How might event segmentation abilities contribute to children's social competence in their interactions with others? This section addresses this question from two perspectives. First, given that event predictions (and prediction errors) seem to be the primary mechanism of event segmentation, and given that infants' action predictions may be largely constrained to agentive actions with transparent goals (Monroy et al., 2017a; Monroy et al., 2017), we examine whether individual differences in infants' action prediction performance predict individual differences in their social competence. Second, we discuss research suggesting a potential role of non-normative event prediction and segmentation in the social deficits of children with autism spectrum disorder (ASD).

5.2.1 | Links between action prediction and social competence in typically developing children

The prior section provided evidence that mothers who supply greater scaffolding to assist infants with predicting upcoming actions have infants who are more socially engaged in dyadic interaction (Nomikou, Leonardi, et al., 2017). Krogh-Jespersen, Liberman, and Woodward (2015) examined more directly the link between individual differences in children's action prediction and their social competence. Twenty- to 22-month-olds were first familiarized with a video of a woman reaching for and grasping one of two available toys; then, the location of the toys was flipped, and the speed with which children gazed predictively toward the correct goal object was assessed. Prediction speed for location was also measured for trials in which infants incorrectly predicted the location rather than the toy. Children's social competence was separately evaluated in a perspective-taking task, which tested children's ability to recognize that an adult's perspective was distinct from their own perspective and utilize this understanding in a social interaction. Children who were faster to visually predict goals (but not locations) in the goal prediction task were also more successful at taking the adult's perspective in the social interaction (Krogh-Jespersen et al., 2015). It is theorized that speed of action prediction is important for smooth social interaction, because children need to be able to quickly act on their predictions of others' goals to produce timely, well-organized social responses (Krogh-Jespersen et al., 2015).

Indeed, another study with 2.5-year-olds found that individual differences in the ability to predict others' actions in an eye-tracking task were directly related to individual differences in the ability to adapt to a social partner and carry out joint actions in a turn-taking task (Meyer, Bekkering, Haartsen, Stapel, & Hunnius, 2015). Being able to predict upcoming actions makes interactions run more smoothly and contributes to children appearing more socially competent.

5.2.2 | Non-normative event prediction and segmentation in children with ASD

Researchers have asked whether the social communication impairments characteristic of children with ASD may in part be attributed to differences in their action predictions and in how they segment events (Krogh-Jespersen, Kaldy, Valadez, Carter, & Woodward, 2018; von Hofsten, Uhlig, Adell, & Kochukhova, 2009; Zalla et al., 2013). One study found that when watching a video of two adults in a typical turn-taking conversation, preschoolers with ASD (mean age of 4.7 years) made fewer predictive saccades from one speaker to the next compared to typically developing (TD) 3-year-old children (von Hofsten et al., 2009). This suggests that children with ASD may fail to recognize an action boundary when one person's turn ends and the next begins. However, when watching a video of two objects taking turns moving up and down with corresponding object sounds, predictive saccades from one object to the next were comparable for children with ASD and TD children (von Hofsten et al., 2009). Thus, children with ASD do not seem to have general impairments in predicting visual events, but rather their difficulty with event prediction is specific to agentive action.

Research has also examined *why* children with ASD struggle with making predictions in agentive action. Krogh-Jespersen et al. (2018) adapted the paradigm developed by Woodward (1998) to assess the action prediction capabilities of children with ASD. Children were familiarized with a video of an actor reaching for and grasping one of two objects presented side-by-side; then, the location of the toys was flipped, and the actor raised her hand to initiate another reaching action but paused prior to making a selection. During the familiarization—when the trajectory of the reach was visible—2-year-old children with ASD predicted the goal similar to TD children. However, when viewing the actor's subsequent incomplete reach, 2-year-old children with ASD, unlike TD children, systematically made action predictions based on the prior *location* of the actor's goal rather than the actor's prior goal (Krogh-Jespersen et al., 2018). Thus, while TD children use prediction of actors' goals to parse agentive action, children with ASD may be more likely to base their action predictions on low-level movement information, such as action kinematics.

The aforementioned studies focused on action prediction (i.e., the theorized mechanism of event segmentation), but a study by Zalla et al. (2013) examined more directly whether non-normative segmentation of goal-directed action events may contribute to the deficiencies in social competence that are characteristic of children with ASD. Specifically, this research asked whether the performance of individuals with ASD on an event segmentation task was linked with their success on two theory of mind (ToM) tasks, which tested their ability to attribute false beliefs to others. First, individuals with ASD showed impaired detection of normative event boundaries for everyday action events (e.g., brushing teeth) at the level of both broader goals and finer subgoals relative to TD age-matched children. Importantly, individuals with ASD who segmented events more normatively (i.e., at the level of goals and subgoals) were more likely to succeed at two ToM tasks relative to individuals with ASD who failed to note those boundaries (Zalla et al., 2013). Thus, the difficulties children with ASD have with attributing internal mental states to others in social situations may stem from differences in the earlier stages of action processing, specifically differences in how goal-directed actions are segmented.

In sum, the research on TD children suggests that speed of successful action prediction is linked to more successful social interactions, likely because social interaction demands that children respond to others' social bids in real time, before the interactive moment has passed. Additionally, research on children with ASD reveals that the extent to which children's action prediction and event segmentation are informed by actors' goals relates to individual differences in social competence, likely because success in social interaction relies on anticipating others' goals (which are often not unambiguously available in the perceptual input). However, the research to date is correlational; future research is needed to evaluate how action prediction and event segmentation are informed by goal structure and how these processes may causally impact social competence.

5.3 | Segmenting events for learning language

In addition to supporting children's developing social competence, action segmentation skills may also play a role in language development. Learning language demands that children transform their continuous experiences into meaningful semantic units (Göksun, Hirsh-Pasek, & Golinkoff, 2010). Researchers have theorized that the individuation of word referents is a critical factor for early word learning (Gentner & Boroditsky, 2001; Maguire, Hirsh-Pasek, & Golinkoff, 2006), just as segmentation of the sound stream is essential for learning language (Evans, Saffran, & Robe-Torres, 2009; Kooijman, Junge, Johnson, Hagoort, & Cutler, 2013; Newman, Ratner, Jusczyk, Jusczyk, & Dow, 2006; Singh, Reznick, & Xuehua, 2012). That is, children must not only find individual sound patterns that link to individual objects, actions, and events, but also determine what in an event is serving as the referent for the word.

Patterns of lexical acquisition hint at the importance of event segmentation. In particular, children's knowledge of nouns—which have, on average, the most easily segmented referents (e.g., objects, animate entities)—exceeds their knowledge of other types of words in comprehension and production (Gentner, 1982; Goldin-Meadow, Seligman, & Gelman, 1976; Hirsh-Pasek & Golinkoff, 2006). The noun bias is a cross-linguistic phenomenon, holding true not only for "noun-friendly" languages such as English and French but also for "verb-friendly" languages such as Mandarin and Korean, which use verbs in more prominent sentence locations and frequently drop noun phrases in conversation (Bornstein et al., 2004; Gentner, 1982; Imai et al., 2008; Waxman et al., 2013). Additionally, Nomikou, Koke, et al. (2017) found that the extent to which mothers align verbs with actions (within vs. outside a 2-s window) when interacting with their infants predicted children's later vocabulary size; the temporal alignment of verbs with their referents may enable infants to segment out verb-action pairings as meaningful couplings, thereby facilitating vocabulary acquisition. Together, the consistent pattern of acquiring words for more easily segmented referents (i.e., nouns vs. verbs) earlier in development and the predictive association between acoustic packaging and vocabulary size are suggestive of a link between event segmentation and language learning.

This link has been examined more directly in two studies. A study by Kaduk et al. (2016) examined relations between infants' neurophysiological processing of expected and unexpected outcomes of action events (e.g., bringing a pretzel to one's mouth vs. one's ear) and their vocabulary knowledge. Infants who at 9 months showed an N400 event-related potential response to unexpected outcomes, indicating semantic processing of noncommunicative goal-directed actions, were those with larger vocabularies both concurrently and 9 months later (Kaduk et al., 2016). This suggests that learning the predictable structure of events may set a foundation for lexical acquisition.

A second study examined links between event segmentation and language by evaluating the ability of 3-year-olds to statistically segment a novel action event and testing their concurrent vocabulary knowledge (Levine, 2017). Statistical action segmentation was evaluated by first familiarizing children with a sequence of body motions in which the only cues to action boundaries were TPs between motions (as in the infancy research described earlier, Roseberry et al., 2011; Stahl et al., 2014). Following familiarization, children's action segmentation skill was tested by comparing their visual attention to intact action units (with TPs of 1.0) to their attention to action units with lower TPs based on the familiarization sequence. Children's vocabulary was assessed, and other measures of children's linguistic and nonlinguistic abilities were included as control variables in examining the relation between action segmentation and vocabulary. Children's action segmentation performance explained significant unique variance in vocabulary knowledge (Levine, 2017), providing the first evidence of a direct link between action segmentation and vocabulary development. Given effects of language on event segmentation (e.g., Wagner & Carey, 2003; Zacks, Tversky, et al., 2001), future research is needed to probe the directionality of this link and determine how action segmentation may support word learning. Nevertheless, action segmentation may bootstrap lexical acquisition by helping children learn the words that map onto units of events.

6 | CONCLUSION

Event segmentation is a fundamental process by which human cognition gathers and selectively organizes the abundance of continuous information in our environment. This paper set out to answer four questions about the development of this fundamental process: First, what is the mechanism of event segmentation in adults? Second, how do infants begin to segment events? Third, how might caregivers scaffold infants' event segmentation? Finally, how is event segmentation linked to other developmental achievements?

Action prediction seems to serve as the primary mechanism by which adults segment events, and there is support for a parallel mechanism in infants. Infants leverage their statistical learning abilities to make action predictions based on movement regularities and also utilize their burgeoning understanding of actors' goals to make predictions that are increasingly informed by hierarchical goal structure. For many everyday action events, movement features and goals will provide redundant cues to event boundaries, because the same sequences of movements are generally used to achieve the same higher-level goals. In addition, caregivers of infants appear to assist their offspring in finding events, by providing numerous supplemental event boundary cues in the form of IDA and acoustic packaging. Developing event segmentation abilities are foundational for building event memories, because memory largely preserves the event structure that is constructed during event segmentation. Research also hints at effects of event segmentation on developing social competence and language skills, yet more research is needed to evaluate causal effects in these domains.

The process of event segmentation has not been studied as long as other areas of cognition. Yet, the synthesis of research literatures in this review provides unique insights about how children find junctures in ongoing change. This review also illuminates new perspectives on the significance of this process for children's cognitive and social development.

ENDNOTES

[1]It should be noted that although the developmental trajectory for predicting goal-directed actions is protracted, infants' ability to predict simple physical motion, such as predicting the trajectory of an object moving along a linear path, is available by 6 months and does not have the same protracted development (Green, Kochukhova, & Gredebäck, 2014). We focus here on the more complex events that are a part of children's everyday experience, which go beyond physical reasoning about object motion.

ORCID

Dani Levine http://orcid.org/0000-0003-3916-6537

REFERENCES

Adam, M., Reitenbach, I., & Elsner, B. (2017). Agency cues and 11-month-olds' and adults' anticipation of action goals. *Cognitive Development*, *43*, 37–48. https://doi.org/10.1016/j.cogdev.2017.02.008

Ambrosini, E., Reddy, V., de Looper, A., Costantini, M., Lopez, B., & Sinigaglia, C. (2013). Looking ahead: Anticipatory gaze and motor ability in infancy. *PLoS One*, *8*(7), e67916. https://doi.org/10.1371/journal.pone.0067916

Aslin, R. N. (2017). Statistical learning: A powerful mechanism that operates by mere exposure. *Wiley Interdisciplinary Reviews: Cognitive Science*, *8*, e1373.

Bailey, H. R., Kurby, C. A., Giovannetti, T., & Zacks, J. M. (2013). Action perception predicts action performance. *Neuropsychologia*, *51*(11), 2294–2304. https://doi.org/10.1016/j.neuropsychologia.2013.06.022

Baldwin, D., Andersson, A., Saffran, J., & Meyer, M. (2008). Segmenting dynamic human action via statistical structure. *Cognition*, *106*(3), 1382–1407. https://doi.org/10.1016/j.cognition.2007.07.005

Baldwin, D. A., & Baird, J. A. (2001). Discerning intentions in dynamic human action. *Trends in Cognitive Sciences*, *5*(4), 171–178. https://doi.org/10.1016/S1364-6613(00)01615-6

Baldwin, D. A., Baird, J. A., Saylor, M. M., & Clark, M. A. (2001). Infants parse dynamic action. *Child Development*, *72*(3), 708–717. https://doi.org/10.1111/1467-8624.00310

Bauer, P. J. (1992). Holding it all together: How enabling relations facilitate young children's event recall. *Cognitive Development*, *7*, 1–28. https://doi.org/10.1016/0885-2014(92)90002-9

Bauer, P. J., & Mandler, J. M. (1989). One thing follows another: Effects of temporal structure on 1-to 2-year-olds' recall of events. *Developmental Psychology*, *25*(2), 197–206. https://doi.org/10.1037/0012-1649.25.2.197

Ben-Yakov, A., & Henson, R. N. (2018). The hippocampal film-editor: Sensitivity and specificity to event boundaries in continuous experience. *Journal of Neuroscience*. https://doi.org/10.1523/JNEUROSCI.0524-18.2018

Bläsing, B. E. (2015). Segmentation of dance movement: Effects of expertise, visual familiarity, motor experience and music. *Frontiers in Psychology*, *5*, 1500.

Bornstein, M. H., Cote, L. R., Maital, S., Painter, K., Park, S. Y., Pascual, L., ... Vyt, A. (2004). Cross-linguistic analysis of vocabulary in young children: Spanish, Dutch, French, Hebrew, Italian, Korean, and American English. *Child Development*, *75*(4), 1115–1139. https://doi.org/10.1111/j.1467-8624.2004.00729.x

Brand, R. J., Baldwin, D. A., & Ashburn, L. A. (2002). Evidence for 'motionese': Modifications in mothers' infant-directed action. *Developmental Science*, *5*(1), 72–83. https://doi.org/10.1111/1467-7687.00211

Brand, R. J., Escobar, K., Baranès, A., & Albu, A. (2015). Crawling predicts infants' understanding of agents' navigation of obstacles. *Infancy*, *20*(4), 405–415. https://doi.org/10.1111/infa.12084

Brand, R. J., Hollenbeck, E., & Kominsky, J. F. (2013). Mothers' infant-directed gaze during object demonstration highlights action boundaries and goals. *IEEE Transactions on Autonomous Mental Development*, *5*(3), 192–201. https://doi.org/10.1109/TAMD.2013.2273057

Brand, R. J., McGee, A., Kominsky, J. F., Briggs, K., Gruneisen, A., & Orbach, T. (2009). Repetition in infant-directed action depends on the goal structure of the object: Evidence for statistical regularities. *Gesture*, *9*(3), 337–353. https://doi.org/10.1075/gest.9.3.04bra

Brand, R. J., & Shallcross, W. L. (2008). Infants prefer motionese to adult-directed action. *Developmental Science*, *11*(6), 853–861. https://doi.org/10.1111/j.1467-7687.2008.00734.x

Brand, R. J., Shallcross, W. L., Sabatos, M. G., & Massie, K. P. (2007). Fine-grained analysis of motionese: Eye gaze, object exchanges, and action units in infant-versus adult-directed action. *Infancy*, *11*(2), 203–214. https://doi.org/10.1111/j.1532-7078.2007.tb00223.x

Brand, R. J., & Tapscott, S. (2007). Acoustic packaging of action sequences by infants. *Infancy*, *11*(3), 321–332. https://doi.org/10.1111/j.1532-7078.2007.tb00230.x

Brunec, I. K., Moscovitch, M., & Barense, M. D. (2018). Boundaries shape cognitive representations of spaces and events. *Trends in Cognitive Sciences*, *22*(7), 637–650. https://doi.org/10.1016/j.tics.2018.03.013

Buchsbaum, D., Canini, K. R., & Griffiths, T. L. (2011). Segmenting and recognizing human action using low-level video features. In L. Carlson, C. Holscher, & T. F. Shipley (Eds.), *Proceedings of the 33rd Annual Conference of the Cognitive Science Society* (pp. 3162–3167). Austin, TX: Cognitive Science Society.

Buchsbaum, D., Gopnik, A., Griffiths, T. L., & Shafto, P. (2011). Children's imitation of causal action sequences is influenced by statistical and pedagogical evidence. *Cognition*, *120*(3), 331–340. https://doi.org/10.1016/j.cognition.2010.12.001

Buchsbaum, D., Griffiths, T. L., Plunkett, D., Gopnik, A., & Baldwin, D. (2015). Inferring action structure and causal relationships in continuous sequences of human action. *Cognitive Psychology*, *76*, 30–77. https://doi.org/10.1016/j.cogpsych.2014.10.001

Cannon, E. N., & Woodward, A. L. (2012). Infants generate goal-based action predictions. *Developmental Science*, *15*(2), 292–298. https://doi.org/10.1111/j.1467-7687.2011.01127.x

Csibra, G., & Gergely, G. (2009). Natural pedagogy. *Trends in Cognitive Sciences*, *13*(4), 148–153. https://doi.org/10.1016/j.tics.2009.01.005

Eshuis, R., Coventry, K. R., & Vulchanova, M. (2009). Predictive eye movements are driven by goals, not by the mirror neuron system. *Psychological Science*, *20*(4), 438–440. https://doi.org/10.1111/j.1467-9280.2009.02317.x

Evans, J. L., Saffran, J. R., & Robe-Torres, K. (2009). Statistical learning in children with specific language impairment. *Journal of Speech, Language, and Hearing Research*, *52*(2), 321–335. https://doi.org/10.1044/1092-4388(2009/07-0189)

Falck-Ytter, T., Gredebäck, G., & von Hofsten, C. (2006). Infants predict other people's action goals. *Nature Neuroscience*, *9*(7), 878–879. https://doi.org/10.1038/nn1729

Fernald, A., Taeschner, T., Dunn, J., Papousek, M., de Boysson-Bardies, B., & Fukui, I. (1989). A cross-language study of prosodic modifications in mothers' and fathers' speech to preverbal infants. *Journal of Child Language*, *16*(3), 477–501. https://doi.org/10.1017/S0305000900010679

Filippi, C. A., & Woodward, A. L. (2016). Action experience changes attention to kinematic cues. *Frontiers in Psychology*, *7*, 19. https://doi.org/10.3389/fpsyg.2016.00019

Flores, S., Bailey, H. R., Eisenberg, M. L., & Zacks, J. M. (2017). Event segmentation improves event memory up to one month later. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *43*(8), 1183–1202.

Friend, M., & Pace, A. E. (2016). Action interrupted: Movement and breakpoints in the processing of motion violations in toddlers and adults. *Journal of Cognition and Development*, *17*(1), 105–121. https://doi.org/10.1080/15248372.2015.1016611

Gampe, A., Keitel, A., & Daum, M. M. (2015). Intra-individual variability and continuity of action and perception measures in infants. *Frontiers in Psychology*, *6*, 327. https://doi.org/10.3389/fpsyg.2015.00327

Gentner, D., & Boroditsky, L. (2001). Individuation, relativity and early word learning. In M. Bowerman, & S. Levinson (Eds.), *Language acquisition and conceptual development* (pp. 215–256). Cambridge, UK: Cambridge University Press.

Gentner, D. (1982). Why nouns are learned before verbs: Linguistic relativity versus natural partitioning. *Center for the Study of Reading Technical Report*, *257*.

Gergely, G., & Csibra, G. (2005). The social construction of the cultural mind: Imitative learning as a mechanism of human pedagogy. *Interaction Studies*, *6*(3), 463–481.

Göksun, T., Hirsh-Pasek, K., & Golinkoff, R. M. (2010). Trading spaces carving up events for learning language. *Perspectives on Psychological Science*, *5*(1), 33–42. https://doi.org/10.1177/1745691609356783

Gold, D. A., Zacks, J. M., & Flores, S. (2017). Effects of cues to event segmentation on subsequent memory. *Cognitive Research: Principles and Implications*, *2*, 1.

Goldin-Meadow, S., Seligman, M. E., & Gelman, R. (1976). Language in the two-year old. *Cognition*, *4*(2), 189–202. https://doi.org/10.1016/0010-0277(76)90004-4

Green, D., Kochukhova, O., & Gredebäck, G. (2014). Extrapolation and direct matching mediate anticipation in infancy. *Infant Behavior and Development*, *37*(1), 111–118. https://doi.org/10.1016/j.infbeh.2013.12.002

Green, D., Li, Q., Lockman, J. J., & Gredebäck, G. (2016). Culture influences action understanding in infancy: Prediction of actions performed with chopsticks and spoons in Chinese and Swedish infants. *Child Development*, *87*(3), 736–746. https://doi.org/10.1111/cdev.12500

Hard, B. M., Recchia, G., & Tversky, B. (2011). The shape of action. *Journal of Experimental Psychology: General*, *140*(4), 586–604. https://doi.org/10.1037/a0024310

Hirsh-Pasek, K., & Golinkoff, R. M. (1996). *The origins of grammar: Evidence from early language comprehension*. Cambridge, MA: MIT Press.

Hirsh-Pasek, K., & R. M. Golinkoff (Eds.) (2006). *Action meets word: How children learn verbs*. New York, NY: Oxford University Press.

Imai, M., Li, L., Haryu, E., Okada, H., Hirsh-Pasek, K., Golinkoff, R. M., & Shigematsu, J. (2008). Novel noun and verb learning in Chinese-, English-, and Japanese-speaking children. *Child Development*, *79*(4), 979–1000. https://doi.org/10.1111/j.1467-8624.2008.01171.x

Kaduk, K., Bakker, M., Juvrud, J., Gredebäck, G., Westermann, G., Lunn, J., & Reid, V. M. (2016). Semantic processing of actions at 9 months is linked to language proficiency at 9 and 18 months. *Journal of Experimental Child Psychology*, *151*, 96–108. https://doi.org/10.1016/j.jecp.2016.02.003

Kanakogi, Y., & Itakura, S. (2011). Developmental correspondence between action prediction and motor ability in early infancy. *Nature Communications*, *2*, 341. https://doi.org/10.1038/ncomms1342

Keitel, A., Prinz, W., & Daum, M. M. (2014). Perception of individual and joint action in infants and adults. *PLoS One*, *9*(9), e107450. https://doi.org/10.1371/journal.pone.0107450

Kemler-Nelson, D. G., Hirsh-Pasek, K., Jusczyk, P. W., & Cassidy, K. W. (1989). How the prosodic cues in motherese might assist language learning. *Journal of Child Language*, *16*(1), 55–68. https://doi.org/10.1017/S030500090001343X

Kim, E. Y., & Song, H. J. (2015). Six-month-olds actively predict others' goal-directed actions. *Cognitive Development*, *33*, 1–13. https://doi.org/10.1016/j.cogdev.2014.09.003

Kooijman, V., Junge, C., Johnson, E. K., Hagoort, P., & Cutler, A. (2013). Predictive brain signals of linguistic development. *Frontiers in Psychology*, *4*, 25. https://doi.org/10.3389/fpsyg.2013.00025

Koterba, E. A., & Iverson, J. M. (2009). Investigating motionese: The effect of infant-directed action on infants' attention and object exploration. *Infant Behavior and Development*, *32*(4), 437–444. https://doi.org/10.1016/j.infbeh.2009.07.003

Krogh-Jespersen, S., Kaldy, Z., Valadez, A. G., Carter, A. S., & Woodward, A. L. (2018). Goal prediction in 2-year-old children with and without autism spectrum disorder: An eye-tracking study. *Autism Research*, *11*, 870–882. http://doi.org/10.1002/aur.1936

Krogh-Jespersen, S., Liberman, Z., & Woodward, A. L. (2015). Think fast! The relationship between goal prediction speed and social competence in infants. *Developmental Science*, *18*(5), 815–823. https://doi.org/10.1111/desc.12249

Krogh-Jespersen, S., & Woodward, A. L. (2014). Making smart social judgments takes time: Infants' recruitment of goal information when generating action predictions. *PLoS One*, *9*(5), e98085. https://doi.org/10.1371/journal.pone.0098085

Lakusta, L., & Carey, S. (2015). Twelve-month-old infants' encoding of goal and source paths in agentive and non-agentive motion events. *Language Learning and Development*, *11*(2), 152–175. https://doi.org/10.1080/15475441.2014.896168

Levine, D. (2017). Foundations of vocabulary: Does statistical segmentation of events contribute to word learning? Unpublished doctoral dissertation, Temple University, Philadelphia, PA.

Levine, D., Hirsh-Pasek, K., Pace, A., & Golinkoff, R. M. (2017). A goal bias in action: The boundaries adults perceive in events align with sites of actor intent. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *43*(6), 916–927.

Loucks, J., & Meltzoff, A. N. (2013). Goals influence memory and imitation for dynamic human action in 36-month-old children. *Scandinavian Journal of Psychology*, *54*(1), 41–50. https://doi.org/10.1111/sjop.12004

Loucks, J., Mutschler, C., & Meltzoff, A. N. (2017). Children's representation and imitation of events: How goal organization influences 3-year-old children's memory for action sequences. *Cognitive Science*, *41*(7), 1904–1933. https://doi.org/10.1111/cogs.12446

Ma, W., Golinkoff, R. M., Houston, D. M., & Hirsh-Pasek, K. (2011). Word learning in infant-and adult-directed speech. *Language Learning and Development*, *7*(3), 185–201. https://doi.org/10.1080/15475441.2011.579839

Maguire, M., Hirsh-Pasek, K., & Golinkoff, R. M. (2006). A unified theory of word learning: Putting verb acquisition in context. In K. Hirsh-Pasek, & R. M. Golinkoff (Eds.), *Action meets word: How children learn verbs* (pp. 364–391). New York, NY: Oxford University Press.

Meyer, M., & Baldwin, D. (2011). Statistical learning of action: The role of conditional probability. *Learning & Behavior*, *39*(4), 383–398. https://doi.org/10.3758/s13420-011-0033-7

Meyer, M., Baldwin, D. A., & Sage, K. D. (2011). Assessing young children's hierarchical action segmentation. In L. Carlson, C. Hölscher, & T. Shipley (Eds.), *Proceedings of the 33rd Annual Conference of the Cognitive Science Society* (pp. 3156–3161). Austin, TX: Cognitive Science Society.

Meyer, M., Bekkering, H., Haartsen, R., Stapel, J. C., & Hunnius, S. (2015). The role of action prediction and inhibitory control for joint action coordination in toddlers. *Journal of Experimental Child Psychology*, *139*, 203–220. https://doi.org/10.1016/j.jecp.2015.06.005

Meyer, M., Hard, B., Brand, R. J., McGarvey, M., & Baldwin, D. A. (2011). Acoustic packaging: Maternal speech and action synchrony. *IEEE Transactions on Autonomous Mental Development*, *3*(2), 154–162.

Monroy, C. D., Gerson, S. A., Domínguez-Martínez, E., Kaduk, K., Hunnius, S., & Reid, V. (2017). Sensitivity to structure in action sequences: An infant event-related potential study. *Neuropsychologia*. https://doi.org/10.1016/j.neuropsychologia.2017.05.007

Monroy, C. D., Gerson, S. A., & Hunnius, S. (2017a). Toddlers' action prediction: Statistical learning of continuous action sequences. *Journal of Experimental Child Psychology*, *157*, 14–28.

Monroy, C. D., Gerson, S. A., & Hunnius, S. (2017b). Infants' motor proficiency and statistical learning for actions. *Frontiers in Psychology*, *8*, 2174.

Monroy, C. D., Gerson, S. A., & Hunnius, S. (2018). Translating visual information into action predictions: Statistical learning in action and nonaction contexts. *Memory & Cognition*, *46(4)*, 600–613. https://doi.org/10.3758/s13421-018-0788-6

Newman, R., Ratner, N. B., Jusczyk, A. M., Jusczyk, P. W., & Dow, K. A. (2006). Infants' early ability to segment the conversational speech signal predicts later language development: A retrospective analysis. *Developmental Psychology*, *42*(4), 643–655. https://doi.org/10.1037/0012-1649.42.4.643

Nomikou, I., Koke, M., & Rohlfing, K. J. (2017). Verbs in mothers' input to six-month-olds: Synchrony between presentation, meaning, and actions is related to later verb acquisition. *Brain Sciences*, *7*(5), 52.

Nomikou, I., Leonardi, G., Radkowska, A., Rączaszek-Leonardi, J., & Rohlfing, K. J. (2017). Taking up an active role: Emerging participation in early mother–infant interaction during peekaboo routines. *Frontiers in Psychology*, *8*, 1656.

Pace, A., Levine, D., Licht, V. H., Zaw, K., Hirsh-Pasek, K., Golinkoff, R. M., & Carver, L. J. (2014, July). Break it up: Behavioral and ERP evidence for infant attention to boundaries in complex events. Paper presented in A. Pace (Chair), *Finding breaks in the action: Exploring multiple mechanisms for infant event segmentation*. Symposium at the Biennial International Congress on Infant Studies, Berlin, Germany

Reid, V. M., Hoehl, S., Grigutsch, M., Groendahl, A., Parise, E., & Striano, T. (2009). The neural correlates of infant and adult goal prediction: Evidence for semantic processing systems. *Developmental Psychology*, *45*(3), 620–629. https://doi.org/10.1037/a0015209

Richmond, L. L., & Zacks, J. M. (2017). Constructing experience: Event models from perception to action. *Trends in Cognitive Sciences*, *21*(12), 962–980. https://doi.org/10.1016/j.tics.2017.08.005

Rohlfing, K. J., Fritsch, J., Wrede, B., & Jungmann, T. (2006). How can multimodal cues from child-directed interaction reduce learning complexity in robots? *Advanced Robotics*, *20*(10), 1183–1199. https://doi.org/10.1163/156855306778522532

Roseberry, S., Richie, R., Hirsh-Pasek, K., Golinkoff, R. M., & Shipley, T. F. (2011). Babies catch a break 7-to 9-month-olds track statistical probabilities in continuous dynamic events. *Psychological Science*, *22*(11), 1422–1424. https://doi.org/10.1177/0956797611422074

Saffran, J. R., Aslin, R. N., & Newport, E. L. (1996). Statistical learning by 8-month-old infants. *Science*, *274*, 1926–1928. https://doi.org/10.1126/science.274.5294.1926

Saffran, J. R., & Kirkham, N. Z. (2018). Infant statistical learning. *Annual Review of Psychology*, *69*, 181–203. https://doi.org/10.1146/annurev-psych-122216-011805

Sargent, J. Q., Zacks, J. M., Hambrick, D. Z., Zacks, R. T., Kurby, C. A., Bailey, H. R., … Beck, T. M. (2013). Event segmentation ability uniquely predicts event memory. *Cognition*, *129*(2), 241–255. https://doi.org/10.1016/j.cognition.2013.07.002

Saylor, M. M., Baldwin, D. A., Baird, J. A., & LaBounty, J. (2007). Infants' on-line segmentation of dynamic human action. *Journal of Cognition and Development*, *8*(1), 113–128. https://doi.org/10.1080/15248370709336996

Schachner, A., & Carey, S. (2013). Reasoning about 'irrational' actions: When intentional movements cannot be explained, the movements themselves are seen as the goal. *Cognition*, *129*(2), 309–327. https://doi.org/10.1016/j.cognition.2013.07.006

Schillingmann, L., Wrede, B., & Rohlfing, K. J. (2009). A computational model of acoustic packaging. *IEEE Transactions on Autonomous Mental Development*, *1*(4), 226–237. https://doi.org/10.1109/TAMD.2009.2039135

Sharon, T., & Wynn, K. (1998). Individuation of actions from continuous motion. *Psychological Science*, *9*(5), 357–362. https://doi.org/10.1111/1467-9280.00068

Singh, L., Reznick, J. S., & Xuehua, L. (2012). Infant word segmentation and childhood vocabulary development: A longitudinal analysis. *Developmental Science*, *15*(4), 482–495. https://doi.org/10.1111/j.1467-7687.2012.01141.x

Sommerville, J. A., Woodward, A. L., & Needham, A. (2005). Action experience alters 3-month-old infants' perception of others' actions. *Cognition*, *96*(1), B1–B11. https://doi.org/10.1016/j.cognition.2004.07.004

Southgate, V., Johnson, M. H., Karoui, I. E., & Csibra, G. (2010). Motor system activation reveals infants' on-line prediction of others' goals. *Psychological Science*, *21*(3), 355–359. https://doi.org/10.1177/0956797610362058

Speer, N. K., Swallow, K. M., & Zacks, J. M. (2003). Activation of human motion processing areas during event perception. *Cognitive, Affective, & Behavioral Neuroscience*, *3*(4), 335–345. https://doi.org/10.3758/CABN.3.4.335

Stahl, A. E., Romberg, A. R., Roseberry, S., Golinkoff, R. M., & Hirsh-Pasek, K. (2014). Infants segment continuous events using transitional probabilities. *Child Development*, *85*(5), 1821–1826. https://doi.org/10.1111/cdev.12247

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*(2), 236–257. https://doi.org/10.1037/a0015631

Thiessen, E. D., Hill, E. A., & Saffran, J. R. (2005). Infant-directed speech facilitates word segmentation. *Infancy*, *7*(1), 53–71. https://doi.org/10.1207/s15327078in0701_5

Tomasello, M., & Kruger, A. C. (1992). Joint attention on actions: Acquiring verbs in ostensive and non-ostensive contexts. *Journal of Child Language*, *19*(2), 311–333. https://doi.org/10.1017/S0305000900011430

Uithol, S., & Paulus, M. (2014). What do infants understand of others' action? A theoretical account of early social cognition. *Psychological Research Psychologische Forschung*, *78*(5), 609–622. https://doi.org/10.1007/s00426-013-0519-3

van Elk, M., van Schie, H. T., Hunnius, S., Vesper, C., & Bekkering, H. (2008). You'll never crawl alone: Neurophysiological evidence for experience-dependent motor resonance in infancy. *NeuroImage*, *43*(4), 808–814. https://doi.org/10.1016/j.neuroimage.2008.07.057

von Hofsten, C., Uhlig, H., Adell, M., & Kochukhova, O. (2009). How children with autism look at events. *Research in Autism Spectrum Disorders*, *3*(2), 556–569. https://doi.org/10.1016/j.rasd.2008.12.003

Wagner, L., & Carey, S. (2003). Individuation of objects and events: A developmental study. *Cognition*, *90*(2), 163–191. https://doi.org/10.1016/S0010-0277(03)00143-4

Waxman, S., Fu, X., Arunachalam, S., Leddon, E., Geraghty, K., & Song, H. J. (2013). Are nouns learned before verbs? Infants provide insight into a long-standing debate. *Child Development Perspectives*, *7*(3), 155–159. https://doi.org/10.1111/cdep.12032

Williamson, R. A., & Brand, R. J. (2014). Child-directed action promotes 2-year-olds' imitation. *Journal of Experimental Child Psychology*, *118*, 119–126. https://doi.org/10.1016/j.jecp.2013.08.005

Woodward, A. L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition*, *69*(1), 1–34. https://doi.org/10.1016/S0010-0277(98)00058-4

Wynn, K. (1996). Infants' individuation and enumeration of actions. *Psychological Science*, *7*(3), 164–169. https://doi.org/10.1111/j.1467-9280.1996.tb00350.x

Zacks, J. M. (2004). Using movement and intentions to understand simple events. *Cognitive Science*, *28*(6), 979–1008. https://doi.org/10.1207/s15516709cog2806_5

Zacks, J. M., Braver, T. S., Sheridan, M. A., Donaldson, D. I., Snyder, A. Z., Ollinger, J. M., … Raichle, M. E. (2001). Human brain activity time-locked to perceptual event boundaries. *Nature Neuroscience*, *4*(6), 651–655.

Zacks, J. M., Kumar, S., Abrams, R. A., & Mehta, R. (2009). Using movement and intentions to understand human activity. *Cognition*, *112*(2), 201–216. https://doi.org/10.1016/j.cognition.2009.03.007

Zacks, J. M., Kurby, C. A., Eisenberg, M. L., & Haroutunian, N. (2011). Prediction error associated with the perceptual segmentation of naturalistic events. *Journal of Cognitive Neuroscience*, *23*(12), 4057–4066. https://doi.org/10.1162/jocn_a_00078

Zacks, J. M., Speer, N. K., & Reynolds, J. R. (2009). Segmentation in reading and film comprehension. *Journal of Experimental Psychology: General*, *138*(2), 307–327. https://doi.org/10.1037/a0015305

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*(2), 273–293. https://doi.org/10.1037/0033-2909.133.2.273

Zacks, J. M., Speer, N. K., Swallow, K. M., & Maley, C. J. (2010). The brain's cutting-room floor: Segmentation of narrative cinema. *Frontiers in Human Neuroscience*, *4*, 168. https://doi.org/10.3389/fnhum.2010.00168

Zacks, J. M., Speer, N. K., Vettel, J. M., & Jacoby, L. L. (2006). Event understanding and memory in healthy aging and dementia of the Alzheimer type. *Psychology and Aging*, *21*(3), 466–482. https://doi.org/10.1037/0882-7974.21.3.466

Zacks, J. M., & Tversky, B. (2001). Event structure in perception and conception. *Psychological Bulletin*, *127*(1), 3–21. https://doi.org/10.1037/0033-2909.127.1.3

Zacks, J. M., Tversky, B., & Iyer, G. (2001). Perceiving, remembering, and communicating structure in events. *Journal of Experimental Psychology: General*, *130*(1), 29–58.

Zalla, T., Labruyère, N., & Georgieff, N. (2013). Perceiving goals and actions in individuals with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, *43*(10), 2353–2365. https://doi.org/10.1007/s10803-013-1784-0

How to cite this article: Levine D, Buchsbaum D, Hirsh-Pasek K, Golinkoff RM. Finding events in a continuous world: A developmental account. *Developmental Psychobiology*. 2019;61:376–389. https://doi.org/10.1002/dev.21804