Children Use an Agent's Goals to Determine Event Culmination

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Humans are surrounded by continuous dynamic environments but the human mind extracts units, or *events*, from the stream of dynamic activity. Both adults (Magliano et al., 2001; Newtson et al., 1977; Zacks, 2004; Zacks et al., 2007) and young children (Baldwin et al., 2001; Hespos et al., 2009; Meyer et al., 2011; Pace et al., 2013; Saylor et al., 2007; Stahl et al., 2014; Zheng et al., 2020) routinely segment the continuous flow of activity into discrete events. In doing so, they rely on a variety of cues, including both perceptual (Magliano et al., 2012; Zacks, et al., 2007) and conceptual knowledge to identify event boundaries (Baldwin et al., 2001; Newtson, 1973; Vallacher & Wegner, 1987; Wilder, 1978; Zacks, 2004).

Because of its emphasis on how people place event boundaries, research on event segmentation has not addressed the question of how children and adults process the representational unit *within* event boundaries (or even the notion of *event boundary* itself; Ji & Papafragou, 2020a, b, 2022). In traditional event segmentation models, placing a boundary within a stream of events indicates an event breakpoint. However, this placement does not indicate how individual events are represented internally, for instance, whether at a certain breakpoint an event came to an end (i.e., finished or culminated), or simply stopped and a new one began. To address this gap, recent work has focused on the representation of individual events (and event boundaries) as opposed to global transitions from one event to another. This work has shown that both children and adults can distinguish between events that involve a change towards a well-defined endpoint after which the event can no longer continue (e.g., dressing a teddy bear), and events that have no well-defined boundary and could in principle continue forever (e.g., patting a teddy bear; Ji & Papafragou, 2022, 2024). Only the first type of event truly culminates; the second type simply stops.

Currently, both the mechanisms for representing event content and the development of such mechanisms are under intense exploration. One such mechanism pursues the link between eventhood and change of state in some object (Altmann & Ekves, 2019). Both children and adults generally take into account the state of an affected object when answering questions about an event (e.g., Arunachalam & Kothari, 2011; Jeschull, 2007; Li & Bowerman, 1998; Schulz & Penner, 2002; van Hout, 2018; Weist et al., 1991). Clearly, many events

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[*] The dataset for this and subsequent experiments in the current paper is available at https://osf.io/mfhsj/?view_only=dccdec62afca4363b2a730aa7d7f6589.

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can be taken to end (or culminate) when the object that is affected by them reaches a complete change of state.

A separate, much less studied mechanism involves the role of intentionality in the representation of internal event content. In a recent study by Mathis and Papafragou (2022), adults read a sentence about an agent's goal (e.g., "Patrick needs to use the pitcher for juice", or "Patrick needs to drink a glass of water"). People were then shown images of partly-changed objects (e.g., a pitcher with only some of the water missing) and had to answer a question about the event (e.g., "Did he pour the water out of the pitcher?"). The event in the test question was always a subevent en route to achieving the agent's stated goal. The results showed that people were more likely to give a negative response when the agent's stated goal placed a higher threshold on the subevent (as in "use the pitcher for water", that requires that all of the water be removed from the pitcher) as opposed to a lower threshold (as in "drink a glass of water", where even some of the water removed from the pitcher is enough). The authors concluded that, even for events with "natural" endpoints, intentionality - beyond observable cues such as the state of an object - affects construals of how an event unfolds and comes to an end. Currently, however, it is unknown whether children are sensitive to intentionality under similar conditions (even though goal reasoning emerges early in life: Brandone & Wellman, 2009; Gergely & Csibra, 2003; Luo & Johnson, 2009; Woodward, 1998, a.o.).

In the current study, building on Mathis and Papafragou (2022), we ask whether 4-5-year-old children can use intentionality to determine event culmination, even in the presence of visual cues. We select this age group because of significant changes in children's readiness to calculate others' beliefs and mental states around this time (see, e.g., Wellman, 2017). Theoretically, the results are important for understanding the mechanisms underlying event progression and culmination, and can throw light onto a central, but understudied, aspect of early event cognition.

1. Experiment 1

1.1. Participants

Thirty-nine adults and thirty-nine 4-5-year-old children (age range: 4;1-5;11, mean 4;11) were recruited for the study. All were native English speakers and resided in the United States. The adult participants were recruited from Prolific, an online recruitment platform, and were paid $1 for the 6-minute study. The child participants were recruited from an internal developmental database of families interested in research that was maintained at the University of Pennsylvania. Their families were given a $10 gift card for participating. The sample size was determined in accordance with prior studies (e.g., Mathis & Papafragou, 2022).

1.2. Stimuli

We used a set of 15 target and 10 filler items. All items were selected from Mathis and Papafragou (2022) and adapted to be more child friendly. Each item consisted of a static image of an object at some state of change. Target items involved an object indicating a Partly Complete visual outcome (partial change to the object, e.g., a partly peeled orange; see Figure 1). Fillers involved either an Incomplete visual outcome (no visual change to the object; n=5) or a Complete visual outcome (an entirely changed object; n=5).

Each image was accompanied by a test question containing a telic verb phrase (i.e., a verb phrase denoting an event with an inherent endpoint) in perfective aspect that required a Yes or No answer (e.g., "Did she peel the orange?", for the target item in Figure 1). The verb phrases used in the study were chosen for their scalar properties or the fact that they denoted incremental changes.

For each target and filler image, we also provided a Context to be displayed before the image. Contexts consisted of a single sentence that stated the event agent's goal (and included either *want* or *need*). For each target (such as the partly peeled orange in Figure 1), there were 3 possible Contexts: (a) High Goal Contexts introduced a goal for which a greater development of the subevent was needed; (b) Low Goal Contexts introduced an overarching goal that could be satisfied even by a relatively modest degree of progress along the subevent timeline; (c) Neutral Goal Contexts simply included a goal later found in the test question. See Figure 1 for examples and Supplemental Materials Tables SM1 for a full list.

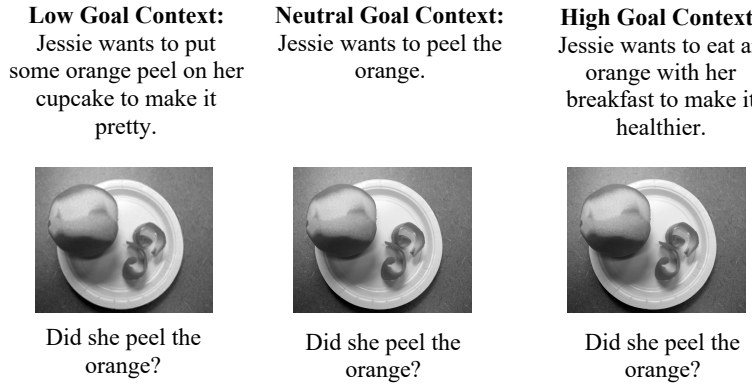

Figure 1. A sample target trial (with three Contexts) from Experiment 1. Each participant saw only one of these Contexts for each object. Context (Low Goal, Neutral Goal, and High Goal) was a within-subjects variable.

For each filler, there was a single Context that overlapped with the test question. For instance, in one Complete outcome trial, participants were told, "Grayson wants to scare his little sister with the balloon". Then they saw an image of a popped balloon and were asked, "Did he pop the balloon?". Unlike target items, for which the Goal type was expected to shift responses, filler trials were expected to elicit answers that were consistently positive (in the case of Complete outcomes) or negative (in the case of Incomplete outcomes, where the event had not even begun).

1.3. Procedure

Three lists were created by counterbalancing the Contexts for target trials and each participant was assigned to one of the lists. Participants saw a total of 25 trials: 15 target trials (5 Partly Complete Outcomes in each of the 3 types of Context: Low Goal, High Goal, and Neutral Goal) and 10 fillers (5 Incomplete visual outcomes and 5 Complete visual outcomes).

Experiment 1 was programmed in Qualtrics and administered virtually through Prolific (adults) or by a researcher over individual Zoom sessions (children). Prior to beginning the experiment, adults were asked to "read the following scenarios, look at the accompanying image, and answer each question". Each trial the context sentence was shown, then participants were instructed to press the spacebar after reading the sentence. Next the image of an event at a certain visual outcome appeared below the Context sentence. The test question and response options (Yes/No) automatically appeared below the image after an additional 500ms. The Context sentence, image, and test question remained on screen until adults responded by pressing an on-screen button for either Yes or No.

For the children, the researcher presented the same scenarios given to adults but read aloud each sentence and test question, and entered the children's responses by pressing the corresponding on-screen button.

1.4. Results

Both adults and children responded accurately in filler items, giving overwhelmingly negative answers for Incomplete outcomes (M_{adults} = 0.11, $M_{children}$ =.14) and positive answers for Complete outcomes (M_{adults} = .96, $M_{children}$ = .86).

Responses on the target (Partly Complete) items were coded on a binary scale (Yes = 1; No = 0). For these items, and separately for each age group, we conducted a multi-level mixed effects logistic regression that included Responses as the binary dependent variable and participants and items as crossed random intercepts. Figure 2 summarizes the data. The best fit for these data was a model that included Context (Low Goal, Neutral Goal, High Goal) as a first level predictor. Table 3 presents the odds ratios for the multi-level model of Context.

For this analysis, Neutral Goal was used as the comparison level. For adults, Low Goal contexts elicited Yes responses significantly more often (M = 0.59) than Neutral Goal contexts (M = 0.47, p < .05). There was no difference in responses to Neutral Goal and High Goal contexts (p = 1.00). For children, there was no difference among Context types.

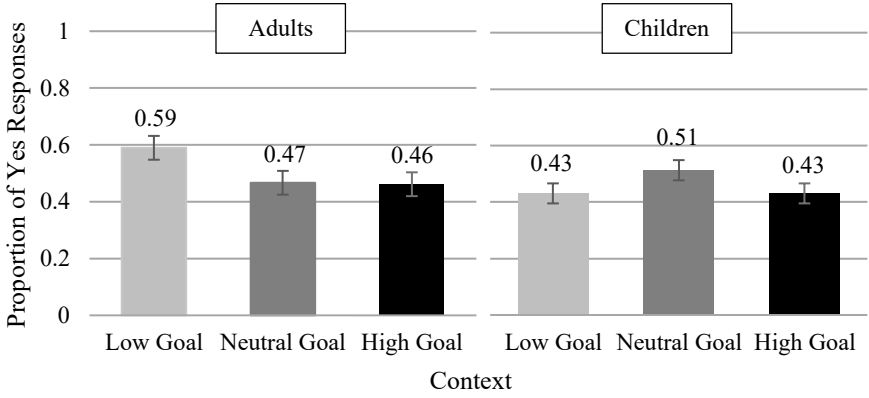

Figure 2. Proportion of Yes responses by Context and Age in the target trials of Experiment 1.

Table 3. Odds ratios for the multi-level model of Yes responses by Context in the target trials of Experiment 1. Significance levels: * p < .05, ** p < .01, *** p < .001

	Effect	Odds Ratio	SE	z value
Adults	(Intercept)	0.84	1.68	-0.50
	Low Goal	1.91	0.69	2.77**
	Neutral Goal	1.00		
	High Goal	0.97	8.34	-0.12
Children	(Intercept)	1.04	0.38	0.10
	Low Goal	0.65	0.15	-1.83
	Neutral Goal	1.00		
	High Goal	0.63	0.15	-1.96

1.5. Discussion

In Experiment 1, our findings suggest that young children do not seem to rely on intentionality to determine when an event ends; adults, however, do so, at least when visual information (e.g., the state of the object affected by the event) is

sufficiently ambiguous.[1] Specifically, adult participants were more likely to treat events accompanied by Low Goal contexts as culminated compared to events accompanied by Neutral contexts (replicating Mathis & Papafragou, 2022).

Why did children fail to integrate goal information? One possibility is that children may have difficulty incorporating higher-order goal information in the determination of event culmination. It is possible that children at this age are conceptually limited to considering observable, physical cues only to event culmination (since these cues are more reliable) and have not yet developed the more nuanced adult-like ability to take into account multiple sources of information to determine when an event ends. Another possibility is that children may not link the agent's goal to the target sub-event, instead interpreting the test question primarily in terms of the visible state of the object. In Experiment 2, we use a different paradigm to adjudicate between these two possibilities.

2. Experiment 2

In Experiment 2, we adjusted our methods to probe whether children are unable to use goal information to determine event culmination, or simply failed to do so in Experiment 1 because of task characteristics. As in Experiment 1, participants were initially presented with a sentence about the goals of an agent A. Later, during a video, they saw A interact with another agent B who then went on to partly execute an event E such that the outcome was either helpful or not with respect to A's goals. Participants were asked, "Did B <*perform event E*> for A?". As in Experiment 1, of interest was whether participants would be more likely to say Yes if the outcome of B's action satisfied A's goals.

We reasoned that, if children's difficulties in Experiment 1 were due to failure to treat goal information as relevant (or remember that information in the first place), their performance would improve in Experiment 2 as a result of two major methodological changes. First, we used videos depicting an entire social interaction, rather than still images of an affected object (without an agent present): we expected dynamic stimuli depicting joint activity between two agents to help highlight and track goal information. Second, and relatedly, in the new design, A was the beneficiary of B's action and the test question included a beneficiary phrase ("for A"). We know that even very young children engage in prosocial actions such as helping (Warneken & Tomasello, 2006); moreover, both

[1] As in Mathis and Papafragou (2022, Exp.1), we did not find a difference between Neutral and High Goal contexts. However, Neutral Goal contexts were not expected to represent a halfway point between the Low and High Goal contexts; indeed, much prior literature has assumed that, even in the absence of a specific context, an event such as emptying a pitcher would culminate at its natural endpoint (Filip, 2017; see also Hindy et al., 2012; Solomon et al., 2015, among others). The High Goal contexts of Experiment 1, while designed to require a high degree of subevent completion, did not actually necessitate strict completion. (Later experiments in Mathis and Papafragou, 2022, found a Neutral vs. High Goal difference when the High Goals impose a stricter threshold of completion than in the present study.)

children and adults evaluate others' helping behavior based on whether it satisfies a beneficiary's specific preferences (Hamlin et al., 2007; Hamlin et al., 2013; Van de Vondervoort & Hamlin, 2016; Zang et al., 2023; see also Grant & Dutton, 2012). We hypothesized that the beneficiary phrase would act as an explicit cue to consult A's role when participants evaluated B's action (participants would still have to contextually infer that it is A's goals – as opposed to a general benefit for A – that provide a threshold for event completion). By contrast, if children's difficulties in Experiment 1 were due to a conceptual inability to consider goal information in computing event culmination, neither of these changes should affect performance, and we should see children persistently exhibit insensitivity to goal information in Experiment 2.

2.1. Participants

Forty adults were recruited from Prolific and were paid $1 for the 6-minute study. Forty 4–5-year-old children (range: 4;0-5;11, mean: 5;1) were recruited through social media ads that were restricted to participants living in the United States. They participated via Zoom and their families were given a $10 gift card after completion of the study as a token of appreciation. All adult and child participants were native English speakers.

2.2. Stimuli

We created 8 short (M = 11.3s) target videos in which two girls interacted in everyday scenes. The target videos were preceded by information about one girl's goal: either a Low Goal sentence or a High Goal sentence (manipulated within participants; see Figure 3). (For simplicity, and because stimuli were similar to those in Experiment 1, we did not include a Neutral Goal.) The videos were similar across Low and High Goals but with some differences so as to be congruent with the goal sentences (e.g., in the event in Figure 3, both girls were seated across a cluttered table but one of them held either a small book or a large box). During each video, a second girl partly performed an action (e.g., partly cleaned the table). We also created a Yes/No test question about the action of the second girl (e.g., "Did the other girl clean the table for her?") to be displayed after the video. Of interest was whether a High Goal context would elicit fewer Yes responses (since it raises the threshold for the culmination of the event in the test question). A full list of stimuli is given in Supplemental Materials, Table SM2.

In addition, we created 4 filler videos that contained interactions between the same two girls. However, the filler test questions differed from the target test questions as they had a simple correct or incorrect answer that did not involve actions (e.g., "Is there a toy truck on the couch?").

2.3. Procedure

Participants were randomly assigned to one of four presentation lists. Each of the four lists contained the four filler videos and eight target videos (those

differed across lists). The context, or goal, and scene combination and order of the target videos was counterbalanced across the four presentation lists.

After confirming their volume settings, adults read the following instructions: "In this experiment, you will see several short video clips. After each video, you will answer a question about what you saw. You will not be able to replay the video, so make sure to pay close attention." As soon as the video started, a prerecorded female voice read out the Context sentence. Once the video was finished, the last frame of the video remained on the screen and the test question appeared below the video with a forced-choice response of yes or no. Participants could not proceed to the next video until they submitted a response by selecting either a Yes or No button that appeared below the test question. For the child participants, the procedure was the same but all instructions, goal sentences and test questions were given verbally by a researcher who also entered the child's response.

Low Goal Context: One girl needs to set her small book on the table.

Did the other girl clean the table for her?

High Goal Context: One girl needs to set her big box on the table.

Did the other girl clean the table for her?

Figure 3. Still frames from the video stimuli in a sample target trial from Experiment 2.

2.4. Results

We excluded participants who did not get 75% or higher on the filler questions (this resulted in six children being excluded). The adult participants had 99% accuracy and the remaining child participants had 95% accuracy on the filler questions.

We then looked at the target responses for effects of Context. Figure 4 summarizes the data. We used a model that included Responses (Yes/No) as the binary dependent variable and participants and items as random intercepts. Context was entered as a single 0/1 predictor (Low = 0, High = 1). Table 4 presents the results.

We found that Context was a significant predictor in the expected direction, with High Goal contexts eliciting Yes responses significantly less often than Low Goal contexts. In addition, we found that Age was a significant predictor, with adults producing fewer Yes responses than children. We also found a significant interaction between Context and Age. Probing the interaction further revealed that the proportion of Yes responses in Low Goal contexts did not differ across age groups (adults: M = 0.85; children: M = 0.86) but in High Goal contexts adults were less likely to offer a Yes response – and thus were stricter in applying goal information than children (adults: M = 0.51; children: M = 0.72). Importantly, the proportion of Yes responses in Low Goal contexts was significantly higher than the proportion of Yes responses in High Goal contexts for both adults ($p < .001$) and children ($p < .01$).

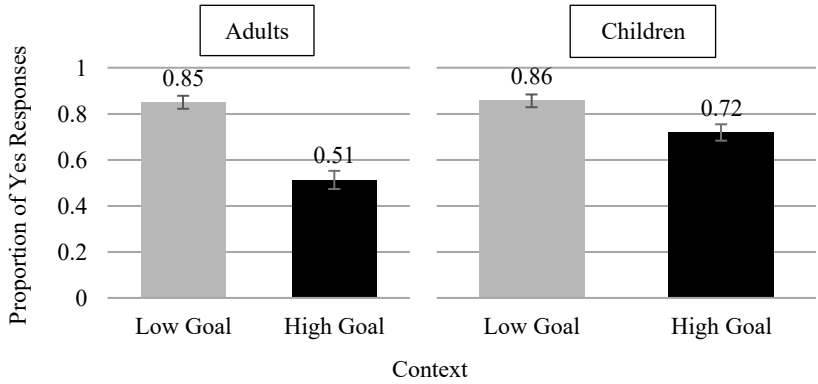

Figure 4. Proportion of Yes responses by Context and Age in the target trials of Experiment 2.

Table 4. Summary of fixed effects from a Generalized Linear Mixed Model predicting binary responses in target trials as a function of Context, Age, and their interaction in Experiment 2.
Significance levels: * $p < .05$, ** $p < .01$, *** $p < .001$

Predictor	Estimate	SE	z value
(Intercept)	1.2492	0.2313	5.402***
Context (High vs. Low)	-1.2458	0.4611	-2.702**
Age (Adults vs. Children)	0.5767	0.2091	2.758**
Context x Age	1.0501	0.4182	2.511*

2.5. Discussion

In Experiment 2, we found that both adults and children were more likely to accept a Partly Complete outcome as a culminated event if the outcome satisfied the agent's goal. Thus both groups were sensitive to goal information when interpreting event culmination. Experiment 2 thus shows that one of the possibilities left open in Experiment 1 – namely, that children are unable to rely on intentionality to specify event culmination – is not viable. Instead, prior difficulties in Experiment 1 may have been due to incorrect assessments of the kind of information that was relevant to event culmination and/or the ability to remember goal information. We hypothesize that the video presentation containing two agents engaged in social interaction (rather than an agentless still image) might have helped the children to integrate the steps of the event and better understand the relevance of goal information. It is also likely that the inclusion of a beneficiary ("for her") in the test question shifted the children's focus from the physical completion of the event to the fulfillment of a social partner's goal. Despite their similarity to adults, however, children were not entirely adult-like in Experiment 2, especially when they had to adopt a stricter criterion for event completion (High, compared to Low, Goal contexts). This finding, together with children's difficulties in Experiment 1, suggests that children are still developing the ability to fully integrate goal information with event completion judgements.

A possible concern with Experiment 2 is that the beneficiary phrase (i.e., for her) may have encouraged participants to focus on helpfulness rather than event completion. However, helpfulness in this context necessarily depends on the beneficiary's goals: interpreting the beneficiary phrase requires considering what the other person intends or needs. Thus, even if participants attended to helpfulness, doing so still entails goal reasoning. Nonetheless, future work could test whether similar results obtain when goal information is not explicitly cued (e.g., when the beneficiary phrase is omitted).

A second concern is that children's responses may have been guided by visual cues in the videos rather than by intentionality information conveyed in the context sentences. Although visual evidence differed across contexts, such cues are themselves informative about agents' goals (e.g., holding a large object may imply a need for space). Because goals were not always unambiguously recoverable from visual information alone, we opted to state goal information explicitly and ground it in limited visual cues. Future work could examine whether children and adults rely on goal information inferred solely from the visual scene to determine event culmination.

3. General Discussion

Young children are surrounded by (and participate in) dynamic events. Even though it is widely understood that both perceptual and higher-order conceptual information contribute to event conceptualization, the role of the latter has been understudied in the literature. In this study, inspired by prior adult studies (Mathis & Papafragou, 2022), we probed whether a particular type of conceptual

information - knowledge of an agent's goals - affects children's assessment of when an event ends (or culminates), even when visual cues to culmination are kept constant. We found that 4-5-year-old children, unlike adults, failed to integrate goal information when computing event culmination from static images, as shown by their answers to questions such as "Did (s)he V the N?" (Experiment 1). However, in a prosocial interaction within a video in which an agent acts for the sake of an explicit beneficiary ("Did she V the N for her?"), 4-to-5-year-old children successfully integrated intentionality when conceptualizing event culmination – even though not to the same degree as adults (Experiment 2).

Together, these findings suggest that even young viewers can use higher-order goal information to conceptualize when an event ends, even though this ability is not consistently implemented. Our data argue against the possibility that children in our sample rely on observable cues such as external changes in event participants to track and understand events (including their temporal stages and, where applicable, their completion) and only later come to integrate the more diffuse and less reliable intentionality cues. Instead, as suggested at the end of Experiment 2, goal information is in principle available to 4-5-year-olds but its relevance or salience for event construal may not be obvious to the learner, especially when physical cues to event culmination are always available. Prosocial interactions where one agent acts in a way that benefits another agent's goals (such as those in Experiment 2) might particularly highlight the importance of one's mental perspective on an event, and not simply the strictly observable characteristics of an event.

These findings have several implications for the workings and development of event cognition. As mentioned already, models of event segmentation in both adults (e.g., Zacks et al., 2007) and young children (Baldwin et al., 2001; Hespos et al., 2009; Meyer et al., 2011; Pace et al., 2013; Saylor et al., 2007; Stahl et al., 2014; Zheng et al., 2020) are primarily concerned with how people identify event boundaries, but not with how people form representations *within* event boundaries (e.g., representations of the way an event develops and culminates). Our data show that, for both adults and 4-5-year-old learners, event boundaries coincide with significant perceptual changes (cf. Zacks et al., 2007). However, they also suggest that the same degree of visual change in features of an event can be interpreted differently depending on higher-level factors such as intentionality.

Consider next the proposal that an event is defined by a change of state in an object that participates in the event (Altmann & Ekves, 2019; Hindy et al., 2012; Solomon et al., 2015). Our data do show that the visual degree of event completion (and corresponding degree of change in the affected object) influences intuitions about event endpoints. For instance, both children and adults' judgments are affected by visual cues about the development of an event (see test and filler trials in Experiment 1). However, our findings, especially from Experiment 2, show that event cognition goes beyond representing objects and their perceptible changes to engage social cognition. Furthermore, rather than being peripheral and limited, the role of goal information can be strong (more so for adults; Experiment 2): the very same physical, observer-independent changes in an object can lead to vastly

different assessments of event completion depending on whether the beneficiary's goals have been met.

Summarizing, across two experiments, we probed children's (and adults') construal of how individual events unfold and end. Our results reveal the rich and varied kinds of evidence available to young learners for tracking and understanding event structure.

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