Language and Cognition (2023), 1–15
doi:10.1017/langcog.2023.54

ARTICLE

Event end-state encoding in 13-month-olds—completed and non-completed events are different

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(Received 28 February 2023; Revised 16 October 2023; Accepted 17 October 2023)

Abstract

Young children sometimes incorrectly interpret verbs that have a "result" meaning, such as understanding 'fill' to refer to adding liquid to a cup rather than filling it to a particular level. Given cross-linguistic differences in how event components are realized in language, past research has attributed such errors to non-adultlike event-language mappings. In the current study, we explore whether these errors have a non-linguistic origin. That is, when children view an event, is their encoding of the event end-state too imprecise to discriminate between events that do versus do not arrive at their intended endpoints? Using a habituation paradigm, we tested whether 13-month-old English-learning infants ($N = 86$) discriminated events with different degrees of completion (e.g., draw a complete triangle versus draw most of a triangle). Results indicated successful discrimination, suggesting that sensitivity to the precise event end-state is already in place in early infancy. Thus, our results rule out one possible explanation for children's errors with change-of-state predicates—that they do not notice the difference between end-states that vary in completion.

Keywords: event concepts; infant cognition; language acquisition; change-of-state

1. Introduction

On a lovely Sunday morning, Joanna was baking some bread. Her 5-year-old daughter Emily wanted to help. She pointed to the bowl of dough, saying, "Honey, can you cover it with a towel please?" Emily nodded, picked up a towel and draped it over the dough, and proudly reported: "Done, mommy!" Joanna looked at the dough. More than half of it was still exposed.

While Joanna and Emily were enjoying their bread, linguists pondered: What does the verb 'cover' mean? To English-speaking adults, the verb 'cover' in this context denotes an event with a particular result or end-state—the entity being covered becomes completely occluded. Such an end-state might be achieved by a variety of manners, including draping (e.g., covering the dough with a towel), lowering (e.g., covering the bread bowl with a pot lid), or smearing (e.g., covering the dough with butter). The verb 'cover' is a result verb, denoting an end-state of "becoming occluded", but does not specify the manner in which this is achieved.

But a large body of work shows that children acquiring English as well as other languages often misinterpret predicates that denote changes, including predicates with incremental theme verbs and change-of-state verbs (Gentner, 1978; Gropen et al., 1991; Jeschull, 2007; Martin et al., 2020; Ogiela, 2007; Patt et al., 2020; Schulz, 2018; Schulz et al., 2001; van Hout, 1998; Wittek, 2002). For instance, they are more likely to use 'fill' to mean "pouring" rather than "something being made full", to use 'empty' to mean "dumping" rather than "something being made vacant" (Gropen et al., 1991), and to use 'mix' rather than "stir" even when the substance is non-mixable (Gentner, 1978). In making these errors, children seem to be neglecting the entailed end-state of linguistic descriptions using these predicates.

Why might children make such errors? On one type of account, these errors might be attributed to how they map events to language. As children acquire a language, they learn to map information from the non-linguistic world onto linguistic expressions. For instance, they learn to map a feline animal onto the nominal label 'cat' and map a simple self-propelled action like springing clear of the ground onto the verbal label 'jump'. In the case of change-of-state events, multiple components are involved—minimally, a manner component and a result component—and young children need to learn how these components are described linguistically.

In so doing, an intrinsic bias may be at play. According to one account (Behrend et al., 1995; Gropen et al., 1991), children are more likely to encode the perceptual information of an event into a verb meaning than the functional information. Because in a change-of-state event perceptual information is often carried by the manner component and functional information by the result component, young children demonstrate a bias to lexicalize the manner. When learning the verb 'fill', children may encode both the perceptual information "pouring" and the functional information "making full" from the event but have a bias to include the former in their representation of the verb. This is often called a *manner bias* (Gentner, 1978).

This manner bias may in part be attributable to a typological feature of English. According to Talmy (1985, 1991), some languages are *verb-framed* while others are *satellite-framed*. In verb-framed languages, the core schema of an event is usually encoded by the main verb, whereas in the latter, it is usually described with a satellite morpheme. The theory applies both to motion events, in which the core schema is the path of motion, and to change-of-state events, in which the core scheme is the state change (Talmy, 1991). For a change-of-state event like blowing out a candle, in a verb-framed language like Spanish, this event would be described by a sentence like (1), with the state change encoded by the main verb, but in a satellite-framed language like Mandarin, the state change would be expressed by a particle meaning "out" in (2).

(1) Apagué la vela soplándola.
extinguished the candle blow

(2) Wo chui Mie Le lazhu.
I blow Out ASP candle

(3) I blew out the candle.

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There are, of course, exceptions to these patterns within languages, and English offers many such exceptions. On the one hand, it is typically categorized as a satellite-framed language. For instance, the above event would be described in English in a sentence like (3), expressing the core schema with a satellite morpheme, rather than by the main verb. But on the other hand, it does not do so consistently—some change-of-state events are lexicalized by a single morpheme as in result verbs like 'fill' and 'mix', while others are expressed with a verb-particle construction like 'blow out'. Moreover, even verbs like 'fill' and 'mix' can occur with particles (e.g., 'up') to emphasize that the event is truly complete. Therefore, English-learning children might originally categorize English as satellite-framed and thus expect verbs like 'fill' and 'mix' to only express manner information, leading to interpretation errors with these verbs. In fact, children's errors with result verbs are reported almost exclusively with mono-morphemic verbs in English (Gentner, 1978; Gropen et al., 1991).

Another possibility is that children's event-to-language mappings are not categorically incorrect, but instead, are imprecise. Rather than misidentifying result verbs as having manner meanings, children may correctly recognize that a result component is part of the verb's meaning, but they are not particular about what this result is. For example, in Wittek's (2002) study with German-acquiring 4- to 5-year-olds, she found that children accepted verbs like 'wecken' ("wake") even when the expected end-state did not come about: when asked (translated into English) "did the girl make the man awake?", children answered "yes" even though the man was in fact not awake. However, these children seemed to know that an expected end-state was part of the sentence meaning—they would often voluntarily elaborate their answers with "but he did not stand up". Wittek (2002) called this a *Weak Endstate interpretation*: "[Children] do not completely neglect the end-state—they interpret change-of-state verbs as if a particular end-state might well come about, but need not" (p. 103).

In fact, when we look at the world's languages, there are indeed languages in which event descriptions that involve change-of-state predicates implicate, but do not entail, a particular end-state. These so-called "non-culminating accomplishments" are illustrated in examples (4) in Mandarin and (5) in Hindi, which implicate the end-states of being dead and being completely consumed, respectively, but do not necessarily entail these end-states. As a result, canceling the implied end-state is acceptable. There is an enriched reading in these examples that an attempt was made at achieving the end-state, but this is not always the case (Pederson, 2007). (See also Bar-el et al., 2005; Jacobs, 2011; Pederson, 2007; Singh, 1998; Soh and Kuo, 2005 for examples in other languages). In these languages, particles or serial verb constructions are typically required to signal completion (e.g., Talmy, 1991). But in other languages, cancellation of end-state leads to oddity. Many Germanic and Romance languages show this pattern, including English (e.g., (6)–(8)).[1] Given such variation within and across languages, it is plausible that young children, when first acquiring a language, begin with a Weak End-state assumption, taking descriptions involving change-of-state verbs to implicate but not entail an end-state (Wittek, 2002).

[1]But see, for example, Arunachalam and Kothari (2011) and Minor et al. (2022), for evidence that even English speakers sometimes permit endstates to be cancelled.

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(4)

Zhangsan	sha le	cangying,	danshi	cangying	meiyou	si.
Zhangsan	kill Perf	fly,	but	Fly	not	die

"Zhangsan has killed the fly, but it did not die."

(5)

Maya-ne	biskut-ko	khaa-yaa	par	us-e	puuraa	nahiin	khaa-yaa.
Maya-Erg	cookie-Acc	eat-Perf	but	it-Acc	full	not	eat-Perf

"Maya ate a cookie, but not completely."

(6) # Ruth killed the fly, but it did not die.
(7) # Maya ate the cookie, but not completely.
(8) # Bruce filled the glass, but it was not full.

In both the Manner Bias account and the Weak End-state accounts mentioned above, children's errors with change-of-state predicates are attributed to how they form *mappings* between events and language. Another possibility, however, is that their conceptual encodings of these events *per se* give rise to these errors even in the absence of encoding in language. That is, could it be that when children view a change-of-state event, they either only notice its manner and do not notice its end-state at all (resulting in a Manner Bias) or that they attend to the end-state but do not encode it with precision (resulting in a Weak End-state interpretation)? To begin to investigate this issue, we examine young children who are only just beginning to acquire verbs.

Infants' conceptual representations of events have been of great interest to researchers. We know, for example, that they can segment continuous streams of action into smaller discrete events (e.g., Göksun et al., 2010; Pace et al., 2013) and that they distinguish event participants from event bystanders by 11 months (Gordon, 2003; He et al., 2013; Wellwood et al., 2015). Importantly, from early on, infants can distinguish between different components of motion events—manners and paths by around 13–15 months (e.g., Pruden et al., 2012; Pulverman et al., 2008, 2013) sources and goals by 16 months (Lakusta and DiFabrizio, 2017)—and show an early bias for goals over sources (e.g., Lakusta and Carey, 2015; Lakusta et al., 2007). This work suggests that infants are well equipped to notice whether an event includes a change of state or location that signals a resultant subevent. It is unlikely, then, that they have a Manner Bias resulting from a failure to notice end-states at all. However, we do not yet have direct evidence about whether this is the case, as previous studies on infants' event concepts have not directly contrasted manner versus result components.

We also do not yet know if infants are sensitive to the precise endpoints of events. Perhaps infants note whether an event is proceeding broadly toward an end goal, but they do not precisely register what that end should look like as part of their conceptual event representation. For example, they may not discriminate between an event of covering a bowl of dough completely and an event of covering part of the dough. This lack of precision in event encoding could explain why, when children begin to acquire verbs, they have difficulty acquiring end-state entailments for event descriptions that involve change-of-state predicates.

Therefore, in the current study, we examine infants' encoding of event end-states. We focused on infants from 11 to 15 months of age because the literature reviewed above indicates that infants' abilities to represent event components including manner and result have begun to develop during this period. We ask two research questions. First, do young children encode the event end-state with the precision necessary to discriminate between events that complete fully and those that do not?

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Second, we ask whether the answer to this question is contingent upon the intentionality of the event. This hypothesis is grounded in Demirdache and Martin's (2015) observation that agent intentionality determines the acceptability of canceling the end-state in a linguistic description of a change-of-state event. Even in languages that commonly permit end-states to be canceled—see (4) above from Mandarin—events with a natural cause, like the pandemic, cannot generally be described with a predicate whose end-state is canceled, as shown in the Mandarin example in (9):

(9) Nachang yiqing sha le ta fumu, #danshi tamen meiyou si.
that pandemic kill Perf his parents, But they not die
"That pandemic killed his parents, but they did not die."

Research with children supports this hypothesis; children are more likely to accept descriptions of non-culminating events with change-of-state predicates for those with animate, intentional agents than natural causes (e.g., Hodgson, 2010; van Hout et al., 2017). Although Demirdache and Martin's (2015) observation is about the syntax-semantics of accomplishment predicates in languages that permit end-state cancelation, it could still be the case that infants—who do not, after all, start out knowing whether they are learning a language like Mandarin or a language like English—show differences in their conceptual understanding of end-states in events with and without intentional agents. A rich literature documents young infants' early sensitivity (by age 12 months) to the distinction between intentional and non-intentional causes (e.g., Gergely et al., 2002; Gergely and Csibra, 2003; Leslie, 1984; Liu et al., 2017; Muentener and Carey, 2010; Pauen and Träuble, 2009; Woodward, 1998); this suggests that infants could in principle treat events with and without intentional agents differently as they form representations for the concepts associated with change-of-state events. We therefore hypothesize that event intentionality may have an effect on infants' construals of event end-states; specifically, infants may be less sensitive to the difference between completion and non-completion in an event with an intentional agent (e.g., a person draws a triangle) than they are for an event with a natural cause (e.g., a paper falls and covers a spoon) because intentional agents may intend to achieve either a full or partial end-state, but the endpoints of events with natural causes are harder to cancel.

To answer these research questions, we adopt a common method in studies of infants' event encoding: the habituation paradigm. This method capitalizes on the inherent human tendency to experience boredom when exposed to the same event repeatedly and to experience renewed attention when a change is detected. This method has been used to demonstrate infants' attunement to changes that have perceptual or conceptual relevance. For example, in Gordon (2003), 10-month-old infants were habituated (i.e., became bored, as indexed by decreased looking time) to an event in which a girl hugged a boy while holding a toy; when they saw a new event that was nearly identical to the old event except for the absence of the toy, they were not surprised (i.e., attention continued to decrease). However, in a similar scenario in which the action being performed was not hugging but instead giving (with the toy as the item being delivered), the removal of the toy was readily detected (i.e., infants' attention increased to this new event). Given this design logic, the habituation paradigm well suits our current purpose. By presenting two events with the same trajectory but different endpoints——an event that completes fully versus an event that completes partially, we can see whether young infants detect the change from one to another. Following prior work, in our study, infants are habituated to one event token (i.e., they view the same exemplar repeatedly until they become bored and look away), and then a different event token is presented to see if they dishabituate (i.e., show renewed interest). Dishabituation is taken as evidence that the infants discriminated between the two event tokens.

This investigation represents a starting point in teasing apart various explanations for (older) children's difficulty acquiring change-of-state predicates. If infants do not discriminate between fully completed and partially completed events, then we will conclude that they are not sensitive to the precise end-states of events at all. This outcome would suggest that future work should investigate how this early failure to discriminate end-states might affect their verb acquisition as they grow older. If infants do discriminate between events with different end-states, we can rule out failure to perceive end-states with precision as an explanation for their behavior with change-of-state predicates. Instead, future work should investigate the conceptual representations that result from infants' perception of these different end-states—that is, do infants not only perceive the difference between fully and partially complete events but also assign these events to different event categories?

Although our study is designed to address the prerequisite question of whether infants *perceive* differences in end-states, we do include one manipulation aimed at the beginning to address whether they also have different event *concepts* for events that are fully versus partially complete. Specifically, we manipulate the order in which we present the two events during the study. In one order, infants are habituated to the fully completed event and we ask whether they dishabituate to the partially completed event. In the other order, infants are habituated to the partially completed event and we ask whether they dishabituate to the fully completed event. In both cases, if infants dishabituate at the test, they will show that they have perceived the difference between the two events. Conceptually, however, the two orders may differ. If the fully completed event is shown first, we expect that infants will develop the expectation that this event ought to achieve a particular endpoint, particularly for an event with an intentional agent. They should then be more surprised when only a partially completed event comes about. However, if the partially completed event is shown first, infants are not expected to develop a particular expectation about the precise endpoint of the event, as the partial ending is not a natural culmination. They may not therefore be very surprised when a fully completed event is shown, as the expectation they have formed is simply about an event that includes some unspecified kind of change. Thus, if we see differences in infants' behavior in the two orders, we may have a hint that infants not only perceive the differences between the two events but conceptualize them differently—partially completed events are not good exemplars of fully completed events, but fully completed events are acceptable exemplars for events that broadly include any kind of change.

Taken together, in this study, we examined the precision of infants' encoding of event end-states, asking whether they can discriminate two events with the same trajectory that differ only in their end-states—fully completed versus partially completed—and whether their ability to do so holds for events with and without intentional agents.

2. Methods

2.1. Participants

Eighty-six infants (52 male and 34 female) between 11,30 and 15,12 months (mean age 13,8 months) participated in a habituation task. Infants were reported by their parents to be exposed to English at least 75% of the time, to have been born at ≥35 weeks' gestation, and to have no developmental delays.[2] They were recruited from lab participant pools in Boston and New York, United States. Data from an additional 36 children were excluded because they failed to reach the habituation criterion (n = 15), because they fussed out of the task (n = 14), or because of recruitment error (e.g., a preterm infant was mistakenly recruited) (n = 2) or equipment error (n = 5). This exclusion rate is similar to other studies with this age group using habituation methods (e.g., Babineau et al., 2020; He and Lidz, 2017; Höhle et al., 2020).

2.2. Stimuli

The experimental stimuli consisted of recordings of four different event tokens. In two events, infants viewed a hand drawing on a piece of paper with a green crayon. In the fully completed event, a triangle was drawn[3]; in the partially completed event, approximately 85% of a triangle was drawn, with one of the lines left unfinished. We chose this criterion of "approximately 85%" to depict an event whose natural culmination point of "a triangle" would be clear (at least to an adult), but for which it was obvious that that point was not reached; several similar studies have depicted partially completed events as somewhere between 75% and 90% complete (e.g., Kaplan et al., 2021; Kasher and Hacohen, 2023). In the other two events, infants viewed a piece of paper that fell from above. In the fully completed event, the spoon was completely covered by the paper; in the partially completed event, approximately 85% of the spoon was covered. Each event token lasted about 5 seconds; and six of the same token were concatenated to make up one trial, with a one-second black screen inserted after each event to give the event onset and offset a clear boundary. The video clips for all four event tokens (fully completed drawing event, partially completed drawing event, fully completed covering event, partially completed covering the event) were the same length, although the fully completed drawing event took slightly longer (0.17 seconds) than the partially completed drawing event in terms of the time that elapsed before the crayon lifted off the page. In total, each trial lasted 39 seconds. In addition to these experimental stimuli, a 39-second video of animated shapes (which did not include any triangles) served as the Pre-test and Post-test stimuli, and a smiling baby video served as an attention-getter. All stimuli played in silence.

[2]Although this is a nonlinguistic task, because languages differ in how event completion is realized (e.g., whether nonculminating accomplishments are permitted, whether completion can be expressed via reduplication or particles, etc.), we wanted to ensure that infants had similar language backgrounds.

[3]Young infants are highly sensitive to shape and appear to have the category *triangle* by 9 months, well before they know words like "triangle" (e.g., Quinn et al., 2001; Dewar & Xu, 2010).

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2.3. Design

We used the habituation paradigm (Casasola and Cohen, 2000; Stager and Werker, 1997) with Habit software (version 2.0) (Oakes et al., 2019). The experiment consisted of a Pre-test phase, followed by a Habituation and a Test phase, and concluded by a Post-test phase. The Pre- and Post-test each had 1 trial, playing the same video (animated shapes), allowing us to compare infants' attention to control for fatigue.

The Habituation phase included a maximum of 12 trials, but the actual number of trials each infant viewed varied depending on how fast they reached Habituation (see below). During this phase, infants viewed an event repeatedly (e.g., a person drawing 85% of a triangle) until a pre-set habituation criterion was reached—when an infant's average looking time during any block (i.e., three consecutive trials) dropped to less than 50% of the average looking time of the most-attended block. If at the end of the Habituation phase the infant still did not reach habituation, the Test phase still began but they would be excluded from the final data sample. The Test phase presented a different event from Habituation (e.g., a person drawing a complete triangle), and it included a fixed number of 2 trials.

The design included one dependent variable—infants' looking time to the stimuli, and three independent variables: (a) 2 phases—end-of-Habituation and Test; (b) 2 *event types*—Draw (with intentionality) versus Cover (without), and (c) 2 *orders*—the fully completed event occurring during Habituation and the partially completed event during Test (Full-to-Partial), or vice versa (Partial-to-Full). Factor (a) was within-participant and factors (b) and (c) were between-participant. See Fig. 1. This design allows us to see whether infants' looking time increases from the end of Habituation to Test (i.e., dishabituation) and further, whether their tendency to dishabituate holds for event types with and without intentional agents, and for both Full-to-Partial and Partial-to-Full orders.

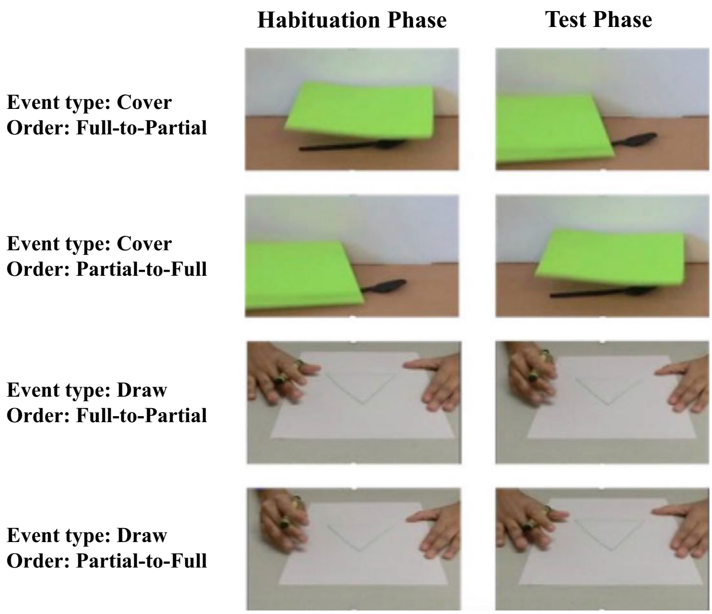

Figure 1. Still images depicting the critical moments of each event in each condition.

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Note that for the variable (a), "end-of-Habituation" referred to the last 2 Habituation trials, following previous studies using similar paradigms (e.g., He and Lidz, 2017; de Carvalho et al., 2019).[4] In order to see whether the infant's attention recovered upon viewing the Test trials, we must compare it to their previously diminished attention, which, by design, was the end of the Habituation phase. Because there were 2 trials during the Test, we used 2 trials from (the end of) Habituation to make the comparison.

2.4. Procedure

All procedures were approved by Institutional Review Boards at Boston University and New York University. The infant participant and one parent were invited into a laboratory room. The infant sat in front of the TV monitor with a built-in digital camera. The infant either sat on the parent's lap or in a car seat; if the former, the parent was asked not to speak during the experiment and to wear a blindfold in order to minimize inadvertent influence. An experimenter sat behind a curtain, controlling the Habit program to run the experiment.

When the infant was ready, the experimenter first displayed the attention-getter. Once the infant's attention was captured, the experiment began. For each trial, the experimenter pressed a key when the infant attended to the stimulus and held it until the infant looked away; if the infant looked away for more than 2 continuous seconds, the program would end the current trial and continue to the next. The same coding procedure was held for all trials in Pre-test, Habituation, Test, and Post-test. The preset Habituation criterion applied automatically, transitioning from the Habituation phase to the Test phase at different time points contingent on each infant's attention profile.

2.5. Predictions

We made three predictions. First, we took dishabituation—an increase in attention from end-of-Habituation to Test—as evidence for perceptual discrimination because infants could only dishabituate if they noticed the difference between the events. Second, we might not see dishabituation in both events with intentional agents and events without intentional agents. One possibility is that infants will not dishabituate for events with intentional agents—after all, intentional agents may intend to achieve only partial completion, but endpoints of events with natural causes are hard to cancel. Finally, we might not see dishabituation in both orders. Specifically, we might expect that the Full-to-Partial order would be more likely to yield dishabituation than the Partial-to-Full order because the former sets up an expectation of what the full trajectory of the event should look like and infants may be surprised if it is not achieved.

3. Results

Data were analyzed in R version 4.1.0. Deidentified data and R script are available at: https://osf.io/zh34s/?view_only=c0b7cc3dbb8f4bf49e3a95925a821f23.

[4] Different baselines were adopted in some other studies: for example, some used the average of the last 4 Habituation trials (Oshima-Takane et al., 2011) to compare with Test; some used the last 1 Habituation trial as baseline (e.g., Oshima-Takane et al., 2011). We chose 2 to match the number of Habituation and Test trials.

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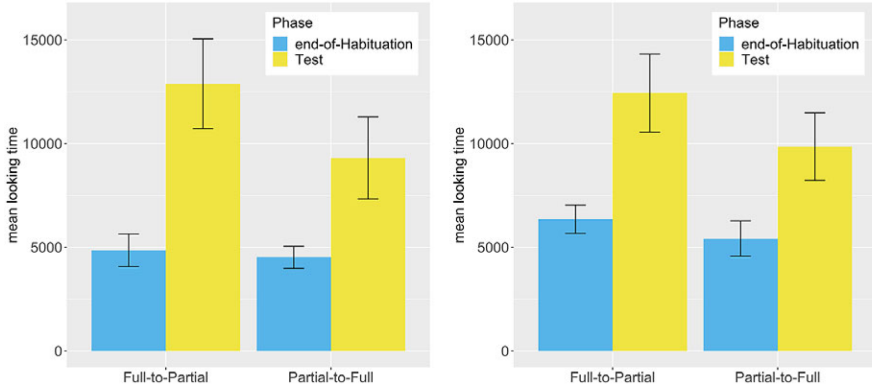

Figure 2. Infants' mean looking time during end-of-Habituation (i.e., last two Habituation trials) and Test by order and event type (Left: Cover; Right: Draw). Error bars depict the standard error of participant means.

All children included in the final sample successfully habituated. A comparison between the Pre- and Post-test phases further confirmed that this was real habituation due to the repeated display of the same stimuli, rather than mere fatigue. If it were fatigue that drove habituation, then we would expect continued low attention into the Post-test phase. However, the results of paired two-tailed t-tests revealed that infants either showed the same level of attention between Pre- and Post-test ($p = .66$) (the Cover, Full-to-Partial group), or increased attention ($ps < .042$) (all other groups).

Having determined that infants habituated, we then entered the data into a three-way mixed ANOVA model with phase (end-of-Habituation versus Test) as the within-participant factor, and *event type* (Draw versus Cover) and *order* (Full-to-Partial versus Partial-to-Full) as the between-participant factors. The model revealed no effect of event type ($F(1, 82) = 0.31$, $p = .58$), no effect of order ($F(1, 82) = 2.74$, $p = 0.10$), no interaction (all $ps > .21$), but a significant effect of phase ($F(1, 82) = 36.55$, $p < .001$, eta-squared = 0.16). Specifically, for the main effect of phase, across all conditions, infants looked longer during the Test phase ($M = 110.24$ s, $SD = 89.84$ s) than during the Habituation phase ($M = 52.05$ s, $SD = 34.06$ s). See Fig. 2.

Because our sample included a 3-month age range during which infants may be undergoing rapid development in how they conceptualize events, we also investigated the role of age. We examined the correlation between infants' ages (in number of days) and dishabituation score (looking time at the Test minus looking time at end-of-Habituation). The correlation was not significant ($r(84) = 0.07$, $p = 0.52$). Moreover, infants who habituated and were included in the sample did not differ in age (mean age: 418 days, $SD = 31$ days) from those who failed to habituate (mean age: 404 days, $SD = 30$ days) ($t(22) = 2.07$, $p = 0.11$).

4. Discussion

Young children show difficulty acquiring change-of-state predicates, often neglecting the entailed or implicated end-state—for example, taking 'cover' to mean "drape" rather than "completely occlude". Previous accounts have attributed such errors to their immature mappings between events and language, arguing for either a Manner

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Bias (e.g., Gentner, 1978; Gropen et al., 1991) or a Weak End-state interpretation (e.g., Wittek, 2002). The current study explores another possibility, focusing on children's event encodings per se even in the absence of linguistic encoding.

In particular, we asked two research questions. First and primary, we asked whether 13-month-old infants, who are not yet at the stage of showing difficulty with the linguistic representation of change-of-state predicates, encode event end-states with the precision necessary to discriminate between two events with the same trajectory but differing in whether the end-state is fully or partially achieved. Second, motivated by the observation that in linguistic descriptions, an expected end-state is more readily canceled in event descriptions with intentional agents than those with natural causes, we asked whether the precision of infants' event end-state encoding was contingent on the intentionality of the event.

To answer these questions, we tested 13-month-old English-learning infants in a non-linguistic task. Two event tokens made a full/partial pair——that is, they were identical except that one was fully completed and the other only partially. There were two such pairs, each representing a different event type. In one pair, a person (an intentional agent) drew all or part of a triangle; in the other, a piece of paper fell from above (a non-intentional agent) to fully or completely cover a spoon. For each pair, infants were habituated to one event token and tested for dishabituation with the other. Results revealed successful discrimination, as indicated by dishabituation at the test, regardless of the event type.

These findings suggest that young children are able to attend to the precise end-states of events and that their sensitivity applies to two very different event types. Moreover, the drawing and covering events we used in the current experiment differed not only in intentionality but also in incrementality. The triangle in the drawing event was an incremental theme—halfway through the drawing event, half the triangle was drawn—which means that the partially completed event is a proper subpart of the fully completed event. Nevertheless, infants were similarly sensitive to the precise end-state for both the incremental (drawing) event and the non-incremental (covering) event regardless of the order in which we presented the events. The fact that infants showed the same patterns for these two very different event types suggests that they are prepared to attend to precise end-states for a wide variety of events in the world. This finding is particularly noteworthy given that some studies show that children behave differently with different verb types; they are more likely to accept non-culminating accomplishment descriptions with incremental theme verbs than change-of-state verbs (e.g., Hacohen, 2010; Ogiela et al., 2014; see van Hout, 2018 for discussion). Our study therefore demonstrates that infants are sensitive not only to manners and paths but also to different types of end-state outcomes.

This finding casts doubt on the hypothesis that children's interpretation errors with change-of-state and incremental theme verbs have a non-linguistic origin. The results are consistent with previous accounts that attributed these errors to event-language mappings in children's acquisition of verb meanings, such as Martin et al. (2020), who recently reviewed a large body of work on children's errors with change-of-state and incremental theme verbs and concluded that these errors are due to language-specific learning challenges. By adding evidence from a non-linguistic task and showing the same pattern for two different event types, we further strengthen their conclusion that non-linguistic conceptual biases may not be to blame. Instead, it is likely that children struggle as they explore the typological spaces in which their language might reside (e.g., Talmy, 1991), as well as the complexity of how completion is realized in tense/aspect marking across languages (e.g., Martin et al., 2020).

Our results are, however, also compatible with another possibility. It could be that infants dishabituated at the test because they perceived the difference between the two event types but that they nevertheless did not "care about" it. That is, if asked to categorize the events, they would place them in the same category. This possibility remains because of indirect evidence offered by our study. Recall that in our design, we manipulated the *order* in which we present the two event tokens, Full-to-Partial versus Partial-to-Full. These two orders present the same contrast perceptually, but they may result in different conceptual representations.

Specifically, we hypothesized that if the fully completed event is presented first, infants may establish an expectation of seeing a covering event, rather than a draping event, and would be surprised if later shown a draping event. But if the partially completed event is presented first, infants may not be surprised when seeing the fully completed event because a covering event is a type of draping event. Therefore, if the results had patterned differently in these two orders, as we hypothesized we might have some indirect evidence that infants not only perceived the difference between fully and partially completed events but also that they conceptualized the two event types differently. The fact that we did not see a difference between the two orders means that we do not have evidence that this is the case. Of course, this is only one possible way to test this hypothesis, and future work should test it more directly, for example by including a control condition in which the difference between the two events is of the same magnitude, but both events are partially completed—say, one is 85% completed and the other is 70% completed (in contrast to the 100% and 85% completion in the current experiment).[5] We would expect infants to be insensitive to this contrast if they categorize partially completed events as members of the same type of event.

Therefore, in essence, the present study provides evidence that infants possess the ability to discern that two events with the same trajectory but differing endpoints *are* distinct from each other. However, it does not explicitly demonstrate that infants have an understanding of the specific nature of these differences.

In addition to the fact that we did not thoroughly examine different ways of testing infants' categorization of the events, there are several other limitations of the current study that can be addressed in future work. First, we used an age range in which infants are likely to be actively in the process of developing their abilities to categorize events according to event components like manner and result. This was an intentional design choice on our part for this initial investigation, but our results suggest that looking at older toddlers and preschoolers would provide an opportunity to see whether manner and result components are represented differently as they learn more about the language they are acquiring. Second, we used only two event types: drawing a triangle and covering a spoon. Our main goal was to manipulate intentionality, but the events also differ in other ways, including incrementality. Including a larger range of event types, including other types of drawing and covering events (e.g., drawing a circle and a napkin covering a bowl) would allow us to examine generalizability.

[5]Thanks to an anonymous reviewer for this suggestion.

https://doi.org/10.1017/langcog.2023.54 Published online by Cambridge University Press

The current study contributes to our understanding of infants' event representations by establishing that infants are sensitive to the precise endpoints of events early in development. This sensitivity is an important prerequisite for several aspects of later language acquisition and is consistent with other work suggesting that infants' early conceptual representations of the world closely reflect relevant linguistic categories (e.g., Wagner & Lakusta, 2009).

Data availability statement. Quantitative data summaries are accessible at https://osf.io/zh34s/?view_only=c0b7cc3dbb8f4bf49e3a95925a821f23.

Acknowledgments. We are grateful to the participating infants and their families; Hannah Clancy for assistance with data collection; and the audience at the TELIC 2017 workshop in Stuttgart, Germany, and the anonymous reviewers for helpful feedback.

Financial disclosure. This work was partially supported by NSF BCS-1748826 awarded to S.A.

Competing interest. The authors declare none.

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Cite this article: He, A. X., & Arunachalam, S. (2023). Event end-state encoding in 13-month-olds—completed and non-completed events are different, *Language and Cognition*, 1–15. https://doi.org/10.1017/langcog.2023.54