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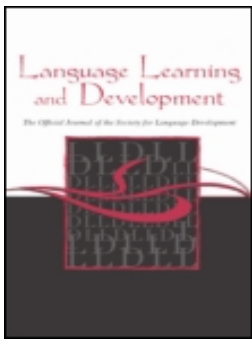
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Twelve-Month-Old Infants' Encoding of Goal and Source Paths in Agentive and Non-Agentive Motion Events

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Across languages and event types (i.e., agentive and nonagentive motion, transfer, change of state, attach/detach), goal paths are privileged over source paths in the linguistic encoding of events. Furthermore, some linguistic analyses suggest that goal paths are more central than source paths in the semantic and syntactic structure of motion verbs. However, in the nonlinguistic memory of children and adults, a goal bias shows up only for events involving intentional, goal-directed, action. Three experiments explored infants' nonlinguistic representations of goals and sources in motion events. The findings revealed that 12-month-old infants privilege goals over sources only when the event involves action of an agent. Thus, unlike language (but similar to the memory of children and adults), an endpoint bias in infant thought may be restricted to events involving goal-directed motion by an agent. These results raise the question of how children later learn to collapse over conceptual domains for purposes of coding paths in language.

Early in development, mappings between nonlinguistic and linguistic categories are established, and these mappings support further syntactic and semantic development (Golinkoff & Hirsh-Pasek, 2008; Landau & Gleitman, 1985; Pinker, 1984). The mappings young children have constructed are informative to researchers because they reveal ways in which nonlinguistic categories (e.g., agent, cause) and salience differences (agent > patient) are reflected in early language, suggesting possible mechanisms for language development. For example, the difference in saliency between agents and patients for infants (e.g., Cohen & Oakes, 1993; Grace & Suci, 1985) may align with prominence hierarchies observed in language; specifically, in semantic structure, agents are more prominent than patients and in syntactic structure, subjects are more prominent than objects (Fisher, Hall, Rakowitz, & Gleitman, 1994; Grimshaw, 1981; Pinker, 1989). Given that infants are able to align different representations (cognitive, semantic, and syntactic), infants' representations of agents and patients may serve as a bootstrap in language acquisition (see Fisher & Song, 2006).

The current study is part of an exploration of other mappings that emerge early in development, focusing on infants' representations of goal and source paths in motion events. Motivating this case study is evidence that in linguistic structure goal paths have a different status than source paths, and in language use goal paths are more prominent than source paths. These generalizations hold at very abstract levels of linguistic analysis (semantic and syntactic structure) and across events falling into different conceptual domains (motion events, transfer events, change of state events). Greater prominence of goal paths, relative to source paths, has also been observed in people's nonlinguistic representations of events. Although there have been some studies of infants' representations of motions events, there has been less attention to the question of how infants' event representations relate to linguistic ones. The present study begins to explore whether and how differential salience of goals and sources in infants' event representations might play a role in learning how these event roles are expressed in language.

Source and Goal Paths in Language

The path expression in motion events (e.g., dog dashing from his doghouse to the pool) can be universally divided into different types, including FROM paths, in which the figure moves from a reference object that is its starting point (hence, 'source path'; e.g., from his doghouse) and TO Paths, in which the figure moves to a reference object that is its endpoint (hence, 'goal path'; e.g., to the pool) (Jackendoff, 1983). Source and goal paths extend beyond the domain of motion events, *per se*. A fundamental property of language is that parallel linguistic structures are used to encode events in a variety of domains—an observation captured formally by Jackendoff's Thematic Relations Hypothesis (1983). For example, the events of a 'ball rolling OFF a book and INTO a cup' and a 'dog dashing FROM his doghouse TO a pool', 'a doll being transferred FROM Jessica TO Nicholas,' and "a chameleon turning FROM green TO brown" all include source and goal paths, despite the deep conceptual differences among animate and inanimate motion events, let alone transfer and change of state events. In semantic structure these events are encoded in terms of a source path ([FROM X]) and a goal path ([TO X]) and, in English syntactic structure both paths are encoded in prepositional phrases. Following linguistic theory, in this article, when we talk about the encoding of source and goal paths in language, we use the terms abstractly and refer to them as 'source' and 'goal.' Since the terms 'source' and especially 'goal' may take on different meaning in non-linguistic event representations, when we describe non-linguistic motion event representations, we use 'starting point' and 'endpoint.'

Goal and Source Paths in Linguistic Structure and in Language Use

Many linguists have proposed that source paths and goal paths are expressed differently in syntactic structure, semantic structure, or both (e.g., Filip, 2003; Markovskaya, 2006; Nam, 2004, but see Gehrke, 2005, for a different view). For example, goal PPs form telic predicates (e.g., Mary ran to the store in 10 minutes), whereas source PPs do not (Mary ran from the store for 10 minutes, but *not* 'in 10 minutes'). This observation is captured in semantic and syntactic structure in the following analysis: in semantic structure locative goal paths constitute *core* events (result states), whereas locative source paths *modify* the process of the event and in syntactic structure the goal path is a direct argument of the verb whereas the source path is an adjunct (Nam, 2004).

In language use, source paths surface less than goal paths in descriptions of events across a variety of languages (Ihara & Fujita, 2000; Lakusta & Landau, 2005; Lakusta & Landau, 2012; Landau & Zukowski, 2003; Papafragou, 2010; Regier & Zheng, 2007). For example, when children and adults watch simple motion events (e.g., a bird flying out of a bowl into a pot) and then are asked to describe them, they mention goal paths more often than source paths (“the bird flew *into the pot*” rather than “the bird flew out of the bowl” or “the bird flew from the bowl to the pot”). This pattern also holds for transfer, change of state, and attachment/ detachment events (Lakusta & Landau, 2005), as well as for events involving motion by an inanimate figure (e.g., a pen rolling from camera to eyeglass case is often described as “a pen rolled *to the eyeglass case*”; Lakusta & Landau, 2012).

Are Goals More Salient Than Sources in Non-Linguistic Cognition?

What accounts for the broad and robust goal biases in language structure and in language use? One possibility is that the asymmetry between source and goal paths in language is rooted in nonlinguistic representations of events, perhaps as a general memory or attention bias to encode endpoints more robustly than starting points (Regier, 1996; Regier & Zheng, 2007). An asymmetry in nonlinguistic cognition of motion events that makes goals more salient or better remembered than sources could straightforwardly explain the difference in language use (after all, to surface in a description, something must be noticed and remembered). It might also explain the asymmetry in linguistic structure if there is a general tendency for more salient aspects of nonlinguistic representations to end up in more central aspects of linguistic structure. The idea of a general memory or attention bias for endpoints receives preliminary empirical support from results suggesting that people remember endpoints better than starting points in motion events (Lakusta & Landau, 2012; Papafragou, 2010; Regier & Zheng, 2007). For example, in a recent study by Lakusta and Landau (2012), adults and 4-year-old children were presented with pairs of manner of motion events involving a human moving from a starting point to an endpoint (e.g., man hopping from a TV to a desk). The second event in each pair either had a change in starting point, endpoint, figure or motion, or there was no change at all (the events were the same). In order to disrupt linguistic encoding, participants viewed each pair of events while engaging in a verbal shadowing task. After viewing each pair, participants were asked to judge whether the events were the same or different. Both children and adults remembered endpoint changes better than starting point changes, suggesting an endpoint bias in the way they remembered the events.

However, additional results from the Lakusta and Landau (2012) study described above suggest that the goal bias in language use and the asymmetry in linguistic structure cannot fully be explained by people’s nonlinguistic representations of events. Specifically, in this study, a robust endpoint bias was *not* found for adults’ and children’s memories of endpoints and starting points in motion events involving nonagentive figures, such as a pen rolling from a coaster to an eyeglass case. For these event types, neither adults nor children differed in how well they remembered endpoint and starting point changes. However, when asked to describe these events using language, the familiar goal bias was found; adults and children were more likely to include the goal path in the prepositional phrase over the source path (e.g., “the pen rolled *to the eyeglass case*”). Thus, a discrepancy was observed between language and nonlinguistic memory of sources and goals. Although the goal bias in language use may be partially explained by how endpoints and starting

points are remembered (Regier & Zheng, 2007), at least some of the pressure to encode goals in favor of sources in language may stem from constraints internal to language. People may mention goals more than sources in their descriptions of events because, as previously discussed, goal paths are semantic and/or syntactic arguments of motion verbs, whereas source paths are adjuncts (Nam, 2004). Pragmatic constraints may also play a role in language; goal paths may be mentioned more often than source paths because an event that culminates in a goal presupposes some starting state (source), although the reverse is not true (Riemsdijk, 2007).

Consider the implications of the fact that the 4-year-old children and the adults in the Lakusta and Landau (2012) study showed a discrepancy between how they encoded goals and sources in language and endpoints and starting points in nonlinguistic cognition. They showed a goal bias for both agentive and nonagentive events in language, but only for agentive, goal-directed events in nonlinguistic memory. This suggests that, at least by the age of four years, children are sensitive to the language internal constraints that may play a role in a linguistic goal bias in language use.

Representations of Endpoints and Starting Points Early in Language Development

Findings from language development studies suggest that children express goal and source paths linguistically as early as one- and two-word speech (e.g., Choi & Bowerman, 1991; Clark, Carpenter, & Deutsch, 1995). For example, Choi and Bowerman (1991) reported that 14–21-month-olds who are learning English produce ‘out,’ ‘up,’ and ‘down’ to encode their own paths and ‘on,’ ‘in,’ and ‘off’ for those of objects. Further, 14–21-month-olds who are learning Korean produce verbs such as ‘anta’ and ‘ancta’ to encode their own paths, and ‘kkita’ and ‘ppayta’ for those of objects. These path expressions appear to encode both goal and source path types; for example, these include paths in which one object is removed from another (e.g., ‘off’ in English; ‘ppayta’ in Korean) and paths in which an object is inserted or placed in another (e.g., ‘in’ for English; ‘kkita’ for Korean). In addition to knowing and talking about paths, children also know and talk about the initial states and result states of such paths. For example, by the age of 2, children start talking about a broad range of resultant states. These include causal events in which an object affected undergoes some change, as well as change of location events, in which an object moves from one location to another (Clark, 2002). Children also have knowledge of initial states from an early age. Clark, Carpenter, and Deutsch (1995) reported that, in English, children mark reversals (return to a prior reference state) as early as one year, with general verbs such as ‘open’ being used at first, followed by the use of particles, such as ‘out,’ and then the prefix ‘-un.’ By the time children are 2;6 to 3;0 years old, they have also begun to use a variety of expressions to encode a broader notion of source, which goes beyond the physical and spatial motions of objects (Clark & Carpenter, 1989, 1994).

Infants' Representations of Spatial Motion Events

Given that children have a productive spatial vocabulary at such an early age, perhaps it is not surprising that *infants* represent spatial motion events in terms of the components that are relevant for verb meaning. For example, 7-month-old infants attend to manner and path changes in motion events (Pulverman, Golinkoff, Hirsh-Pasek, & Sootsman-Buresh, 2008), 10- and 13-month-old infants categorize paths and manners in motion events, respectively (Pruden, Göksun, Roseberry, Hirsh-Pasek, & Golinkoff, 2012; Pruden, Hirsh-Pasek, Maguire, & Meyer, 2004), and 11- and

14-month-old infants differentiate figures and grounds in motion events (Göksun et al., 2011; see Göksun, Hirsh-Pasek, & Golinkoff, 2010, and Wagner & Lakusta, 2009, for reviews). Focusing specifically on the endpoint and starting point, there is now abundant research suggesting that infants represent endpoints in events involving goal-directed action (e.g., Csibra, 2008; Gergely, Nadasday, Csibra, & Biro, 1995; Johnson, Ok, & Luo, 2007; Luo & Baillergeon, 2005; Meltzoff, 1995; Wagner & Carey, 2005; Woodward, 1998, 1999; Woodward & Somerville, 2000), and most pertinent to the current study, there is also evidence that infants represent endpoints, as well as starting points, in manner of motion events, and that infants represent endpoints *in preference to* starting points in these very same events. Lakusta et al. (2007) familiarized 12-month-old infants to a motion event where an animate-like, stuffed duck moved from one of two starting point objects to one of two endpoint objects. During test, infants viewed either the duck move from a *different starting point object* to the *same endpoint object* or from the *same starting point object* to a *different endpoint object*. Infants looked longer at the test trials where the duck moved from the same starting object to a different end object (i.e., when there was a change in the endpoint), than when the duck moved from a different starting object to the same end object (i.e., when there was a change in the starting point). This suggests that, during familiarization, infants encoded the end object more robustly than the starting object.

The Lakusta et al. (2007) study discussed above involved a toy duck moving from a starting point object to an endpoint object, an event likely to be construed as a motion event involving an agentive figure moving in a goal-directed fashion from *x* to *y*. This infant study is essentially a change detection paradigm, and extends the Lakusta and Landau (2012) finding to infancy. Recall that Lakusta and Landau (2012) observed that endpoint objects are more salient than starting point objects in children's and adults' nonlinguistic memory of motion events involving goal-directed agents. Recall also that this finding did not hold for motion events involving non-agentive figures. What is not known is whether a similar pattern of findings is found in infancy—whether infants also would fail to privilege endpoints in motion events involving *non-agentive entities*. The present study addresses this question.

At question is whether there is continuity, from infancy through adulthood, in non-linguistic encoding of beginning and endpoints in motions events. The answer to this question will constrain our accounts of how children learn to express motion events linguistically. If infants show a bias for endpoints over starting points for both agentive and nonagentive motion events, then the same factors that underlie it may straightforwardly explain the widespread higher likelihood of expressing goals than sources in linguistic descriptions of all types of events; for example, what captures one's attention nonlinguistically is likely to be expressed in one's description of an event. Also, assuming that more salient and central features of non-linguistic representations of events are taken by children to be expressed as arguments of the relevant verbs, then such a finding would suggest that the abstract linguistic structures that treat motion events alike, whether the moving figures are intentional agents or not, build on abstract conceptual structures that unite these two types of events. However, if infants, like older children and adults, show a goal bias in their non-linguistic encoding of motion events involving agentive, goal-directed entities, but not for events involving non-agentive entities, then a different learning story will be called for. We return to the implications of our findings in the general discussion, after we have presented them.

EXPERIMENT 1: MOTION EVENTS INVOLVING A NONAGENTIVE FIGURE—METHOD

Participants

Participants were 7 male and 13 female 12-month-old infants (Mean age = 12 months, 2 days; Range: 11 months, 17 days to 12 months, 19 days). Two additional infants were excluded because of fussiness. Following Lakusta et al. (2007), 12-month-olds were tested in the current study because infants at this age can be considered ‘linguistic novices.’ As reviewed above, infants represent many of the essential components of motion events (manner, goal, figure) that are relevant for verb meaning, although they are not yet producing (nor likely comprehending) adult-like motion event descriptions at this age.

Stimuli

The motion events included one of two starting point objects (a 4.70” high × 3.70” wide shiny blue block decorated with colorful pipe cleaners and a 4.20” high × 4.65” wide orange bowl decorated with colorful cotton balls and sequins), one of two endpoint objects (a 3.00” high × 2.50” wide red block and a 1.75” high × 4.90” wide green bowl), a figure (a 6.5” tall balloon), and a motion (three second float). With the exception of the balloon, these were the same stimuli as those used by Lakusta et al. (2007; see Figure 1). The starting point objects were made more salient than the endpoint objects, because Lakusta et al. found that this was necessary for infants to encode the starting point objects at all, even when there were no endpoint objects in the events. A balloon was chosen to portray a nonagentive figure (rather than, e.g., a ball) because it could easily be portrayed as ‘floating’ or being blown (and thus the balloon would not appear odd when appearing to move on its own during the familiarization and test trials). A metronome was used

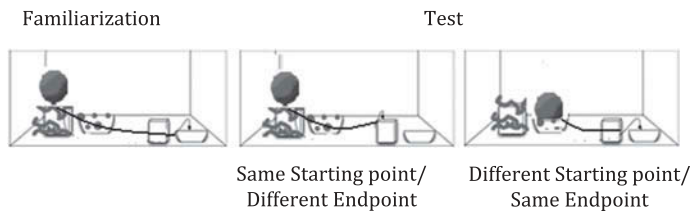


FIGURE 1 Schematic of the stimuli used in Experiment 1. In familiarization, the figure moved from one of two salient starting point objects to one of two endpoint objects. During inter-trial the objects did *not* switch locations (not shown). In three test trials, the figure moved from the same starting point but to a different endpoint and in three test trials the figure moved from a different starting point but to the same endpoint.

Note: The starting point objects were made more salient than the endpoint objects because Lakusta et al. (2007) found that it was under these conditions that infants responded to a change in starting point when there weren't any endpoint objects presented on the stage.

to ensure consistent motion timings. The balloon was attached to a thin black string that was held by an experimenter who was hidden from the infant's view. The string was invisible against the black background of the stage. Starting point objects were located in the middle of the stage (i.e., neither front nor back; objects' centers were 7" from the stage's front or back edge) on either the right or the left side (the object's center that was closest to the stage side was about 4.75" from the side; the objects' centers were about 6.75" apart from each other). Endpoint objects were located in the back or the front corner of the stage (objects' centers were 3" from the stage's front or back edge; the object's center that was closest to the stage side was about 3" from the side; the objects' centers were about 6" apart from each other). The positions were counterbalanced for front/back and left/right across infants. Starting points and endpoints were always positioned on opposite sides of the stage.

Design and Procedures

Following Lakusta et al. (2007), infants were seated in a high chair located about one meter in front of a stage that was 33.5" wide \times 13" high \times 14" deep. A curtain was attached to the front of the stage and was lowered to reveal the stage at the beginning of each trial and was raised to cover the stage at the end. A parent sat next to the infant and was asked to close his or her eyes during the inter-trial and test trials.

The experiment began with the experimenter calibrating infants' looking space by squeaking a toy (and thus directing infants' attention) at the stage's top, bottom, left and right sides, and center. After calibration, there was a prefamiliarization period. During this period, infants viewed the experimenter's hand hitting the balloon around on the stage for 20 seconds. The purpose of this prefamiliarization period was to acquaint infants with the features of the balloon as a nonagentive, dispositionally inert object, that is, as an object that does not act as a causal or intentional agent. Many previous studies have shown that the presence of a face or limbs, and the capability of self-propelled movement promote categorization of an entity as a dispositional agent, whereas absence of these features promote categorization of the entity as dispositionally inert and nonagentive (e.g., Golinkoff, Harding, Carlson, & Sexton, 1984; Johnson, Slaughter, & Carey, 1998; Luo & Baillargeon, 2005; Luo, Kaufman, & Baillargeon, 2009; Muentener & Carey, 2010; Saxe, Tenenbaum & Carey, 2005; Saxe, Tzelnic, & Carey, 2007, Shimizu & Johnson, 2004). In addition, in order to stress to the infant that the balloon was an inert, nonagent, prior to bringing the infant and parent into the testing room, infants received first-hand experience with the balloon in the waiting room for about 60 seconds. Infants were able to hold the balloon and the experimenter would hit the balloon and blow on it to make it move. During this time the experimenter engaged the infant's attention by saying, for example, "look at this."

After prefamiliarization, infants were familiarized over seven trials to an event in which the balloon moved from one of the two starting point objects to one of the two endpoint objects, always the same starting and ending point for a given infant. Then there was a single inter-trial where infants were able to view the starting point and endpoint objects alone on the stage without the figure. This inter-trial ensured that the infant encoded the objects fully, maximizing the possibility that they would notice that the balloon begins from a different starting point or ends at a different endpoint in the test trials. Finally, infants viewed six test trials. In three test trials infants saw the balloon move from a different starting point as in familiarization, but to the same endpoint (different starting point/same endpoint; hereafter called "different starting point trials");

in the other three, infants saw the balloon move from the same starting point as in familiarization, but to a different endpoint (same starting point/different endpoint; hereafter, "different endpoint trials"). The two test trial types were shown in alternation, and order was counterbalanced over infants.

At the beginning of each familiarization and test trial, prior to moving, the balloon remained in place for about two seconds either in the salient bowl or on the salient block as the experimenter said "Look (baby's name), Look!". The balloon then floated (3 seconds) out of or off of the object to either the ordinary green bowl or the ordinary red block. Once the balloon reached the endpoint object it landed in or on the object and the experimenter then said, "Look, (baby's name), Look!" This was done to ensure that the infant attended to both the beginning and end of the event. A trained observer recorded how long the infant looked at the stage during each familiarization and test trial. Looking times were recorded using the computer program MacXHAB (Pinto, 1994). When the infant looked away from the stage for two continuous seconds, or 120 seconds had elapsed, the computer signaled and the experimenter raised the curtain, covering the stage, and then revealed the stage again and proceeded to the next trial. Note that although the criterion was 120 seconds, the longest looking time recorded was 100 seconds.

Video Coding

Since we are interested in how infants respond to starting point and endpoint changes it was critical that infants viewed the entire motion event (i.e., the balloon at the starting point as well as the balloon at the endpoint) during a given test trial. For both Experiments 1 and 3, an experimenter blind to the infant's testing condition reviewed all test trials where infants' looking time was less than five seconds to identify any test trials in which the child was not looking when the balloon reached the endpoint. This never occurred for the first trial pair; when this occurred on the second or third test trial pairs, looking times for these trials (as well as the corresponding trial in that pair) were excluded from the analysis (4.2% of the test trials for Experiment 1 and 2.5% for Experiment 3).

For this experiment, as well as in Experiment 3, in order to ensure that the experimenter did not unintentionally bias the infant's looking at the starting point and/or endpoint for the two different types of test trials (different endpoint vs. different starting point), a coder blind to the infant's testing condition reviewed half of the video-recordings (Exp 1: $n = 10$; Exp. 3, $n = 20$) off-line and coded for 1) how engaging the "Look (baby's name) Look" phrase sounded when the figure was at the starting point versus when the figure was at the endpoint, 2) exactly when the "Look (baby's name) Look" phrase was uttered with respect to when the figure reached the endpoint (in case the experimenter uttered the phrase after the figure reached the endpoint, thus prolonging the infant's looking at the endpoint), and 3) to what extent the figure moved at the endpoint and starting point (in case the experimenter's hand was not completely still while holding the string attached to the balloon). There were no significant differences found between different endpoint and different starting point test trials for any of these analyses ($ps > .10$).

Reliability Coding

In order to assess coding reliability, 15 of the 20 infants in Experiment 1 and 24 of the 40 infants in Experiment 3 were coded on-line by a second trained observer. Average percent agreement

between coder one and coder two was calculated by XHAB (XHAB samples the inputs from the two coders every 100 msec and computes observer reliability based on whether during each time slice the two coders were both coding the infant as looking at or away from the stage). Average inter-observer agreement for Experiment 1 was 93% ($SD = 2.0$) and for Experiment 3 was 94% ($SD = 2.19$).

RESULTS AND DISCUSSION

Familiarization

As shown in Figure 2, the infants' average looking times decreased from the first ($M = 34.05$ seconds) to the seventh familiarization trial ($M = 10.99$ seconds); the difference between looking times at the first versus the last familiarization trial was significant, paired- $t(19) = 5.23$, $p < .01$, 2-tailed. Thus, infants were attentive to these events, and their interest waned over the familiarization trials.

Test Trials

We first compared the first test trial of each type with the last familiarization trial to assess whether infants recovered interest to events with new endpoints, new starting points, or both. Although Figure 2 suggest that infants may have recovered interest to the events with different starting

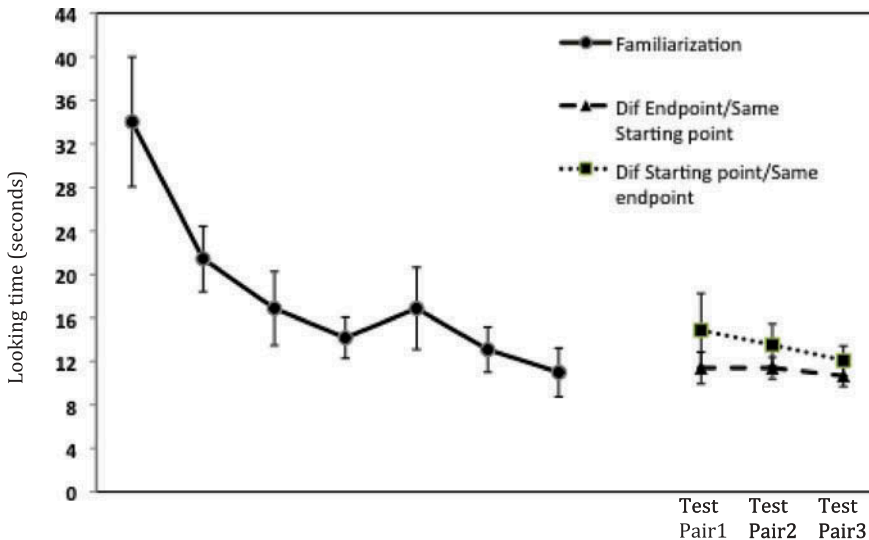


FIGURE 2 Average looking times (and SEs) at the seven familiarization events and the test trial events (for each of the test trial pairs) that were shown in Experiment 1. (Color figure available online.)

points, planned comparisons of the last familiarization trial versus 1) the first different endpoint test trial and 2) the first different starting point test trial did not result in any significant differences ($ps > .10$).

A 2×3 ANOVA examined the effects of trial type (different endpoint, different starting point) and test trial pair (first, second, third) on looking times during the test trials. There were no significant effects of trial type, $F(1, 19) = 1.99, p > .10$, or test trial pair, $F(2, 38) = .52, p > .10$. There was also no significant interaction, $F(2, 38) = .20, p > .10$. Infants looked slightly longer at the different starting point test trials for all trial pairs (Mean difference between looking time at the different endpoint vs. different starting point for test trial pairs 1, 2, and 3, respectively: $-3.46, -2.13, -1.39$), although the preference for the different starting point test trials was not significant. Fifteen of the 20 infants showed this pattern, which nevertheless did not differ from chance (Wilcoxon signed ranks test, $z = -1.49, p > .10$, 2-tailed).

Additional analyses tested whether any of the four counterbalanced variables (different endpoint test trial presented first vs. second; endpoints positioned front vs. back of stage; endpoints positioned right vs. left of stage; male vs. female) affected looking times during the test trials, both for Experiment 1 and Experiment 3. There were no main effects of any of these variables in in either study, nor did any of these variables interact with the variable of interest (trial type) in either study.

Summary

Infants did not preferentially attend to the endpoint during familiarization, for during test they did not look longer at a change in the endpoint than a change in the starting point. Rather, infants looked slightly, but not significantly, longer at the test trials with different starting points. It is possible that the infants were reasoning about the cause of the inert balloon's movement, and thus their attention was drawn to the starting point. These findings contrast sharply with the endpoint bias that 12-month-olds have exhibited in two independent previous studies in which the moving figure was a toy duck that appeared to move on its own (Lakusta et al., 2007; Lakusta, Reardon et al., 2007). This suggests that in infancy a bias for encoding endpoints over starting points may be strongest for goal-directed events in which the moving figure is construed as an intentional agent—the pattern that was also observed for the nonlinguistic memory of starting points and endpoints of 4-year-old children and adults (Lakusta & Landau, 2012).

However, this study differed from prior studies with infants involving a moving duck as the figure in several respects. The motion of the balloon was quite different from that of the duck, and the balloon was featureless and round, whereas the duck had articulated parts. Furthermore, the infants had been familiarized with the balloon in the waiting room prior to the experiment, whereas, in the previous studies, infants were not familiarized to the duck in the same manner. These differences that exist between previous studies and the current study make it difficult to directly compare infants' representations of starting points and endpoints in motion events involving agent-like figures vs. non-agent figures. Because of this, in Experiments 2 and 3 we seek stronger evidence for the hypothesis that a bias to attend to endpoints over starting points in infants is strongest for events involving an agent moving toward a goal. In Experiment 2 we test whether given the appropriate cues to agency, infants would categorize a balloon as an agent.

Then, in Experiment 3, we test whether infants show an endpoint bias for motion events involving an agentive balloon but not for motion events involving an inert, nonagentive balloon.

EXPERIMENT 2: ENCODING A SELF-MOVING BALLOON WITH A FACE AS A GOAL-DIRECTED AGENT IN THE WOODWARD (1998) PARADIGM

Previous studies have shown that variables such as capacity for self-generated motion and presence of a face influence infants' encoding of entities as causal and intentional agents (e.g., Johnson, Slaughter, & Carey, 1998; Luo & Baillargeon, 2005; Luo, Kaufman, & Baillargeon, 2009; Muentener & Carey, 2010; Saxe, Tenenbaum & Carey, 2005; Saxe, Tzelnic, & Carey, 2007). Further, several studies have explored the conditions under which infants attribute goals or preferences to the moving figure in the Woodward (1998) paradigm (Csibra, 2008; Kamewari, Kato, Kanda, Ishiguro, & Hiraki, 2005; Lakusta et al., 2007; Woodward 1999; see Carey, 2011 for a review) in which a figure repeatedly approaches one of two objects (e.g., a bear, rather than a ball) during habituation or familiarization. During test, the locations of the bear and the ball are switched, and infants' attention is drawn more to test trials in which the figure (e.g., a hand, a stuffed animal, a stick, a robot) approaches the new object in the old location, rather than vice versa, suggesting that they interpreted the object as the goal of an intentional approach. In Experiment 2, we use this Woodward paradigm to assess whether the presence of a face, in addition to evidence for the capacity for self-generated motion, on a balloon would lead 12-month-old infants to treat the balloon's approach to one of two objects as an intentional and goal-directed action.

Participants

Participants were six male and six female 12-month-old infants (Mean age = 12 months, 0 days; Range: 11 months, 9 days to 13 months, 4 days). Two additional infants were excluded because of fussiness.¹

Stimuli, Design, and Procedure

The stimuli, design, and procedures were exactly the same as those used in Experiment 1 with the following exceptions. The balloon was made to portray an agent by giving it eyes, a nose, and a mouth (see Figure 3). Infants were not exposed to the balloon in the waiting room (as in Experiment 1); rather, all exposure to the balloon was provided on the stage. During prefamiliarization, infants viewed a hand and the balloon resting on the stage next to each other (1 sec). Infants then viewed the balloon move on its own (3 sec) while the hand remained still on the stage. Then the balloon (and hand) remained still on the stage (1 sec.). This sequence was repeated four times, for a total prefamiliarization period of about 20 seconds. A trained

¹A sample size of twelve infants was used because similar studies have found significant results with a sample size of twelve infants (e.g., Csibra, 2008) and a power analysis conducted on the pilot data ($N = 7$) of the current experiment suggested that a sample size of 12-15 infants would be required to attain 80% power (alpha set at .10 and .05, respectively).

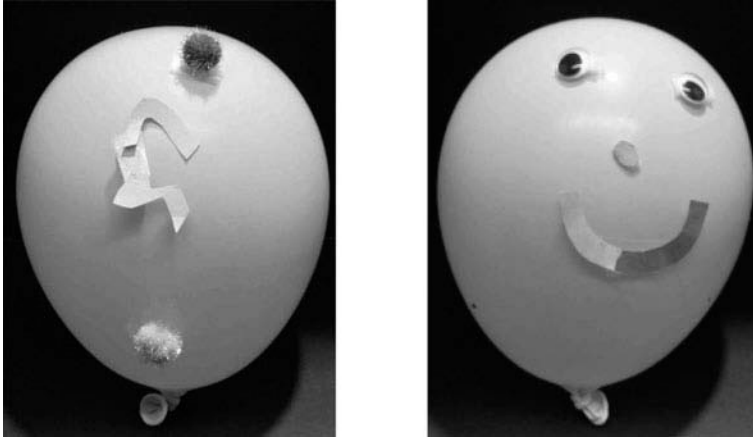


FIGURE 3 Photographs of the figure objects used in Experiments 2 and 3: balloon with a pattern (used in Experiment 3) and balloon with a face (used in Experiments 2 and 3).

observer coded on-line for how long the infants watched the prefamiliarization event. Further, in this experiment, the curtain was lowered to cover the stage and raised to reveal the stage.

Unlike Experiment 1, the familiarization and test events shown to the infants did not include starting point objects. Rather, during familiarization, infants viewed the agentive balloon moving to one of two endpoint objects (green bowl or red block). Then the curtain was lowered and the experimenter switched the locations of the two endpoint objects. Infants then viewed the objects in their new locations. During test, infants viewed three test trials where the agentive balloon moved to the same endpoint as in familiarization, but in a different location (same endpoint/different location) and three test trials where the agentive balloon moved to a different endpoint as in familiarization but in the same location (different endpoint/same location). If the face and capacity for self-generated motion is sufficient to induce infants to categorize the balloon as a dispositional agent, and the events as goal-directed toward the endpoint object, then they should find the test events in which the balloon approaches the different endpoint object/same location more attention grabbing than those in which it approaches the same endpoint object/different location.

Reliability Coding

In order to assess coding reliability, 11 of the 12 infants were coded on-line by a second trained observer. Average inter-observer agreement was 95% ($SD = 1.32$).

Prefamiliarization and Familiarization

Infants watched the prefamiliarization events 100% of the time. The infants' average looking times significantly decreased from the first to seventh familiarization trial ($M_s = 22.00, 10.35$ and

$SEs = 3.01, .98$ for trials one and seven, respectively), paired- $t(11) = 3.60, p < .01$, 2-tailed. Thus infants attended to these events, and their interest waned upon repetition.

Test Trials

A 2×3 ANOVA examined the effects of trial type (different endpoint, different location) and test trial pair (first, second, third) on looking times during the test trials. There was a significant effect of test trial pair, $F(2, 22) = 6.95, p < .05$; infants looking times decreased from the first to the third test trial pairs ($Ms = 13.04, 10.49, 8.99$; $SEs = 1.28, 1.02, .99$, for test pairs one to three, respectively). There was also a significant effect of trial type, $F(1, 11) = 6.04, p < .05$; infants looked longer at the different endpoint/same location test trials ($M = 12.10, SE = 1.09$) than the same endpoint/different location test trials ($M = 9.82; SE = .85$). There was no significant test trial type by test trial pair interaction, $F(2, 22) = .13, p > .10$. Ten of the 12 infants looked longer at the different endpoint vs. different location test trials, which significantly differs from chance (Wilcoxon signed ranks test, $z = -2.04, p < .05$, 2-tailed).

Additional analyses found that none of the four counterbalanced variables (different endpoint test trial presented first vs. second; endpoints positioned front vs. back of stage; endpoints positioned right vs. left of stage; male vs. female participants) significantly interacted with the main variable of interest (trial type) and there were no main effects of any of these variables ($ps > .10$).

Infants must have attended to the endpoint during familiarization, and during test they looked longer at a change in endpoint object versus a change in location. It is well known that this pattern of findings in the Woodward paradigm is sensitive to variables that signal an intentional construal; for example, it is sensitive to whether the hand acts intentionally versus flops unintentionally, whether the actor takes multiple paths toward the goal (equifinality), whether the actor causes a change of state to the goal, and whether the actor can see both objects during familiarization (see Carey, 2011 for a review). Thus, it is very likely that the sensitivity to a change in endpoint object in this paradigm reflects infants' construing the event as an intentional, goal directed action by an agent. Thus, we conclude that together the face and the evidence that the balloon was capable of self-generated motion were sufficient for 12-month-old infants to categorize the balloon in this study as an intentional agent, and to construe the event as goal directed.

With this result in hand, Experiment 3 seeks an even stronger test of the hypothesis that a bias to attend to endpoints over starting points in infants, like that of 4-year-olds and adults, is observed only if the events involve an agent moving toward a goal. In Experiment 3, there are two conditions, both involving a balloon. In one condition, the agentive balloon from Experiment 2 is the figure; like Experiment 2, it has markings on it that resemble a face, and prior to the experiment infants are shown it apparently moving by itself on the stage. In the other condition, the balloon has markings of comparable complexity, not resembling a face, and prior to the experiment the infants are shown it being batted around by a hand on the stage. In the experiment proper, the events in the two conditions are identical (except for the appearance of the balloon—face or markings). Thus any difference in an endpoint bias would most likely be due to the construal of the moving figure, and consequent construal of the event itself, rather than to any low level perceptual features of the events.

EXPERIMENT 3: MOTION EVENTS INVOLVING AN AGENTIVE OR AN INERT BALLOON—METHOD

Participants

There were 20 infants in each of the agentive and inert balloon conditions: In the inert balloon condition participants were 11 male and 9 female 12-month-old infants (Mean age = 12 months, 10 days; Range: 11 months, 21 days to 12 months, 28 days); in the agentive balloon condition participants were 11 male and 9 female 12-month-old infants (Mean age = 12 months, 13 days; Range: 11 months, 19 days to 12 months, 30 days). One additional infant was excluded in the inert balloon condition due to fussiness that precluded finishing the experiment.

Stimuli, Design, and Procedures

The stimuli, design, and procedures were exactly the same as those used in Experiment 1 with the following exceptions. The balloon in the inert figure condition had a pattern constructed from two sparkly pom-poms (the size of cotton balls) and a squiggly piece of construction paper. The balloon in the agentive condition was the same as the balloon used in Experiment 2; it had eyes, a nose, and a mouth (see [Figure 3](#)). Infants were not exposed to either balloon in the waiting room (as in Experiment 1); rather, all exposure to each type of balloon was provided on the stage. During pre-familiarization, infants in *both* the inert and agentive balloon conditions first viewed a hand and the balloon resting on the stage next to each other (1 sec). Infants in the inert balloon group then viewed the hand hit the balloon, the balloon moved (3 sec), and then the balloon remained still on the stage (1 sec). This sequence was repeated four times, for a total pre-familiarization period of about 20 seconds. Similar to Experiment 2, infants in the agentive balloon condition viewed exactly the same sequence of events, except the hand never hit the balloon to make it move. Rather, the balloon appeared to initiate its own movement while the hand remained still on the stage. A trained observer coded on-line for how long the infants watched the prefamiliarization event in order to assess whether infants in each condition watched the events for equal amount of time.

Familiarization and test trials were the same for infants in the inert and agentive balloon conditions and were the same as those in Experiment 1; however, in this experiment infants received only two (rather than three) test trial pairs, since, in the previous two experiments, the most robust effects were found over the first two test trial pairs.

RESULTS AND DISCUSSION

Prefamiliarization

Infants in both conditions were near ceiling in how long they watched the pre-familiarization events (for the inert and agentive balloon conditions, respectively, infants watched 97% and 99% of the time). There was no significant difference in the interest shown during prefamiliarization.

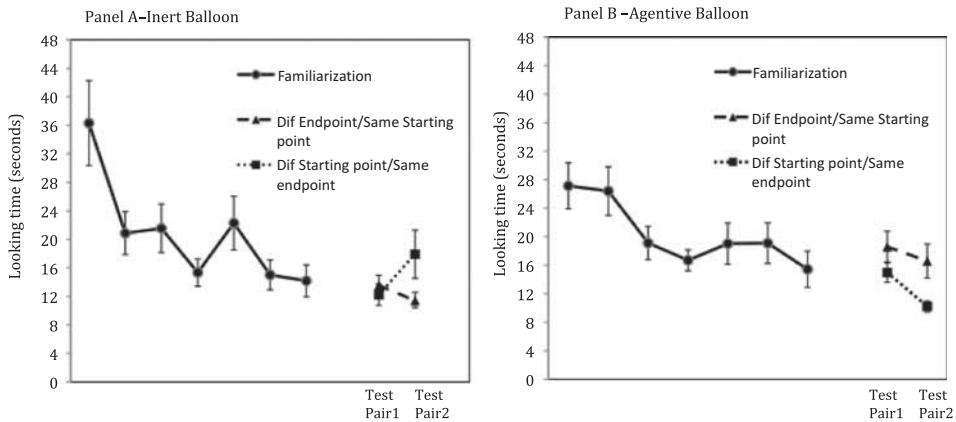


FIGURE 4 Panel A: Inert balloon. Panel B: Agentive Balloon. Average looking times (and SEs) at the seven familiarization events and the test trial events (for each of the test trial pairs) that were shown in Experiment 3.

Familiarization

Figure 4 depicts the results. A 7×2 mixed ANOVA examined the effects of familiarization trial (1–7) and condition (inert vs. agentive balloon) on infants' looking times during the familiarization trials. There was a significant main effect of familiarization trial, $F(6, 228) = 8.74, p < .01$; infants' looking times declined over familiarization. There was no significant main effect of condition, $F(1, 38) = .02, p > .10$, nor was there a significant interaction between familiarization trial and condition, $F(6, 228) = 1.64, p > .10$. To further confirm that infants lost interest during the familiarization events in each condition, separate planned comparisons for each condition showed that infants' looking times decreased from the first to the seventh familiarization trial (see Figure 4; Panel A: inert balloon condition: $M_s = 36.32, 14.18$; $SE_s = 5.95, 2.23$ for trials one and seven, respectively, paired- $t(19) = 4.39, p < .01$, 2-tailed; Panel B: agentive balloon condition: $M_s = 27.14, 15.44$; $SE_s = 3.24, 2.53$ for trials one and seven, respectively, paired- $t(19) = 3.35, p < .01$, 2-tailed). Further, although infants in the inert balloon condition looked longer at the first familiarization trial than infants in the agentive balloon condition, a oneway ANOVA revealed that the difference was not significant, $F(1, 39) = 1.84, p > .10$.

In sum, infants in the inert and agentive balloon conditions attended (as indicated by their looking times) to each familiarization event to a similar extent, and infants in each condition entered the test trials in the same attentional state.

Test Trials

Planned comparisons of the last familiarization trial vs. 1) the first different endpoint test trial and 2) the first different starting point test trial did not result in any significant differences ($p_s > .10$),

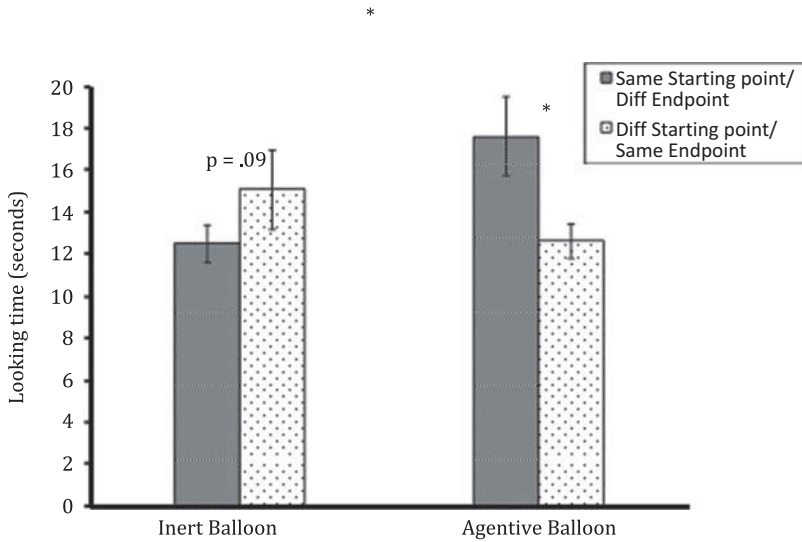


FIGURE 5 Average looking times (and SEs) at the two different trial types (different endpoint vs. different starting point) in Experiment 3.

despite the appearance that compared with the last familiarization trial, infants in the agentive balloon condition seem to have looked longer at the different endpoint test trial (Figure 4, Panel B). We interpret the lack of differentiation of the last familiarization trial from any of the test trials as reflecting the fact that infants were still in the process of becoming bored with these events at the end of familiarization.

A $2 \times 2 \times 2$ mixed ANOVA examined the effects of condition (inert vs. agentive balloon), trial type (different endpoint vs. different starting point), and trial pair (first, second) on looking times during the test trials. There were no main effects or interactions involving trial pair. There were also no significant main effects of condition, $F(1, 38) = .53, p > .10$ or of trial type $F(1, 38) = 1.36, p > .10$. However, there was a significant interaction between condition and trial type, $F(1, 38) = 13.81, p < .01$, reflecting that infants' attention was preferentially drawn to the change of the endpoint, relative to change of the starting point, for motion events involving the agentive balloon but *not* for motion events involving the inert balloon (Figure 4 and 5).

This significant interaction was explored with planned contrasts. Infants in the inert balloon condition looked marginally longer at the different starting point test trials ($M = 15.08, SE = 1.89$) than at the different endpoint test trials ($M = 12.48, SE = .91$), paired- $t(19) = 1.80, p = .09$, 2-tailed. On nonparametric measures, this pattern did not approach significance: 11 of the 20 infants looked longer at the different starting point test trials (Wilcoxon signed ranks test, $z = -1.42, p > .10$, 2-tailed). In contrast, infants in the agentive balloon condition looked significantly longer at the different endpoint test trials ($M = 17.59, SE = 1.88$) than the different starting point test trials ($M = 12.60, SE = .84$), paired- $t(19) = -3.46, p < .01$, 2-tailed. This pattern was robust, confirmed by non-parametric analyses; seventeen of the 20 infants showed it (Wilcoxon signed ranks test, $z = -2.99, p < .01$, 2-tailed).

Summary

Replicating the findings reported in Experiment 1, when infants were prefamiliarized to a balloon as nonagentive and inert (having a nonface pattern and moving only when contacted), during test, they did *not* look longer at a change in the endpoint than a change in the starting point; rather they looked marginally longer at a change in the starting point. In contrast, when infants were prefamiliarized to a balloon appearing agentive (i.e., having a face and engaging in self-propelled movement), during test, a change in the endpoint elicited robustly more attention than did a change in the starting point. This pattern—an endpoint bias for the agentive balloon events and no endpoint bias for the inert balloon events—was observed *despite* the infants showing comparable looking times at these entities during prefamiliarization and during the familiarization trials. Thus, even when the infants appear to enter the test with similar attentional states, a bias to encode endpoints over starting points was only observed for motion events involving an agentive balloon.

Note that these results leave open exactly which of the agentive balloon's features (face, self-propelled motion) led infants to attend differentially to the endpoint. These features were both manipulated to maximize the probability that infants would be more likely to construe the balloon in the agentive figure condition as an intentional agent than they would the balloon in the dispositionally inert figure condition. Further studies would be needed to determine just what features underlie the contrast we observed here.

GENERAL DISCUSSION

When the moving figure in a motion event is a balloon with a face that has been shown to be capable of self-generated motion, 12-month-olds find the endpoint of the event more salient than the starting point (Experiment 3). This is also the case if the moving figure is a toy duck (Lakusta et al., 2007; Lakusta, Reardon et al., 2007). In contrast, when the moving figure is a balloon with no features of known agents, infants' attention is not drawn more to a change in endpoint than to a change in starting point (Experiments 1 and 3). Rather, they look slightly longer at the change in the starting point. Thus, it seems that, similar to adults and 4-year-olds, in nonlinguistic encoding of simple motion events, the endpoints are more salient than the starting points when the event is construed as the motion of a goal-directed agent, but not when it is construed as the motion of an inert non-agent. These findings bear on our characterization of infants' representations of motion events, and constrain our accounts of the origin of the goal bias in language use and the asymmetries between the representations of source and goal paths in linguistic structure.

Infants' Cognitive Representations of Endpoints and Starting Points

One question left open by the current study is whether infants were encoding the endpoint and starting point of the figure's movement in terms of the ground objects themselves (bowl and block), the locations occupied by the ground objects, or even in terms of the endstate and starting state of the figure with respect to the ground object (e.g., balloon in the bowl, vs. on the box). Given the results of Experiment 2, it is unlikely that the location of the ground objects specifies

the endpoint in Experiments 1 and 3, for in Experiment 2 the expected endpoint of the agentive balloon's action was represented in terms of the goal object, not the goal location. Future research could explore the precise nature of infants' starting point and endpoint representations by designing a method that does not conflate the actual ground object in the event with its location and state. For example, object and location could be deconfounded by familiarizing infants to events of a figure moving from a starting point object to an endpoint object and the objects could occupy various locations over the familiarization trials. Whichever turns out to be the correct characterization, for present purposes what is significant is infants' differential encoding of the starting point relative to the endpoint in the two types of events (agentive vs. nonagentive figures).

The present results bear on a possible low-level account for why infants looked longer at test trials involving different endpoints than they did at test trials involving different starting points in the original Lakusta et al. studies (2007; Lakusta, Reardon, Oakes, & Carey, 2007), as well as in the current study (Experiment 3) in which the moving figure was a balloon with a face that had been shown to be capable of self-generated motion. In these studies, infants' looking continues to be measured at the end of the event, when the figure is on or in the endpoint object. At this point of measurement, the relation between the moving figure and the starting point object is held in memory. For this reason alone, one might expect infants' attention is drawn more to a new endpoint object. Again, if this were the sole reason for the endpoint bias, it would be observed also in the non-agent conditions of Experiments 1 and 3, for their event structure is identical to that of the agentive figure condition.

The present results also rule out several other potential explanations for an endpoint bias in infants' representations of motion events. First, the current findings rule out the possibility that an endpoint bias is simply a recency effect in memory. As is well known, under many circumstances people tend to remember best the last few items in a list (e.g., Shriffrin, 1973), a finding that might be extended to remember best the last parts of an event unfolding in time. But, if an endpoint bias simply reflects a recency effect in memory, it should have emerged for infants in the nonagentive balloon conditions of Experiments 1 and 3, but it did not. For similar reasons, the current findings also call to question whether an endpoint bias in infant cognition can be explained *solely* as a perceptual bias that directs attention to endpoints, as has been proposed by Regier (1996) in a computational model of spatial term learning (see also Regier & Zheng, 2007). Rather, these findings suggest that for the infants in the current study, as well as the children and adults in the Lakusta and Landau (2012) study, representations of goal-directed agents play an important role in modulating one's attention to endpoints and starting points in non-linguistic event representations.

If agency plays a role in infants' representations of endpoint and starting points, then the question arises about exactly which aspects of agency are relevant? In Experiment 3 of the current study we manipulated whether the balloon had a face and engaged in self-propelled motion. In studies with infants, these two cues have been shown to influence whether an unfamiliar entity is seen as the kind of thing that might be construed as a causal agent (Luo & Baillargeon, 2005; Luo, Kaufman, & Baillargeon, 2009; Muentener & Carey, 2010; Saxe, Tenenbaum & Carey, 2005; Saxe, Tzelnic, & Carey, 2007) and also whether it might be construed as an intentional agent (e.g., Johnson, Slaughter, & Carey, 1998; Shimizu & Johnson, 2004). We suggest that in the present experiments, it is intentional agency that is at stake, given that infants appear to be reasoning about the entity's goals (Experiment 2), and given that moving the figure causes no change in the goal object's state. This interpretation also receives support from the findings reported by Lakusta and Landau (2012) in which a non-linguistic endpoint bias was not observed

for 4-year-olds and adults for events in which a human moved from a starting point to an endpoint while *looking back* at the starting point. Thus, given the current findings with infants and previous findings with children and adults, intentional agency seems to be at work in modulating non-linguistic representations of starting points and endpoints.

Learning the Language of Motion Events

The current results present a case of developmental continuity over infancy, the preschool years, to adulthood. When encoding motion events nonlinguistically in working memory, participants privilege goal paths over source paths if the figure is an agent acting intentionally, but not if the figure is an inanimate object. However, our results also raise the possibility of a developmental discontinuity in the *linguistic* representations of goal paths and source paths; by age 4, as in adulthood, goal paths are privileged in the linguistic description of events abstractly, including descriptions of motion events involving both animate and inanimate figures, descriptions of change of possession, and descriptions of state changes (Lakusta & Landau, 2005, 2012). As mentioned in the introduction, if infants showed a goal bias for both agentive and nonagentive motion events, then the same factors that underlie it might have straightforwardly explained the widespread higher likelihood of expressing goals than sources in the linguistic descriptions of events. However, this possibility is ruled out by the current study since infants, like 4-year-olds and adults in nonlinguistic change detection tasks (Lakusta & Landau, 2012), show an endpoint bias for agentive, intentional events but *not* for nonagentive events. In the paragraphs that follow we speculate upon a scenario in development that may bear on how young children initially learn to express sources and goals in language, as well as how the eventual asymmetry of sources and goals in linguistic structure, and consequently, in language use, arises in development.

We suggest that representations of intentional events may serve as templates for linguistic structure, over development and perhaps also over evolution. First, consider infants' conceptual representations. Following ideas put forth by Gergely and colleagues (e.g., Gergely & Csibra, 2003), infants may analyze motion events in terms of the efficiency of the action in which the endstate is achieved; if the agent acts efficiently given its means and the environmental context, then the action is interpreted as goal-directed and the endpoint is encoded as an integral part of the event. Next, consider the linguistic structure of verbs; verbs are phrases that refer to actions in an event, and arguments of a verb are those phrases that refer to the core components of the action (e.g., In the sentence 'John hit Mary,' 'John' and 'Mary' are core components of the event; the act of hitting requires an agent that hits and a patient that is hit). In contrast, adjuncts are phrases that usually modify the event (e.g., In the sentence 'John hit Mary on Sunday,' 'on Sunday' modifies the hitting event and is not part of the core meaning of 'to hit'; see Tutunjian & Boland, 2008, for a brief review of the distinction between arguments and adjuncts). Now, merging these two ideas together, consider the language learner: if infants represent the endpoint as an integral part of intentional events (X moves to Y), then when acquiring the meaning of a verb (e.g., 'move'), the learner may represent the endpoint (goal) to be an argument of the verb; in contrast, starting points (sources) are not represented as an integral part of the event and thus are not represented as arguments, but rather as adjuncts, as they modify the event. Note that this learning scenario assumes that the child is able to map conceptual, semantic and syntactic representations into one another, and distinguishes arguments from adjuncts. Given such competencies, plus the assumption that the initial representations of motion events emerges in the context of describing events involving

intentional, goal directed, actions, the conceptual asymmetry of endpoints over starting points in intentional events may serve as the basis for the goal bias that has already been observed in linguistic structure by linguists (Filip, 2003, Nam, 2004; see also Jackendoff, 1990, for a discussion of the semantic structure of motion verbs, goals, and sources, in particular). As reviewed in the introduction, what these linguists propose is that in semantic structure, goals are result states of represented processes encoded as arguments, whereas sources are not (rather they are modifiers of the process; Filip, 2003; Nam, 2004), in syntactic structure, goals are generated under the lower VP (and thus are direct arguments), whereas sources are not (they are generated under the higher VP and thus act more like adjuncts; Nam, 2004), and perhaps even in pragmatics, sources are presupposed, whereas goals are asserted. These fundamental differences in the expression of goal paths and source paths in language then explain the asymmetries observed in language use, such that goal paths are explicitly expressed much more often than source paths (Ihara & Fujita, 2000; Lakusta & Landau, 2005; Lakusta & Landau, 2012; Landau & Zukowski, 2003; Papafraçou, 2010; Regier & Zheng, 2007).

This account provided above can also explain the language asymmetry of source and goal paths in non-intentional motion events, as well as change of possession and change of state. Here we draw on ideas put forth by Jackendoff and others suggesting that due to the constraints of language (e.g., The Design of Language Hypothesis; Landau & Jackendoff, 1993), language often encodes objects, events, etc. at a level coarser than perceptual representations. Thus, language may collapse across different kinds of endpoints (intentional, nonintentional) and come to treat endpoints in general with the special status that intentional endpoints receive in nonlinguistic representations. For example, in terms of a thematic hierarchy, goals (endpoints in intentional OR non-intentional events) may outrank sources. Now considering the language learner, the mapping of endpoints and starting points for representations of intentional events is simple and direct. Intentional endpoints are favored over starting points and this plays a role in the assignment of goals to arguments in linguistic structure. On this proposal the linguistic prominence hierarchy: thematic role goal > thematic role source reflects the conceptual prominence hierarchy: intended endpoint > starting point. Notice that in this proposal, intentional goal is the first notion of goal that is mapped onto a linguistic notion of goal. However, mapping starting points and endpoints of non-intentional events into language is not direct, given that an endpoint bias does not show up strongly for these kinds of representations. In these cases, perhaps children draw on analogical alignment (Gentner, 1983) at the conceptual level, and construct the following analogy for purposes of mapping endpoints and starting points into language: endpoints in nonintentional events are like endpoints (goals) in intentional events, and thus, endpoints (in general) outrank starting points. Hearing analogous expressions in language (e.g., "John ran *from home to the game*," "The leaf floated *from the branch to the lawn*," "The money was transferred *from the donors to the hospital*," "The leaves turn *from green to gold* in October) may play a role in the hypothesized analogical extension. The resulting abstract hierarchy is the linguistic source/goal structure. Such a prominence relationship would then directly reflect the hierarchy in language.

If intentional events serve as templates for the linguistic structure of motion events, and if learning the linguistic structure underlying the expression of non-intentional motion events, or other source/goal events, requires an analogy to be drawn, then we should see early in development that the linguistic expressions of goals and sources are restricted to the linguistic descriptions of events involving intentional actors. Only later in development should children extend the language of motion events to other types of events (nonintentional motion, and maybe

even change of state, change of possession, attachment/detachment). The wealth of children's early descriptions of spatial events (e.g., Bloom, 1973; Choi & Bowerman, 1991; Clark, 2002) show that children mark both goal and source paths at an early age, but these studies do not systematically explore whether there is a difference in children's early markings of these paths in intentional versus non-intentional events. It is notable that the large majority of children's utterances reported in these studies usually involve an agent acting on another object, consistent with the idea that events involving an agent acting on an inanimate object may serve as a basic cognitive schema onto which language can be easily mapped (Slobin, 1985).

A recent study by Muentener and Lakusta (2011) supports an analogous proposal concerning how children learn the linguistic encoding of causal events, namely, by mapping them onto the structure of intentionally caused state changes. In this study, 3.5- to 4-year-old children were asked to describe the following types of causal events: intentionally caused by an agent (e.g., girl intentionally flips a light switch resulting in a light turning off), nonintentionally caused by an agent (e.g., a girl accidentally bumps into a table, resulting in a glass breaking), and object caused (e.g., a ball hits a light switch resulting in a light turning off). Children produced and preferred causal descriptions over noncausal descriptions more for the events that were intentionally caused by agents than for the other two types of events, which did not differ from each other (non-intentionally caused by agents and object caused events). This suggests that children have a bias for mapping intentional events into causal linguistic structures. A similar bias may be present in children's early language of goal and source paths; children may initially restrict their use of goal and source linguistic markings (e.g., prepositions in English) to intentional events and only later in development extend this language to paths that have endpoints and starting points in other domains (e.g., nonintentional motion events, change of state). A systematic exploration of children's early goal and source language across event types could bear on this possibility.

In conclusion, the present experiments tested whether a direct mapping exists between infants' representations of endpoints and starting points in agentive and nonagentive motion events and the encoding of these paths in language. Our results suggest that it does not; similar to non-linguistic encoding of events by children and adults, but unlike either language use or linguistic structure, an endpoint bias emerged only in representations of motion events involving motion of a goal-directed agent. We are currently exploring the implications of these findings for the process of mapping between language and thought in the course of early language acquisition.

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REFERENCES

- Bloom, L. (1973). *One word at a time: The use of single word utterances before syntax*. The Hague, the Netherlands: Mouton.
- Bloom, P. (1999). The role of semantics in solving the bootstrapping problem. In R. Jackendoff, P. Bloom, & K. Wynn (Eds.), *Language, logic, and concepts* (pp. 285–309). Cambridge, MA: The MIT Press.
- Bowerman, M., de León, L., & Choi, S. (1995). Verbs, particles, and spatial semantics: Learning to talk about spatial actions in typologically different languages. In E. V. Clark (Ed.), *Proceedings of the Twenty-seventh Annual Child Language Research Forum* (pp. 101–110). Stanford, CA: Center for the Study of Language and Information.
- Carey, S. (2011). *The origins of concepts*. Oxford, England: Oxford University Press.
- Choi, S., & Bowerman, M. (1991). Learning to express motion events in English and Korean: The influence of language-specific lexicalization patterns. *Cognition*, 41, 83–121.
- Clark, E. V. (2002). Resultant states in early language acquisition. In D. Ravid & H. B.-Z. Shyldkrot (Eds.), *Festschrift for Ruth A. Berman*. Dordrecht, the Netherlands: Kluwer.
- Clark, E. V., & Carpenter, K. L. (1989). On children's uses of from, by, and with in oblique noun phrases. *Journal of Child Language*, 16, 349–364.
- Clark, E. V., & Carpenter, K. L. (1994). The notion of source in language acquisition. In P. Bloom (Ed.), *Language acquisition: Core readings* (pp. 251–284). Cambridge, MA: MIT Press.
- Clark, E. V., Carpenter, K. L., & Deutsch, W. (1995). Reference states and reversals: Undoing actions with verbs. *Journal of Child Language*, 22, 633–662.
- Cohen, L. B., & Oakes, L. M. (1993). How infants perceive a simple causal event. *Developmental Psychology*, 29(3), 421–433.
- Csibra, G. (2008). Goal attribution to inanimate agents by 6.5-month-old infants. *Cognition*, 107, 705–717.
- Filip, H. (2003). Prefixes and the delimitation of events. *Journal of Slavic Linguistics*, 11(1), 55–101.
- Fisher, C., Hall, D. G., Rakowitz, S., & Gleitman, L. (1994). When it is better to receive than to give: syntactic and conceptual constraints on vocabulary growth. In L. Gleitman & B. Landau (Eds.), *Acquisition of the lexicon* (pp. 333–375). Cambridge, MA: MIT Press.
- Fisher, C., & Song, H. (2006). Who's the subject? Sentence structure and verb meaning. In K. Hirsh-Pasek & R. Michnick-Golinkoff (Eds.), *Action meets word: How children learn verbs* (pp. 392–425). Oxford, England: Oxford University Press.
- Gehrke, B. (2005). The prepositional aspect of Slavic prefixes and the goal-source asymmetry. In H. de Hoop & J. Zwarts (Eds.), *Proceedings of the ESSLLI workshop on Formal Semantics and Cross-Linguistic Data*, pp. 47–56.
- Gentner, D. (1983). Structure mapping: A theoretical framework for analogy. *Cognitive Science*, 7, 155–170.
- Gergely, G., & Csibra, G. (2003). Teleological reasoning in infancy: The naive theory of rational action. *Trends in Cognitive Science*, 7, 287–292.
- Gergely, G., Nadasdy, Z., Csibra, G., & Biro, S. (1995). Taking the intentional stance at 12 months of age. *Cognition*, 56, 165–193.
- Gleitman, L. (1990). The structural sources of verb meanings. *Language Acquisition*, 1(1), 3–55.
- Göksun, T., Hirsh-Pasek, K., & Golinkoff, R. M. (2010). Trading spaces: Carving up events for learning language. *Perspectives on Psychological Science*, 5, 33–42.
- Göksun, T., Hirsh-Pasek, K., Golinkoff, R. M., Imai, M., Konishi, H., & Okada, H. (2011). Who is crossing where? Infants' discrimination of figures and grounds in events. *Cognition*, 121, 176–195.
- Golinkoff, R., Harding, C., Carlson, V., & Sexton, M.E. (1984). The infant's perception of causal events: The distinction between animate and inanimate objects. In L.P. Lipsitt (Ed.), *Advances in infancy research* (Vol. 3, pp. 145–151). Norwood, NJ: Ablex.
- Golinkoff, R. M., & Hirsh-Pasek, K. (2008). How toddlers begin to learn verbs. *Trends in Cognitive Science*, 12, 397–403.
- Grace, J., & Suci, G. J. (1985). Attentional priority of the agent in the acquisition of word reference. *Journal of Child Language*, 12(1), 1–12.
- Grimshaw, J. (1981). Form, function, and the language acquisition device. In C. L. Baker & J. J. McCarthy (Eds.), *The logical problem of language acquisition* (pp. 165–182). Cambridge, MA: MIT Press.
- Gruber, J. S. (1965). *Studies in lexical relations*. (Unpublished doctoral dissertation). MIT, Cambridge, MA.
- Ihara, H., & Fujita, I. (2000). A cognitive approach to errors in case marking in Japanese agrammatism: The priority of the goal -ni over the source - kara. In F. V. d. L. A. Foolen (Ed.), *Constructions in cognitive linguistics: Selected papers from the fifth international cognitive linguistics conference* (pp. 123–140). Amsterdam, The Netherlands: John Benjamins.

- Jackendoff, R. (1983). *Semantics and cognition*. Cambridge, MA: MIT Press.
- Jackendoff, R. (1990). *Semantic structures*. Cambridge, MA: MIT Press.
- Johnson, S. C., Ok, S.-J., & Luo, Y. (2007). The attribution of attention: 9-month-olds' interpretation of gaze as goal-directed action. *Developmental Science, 10*(5), 530–537.
- Johnson, S., Slaughter, V., & Carey, S. (1998). Whose gaze will infants follow? The elicitation of gaze-following in 12-month-olds. *Developmental Science, 1*(2), 233–238.
- Kamewari, K., Kato, M., Kanda, T., Ishiguro, H., & Hiraki, K. (2005). Six-and-a-half month old children positively attribute goals to human action and to humanoid-robot motion. *Cognitive Development, 20*, 303–320.
- Lakusta, L., & Landau, B. (2005). Starting at the end: The importance of goals in spatial language. *Cognition, 96*, 1–33.
- Lakusta, L., & Landau, B. (2012). Language and memory for motion events: Origins of the asymmetry between goal and source paths. *Cognitive Science, 36*(3), 517–544.
- Lakusta, L., Reardon, R., Oakes, L., & Carey, S. (2007, November). A goal bias in pre-linguistic thought and language: How strong is the homology? Paper presented at the Boston University Conference on Language Development, Boston, MA.
- Lakusta, L., Wagner, L., O'Hearn, K., & Landau, B. (2007). Conceptual foundations of spatial language: Evidence for a goal bias in infants. *Language Learning and Development, 3*(3), 179–197.
- Landau, B., & Gleitman, L. R. (1985). *Language and experience: Evidence from the blind child*. Cambridge, MA: Harvard University Press.
- Landau, B., & Jackendoff, R. (1993). "What" and "where" in spatial language and spatial cognition. *Behavioral and Brain Sciences, 16*, 217–265.
- Landau, B., & Zukowski, A. (2003). Objects, motions, and paths: Spatial language in children with Williams syndrome. *Developmental Neuropsychology, 23*(1&2), 107–139.
- Luo, Y., & Baillargeon, R. (2005). Can a self-propelled box have a goal? Psychological reasoning in 5-month-old infants. *Psychological Science, 16*(8), 601–608.
- Luo, Y., Kaufman, L., & Baillargeon, R. (2009). Young infants' reasoning about physical events involving inert and self-propelled objects. *Cognitive Psychology, 58*, 441–486.
- Markovskaya, E. (2006). Goal-source asymmetry and Russian spatial prefixes. *Nordlyd, 33*, 200–219.
- Meltzoff, A. N. (1995). Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. *Developmental Psychology, 31*(5), 838–850.
- Muentener, P., & Carey, S. (2010). Infants' causal representations of state change events. *Cognitive Psychology, 61*, 63–86.
- Muentener, P., & Lakusta, L. (2011). The language of causal events: Exploring the link between representations of intentional action and causal events. *Cognition, 119*, 341–355.
- Nam, S. (2004, March). *Goal and source: asymmetry in their syntax and semantics*. Paper presented at the Workshop on Event Structure, Leipzig, Germany.
- Papafraou, A. (2010). Source-goal asymmetries in motion representation: Implications for language production and comprehension. *Cognitive Science, 34*, 1064–1092.
- Pinker, S. (1984). *Language learnability and language development*. Cambridge, MA: Harvard University Press.
- Pinker, S. (1989). *Learnability and cognition: The acquisition of argument structure*. Cambridge, MA: MIT Press.
- Pinto, J. (1994). MacXHAB (Version 3.1): Experimental control software for Macintosh [Computer software]. Palo Alto, CA: Author.
- Pleh, C. (1998). Early spatial case markers in Hungarian children. In E. V. Clark (Ed.), *Proceedings of the Twenty-Ninth Annual Child Language Research Forum* (pp. 211–219). Stanford, CA: Center for the Study of Language and Information.
- Pruden, S. M., Göksun, T., Roseberry, S., Hirsh-Pasek, K., & Golinkoff, R. M. (2012). Find your manners: How do infants detect the invariant manner of motion in dynamic events? *Child Development, 83*(3), 977–991.
- Pruden, S. M., Hirsh-Pasek, K., Maguire, M. J., & Meyer, M. A. (2004). Foundations of verb learning: Infants form categories of path and manner in motion events. In A. Brugos, L. Micciulla, & C.E. Smith (Eds.), *Proceedings of the 28th annual Boston University Conference on Language Development* (pp. 461–472). Somerville, MA: Cascadilla Press.
- Pulverman, R., Golinkoff, R. M., Hirsh-Pasek, K., & Sootsman Buresh, J. (2008). Manner matters: Infants' attention to manner and path in non-linguistic dynamic events. *Cognition, 108*, 825–830.

- Regier, T. (1996). *The human semantic potential: Spatial language and constrained connectionism*. Cambridge, MA: MIT Press.
- Regier, T., & Zheng, M. (2007). Attention to endpoints: A cross-linguistic constraint on spatial meaning. *Cognitive Science*, 31, 705–719.
- Riemsdijk, H. C. van (2007, April). The case of source and goal: what determine case in German spatial PPs. Paper presented at Harvard Linguistics Theory Group, Cambridge, MA.
- Saxe, R., & Carey, S. (2006). The perception of causality in infants. *Acta Psychologica*, 123, 144–165.
- Saxe, R., Tenenbaum, J., & Carey, S. (2005). Secret agents: Inferences about hidden causes by 10- and 12-month-old infants. *Psychological Science*, 16, 995–1001.
- Saxe, R., Tzelnic, T., & Carey, S. (2007). Knowing-who-dunnit: Infants identify the causal agent in an unseen causal interaction. *Developmental Psychology*, 43(1), 149–158.
- Shiffrin, R. M. (1973). Visual free recall. *Science*, 180(4089), 980–982.
- Shimizu, Y. A., & Johnson, S. (2004). Infants' attribution of a goal to a morphologically unfamiliar agent. *Developmental Science*, 7(4), 425–430.
- Simons, D. J. (2000). Current approaches to change blindness. *Visual Cognition*, 7, 1–15.
- Slobin, D. I. (1985). Crosslinguistic evidence for the language-making capacity. In D. I. Slobin (Ed.), *The crosslinguistic study of language acquisition: Vol. 2. Theoretical issues* (pp. 1157–1256). Hillsdale, NJ: Erlbaum.
- Talmy, L. (1985). Lexicalization patterns: Semantic structure in lexical forms. In T. Shopin (Ed.), *Language typology and syntactic description: Grammatical categories and the lexicon*. Cambridge, England: Cambridge University Press.
- Tutunjian, D., & Boland, J. E. (2008). Do we need a distinction between arguments and adjuncts? Evidence from psycholinguistic studies of comprehension. *Language and Linguistic Compass*, 2, 631–636.
- Wagner, L., & Carey, S. (2005). 12-month-old infants represent probable endings of Motion events. *Infancy*, 7(1), 73–83.
- Wagner, L., & Lakusta, L. (2009). Using language to navigate the infant mind. *Perspectives on Psychological Science*, 4(2), 177–184.
- Woodward, A. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition*, 69, 1–34.
- Woodward, A. (1999). Infants' ability to distinguish between purposeful and non-purposeful behaviors. *Infant Behavior and Development*, 22, 145–160.
- Woodward, A., & Sommerville, J. A. (2000). Twelve-month-old infants interpret action in context. *Psychological Science*, 11(1), 73–77.