

And, the Winner Is... A Visual Preference for Endpoints over Starting Points in Infants' Motion Event Representations

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Infants represent objects that are endpoints in motion events and show a preference for encoding the endpoint (the duck waddles into a *bowl*) over the starting point (the duck waddles out of a *box*). This asymmetry continues to appear in nonlinguistic cognition and language throughout development. This study tests whether this asymmetry also shows up in 16-month-old infants' visual preferences for motion events, and if so, for which types of events. Infants looked longer at events depicting an "agentive" figure (e.g., duck) moving into an object (endpoint) than out of an object (starting point), and this asymmetry persisted even when the starting point object was larger and more colorful than the endpoint object and when it caused the motion of the figure. However, an asymmetry was not found when motion into/out of the endpoint/starting point involved was performed by a "nonagentive" (e.g., leaf) figure. These findings suggest that an endpoint/starting point asymmetry in infant cognition (1) extends to infants' visual preferences of motion events, (2) shows up most strongly for events that involve an "agentive" figure, and (3) is largely unaffected by the physical saliency of the starting point object. How a visual endpoint preference may support the acquisition of spatial language is considered.

The endpoint of an event plays a critical role in structuring event representations for both adults and children. In event perception, endpoints that are goals (i.e., the endpoint of an intentional action) play a role in structuring an event's parts and subparts. For example, the broad goal of climbing to the top in life can be hierarchically decomposed into its subparts of "getting an education," "working to pass the third grade," "walking to school," "crossing the street," etc. (Barker & Wright, 1954; as cited in Zacks & Tversky, 2001), and indeed event segmentation research has shown that adults are sensitive to this hierarchical, partonomic structure of events (Zacks, Tversky, & Iyer, 2001).

Infants 10–11 months of age are also sensitive to boundaries marked by endpoints in intentional events, such as a person picking a towel up off the floor (Baldwin, Baird, Saylor, & Clark, 2001), and 12-month-olds are sensitive to endpoints of highly

complex actions, such as a triple lutz double toe loop in figure skating (Levine, Hirsh-Pasek, & Golinkoff, 2013). Further, it is now well established that infants, prior to 12 months, encode the endpoint object of goal-directed actions (e.g., Csibra, 2008; Johnson, Ok, & Luo, 2007; Lakusta, Wagner, O’Hearn, & Landau, 2007; Lakusta & Carey, 2015; Luo & Baillargeon, 2005; Meltzoff, 1995; Olofson & Baldwin, 2011; Schlottmann & Ray, 2010; Sodian, Schoeppner, & Metz, 2004; Wagner & Carey, 2005; Woodward, 1998, 1999; Woodward & Sommerville, 2000) and make proactive, anticipatory eye movements to endpoint objects when observing various types of reaches and grasps performed by an agent (e.g., Ambrosini et al., 2013; Falck-Ytter, Gredebäck, & von Hofsten, 2006; Henrichs, Elsner, Elsner, Wilkinson, & Gredebäck, 2014). Thus, before their first birthday, endpoints that may be represented as “goals” play an integral role in structuring infants’ event representations. The aim of the current study was to further our understanding about the prominence of endpoints in infants’ motion event representations.

The classic paradigm that has been used to show infants’ encoding of endpoint objects in events involves habituating (or familiarizing) infants to one event and then showing them two different events that differ from the habituation event along one dimension. For example, in the classic Woodward (1998) study, infants were habituated to a hand reaching for one of two endpoint objects and then viewed the hand reach for a different object (but along the same path that it had reached previously) versus the same object (but along a different path). Longer looking at one change relative to the other change (different object versus different path) was taken as evidence that infants encoded the component and considered it a relevant component of the event. Infants as young as 5–6 months looked longer when the hand reached for a different endpoint object; however, they did not show this pattern when the reaching was performed by a mechanical claw. This suggests that the type of figure performing the action (hand versus claw) modulates infants’ encoding of the endpoint object over the path of motion. Since Woodward’s seminal study, studies have shown that a range of behavioral and morphological cues of the figure in the event influence whether infants represent the endpoint as a relevant component of the event; these cues include the type of motion (biological or not; Schlottmann & Ray, 2010), self-propelled movement (Luo & Baillargeon, 2005), rational action (Csibra, 2008), causation at a distance (Schlottmann, Surian, & Ray, 2009), communicative interaction (Shimizu & Johnson, 2004) and having a face (Bonatti, Frot, Zangl, & Mehler, 2002). It is worth noting that theories differ in their interpretations about how infants are representing the endpoint in events, especially for children younger than 18–24 months. For example, some theories posit that infants use certain cues to identify the figure as an animate agent and represent the action as intentional and *goal*-directed (e.g., Biro & Leslie, 2007), while others argue that infants associate certain properties of the figure (e.g., human arm) with particular actions (reach), which in turn results in the endpoint being encoded in some events and not others (e.g., see Rakison & Poulin-Dubois, 2001 for a review).

Recently, studies (Lakusta & Carey, 2015; Lakusta et al., 2007) have adapted the Woodward paradigm described above to test how infants represent endpoint objects in motion events compared to another event component—the starting point. In motion events (duck walks from a bowl to a box), starting points (from a bowl) are similar to endpoints (to a box) in terms of the spatial structure of the event (both are reference objects of paths of motion; Jackendoff, 1990), although in language they have been shown to have a significantly less prominent role than endpoints (e.g., Lakusta &

Landau, 2005; see General Discussion). In these studies, 12-month-old infants were familiarized to a figure moving from one of two starting point objects to one of two endpoint objects. During test, infants viewed the figure move away from a different starting point (but to the same endpoint) versus to a different endpoint (but away from the same starting point). When the figure was a self-propelled duck or a self-propelled balloon with a face, infants looked longer when the figure moved to a different endpoint object. This suggests that infants attended to and remembered the endpoint object more robustly than the starting point object during familiarization and hence were more surprised when it changed during test compared to when the starting point object changed. However, when the figure was a non-self-propelled balloon with a non-face-like pattern, infants did not show an endpoint bias, rather they looked about equally at the endpoint versus starting point change events. Lakusta et al. (2007) and Lakusta and Carey (2015) concluded that the asymmetry between endpoints and starting points is strongest for agentive events.

The current study

The aim of this study was to provide a conceptual replication of the “agentive”/“non-agentive” pattern of results described above with a very different methodology—one that measures infants’ visual preferences for events while tightly controlling for the amount of time that the figure is located at the starting point and endpoint objects. Additionally, this study aimed to further explore the nature of the asymmetry between endpoints and starting points in infant cognition by modulating other properties of motion events. The Lakusta et al. studies described above (2007, 2015) used a change detection method in which the starting point and endpoint objects both participated in the event. And, at the end of the event, the figure remained at the endpoint until a pre-established criterion was reached. Thus, one possibility is that infants may have paid more attention to the endpoint object over the starting point object because the figure was located at the endpoint at the end of the event. In fact, this is exactly the type of explanation that has been offered for an endpoint bias in some models of spatial term learning (Regier, 1996). This explanation seems unlikely given that Lakusta and Carey (2015) did not observe an endpoint bias for “nonagentive” events, but the strongest evidence against this explanation would be to present infants with events in which the figure is located at the starting point and endpoint for the same exact amount of time. This study does just this by employing a visual preference paradigm in which infants view events with only a starting point object (duck moves out of the box) and with only an endpoint object (duck moves into a box) and, importantly, the events loop, such that the figure is located at the endpoint and starting point for the same amount of time. Utilizing this paradigm also provides the opportunity to explore at what level of information processing such an endpoint bias may exist in infants; rather than testing infants’ memory representations of an event that they viewed during a prior familiarization/habituation period, this study’s visual preference paradigm will simply measure which types of events infants prefer to look at—events with endpoint objects or events with starting point objects. Visual preferences have been reported in domains such as face perception (e.g., Johnson, Dziurawiec, Ellis, & Morton, 1991; Langlois et al., 1987) and motion perception (Simion, Regolin, & Bulf, 2008) and have been shown to play a significant role in infants’ subsequent learning about the environment. Our aim is to establish whether there is a visual preference for

motion events depicting a figure moving into an endpoint object versus out of a starting point object and, if there is, to raise hypotheses about how this preference could support subsequent language learning.

This study tests 16-month-old infants. As will be discussed at length in the General Discussion, previous findings (Lakusta & Carey, 2015; Papafragou, 2010; Regier & Zheng, 2007) suggest that an endpoint/starting point asymmetry in nonlinguistic/preverbal cognition may play a significant role in bootstrapping children's acquisition of spatial language, such as acquiring the semantic and syntactic structure of motion verbs and prepositional phrases that encode starting points ("Jessica ran from the store") and endpoints ("Nicholas ran to the pond"). If this is the case, then any visual preference for endpoints versus starting points should show up during the time in development when children are in the midst of acquiring such spatial language. Research in language acquisition suggests that the period between 12 and 24 months is an active time for the development of spatial language cross-linguistically, with children around 14 months starting to produce language encoding starting points and endpoints in motion events (prepositions in English, such as "on," "into," "out of," and "off," Choi & Bowerman, 1991) and children by 18 months starting to broaden their understanding of prepositions such as "on" (Meints, Plunkett, Harris, & Dimmock, 2002). Thus, if a visual preference for endpoint events influences spatial language acquisition, then such a preference should exist at 16 months.

EXPERIMENT 1

Method

Participants

Twenty-six 16-month-old infants participated; 13 infants in each of the "agentive" and "nonagentive" conditions ("agentive" condition: nine females; mean age = 15 months, 27 days; range: 15 months, 16 days to 16 months, 14 days; "nonagentive" condition: six females; mean age = 15 months, 22 days; range: 15 months, 15 days to 16 months, 16 days). One additional infant was excluded in the "agentive" condition because of fussiness that prevented the experiment from finishing and three additional infants were excluded in the "nonagentive" condition, two because of fussiness and the third because of a technical error.¹ Fussiness was either excessive crying by the infant or an unwillingness to sit on the caregiver's lap.

Stimuli

Infants were shown motion events that were created in Adobe Flash. The motion events depicted a figure (object undergoing the motion) moving out of an object (henceforth the "starting point") *or* into an object (henceforth the "endpoint"). The figures for the "agentive" condition were a duck and a plane and the figures for the

¹For ease of exposition, we refer to the two conditions in Exp. 1 as "agentive" and "nonagentive." However, we acknowledge that it is an open question whether infants actually represent the moving figure as an intentional, goal-directed agent (see Introduction and General Discussion). We use quotes when referring to the experimental conditions to remind readers of this point.

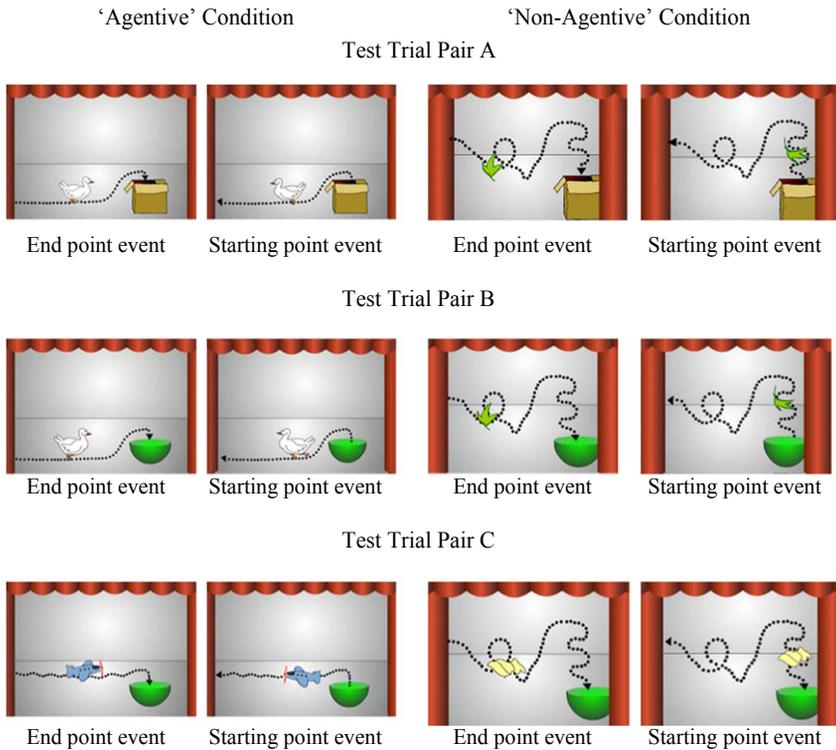


Figure 1 Test events used in Experiment 1, for both the “agentive” and “nonagentive” conditions, respectively. Pair A: A duck walks into a box (endpoint event) and a duck walks out of a box (starting point event)/A leaf floats into a box (endpoint event) and a leaf floats out of a box (starting point event). Pair B: A duck walks into a bowl (endpoint event) and a duck walks out of a bowl (starting point event)/A leaf floats into a bowl (endpoint event) and a leaf floats out of a bowl (starting point event). Pair C: A plane flies into a bowl (endpoint event) and a plane flies out of a bowl (starting point event)/A tissue floats into a bowl (endpoint event) and a tissue floats out of a bowl (starting point event). Note that the events were displayed sequentially (rather than simultaneously; see Method).

“nonagentive” condition were a leaf and a tissue. A plane was included as a figure for the “agentive” condition as an exploratory trial to test whether infants would show a similar pattern of looking as they would show for the duck events (a duck is arguably more likely to be represented as an agent than a plane given that it is an animal and has a face). The starting point and endpoint reference objects were a box and a bowl (see Figure 1). All the events began with an animated curtain opening (.5 sec). Then, for the events including endpoints, the figure emerged from behind the animated curtain and moved (.75 sec) into an endpoint object (and remained there for .75 sec). The animated curtain then closed (.5 sec) and remained closed (.25 sec). The event would then begin playing again; thus, the events looped. The events including starting points were *exactly* the same as the endpoint events except the figure moved out of an object that was its starting point and ended up behind the animated curtain. Whether the endpoint (starting point) objects were located on the right or left side of the stage was counterbalanced across infants.

In addition to the “agentive” and “nonagentive” conditions differing in the type of figure that moved (duck/plane for the “agentive” condition and tissue/leaf for the “nonagentive” condition), the “agentive” and “nonagentive” events also differed in the following ways: (1) given that self-propelled motion is one cue that infants may use to infer goal-directed motion (e.g., Luo, Kaufman, & Baillargeon, 2009), the leaf/tissue events were constructed such that self-propelled motion was not an obvious property of the leaf/tissue; this was accomplished by having an animated curtain partially cover the objects during the test events to make it ambiguous as to how the figure initiated its movement, and (2) the duck/plane in the “agentive” condition moved in a straight path to the endpoint/away from the starting point (the duck “walked”, the plane “flew”), whereas the leaf/tissue in the “nonagentive” condition moved in a circuitous fashion, as to appear as if it was being blown around by wind (see Figure 1). Other than these differences, the events were exactly the same.

Design and procedure

The stimuli were presented on a projection screen. A curtain was attached to the ceiling in front of and above the screen and was raised at the beginning of each trial and was lowered at the end of each trial. The infant sat on their caregiver’s lap about two feet in front of the screen. The parent was asked to close his or her eyes for the duration of the experiment. The infant’s looking time at the screen was recorded by a trained observer. The observer watched the infant on a computer monitor and pressed a key on a computer keyboard whenever the infant looked at the screen. Looking time was not recorded until the infant looked at the event for at least 2.5 continuous seconds; this ensured that the infant viewed the beginning of the event. A computer program (Xhab) calculated the infant’s looking time (Pinto, 1994). When the infant looked away from the screen for two continuous seconds, or until 60 sec had elapsed, the computer program beeped to signal to the experimenter to proceed to the next trial.

The experiment began with the coder calibrating the infants’ looking space by jiggling keys to direct infants’ attention to the top, bottom, center and sides of the screen. After calibration, there was a familiarization phase. The purpose of this phase was to acquaint the infants with the figures and reference objects that they would view during the test phase. During this familiarization phase, infants viewed eight events: four events depicted the figure (2 duck events and two plane events for the “agentive” condition; two leaf events and two tissue events for the “nonagentive” condition) moving back and forth (4 sec) and four events depicted the stationary reference objects (box/bowl) located next to each other (4 sec). For two of the events, the box was located to the left of the bowl, and for the other two events, the bowl was located to the left of the box. The eight familiarization events were always presented such that the figure events preceded the reference object events (e.g., duck, plane, duck, plane, box/bowl, bowl/box, box/bowl, and bowl/box). Whether the duck/plane (leaf/tissue) was presented first was counterbalanced across infants, and the two types of figures were always presented in an alternating fashion (e.g., duck, plane, duck, plane). The familiarization events were presented sequentially and looped until the pre-established looking criterion was reached.

After familiarization, infants were presented with six test events that were presented as a set of three pairs, each pair consisting of an endpoint event and a starting point

event: duck (leaf) moves into/out of box (pair A), duck (leaf) moves into/out of bowl (pair B), and plane (tissue) moves into/out of bowl (pair C)² (see Figure 1). The order in which the pairs were presented was counterbalanced across infants. Further, whether the endpoint or starting point motion event was presented first or second in the pair was counterbalanced across infants (but held constant within each participant; for example, if the endpoint event was presented first, it was presented first for each pair for that participant). The test events were presented sequentially and looped until the pre-established looking criterion was reached (see above).

Reliability

To assess coding reliability, 100 percent of the infants were coded by a second trained observer. Average percent agreement between coder one and coder two was calculated by Xhab. Average interobserver agreement was 94.7% for the “agentive” condition, 94.9% for the “nonagentive” condition, and 95.2% and 96.0% percent for experiments 2 and 3, respectively.

Results

Infants’ looking times at the familiarization events to each figure declined from the first to the second presentation (“agentive”: M_s (SE_s) for duck events = 32.79 (5.04), 20.65 (4.73); M_s (SE_s) for plane events = 26.31 (5.23), 16.71 (4.73)); “nonagentive”: M_s (SE_s) for leaf events = 25.63 (4.73), 13.53 (2.0); M_s (SE_s) for tissue events = 21.53 (5.78), 17.75 (5.13)). On average, infants in the “agentive” condition looked longer at the duck events ($M = 26.72$, $SE = 3.75$) than the infants in the “nonagentive” condition looked at the leaf events ($M = 19.58$, $SE = 2.21$), although the difference was not significant, $t(24) = 1.64$, $p = .11$ ($d = .66$). The difference between looking at the plane events ($M = 21.51$, $SE = 3.92$) for infants in the “agentive” condition compared to the tissue events ($M = 19.64$, $SE = 4.44$) for infants in the “nonagentive” condition was much less and also not significant, $t(24) = .32$, $p = .76$ ($d = .12$).

For both the “agentive” and “nonagentive” conditions, infants’ looking times declined over familiarization (henceforth, “Fam”) to the reference objects (M_s and SE_s for “agentive” Fam 1 versus 4 = 18.06 (3.84) versus 6.31 (1.14) and “nonagentive” Fam 1 versus 4 = 22.18 (3.84) versus 8.24 (1.14)); a mixed 2 (Fam trial: Fam 1, Fam 4) \times 2 (Cond: “agentive,” “nonagentive”) ANOVA revealed a significant main effect of Fam trial, $F(1, 24) = 22.86$, $p < .001$ ($\eta^2 = .49$). There was no significant main effect of condition, $F(1, 24) = 1.04$, $p = .318$ ($\eta^2 = .04$), nor was there a significant interaction between Fam trial and condition $F(1, 24) = .165$, $p = .688$ ($\eta^2 = .007$).

A 2 \times 3 \times 2 mixed ANOVA examined the effects of trial type (endpoint, starting point), test trial pair (A, B, C), and condition (“agentive,” “nonagentive”) on looking times during the test trials. This yielded a significant effect of test trial type, $F(1, 24) = 8.34$, $p = .01$ ($\eta^2 = .26$); however, this main effect was subsumed by a significant interaction between trial type and condition, $F(1, 24) = 4.59$, $p = .04$ ($\eta^2 = .16$); as

²A plane/tissue + box pair was not included because previous experiments revealed that four test trial pairs resulted in too long a test phase. The purpose of including three different trial pairs (rather than simply repeating the same two) was to explore the generalizability of any visual preferences that may be observed across different objects. If a visual preference is robust, it should extend to different objects of the same type—a finding that was observed (see Result sections).

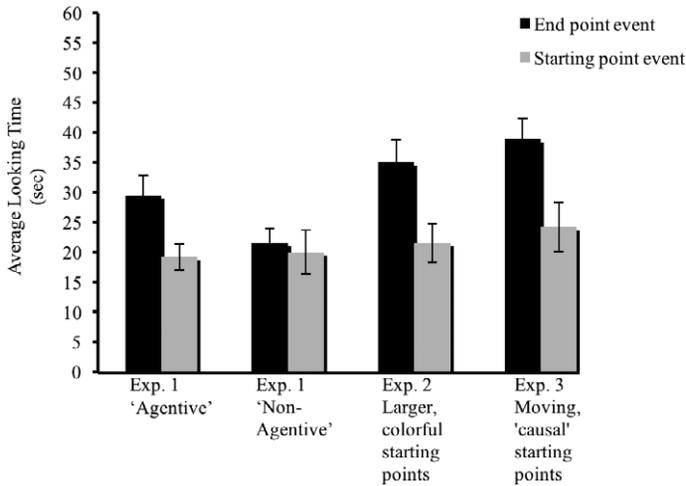


Figure 2 Infants' average looking times (and *SEs*) at the endpoint and starting point test trials for Experiment 1 "agentive"/"nonagentive," Exp. 2, and Exp. 3.

shown in Figure 2, the difference between looking at the endpoint versus starting point trials was greater for infants in the "agentive" condition versus the "nonagentive" condition. There were no other significant main effects or interactions, $ps > .10$.

Additional analyses examining each condition separately confirmed this pattern; two separate 2×3 ANOVAs examined the effects of trial type (endpoint, starting point) and test trial pair (A, B, C) on looking times during the test trials. For the "agentive" condition, there was a significant main effect of trial type, $F(1, 12) = 15.85$, $p < .05$ ($\eta^2 = .57$); infants looked longer at endpoint events than starting point events and 11 of 13 infants showed this pattern, Wilcoxon signed-ranks test, $z = -2.83$, $p < .05$, two-tailed. There were no other significant effects $ps > .10$. Although there was no interaction between trial pair and trial type for the "agentive" condition, the pattern of the means (Figure 3) suggests that test trials with the plane elicited less of a looking preference for endpoints than for starting points than the trials with the duck. Given that the plane may arguably be perceived as less "agentive" than the duck, this pattern is not surprising and is consistent with the results of the "nonagentive" condition presented below. If the plane trial pair is removed from all the analyses, the results remain exactly the same.

For the "nonagentive" condition, the effect of trial type (endpoint versus starting point) was not significant $F(1, 12) = .23$, $p = .64$, nor was the effect of trial pair or the interaction between these two variables, $ps > .10$ (see Figure 4).

Additional analyses tested whether any of the counterbalanced variables (endpoint trial presented first or second, reference objects positioned right or left in the event, and male or female) affected looking times during the test trials. These analyses did not produce any significant results for the "agentive" condition in Exp. 1 or for experiments 2 and 3. However, for the "nonagentive" condition in Exp. 1, a significant interaction was found between trial type and whether the endpoint test trial was presented first or second. $F(1, 11) = 8.79$, $p < .05$, $\eta_p^2 = .44$. Further examination of the means revealed that infants who viewed the endpoint events first in the presentation of the test trial pairs looked longer at the starting point events ($M = 23.20$, $SE = 5.03$) versus

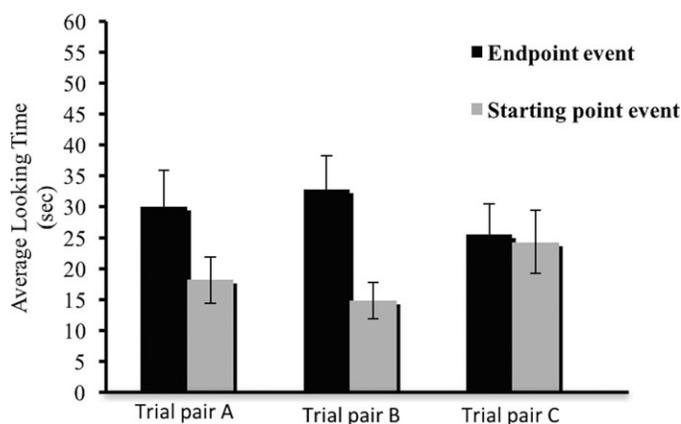


Figure 3 Infants' mean looking times (and *SEs*) at the three endpoint and starting point test trial pairs in Experiment 1, “agentive” condition. *Note:* The average difference scores (and *SEs*) for trial pairs, A, B, and C, respectively, are 11.74 (5.07), 17.9 (4.86), and 1.24 (5.66).

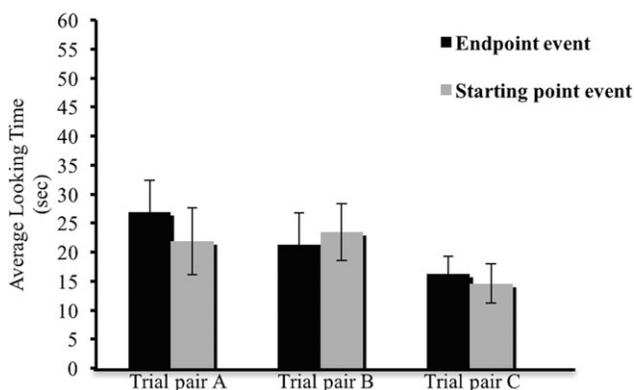


Figure 4 Infants' mean looking times (and *SEs*) at the three endpoint and starting point test trial pairs in Experiment 1, “non-agentive” condition. *Note:* The average difference scores (and *SEs*) for trial pairs, A, B, and C, respectively, are 5.05 (6.22), -2.12 (7.74), and 1.65 (2.63).

the endpoint events ($M = 17.94$, $SE = 3.11$), whereas infants who viewed the starting point events first looked longer at the endpoint events ($M = 25.67$, $SE = 3.36$) than the starting point events ($M = 16.23$, $SE = 5.43$). Thus, infants looked longer at the event that was presented on their second test trial, suggesting that they noticed some difference between the two events—possibly a difference related to the trajectory of the figure's motion.

Extending the results of previous research (Lakusta & Carey, 2015; Lakusta et al., 2007), the current findings revealed that infants looked longer at events depicting a figure moving into an endpoint object versus events depicting a figure moving out of a starting point object and, further, that this visual preference showed up most strongly for events with an animated duck that moved along a straight path into/out of an endpoint/starting point. The presence of this visual preference in infants 16 months of age may have important implications for language learning—a possibility that we consider further in the General Discussion.

If an endpoint bias has implications for subsequent learning, it will be necessary to understand under what conditions this asymmetry may be modulated. The findings above (see also Lakusta & Carey, 2015) suggest that event properties associated with agents (e.g., face, self-propelled movement toward an object) influence the asymmetry; Experiments 2 and 3 test whether increasing the physical saliency of the starting point object may also modulate the observed visual preference. In Experiment 2, the starting point objects are made more salient by increasing their size relative to the endpoint objects and making them more colorful. In Experiment 3, the starting point objects are made more physically salient by making them move; specifically, they *cause* the motion of the figure (the “cannon” propels the duck).

EXPERIMENT 2: LARGER, MORE COLORFUL STARTING POINT OBJECTS

Method

Participants

Participants were 13 16-month-old infants (seven female; mean age = 16 months, 7 days; range: 15 months, 21 days to 16 months, 18 days). One additional infant was excluded because of fussiness.

Stimuli, design, and procedure

The stimuli, design, and procedures were exactly the same as those used in Experiment 1 with the following two exceptions. When the reference objects were starting points in events, they were made more physically salient; the box and bowl objects were made larger and more colorful (see reference objects in Figure 5). In addition, as there were now four different reference objects that would be used in the test events (salient bowl, ordinary bowl, salient box, ordinary box), the four familiarization events depicting the reference objects included the four objects (e.g., ordinary box, salient box, ordinary bowl, salient bowl) stationary on the stage located next to each other.

Results

Infants' looking times at the familiarization events to each figure declined from the first to the second presentation (M s (SE s) for duck events = 40.28 (5.83), 22.67 (4.89); M s (SE s) for plane events = 37.76 (5.57), 17.90 (4.01)). Infants' looking times declined over familiarization to the reference objects; the difference between looking time at the first ($M = 22.79$, $SE = 5.31$) versus last ($M = 11.55$, $SE = 3.25$) familiarization trial was significant, paired $t(12) = 2.17$, $p = .05$, two-tailed ($d = .64$).

A 2×3 ANOVA examined the effects of trial type (endpoint, starting point) and test trial pair (A, B, C) on looking times during the test trials (see Figure 6). There was a significant main effect of trial type, $F(1, 12) = 20.28$, $p < .05$ ($\eta_p^2 = .628$). There was no significant main effect of trial pair, $F(2, 24) = .22$, $p > .10$ ($\eta_p^2 = .018$), nor was there a significant interaction between these two variables $F(2, 24) = .49$, $p > .10$ ($\eta_p^2 = .04$). Twelve of 13 infants looked longer at endpoint events than starting point events, Wilcoxon signed-ranks test, $z = 3.11$, $p < .05$, two-tailed.

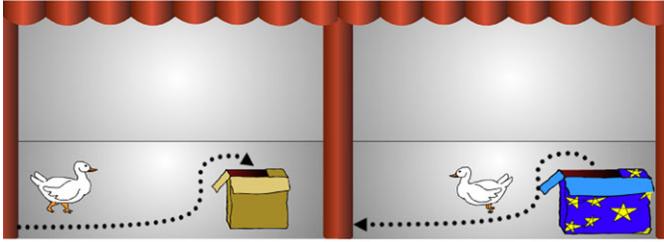
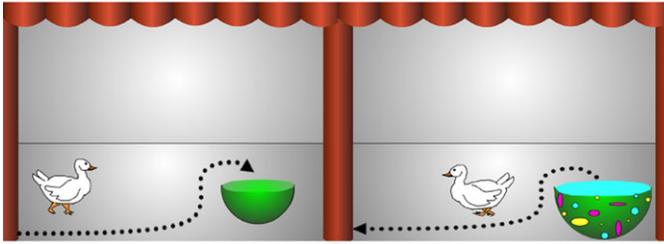
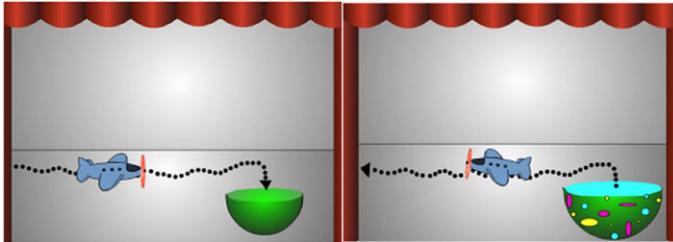
Test Trial Pair A.*Test Trial Pair B.**Test Trial Pair C.*

Figure 5 Test events used in Experiment 2. Pair A: A duck walks into a box (endpoint event) and a duck walks out of a salient box (starting point event). Pair B: A duck walks into a bowl (endpoint event) and a duck walks out of a salient bowl (starting point event). Pair C: A plane flies into a bowl (endpoint event) and a plane flies out of a salient bowl (starting point event).

The results suggest that even when the starting point object is larger and more colorful than the endpoint object, infants continue to look longer at the events depicting a figure moving into an endpoint versus out of a starting point. To confirm that the endpoint bias observed in this experiment was not significantly different than the endpoint bias observed in the “agentive” condition of Experiment 1, a 2×2 mixed ANOVA examined the effects of trial type (endpoint, starting point) and experiment (Exp. 1 “agent,” Exp. 2) on looking times during the test trials (see Figure 2). This yielded a significant main effect of trial type, $F(1, 24) = 36.13, p < .05$ ($\eta_p^2 = .60$); the main effect of experiment was not significant, $F(1, 24) = .95, p > .10$ ($\eta_p^2 = .04$), nor was the interaction between trial type and experiment, $F(1, 24) = .66, p > .10$

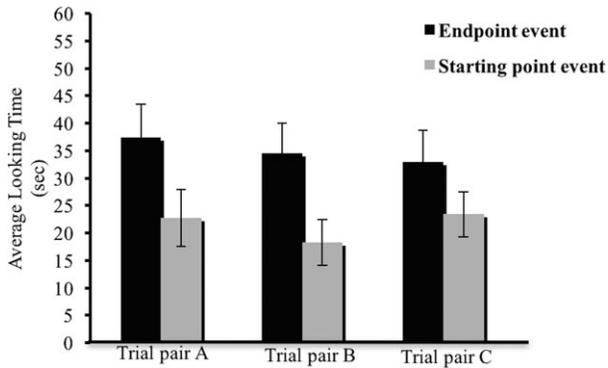


Figure 6 Infants' mean looking times (and *SEs*) at the three endpoint and starting point test trial pairs in Experiment 2. *Note:* The average difference scores (and *SEs*) for trial pairs, A, B, and C, respectively are 14.69 (6.47), 16.25 (4.08), and 9.59 (4.25).

($\eta_p^2 = .03$). Thus, unlike the findings reported in Experiment 1 where the visual preference for endpoints was modulated by changing the properties of the moving figure and motion, increasing the physical saliency of the starting point object did not have a similar effect.

In the last experiment, we further explore the effects of making the starting point more physically salient on a visual preference for endpoint events. We do this by making the starting point *cause* the motion of the figure (a cannon propels the duck out of the starting point versus the duck moves into the endpoint). Making the starting point causal increases the physical salience of the starting point because rather than being a stationary reference object, it now has a part (spring) that moves to propel the figure (see Figure 7), and research reports that a moving object captures infants' attention (Slater, 1989). It is also possible that having the starting point cause the motion of the figure may lead infants to construe the starting point as causal and/or agentive (e.g., Cohen & Amsel, 1998; Golinkoff & Kerr, 1978; Leslie & Keeble, 1987; Muentener & Carey, 2010; Saxe, Tenenbaum, & Carey, 2005), which in turn may result in infants attending more to it since the initial movement of the figure is now dependent on the starting point. Indeed, Henrichs, Elsner, Elsner, and Gredebäck (2012) report that modulating properties of an endpoint object that are relevant for goal-directed reaching actions (size of the endpoint object) influences infants' action prediction; making the starting point causal, the figure's motion may have similar effects. A third possibility is that with a causal starting point the figure may be perceived as less agentive. All these possibilities lead to the prediction that the asymmetry between endpoint and starting point events may lessen for events with causal starting points. However, recent findings by Lakusta et al. (2016) suggest that an endpoint bias persists when young children and adults describe events with causal starting points, and preliminary data reported by Rear-don, Lakusta, Muentener, and Carey (2009) suggest that 12-month-old infants continue to encode the endpoint more than the starting point even when the starting point is causal, leading to the prediction that infants may continue to show a visual preference for endpoint events despite the starting point being more physically salient and causal.

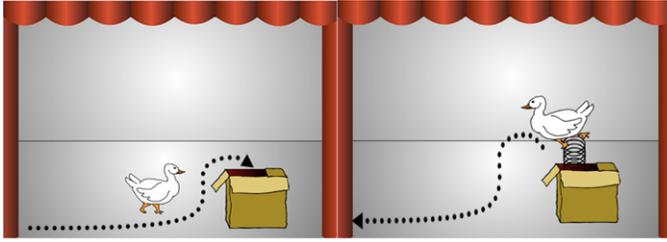
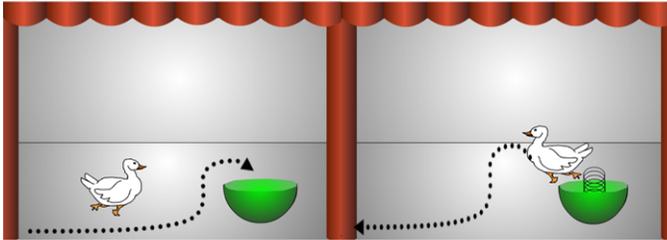
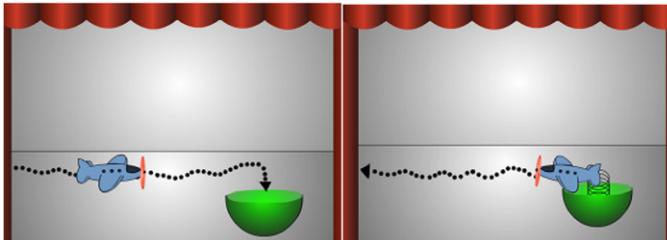
Test Trial Pair A.*Test Trial Pair B.**Test Trial Pair C.*

Figure 7 Test events used in Experiment 3. Pair A: A duck walks into a box (endpoint event) and a duck is sprung out of a box (starting point event). Pair B: A duck walks into a bowl (endpoint event) and a duck is sprung out of a bowl (starting point event). Pair C: A plane flies into a bowl (endpoint event) and a plane is sprung out of a bowl (starting point event).

EXPERIMENT 3: MOVING, CAUSAL STARTING POINTS

Method

Participants

Participants were 13 16-month-old infants (seven female, Mean age = 16 months, 2 days; range: 15 months, 18 days to 16 months, 14 days). One additional infant was excluded because of experimenter error.

Stimuli, design, and procedure

The stimuli, design and procedures were exactly the same as those used in Experiment 1 with the following exception. When the reference objects were starting point objects in the events, they were made more salient; the box and bowl objects were

made to include a mechanism that moved to cause the motion of the figure (see Figure 7). To confirm that the starting point events were successful in portraying that the starting point caused the motion of the figure, 14 adults were asked to describe the events and their language was coded as causal or not (either using a verb that encoded the cause and effect and/or encoding the mechanism of causation, such as the spring). Adults described these events with causal language (e.g., “duck sprung out of bowl”) over 75% of the time, whereas they never encoded the corresponding endpoint events with causal language. This suggests the starting point events portrayed causation (at least for adults). In addition, similar to Experiment 2, as there were now four different reference objects that would be used in the test events (causal bowl, ordinary bowl, causal box, ordinary box), the four familiarization events depicting the reference objects included the four objects.

Results

Infants' looking times at the familiarization events to each figure declined from the first to the second presentation (M_s (SEs) for duck events = 39.44 (5.92) and 24.11 (4.51); M_s (SEs) for plane events = 33.68 (5.09) and 29.58 (6.76)). Infants' looking times declined over familiarization to the reference objects; the difference between looking time at the first ($M = 29.17$, $SE = 5.15$) versus last ($M = 11.14$, $SE = 1.68$) familiarization trial was significant, paired $t(12) = 3.60$, $p = .004$, two-tailed ($d = 1.19$).

A 2×3 ANOVA examined the effects of trial type (endpoint, starting point) and test trial pair (A, B, C) on looking times during the test trials (see Figure 8). There was a significant main effect of trial type, $F(1, 12) = 27.03$, $p < .05$ ($\eta_p^2 = .69$). There was no significant main effect of trial pair, $F(2, 24) = .35$, $p > .10$ ($\eta_p^2 = .03$), nor was there a significant interaction between these two variables $F(2, 24) = .19$, $p > .10$ ($\eta_p^2 = .015$). Twelve of 13 infants looked longer at endpoint events than starting point events, Wilcoxon signed-ranks test, $z = 3.06$, $p < .05$, two-tailed.

The results suggest that even when the starting point has a mechanism that moves, infants continue to look longer at events where a figure moves into a stationary “non-moving” endpoint versus events where a figure moves out of a moving starting point

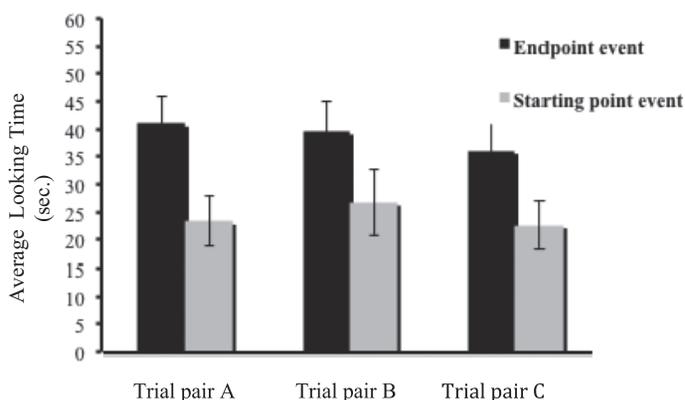


Figure 8 Infants' mean looking times (and SEs) at the three endpoint and starting point test trial pairs in Experiment 3. *Note:* The average difference scores (and SEs) for trial pairs, A, B, and C, respectively, are 17.72 (4.69), 12.88 (5.65), and 13.46 (6.69).

that causes the motion of the figure. To confirm that the endpoint bias was not significantly modulated by the increased saliency/causality of the starting point, a 2×2 mixed ANOVA examined the effects of trial type (endpoint, starting point) and experiment (Exp. 1 “agentive” condition, Exp. 3) on looking times during the test trials (see Figure 2). This yielded a significant main effect of trial type, $F(1, 24) = 42.56, p < .05$ ($\eta_p^2 = .64$); the interaction between experiment and test trial type was not significant $F(1, 24) = 1.32, p > .10$ ($\eta_p^2 = .05$), nor was the main effect of experiment, $F(1, 24) = 2.84, p > .10$.

GENERAL DISCUSSION

When 16-month-old infants viewed events depicting a figure moving into an endpoint object versus events depicting a figure moving out of a starting point object, infants looked longer at the endpoint object events. This asymmetry in looking time was observed for events where both the starting point and endpoint were stationary, solid colored reference objects (Exp. 1, “agentive” condition; e.g., the duck moved into/out of a box), as well as for events where the starting point objects were larger in size and more colorful than the endpoint objects (Exp. 2), and when the starting point objects involved movement and caused the motion of the figure (Exp. 3). In contrast, infants did not look significantly longer at the endpoint events when the events depicted a “nonagentive” figure move into versus out of an object (Exp. 1, “nonagentive” condition; e.g., the leaf flew into/out of a box). This pattern of results has implications for understanding the nature of the asymmetry between starting points and endpoints in infants’ motion event representations and for understanding how a visual preference for endpoints may support subsequent learning. The findings also raise several questions for future research.

The nature of an endpoint/starting point asymmetry in infant cognition

The methodology used in the current study, specifically the looped video presentation of the starting point and endpoint events, rules out any possibility that previous reports of an endpoint/starting point asymmetry can be explained by the figure being located at the endpoint in the motion event for a longer amount of time than the starting point (Lakusta & Carey, 2015; Lakusta et al., 2007). By having the events loop, the length of time that the figure remained stationary at the starting point and endpoint was exactly the same. Further, unlike previous studies, infants were not tested on how long they looked at events that had either a different endpoint (e.g., into a bowl versus onto a block) versus a different starting point (out of a bowl versus off a block) *compared to prior familiarization*. Rather, duration of infants’ gaze was measured for events that either had an endpoint (e.g., into a box) or a starting point (e.g., out of a box), and the results revealed a visual preference for endpoint events. One question raised for future research is whether such a visual preference extends to other spatial paths, such as paths involving support (moving on/off of an object) and toward/away (moving to/from an object). The language findings described in the latter part of this discussion suggest that an endpoint bias is quite general in language, extending to events with a variety of spatial paths; if an endpoint bias in infant

representations reflects the bias found in language, then infants' visual preference for endpoint over starting point events should extend to a variety of spatial relations as well.

The visual preference for endpoints over starting points observed in the current study was influenced by the kind of figure (e.g., duck versus leaf) and/or the type of motion taken by the figure (self-propelled with a direct path versus ambiguous motion initiation with a circuitous path), but *not* by the physical saliency of the starting point objects (Exp. 2: bigger and more colorful; Exp. 3: moving starting point). This suggests that infants' preference for endpoint over starting point events may be influenced by event properties related to agency, and maybe causality,³ and does not apply generally to all endpoints and starting points in spatial events (such as proposed by Regier & Zheng, 2007). Note that this pattern of results is consistent with Lakusta and Carey (2015) who employed a very different methodology (see Introduction), including different "agentive" and "nonagentive" events. Recall that in that study the "nonagentive" events included a balloon (without a face) "floating" along a straight path from a starting point to an endpoint. The similar pattern of results across the two studies despite the differences in methodologies suggests that the looking time differences found for the "agentive" versus "nonagentive" events is likely to be a result of how the events differ in the cues that they portray related to agency and/or causality, rather than as a result of superficial differences between the events. Below, we consider two possible explanations of why infants in the current study may have shown a visual preference for endpoint events over starting point events, thus shedding light on how a visual preference for endpoints over starting points may develop more generally.

One explanation, based on theories referred to as "cue-based bootstrapping" (see Biro & Leslie, 2007), is that the "agentive" events in the current study (Experiments 1—"agentive," 2, and 3) displayed cues that led infants to interpret the events as agentive and goal-directed, and as a result, infants preferred to look at motion events with an agent moving to a clear endpoint (goal) over events without a clear endpoint (i.e., the starting point events). Further, following Gergely and Csibra (2003), infants may have been interpreting the event in terms of the efficiency of the action in which the endstate was achieved. If the action performed by the figure was efficient, such as the figure moving along a direct path to the endpoint, then the action was interpreted as goal-directed and rational; the endpoint was represented as an integral part of the event and more attention was allocated to processing it. In contrast, if the action performed by the figure was inefficient, such as the figure moving in a circuitous path to an endpoint, then the action was not interpreted as goal-directed or rational and further attention was not allocated to it. If the figure moved in a straight path out of the nest (an efficient action), then one prediction is that infants may represent the endstate as getting away from the starting point and the one question for future research is if getting away from the starting point was portrayed to be an overarching goal of the event (e.g., a duck moves out of a nest because the nest is on fire), would the visual preference for an endpoint over a starting point diminish? asymmetry in looking may very well disappear.

³With respect to causality, note that in the nonagentive condition of Exp. 1, the events were constructed such that the cause of motion of the figure (leaf/tissue) was obscured (see Method). In Exp. 3, the starting point events were constructed such that the starting point clearly caused the motion of the figure. Thus, perhaps when the cause of motion is obscure, infants reason about what caused the motion of the figure and allocate less attention to the endpoint and starting point in the events.

Another possibility is that infants may have looked longer at the endpoint events in experiments 1 (“agent”), 2, and 3 because they have learned to associate certain behavioral and/or morphological cues of the moving figure (e.g., self-propelled straight path motion, face) with the outcome of the moving figure reaching an endpoint object, whereas the association between the starting point and these cues is not as strong. Factors such as the distance between the figure and endpoint object decreasing as the event unfolds (the duck approaches the endpoint object) may play a role in the differing association strengths.⁴ Infants may have also made anticipatory, predictive looks at the endpoint object given that the action was performed by an “agent” (see Falck-Ytter et al., 2006; Henrichs et al., 2014), and these anticipatory looks may have contributed to the increased attention to the endpoint events. Future research can test this possibility by examining the precise looking patterns of infants over the course of the event. Under what conditions do infants make predictive eye movements to the endpoint? Note that the learning scenario proposed by this explanation does not necessitate that infants interpreted the figure in the events as animate/agentive or interpreted the event as intentional; rather, the proposal is that infants have learned from their experiences to associate certain cues in the events with endpoints more than starting points (see Rakison & Poulin-Dubois for an detailed discussion of this view, 2001). Indeed, research has shown that infants are sensitive to statistical regularities in their input in a variety of domains (e.g., Saffran, Aslin, & Newport, 1996), including representations of goal-directed actions by 12 months (Henrichs et al., 2014).

One interesting question for future research is whether a visual preference for endpoint events over starting point events may be related to infants’ own engagement in certain types of goal-directed actions (e.g., Falck-Ytter et al., 2006 and see Rakison & Woodward, 2008 for a review). The 16-month-old infants in the current study were likely to be crawling and maybe walking; Are these locomotor abilities related to the endpoint event preference that was observed? Future research could explore this by testing whether younger infants, who are not yet crawling or walking, show a visual preference for endpoints versus starting points and importantly for what types of events (“agentive” versus “nonagentive”).

Mapping of infants’ event representations into language

The current finding that 16-month-olds show a visual preference for endpoint events over starting points events contributes to existing literature reporting other perceptual biases in infants, such as infants’ preferences for faces over nonfaces (e.g., Johnson et al., 1991), biological over nonbiological motion (Simion et al., 2008), and infant-directed speech over adult-directed speech (e.g., Werker & McLeod, 1989). It has been suggested that such biases play a role in learning because they drive attention to important information in the environment (such as attention to word boundaries, in the case of segmenting words in language learning, Thiessen, Hill, & Saffran, 2005). We hypothesize that a visual preference for endpoint versus starting point events may also support subsequent learning, specifically learning about the semantic and syntactic argument structure of motion verbs in language. We consider this hypothesis in more detail below.

⁴We thank an anonymous reviewer for bringing the idea of associative learning to bear on the observed endpoint/starting point asymmetry.

As discussed in the Introduction, by 16 months (the age of the infants in the current study), infants comprehend, and sometimes even produce, language encoding spatial paths and their endpoints (referred to as “goal paths” in language) and spatial paths and their starting points (referred to as “source paths” in language; Bowerman, 1996; Choi & Bowerman, 1991). In addition, much research has shown that there is a robust asymmetry between goal and source paths, both in language structure and in language use, and this asymmetry holds cross-linguistically (see Lakusta & Landau, 2012). In syntactic structure, linguists propose that the endpoint is a direct argument of the verb, whereas the starting point is an adjunct; in semantic structure, “goal paths” constitute *core* events (result states), whereas “source paths” *modify* the process of the event (e.g., Filip, 2003; Markovskaya, 2006; Nam, 2004). This privileged role of endpoints in semantic and syntactic structure is supported by studies reporting that when children and adults are asked to describe events, they include the endpoint object and its path more frequently in their descriptions than the starting point and its path, saying, for example, “the bird flew *into the pot*,” rather than, for example, “the bird flew *out of the bowl*” when viewing an event of a bird flying out of a bowl into a pot (Lakusta & Landau, 2005). Notably, this asymmetry in language also holds for motion events involving a nonagentive figure (e.g., leaf blows from a coaster onto a tape; Lakusta & Landau, 2012).

How can a visual preference for endpoints over starting points in infants support learning the semantic and syntactic structure of goal and source paths in language, such that goal paths get mapped into linguistic structure as arguments of motion verbs, whereas source paths get mapped as adjuncts? Infants’ preferential attention to endpoints (as shown in the current study) and their bias to encode endpoints over starting points (as shown by Lakusta et al., 2007; Lakusta & Carey, 2015) suggest that when infants view motion events they may consider the endpoint but not the starting point as an essential component of the event (i.e., as important information in the environment). Then, when they are presented with the problem of figuring out the reference of a motion verb (e.g., “run,” in English), they may consider the endpoint, but not the starting point, an integral part of the verb’s meaning. Given that children are able to map nonverbal representations into semantic and syntactic representations, and given that they distinguish arguments from adjuncts, during language acquisition, they may represent the endpoint as an argument of the verb and represent the starting point as an adjunct (modifier). Furthermore, consistent with how language often represents events at a courser level compared to perceptual representations of events (Landau & Jackendoff, 1993), this semantic/syntactic structure may extend to all endpoints—endpoints in both “agentive” and “nonagentive” events thus yielding the broad goal bias that has been observed in language (see Lakusta & Carey, 2015, for a detailed explanation).

The challenge for future research is to directly test this hypothesized relationship between infants’ preference for endpoints over starting points and their acquisition of goal and source paths in language and further to determine the directionality of any effects. If a visual endpoint preference supports language, then infants should show this preference prior to the age at which goal and source path language is acquired (as has been shown for many other perceptual preferences in infancy). However, the presence of a visual endpoint bias at 16-month-olds, an age at which children are in the midst of acquiring the semantic structures of motion verbs and their paths, presents initial support for the hypothesized role of this preference in language learning and paves the way for future research.

In conclusion, using a looped video presentation methodology that measured how long 16-month-old infants looked at events depicting a figure moving into an endpoint object versus out of a starting point object, the current study revealed an endpoint/starting point asymmetry; infants preferred the endpoint events. This preference held even when the starting point object was made more physically salient than the endpoint object (i.e., when it was larger and more colorful as in Exp. 2) and when it moved and caused motion of the figure (Exp. 3); however, the preference was *not* observed when the events depicted a “nonagentive” figure that moved in a circuitous path to/from the endpoint/starting point. It is hypothesized that such a preference may have important implications for how children learn the language of goal and source paths.

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