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Conceptual Foundations of Spatial Language: Evidence for a Goal Bias in Infants

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We explored the pre-linguistic foundations of spatial language by testing how 12-month-old infants represent sources and goals in Motion events (e.g., a duck moving out of a bowl and onto a block). Abundant evidence suggests that sources and goals are represented asymmetrically in languages, with goals taking a more prominent role than sources. We asked whether infants encode goals and sources as separate components of Motion events (Experiment 1) and whether they show asymmetric encoding of source and goal when they are part of the same Motion event (Experiment 2). Results showed that infants encode both goals and sources in separate events, but, when both are present, they encode goals in preference to sources. This Source-Goal asymmetry in infants' pre-linguistic representations of Motion events suggests a structure homologous to that found in language. The homology could provide the non-linguistic support for learning the language of events.

Observation tells us that even young children can talk about what they see, mapping their understanding of objects and events to sentences they produce and understand. Researchers have argued that our capacity to talk about spatial

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experience suggests a close relationship between language and our spatial representations of the world (e.g., H. Clark, 1973; Fillmore, 1997; Jackendoff, 1983; Landau & Jackendoff, 1993; Miller & Johnson-Laird, 1976; Regier, 1996; Talmy, 1983). Moreover, many theories of language learning depend on the idea that infants' pre-linguistic representations of the world serve as support to language learning (Bloom, 1973; Bowerman, 1973; Brown, 1973; Slobin, 1973; Mandler, 2004).

This idea is rooted in the theoretical assumption that there are homologies between infants' cognitive systems and the system of language that they must learn. Consistent with this, infants and young children assume that objects are mapped to nouns (Bloom, 1999; Grimshaw, 1981; Waxman & Booth, 2001), properties to adjectives (Waxman & Markow, 1998), and agents to subjects (Fisher, Hall, Rakowitz, & Gleitman, 1994; Grimshaw, 1981). Furthermore, recent evidence by Gordon (2003) suggests that 10-month-olds can distinguish between conceptual entities that are relevant for a particular action (and hence might later be 'arguments' in syntactic structure) and those that are irrelevant (hence might be 'adjuncts'). In this paper, we report evidence for a new homology by showing that the way in which 12-month-olds represent sources and goals in Motion events has important structural similarity to the way that these are encoded in language.

While theories differ in the details of how language maps to non-linguistic representations (e.g., linking rules; Grimshaw, 1981; Landau & Gleitman, 1985; Pinker, 1989; structural alignment; Fisher 2000; Gentner, 1983), many theories share the notion of hierarchy or prominence: In event representations, not all components are equal. Rather, some components are ranked higher (or are more prominent) than others. Such prominence relationships are essential to language learning for they guide the mappings between conceptual structure and syntax (Fisher, 1996; Grimshaw, 1981; Pinker, 1989). One widely studied example of prominence in conceptual structure is the relationship between agents and patients. Children and adults show an 'agency bias'; they are more likely to map agents, rather than patients, into subject position (Fisher et al., 1994). Furthermore, this asymmetry may be present in pre-linguistic representations (see Fisher, 2000), which would suggest a homology between pre-linguistic infants' event representations and the language they will learn.

Our paper reports evidence for another homology that also shows the property of prominence. The homology concerns the path component of Motion events—for example, an event in which a ball rolls *out of a bowl into a pot*. Linguistic theories tell us that Motion events include several components: an object that undergoes the motion (figure), the motion itself, and the path over which it moves (Jackendoff, 1983; Talmy, 1985). Paths are further divided into different types, including, Goal paths in which an object moves *to* or *toward* another object that is its endpoint, and Source paths, in which an object moves *away from* another object that is its starting point. These basic components of Motion events are universally encoded in languages, thus rendering them plausible candidates for components of pre-linguistic representations.

Our studies are based on evidence that—*in language*—there is an asymmetric relationship between sources and goals in Motion events. When children and adults watch simple Motion events, and then are asked to describe them, they tend to encode Goal paths (*into a pot*) in preference to Source paths (*out of a bowl*) (Lakusta & Landau, 2005). This pattern holds not only for Motion events, but for Change of Possession events (give/get), Change of State events (change, turn), and Attachment and Detachment events (hook, unhook)—all of which co-opt spatial terms and structures (Gruber, 1965; Jackendoff, 1983). Additional evidence for this Goal Bias (or Source Vulnerability) comes from formal linguistic analyses (Nam, 2004), computational models (Regier, 1996), cross-linguistic studies of child and adult production (Bowerman, 1996; Regier & Zheng, 2003), and studies of brain-damaged adults (Ihara & Fujita, 2000; see Lakusta & Landau, 2005, for review). For example, Ihara & Fujita (2000) reported that brain-damaged speakers of Japanese tend to drop Source but not Goal case markings, sometimes substituting the latter for the former. The bias to omit sources also extends to children who are congenitally deaf and have received no exposure to a conventional language model (Zheng & Goldin-Meadow, 2002). When describing Motion events, these children are more likely to include figures and endpoints than agents, origins, recipients, or places, raising the possibility that a Goal bias is not acquired from the structure of language, but rather might be a fundamental, perhaps innate characteristic of cognitive structure.

The robustness of a Goal bias in language raises the question of whether it extends to *pre-linguistic* event representations. If infants represent the goal and source of an event asymmetrically, then this would suggest an important homology with the language of Motion events that they will later learn. Alternatively, the failure to find such an asymmetry would suggest that this prominence relationship develops when children first attempt to convey information to another person. That is, the preference of goals over sources may stem fully from the nature of communication. The present experiments test the possibility that a goal bias exists before infants produce full linguistic structures for Motion events.

Thus far, the terms ‘goal’ and ‘source’ have been used broadly to refer to endpoints and starting points that cross-cut a variety of conceptual domains, including events that are intentional as well as non-intentional in nature. This broad usage is motivated by linguistic theory (Gruber, 1976; Jackendoff, 1983) as well as the language findings presented above, suggesting that a *linguistic* Goal/Source asymmetry extends to a variety of event types (see also Clark & Carpenter, 1994 for evidence suggesting a broad “source” category *early* in language learning). However, the *conceptual* distinction between sources and goals on the one hand and starting points and endpoints on the other is subtle and difficult.

Endpoints are not always goals; for example, a rock could fall to some endpoint without it qualifying as a goal. And starting points might be subtly different from sources; for example, the starting point of a race is not necessarily its source. In our experiments, we take a neutral stance on whether the broader *linguistic* categories of source and goal are identical with non-linguistic starting points and endpoints, or alternatively, intentional sources and goals. Our main purpose is to examine whether pre-linguistic infants show the same asymmetry between these elements (source vs. goal and/or starting vs. endpoint) that occurs systematically in language. Thus, in what follows, we adopt the terms 'source' and 'goal' to cover these two possibilities (starting point and intentional source/endpoint and intentional goal), and in the General Discussion we return to the issue of which of these alternative conceptualizations is best.

In Experiment 1, we asked whether infants represent goals and sources when they are part of a Motion event. Although, there is evidence that infants encode goals in a variety of events involving goal-directed actions (e.g., reaching events, Woodward, 1998; events comparing rational and irrational action, Gergely, Nadasdy, Csibra, & Biro, 1995), we specifically ask whether infants encode goals (and sources) in the kinds of Motion events that have been studied extensively by linguists (e.g., Talmy, 1985)—those involving a figure, motion, and path, as discussed above. That is, in order to study pre-linguistic conceptual representations, the current study uses the linguistic structure of Motion events as a basis to explore the conceptual foundations of spatial language.

We first asked whether goals (Experiment 1a) and sources (Experiment 1b–1c) are encoded when they appear separately in Motion events. These experiments are necessary preliminaries to testing a pre-linguistic Goal bias because we first need to show that infants do indeed encode the goal and source when each is presented alone in a Motion event. Then, in Experiment 2, we pitted source and goal against each other in the same Motion event to see whether there is an asymmetry. This second experiment provides direct evidence on the issue of whether the Goal/Source asymmetry observed so robustly in language extends to the prelinguistic spatial cognitive system.

EXPERIMENT 1

Experiment 1a: Goals

Method

Participants. Participants were 8 male and 8 female 12-month-old infants (Mean age = 12 months, 6 days; Range: 11 months, 15 days to 12 months, 24 days). An additional infant was excluded because of fussiness.

Stimuli. The stimuli were Motion events that included one of two goal objects (red block and green bowl), a figure (toy duck), and a motion (slide) (see Figure 1A). The duck was attached to a rod that was held by an experimenter who was hidden from the infant's view. Goal objects were located in the middle of the stage (i.e., neither front nor back), either on the right or left and were

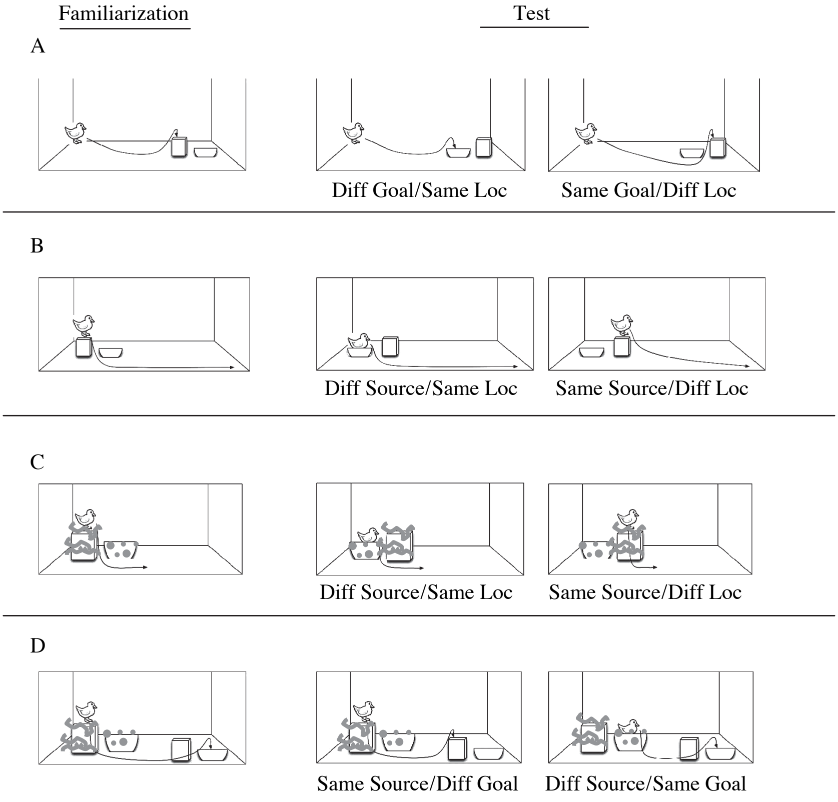

FIGURE 1 Schematic of Experiments 1a, 1b, 1c, and 2. Panel A (Experiment 1a, Goal). In familiarization the duck moved to one of two goal objects. During inter-trial the objects switched locations (not shown). In three test trials the duck moved to a Different Goal/Same Location and in three test trials the duck moved to the Same Goal/Different Location. Panel B (Experiment 1b, Source). Same as Experiment 1a, except now the objects are sources rather than goals. Panel C (Experiment 1c, Super Source). Same as Experiment 1c, except now the objects are 'super' sources. Panel D (Experiment 2, Super Source vs. Goal). In familiarization, the duck moved from one of two salient sources to one of two goals. During inter-trial the objects did *not* switch locations (not shown). In three test trials, the duck moved from the Same Source to a Different Goal and in three test trials the duck moved from a Different Source to the Same Goal.

counterbalanced across infants. The figure's initial position was always in the corner of the stage; the positions were counterbalanced for front/back and left/right across infants. Note that if the figure's initial position was one of the left corners, the goal objects were located on the right side of the stage, and vice versa.

Design and procedures. Following Woodward's (1998) method, infants were seated in a high chair located 34 inches in front of a stage that was 32″ wide × 12.5″ high × 14.5″ deep. A curtain was attached to the front of the stage and was raised (lowered) to reveal (hide) the stage at the beginning (end) of each trial. Infants were first familiarized over seven trials to an event in which the figure moved to one of two goals.[1] Then, the curtain was lowered and the experimenter switched the locations of the two goal objects. Infants then viewed the two goals in their new locations without the figure (inter-trial). Finally, infants viewed six test trials. In three of these, infants saw the figure move to a different goal as in familiarization, but in the same location (Different Goal/Same Location); in the other three infants saw the figure move to the same goal as in familiarization, but in a different location (Same Goal/Different Location). 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 figure waggled in place for about two seconds as an audio recording said "Look (baby's name), Look!" The figure then slid smoothly to either the green bowl or the red block. Once the duck reached the goal object it hopped into or onto the object and then waggled again for about two seconds as the recording again said "Look, (baby's name), Look!"[2] This was done to ensure that the infant attended to both the beginning and end of the event. Throughout the entire trial, a trained observer monitored how long the infant looked at the stage; looking time was calculated by a computer program (Mac Xhab & Pinto, 1994). When the infant looked away from the stage for two continuous seconds, the computer program signaled and the experimenter lowered the curtain, proceeding to the next trial.

In order to assess reliability, a second observer recoded 100% of the trials off-line for half the infants. Inter-observer agreement was above 95% in each experiment.

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[1] Like many studies exploring infants' conceptual representations (e.g., Luo & Baillargeon, 2005; Onishi & Baillargeon, 2005), the present studies used familiarization rather than habituation. Since familiarization usually takes less time than habituation, this method is preferred when testing mobile infants who tend to get fussy with extended testing time. In addition, seven familiarization trials were used because pilot testing revealed that infants' looking time decreased with this amount of exposure to the events.

[2] In order to ensure that test trials were equated for length of time, the duration of test trials for eight of the infants were coded off-line. In each experiment, the duration of the two different Trial Types did not significantly differ, $p > .10$.

Results and discussion. The infants' looking times decreased from the first to seventh familiarization trial (Ms = 18.00, 13.26; SEs = 2.58, 2.21 for trials one and seven, respectively, $F(6, 90) = 1.89, p < .10$).

Infants encoded the goal. Looking times were averaged across test trials and showed that infants looked longer at the Different Goal/Same Location test trials ($M = 12.35$, $SE = 1.19$) compared to Same Goal/Different Location test trials ($M = 10.17$, $SE = 1.38$), $t(15) = 4.50, p < .01$ (one-tailed paired) (see Figure 2).[3] Fourteen of the 16 infants showed this pattern (Wilcoxon signed ranks test, $z = -3.15$, $p < .01$).[4]

Additional analyses explored whether any of the counterbalancing variables (goal object used in familiarization: bowl vs. block, and duck's initial position on

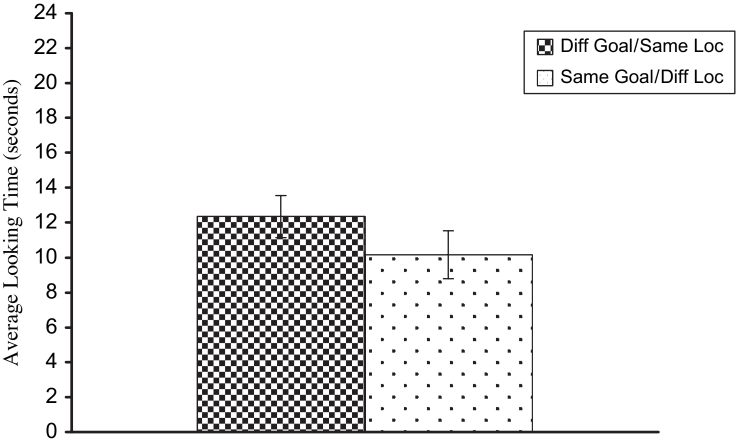

FIGURE 2 Experiment 1a: Goal encoding at 12-months. Average looking times (and SEs) at the two different Trial Types.

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[3] One-tailed t-tests were used in Experiments 1a–1c because, based on previous findings (e.g., Woodward, 1998), we predicted that infants would track and encode the Object in preference to the Location. Two-tailed t-tests were used in Experiment 2 because there were few, if any, previous findings with which to base the directionality of our hypotheses.

[4] Since, familiarization rather than habituation was used, the main comparison in this and every other experiment is between the two different Trial Types (e.g., Different Goal/Same Location vs. Same Goal/Different Location) (see, for example, Luo & Baillargeon, 2005 for a similar approach). However, additional analyses did compare looking time at the last familiarization trial and the Trial Types. For Experiment 1a, looking time at the Different Goal test trials and the last familiarization trial did not significantly differ, $t(15) = .53, p > .10$, whereas infants looked significantly less at the Different Location test trials than the last familiarization trial, $t(15) = 1.97, p = .03$. Thus, infants maintained interest to the Different Goal trials whereas they continued to familiarize to the Different Location test trials, suggesting that infants encoded the Goal.

stage: front vs. back and left vs. right) significantly interacted with Trial Type. These analyses did not produce any significant results except for one (see Experiment 1c).

These findings suggest that infants attended to the goal during familiarization; during test they looked longer at a change in the goal than a change in the location, showing that they do encode the goal in Motion events (see Wagner, 2005 for a similar finding).

Before turning to Experiment 1b, we consider an alternative interpretation of the findings presented above. Infants in Experiment 1a might have been responding to the static end state of the event (duck + bowl/block), rather than to the entire Motion event. That is, perhaps low-level stimulus differences (duck + bowl vs. duck + block) influenced looking time. We addressed this concern in a control experiment by removing the *motion part* of the event. Infants were familiarized with, and then tested on, two configurations—the duck on the red block or in the green bowl. Infants did not look significantly longer at the Different Object/Same Location test trials ($M = 7.41$, $SE = 1.67$) compared to the Same Object/Different Location test trials ($M = 8.42$, $SE = 2.44$), $t(15) = .85$, $p > .10$. This suggests that infants in Experiment 1a had not simply formed an association between the duck and bowl/block that they observed at the end of the event, but rather based their looking on a conceptualization that they had formed of a multipart Motion event (i.e., one involving a figure, motion, path, and goal).

Experiment 1b: Sources

Method

Participants. Participants were 8 male and 8 female infants (Mean age = 12 months, 6 days; Range: 11 months, 26 days to 12 months, 14 days). One additional infant was excluded because of experimental error.

Stimuli, design, and procedures. The stimuli, design, and procedures were exactly the same as those used in Experiment 1a, but this time the Motion events included *sources* rather than *goals* (see Figure 1b). Thus, rather than moving *to* one of two *goals*, the duck moved *from* one of two *sources*.

Results and Discussion

The infants' looking times decreased reliably from the first to seventh familiarization trial (Ms = 17.26, 12.42; SEs = 1.19, 2.17, for trials one and seven, respectively, $F(6, 90) = 2.64$, $p < .05$).

Infants did not show evidence of source encoding. Infants did not look significantly longer at the Different Source/Same Location test trials ($M = 9.69$, $SE = 1.16$) compared to the Same Source/Different Location test trials ($M = 9.73$, $SE = 1.31$), $t(15) = .04$, $p > .10$ (one-tailed paired) (see Fig. 3). Only seven of the

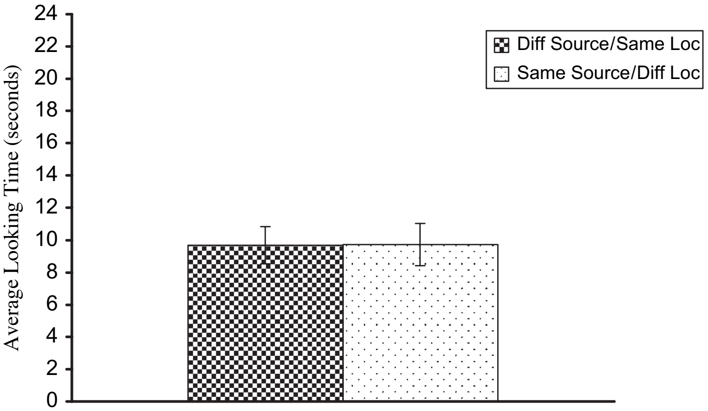

FIGURE 3 Experiment 1b: Source encoding at 12-months. Average looking times (and *SE*s) at the two different Trial Types.

16 infants showed the predicted pattern of looking, with a nonparametric analysis indicating no reliable difference (Wilcoxon signed ranks test, $z = -.21$, $p > .10$).

These findings suggest that infants did not preferentially attend to the source object during familiarization; during test they did not look longer at a change in the source than a change in the location, thus providing no evidence that they encoded the source. This contrasts with the findings of Experiment 1a, which showed—with the very same objects—that infants did encode the goal. These very different results hint that 12-month-old infants may represent goals and sources asymmetrically.

Because a fair test of any asymmetry requires that the infants encode both sources and goals, we carried out Experiment 1c—an experiment like Experiment 1b but with methodological changes meant to increase the likelihood that infants would encode the source.

Experiment 1c: 'Super' Sources

Method

Participants. The first methodological change was to increase sample size in order to increase power. Participants were 14 male and 10 female 12-month-old infants (Mean age = 12 months, 2 days; Range: 11 months, 18 days to 12 months, 13 days). Six additional infants were excluded because of fussiness ($n = 3$), experimental errors ($n = 2$), or influence by the parent ($n = 1$).

Stimuli, design, and procedures. The next methodological changes aimed to increase the salience of the source objects. First, rather than being an 'ordinary' red block and a green bowl, one source object was a big metallic blue block decorated with sparkly pipe cleaners and the other was a big orange bowl decorated with puffs, bows, and sequins. Second, at the beginning of each event, the duck waggled at the source an additional four and a half seconds after the recording said, "Look (baby's name), look!"[5] Third, rather than sliding to the corner of the stage, the duck slid to the middle of the stage after leaving the source, thus remaining closer to the source throughout the entire event (see Figure 1c).

Results and discussion

The infants' looking times decreased reliably from the first to seventh familiarization trial (*M*s = 19.35, 11.29; *SE*s = 1.63, 1.36, for trials one and seven, respectively, $F(6, 138) = 7.43, p < .01$).

Infants showed evidence of source encoding. Infants looked longer at the Different Source /Same Location test trials ($M = 13.80$, $SE = 1.59$) compared to the Same Source /Different Location test trials ($M = 11.78$, $SE = 1.31$), $t(23) = 1.85$, $p < .05$ (one-tailed paired) (see Figure 4). Eighteen of the 24 infants showed this pattern (Wilcoxon signed ranks test, $z = -2.00, p < .05$).[6]

In this experiment, one of the counterbalanced variables significantly interacted with Trial Type. This variable was the source object (bowl or block) that was used during familiarization. A 2 (Source: Bowl vs. Block) × 2 (Trial Type: Different Source/Same Location vs. Same Source/Different Location) mixed analyses of variance showed a significant interaction, $F(1, 22) = 5.60, p < .05$. Simple effects contrasts revealed that only the infants who were familiarized with the duck moving out of the bowl discriminated between the two different test events, $p < .01$. Thus the spatial relationship of the duck relative to the source object (whether it was *in it* and then moved *out of it* or whether it was *on it* and then moved *off of it*) may have mattered for whether or not infants selectively tracked and encoded the object. This suggests that the action performed

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[5] Four and a half seconds was chosen because 6.5 seconds was the average length of time that the infants in Experiment 1a looked at the goal once the duck reached the goal. Thus, the additional 4.5 seconds at the source resulted in the duck remaining at the source for a total of about 6.5 seconds.

[6] As in Experiment 1a, additional analyses compared looking time at the last familiarization trial and the two Trial Types. Infants looked longer at the Different Source test trials than at the last familiarization trial, $t(23) = -1.51, p = .07$, whereas average looking time at the Different Location test trials and last familiarization trial did not significantly differ, $t(23) = -.32, p > .10$. This suggests that infants recovered interest to the Different Source trials, whereas they maintained interest to the Different Location test trials, suggesting that infants preferentially encoded the source.

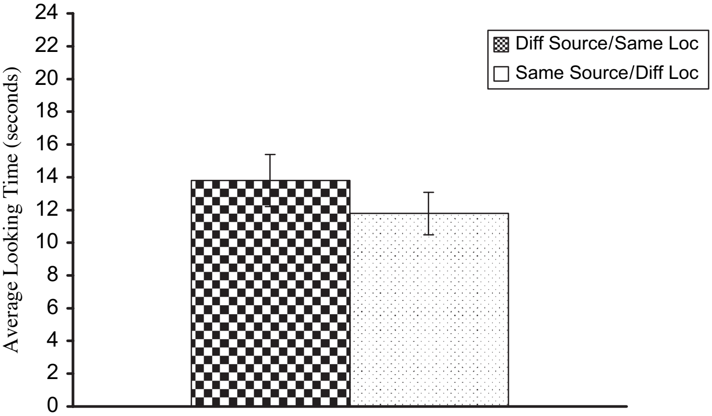

FIGURE 4 Experiment 1c: ‘Super’ Source encoding at 12-months. Average looking times (and *SE*s) at the two different Trial Types.

on the object, rather than simple object identity, may have driven infants’ encoding of the source. Although these results are consistent with recent research suggesting that ‘in’ is a ‘privileged’ spatial relation for pre-linguistic infants (Casasola & Cohen, 2002), we urge the reader to interpret this with caution since this interaction was not significant in the other experiments reported in this paper.

In sum, the findings from Experiment 1c suggest that infants preferentially attended to the salient source object during familiarization; during test they looked longer at a change in the source than a change in the location, showing that they do encode the source in Motion events. We are now in a position to directly test whether 12-month-old infants represent sources and goals asymmetrically. If infants selectively track and encode the goal in preference to the source then this would provide evidence for a Goal bias in pre-linguistic infants.

EXPERIMENT 2: SUPER SOURCE VS. GOAL

Method

Participants. Participants were 10 male and 14 female 12-month-old infants (Mean age = 11 months, 29 days; Range: 11 months, 18 days to 12 months, 11 days). An additional five infants were excluded because of either fussiness (n = 3) or experimental errors (n = 2).

Stimuli. The stimuli were Motion events that included the two 'salient' source objects from Experiment 1c (salient block and salient bowl) and the two 'ordinary' goal objects from Experiment 1a (red block and green bowl). The figure and motion were the same as those used in the previous experiments (see Figure 1d). Sources were located either on the right or the left side of the stage and in the middle of the stage (i.e., neither front nor back). Goals were located in the back or the front corner of the stage. The positions were counterbalanced for front/back and left/right across infants. Sources and goals were always positioned on opposite sides of the stage.

Design and procedures. The design and procedures were the same as those used in the previous experiments with the following exceptions. Infants were familiarized to the figure moving from one of two 'salient' source objects to one of two 'ordinary' goal objects. As in Experiment 1c, the figure waggled at the source an additional 4.5 seconds at the beginning of the event. Also, during inter-trial, the objects' locations were *not* switched. Then, in three test trials infants saw the figure move from a different source as in familiarization, but to the same goal (Different Source/Same Goal); in the other three, infants saw the figure move from the same source as in familiarization, but to a different goal (Same Source/Different Goal). The two test trial types were shown in alternation, and order was counterbalanced over infants.

Results and discussion. Infants' looking times decreased reliably from the first to seventh familiarization trial (*M*s = 26.62, 16.85; *SE*s = 2.65, 1.77, for trials one and seven, respectively, $F(6, 138) = 2.18, p < .05$).

Infants showed a Goal bias. Infants looked longer at the Same Source/Different Goal test trials ($M = 19.85$, $SE = 2.42$) compared to the Different Source/Same Goal test trials ($M = 15.33$, $SE = 1.15$), $t(23) = -2.63, p < .05$ (two-tailed paired) (see Fig. 5). Eighteen of the 24 infants showed this pattern (Wilcoxon signed ranks test, $z = -2.49, p < .05$).[7]

These findings suggest that infants preferentially attended to the goal object during familiarization, and during test they looked longer at a change in the goal than a change in the source, suggesting that infants represent sources and goals asymmetrically – that is, they show a Goal bias.

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[7] Analyses comparing average looking time at the last familiarization trial and the two Trial Types showed that infants looked longer at the Different Goal test trials than at the last familiarization trial, although this analysis did not reach statistical significance, $t(23) = -1.23, p = .11$. Looking time at the Different Source test trials and the last familiarization trial did not significantly differ, $t(23) = .91, p > .10$. Thus, infants recovered interest to the Different Goal trials, whereas they maintained interest to the Different Source trials, suggesting that infants preferentially encoded the goal.

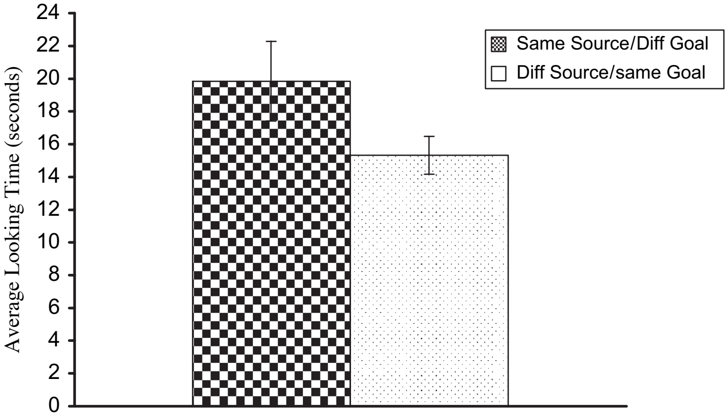

FIGURE 5 Experiment 2: ‘Super’ Source vs. Goal encoding at 12-months. Average looking times (and *SE*s) at the two different Trial Types.

GENERAL DISCUSSION

Our findings show that 12-month-old infants are able to encode goals in Motion events (Experiment 1a). Infants of this age do not show evidence for encoding the source (Experiment 1b) unless the source objects are made sufficiently salient (Experiment 1c). Finally, when shown a Motion event that contains *both* an (ordinary) goal and (salient) source, 12-month-olds encode the goal in preference to the source, thus showing a Goal bias.

These results provide evidence for a new homology between infants’ pre-linguistic representation of events and the linguistic encoding of events in older children and adults. In language, there is a robust asymmetry between goals and sources which is reflected in a variety of ways; for example, the greater likelihood of goals serving as arguments (Nam, 2004), the greater likelihood of Goal paths being produced in children’s and adults’ event descriptions (Lakusta & Landau, 2005), and the greater resilience of Goal markings in cases of brain damage (Ihara & Fujita, 2000). Our findings show that this bias also characterizes the event representations of pre-linguistic infants. Thus, like the homology that has been observed with respect to agents and patients, goals may be ranked higher than sources in non-linguistic representations of events, and this relationship may later be mapped into language.

Although we have argued that infants show a Goal bias, there is an additional interpretation that should be considered. Infants may have been merely remembering the last thing they saw—which, in the familiarization events, would correspond to the figure in contact with the goal. Several facts cast doubt on this interpretation. We showed that infants do encode sources when they are made highly salient (Experiment 1c). When infants did show a Goal bias (Experiment 2), this greater interest was shown across the six test trials in which they observed both source and goal changes. Thus, it seems unlikely that the infants were responding to the "last thing they saw" during familiarization, and more likely that they were encoding the goal of the event more robustly than the source. In addition, recency effects are less likely to be found in our study because they are most evident for stimuli that can be encoded verbally (e.g., Potter, Staub, & O'Connor, 2004; Shiffrin, 1973) and for stimuli that are not followed by a succeeding image (Potter & Levy, 1969). Neither of these conditions applies to our experiments since we tested preverbal infants and included an inter-trial between familiarization and test. Moreover, a typical "list-like" memory effect would have produced both primacy and recency effects, which should have heightened memory for both source and goal. Finally, preliminary evidence from our lab suggests that four-year-olds and adults do *not* show a Goal bias for physical events involving inanimates (e.g., a tissue falling off magazine onto a book; Lakusta, Landau, & Wessel, 2005). If a Goal bias can be explained as a recency effect, then this bias should extend to a variety of event types, but this does not seem to be the case.

The existence of a pre-linguistic bias in event structure has important implications for a variety of theoretical issues in language acquisition and, more generally, human cognitive representations of events. First, if infants are predisposed to represent the goal (over the source), then they may show a difference in their acquisition of terms marking Goal and Source paths. Although children produce Path expressions of both kinds quite early (Bloom, 1973; Choi & Bowerman, 1991), Bowerman (1996) has reported that young children tend to apply Source path terms (e.g., "uit" in Dutch and "out" in English) broadly across a wide variety of exemplars of separation, whereas they narrowly divide up the corresponding category of joining exemplars. This broad notion of separation, but more finely differentiated notion of joining, suggests a parallel to the Goal bias, in which acts "towards" an goal (e.g., joining) are represented in a more detailed, specific way than acts "away from" a source (e.g., separation) (see also Regier & Zheng, 2003).

A Goal bias in infancy might also lead children to later express events in terms of Goal path verbs rather than Source path verbs. Fisher et al. (1994) found that 3–4 year-olds were more likely to interpret ambiguous events as agentive and causal (e.g., "give") rather than non-agentive (e.g., "get"). They interpreted this as reflecting an "agent bias", in which the animate, causal agent receives preferential attention, and subsequent encoding as subject. A complementary interpretation is that children prefer to interpret events in terms of Goal paths, and thus encode the event as a "To-Path" event ("give"), rather than a

"From-Path" event ("get"). Indeed, Lakusta and Landau (2005) found that, when 4-year-olds were instructed to use the verb "get" to describe an event, they sometimes used "give", which takes a To-path expression (but never substituted "get" for "give").

What could be the origin of a non-linguistic Goal bias? There are two possibilities, which are not necessarily mutually exclusive. First, this phenomenon may reflect a fundamental aspect of human cognition: Its forward-looking nature, as observed in a variety of cases. For example, Freyd (1983) first reported that people who observe a static display of motion (e.g., person falling) later remember the object or person being farther along the trajectory than it really was. This phenomenon has been dubbed "representational momentum", suggesting that our representational systems project forward in time and space as if we are anticipating the future. Other phenomena show similar biases; our visual and motoric representations of space show the tendency to anticipate what comes next (e.g., Intraub, 2002; Rosenbaum, Cohen, Meulenbroek, & Vaughan, in press). A Goal bias could reflect a similar tendency to represent the endpoint more robustly than the starting point.

Another possibility is that a Goal bias is specific to reasoning about intentional events. That is, perhaps *only* endpoints that are *goals* in intentional, goal-directed actions are preferred over starting points. We have shown a Goal bias in the context of a stuffed duck moving through space. It's possible that infants construed these events as a figure intending to move to an endpoint that is also its *goal*. In fact, this possibility is consistent with recent research exploring infants' knowledge of intentional actions.

Woodward and colleagues have shown that infants encode the goal of an animate actor's reach (Woodward, 1998), point (Woodward & Guajardo, 2002), and gaze (Woodward, 2003). Infants' goal attributions also extend to events involving an inanimate object if the object is self-propelled and shows a preference for one of two objects (Luo & Baillargeon, 2005; Shimuzu & Johnson, 2004), or if it moves rationally to obtain its goal (e.g., Csibra, Biro, Koos, & Gergely, 2003; Gergely, et al., 1995; Wagner & Carey, 2005). Given that the events in the current study involved a animate-looking duck first waggling, and then appearing to move on its own along a rational path to one of two objects, it is likely that infants interpreted the event as intentional—specifically as the duck choosing or preferring to move *to* the endpoint, rather than as choosing or preferring to move *away from* the starting point. Thus, in terms of event structure, the structure of the events may be teleological in nature, and the endpoint, but not the starting point, may align with the goal state, resulting in a Goal/Source asymmetry (see Gergely & Csibra, 2003 for a discussion of teleological reasoning).

If a Goal bias is specific to intentional reasoning, then this bias may *not* extend to events where the starting point, but not the endpoint, aligns with the *goal state* of the event (e.g., a girl fleeing from a burning house) or to events that are unintentional in nature and thus lack a teleological structure (e.g., a paper falling off a table and into a basket). We are currently investigating this possibility in infants, children and adults by asking whether a Goal bias applies to a full range of events, including those with animate agents and those without. As previously discussed, preliminary evidence suggests that four-year-olds and adults do not show a Goal bias in the context of physical events involving inanimates (Lakusta, Landau, & Wessel, 2005). Developmental continuity would predict that infants should also show this pattern, with a Goal bias in contexts involving animate entities moving purposefully towards some object, but no Goal bias in physical events involving inanimates. If it turns out that a Goal bias is part of the domain that involves animacy and intention, then the empirical question is how children and adults collapse over domains for the purposes of language—a system that does not differentiate between notions of starting points/sources and endpoints/goals, at least in the encoding of paths (Gruber, 1965; Jackendoff, 1983).

In sum, we have reported a new case of a homology between infants' non-linguistic event representations and the language they must learn. Like the asymmetry between agents and patients, the asymmetry between goals and sources is likely to reflect a fundamental characteristic of human cognitive systems, and therefore serves as a crucial link between non-linguistic representations and language.

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