COGNITIVE SCIENCE
A Multidisciplinary Journal

Cognitive Science 36 (2012) 517–544

ISSN: 0364-0213 print / 1551-6709 online
DOI: 10.1111/j.1551-6709.2011.01220.x

Language and Memory for Motion Events: Origins of the Asymmetry Between Source and Goal Paths

Laura Lakusta,[a] Barbara Landau[b]

[a]*Department of Psychology, Montclair State University*
[b]*Department of Cognitive Science, Johns Hopkins University*

Received 23 July 2010; received in revised form 20 April 2011; accepted 3 June 2011

Abstract

When people describe motion events, their path expressions are biased toward inclusion of goal paths (e.g., into the house) and omission of source paths (e.g., out of the house). In this paper, we explored whether this asymmetry has its origins in people's non-linguistic representations of events. In three experiments, 4-year-old children and adults described or remembered manner of motion events that represented animate/intentional and physical events. The results suggest that the linguistic asymmetry between goals and sources is not fully rooted in non-linguistic event representations: linguistic descriptions showed the goal bias for both kinds of events, whereas non-linguistic memory for events showed the goal bias only for events involving animate, goal-directed motion. The findings are discussed in terms of the mapping between non-linguistic representations of goals and sources in language, focusing on the role that linguistic principles play in producing a more absolute goal bias from more gradient non-linguistic representations of paths.

Keywords: Source; Goal; Motion events; Conceptual representations; Semantics; Syntax; Space-language interface; Prominence hierarchies

1. Introduction

This paper is motivated by a linguistic phenomenon and the search for an explanation that is rooted in our non-linguistic representations of events. The phenomenon is an asymmetry between the linguistic encoding of source and goal paths in motion events, with goal paths assuming a different, more prominent role than source paths. As we review below, there is abundant evidence from the linguistics literature that the two path types are quite different.

Correspondence should be sent to Laura Lakusta, Department of Psychology, Montclair State University, Montclair, NJ 07043. E-mail: lakustal@mail.montclair.edu

They are encoded differently in languages, both in the elements they engage and in their syntactic and semantic behavior. There is also evidence that adult and child speakers are more likely to encode goal than source paths when they describe motion events, and that young children acquire goal path terms earlier than source path terms. Our question is whether these broad and pervasive differences between source and goal paths in language have their roots in our non-linguistic representations of events. We address this question by exploring (a) whether non-linguistic representations also show a goal bias and (b) the extent to which any goal bias in non-linguistic representations mirrors the goal bias in language.

The idea that aspects of language structure might stem from the nature of non-linguistic representations is not new. Indeed, many have suggested that there are natural mappings between aspects of our non-linguistic representations and the elements of language, and that these are crucial to the learner. Young children may break into the linguistic system by making certain critical assumptions, for example, that objects are mapped to nouns (Bloom, 1999; Grimshaw, 1981; Landau, Smith, & Jones, 1998; Waxman & Booth, 2001), properties to adjectives (Waxman & Markow, 1998), and causal agents to subjects (Fisher, Hall, Rakowitz, & Gleitman, 1994; Grimshaw, 1981; Slobin, 1985). Some have suggested that understanding of the spatial world might be the foundation for language learning, and there is abundant evidence that language engages aspects of spatial representation; for example, the meaning of many spatial terms (e.g., above, below, right, and left) reflects the reference systems that organize spatial representations (Hayward & Tarr, 1995; Landau & Hoffman, 2005; Landau & Jackendoff, 1993; Munnich, Landau, & Dosher, 2001), and the assignment of objects to their semantic roles as figure or ground is determined in part by their perceptual qualities (Gleitman, Gleitman, Miller, & Ostrin, 1996; Landau & Jackendoff, 1993; Talmy, 1983).

In this paper, we ask whether the source–goal asymmetry that has been observed in language represents another instance of homologous structure between spatial cognition and language and, if so, how direct the mapping is. One possibility is that the very same asymmetries observed in language also appear in non-linguistic tasks. If they do, then this would be strong support for homologous structures and would suggest that the linguistic asymmetries for paths have their origin in our non-linguistic representations. A second possibility is that the pattern of asymmetry observed in language does not appear in non-linguistic tasks, suggesting that the linguistic asymmetries we observe stem solely from properties internal to language, rather from properties of how these paths are represented non-linguistically. In between these two extremes is the possibility that the asymmetries observed in language are only partially reflected in the non-linguistic system. If so, this would suggest that the path asymmetries observed in language stem both from the properties of non-linguistic event representations and constraints internal to language. The aim of the current study is to test these three possibilities.

1.1. The language of source and goal paths

Talmy (1985) proposed that motion events can be understood in terms of four key components: the figure, or object that undergoes motion (usually an NP, in English), the motion that it undergoes (encoded by the verb), the path which it traverses (usually a preposition, in

English), and the path's argument, or reference object (an NP, in English). The complete path expression (PP) can be divided into different types including FROM Paths, in which the figure moves *from* a reference object that is its starting point or source (hence, source path) and TO Paths, in which the figure moves *to* a reference object that is its end point or goal (hence, goal path) (Jackendoff, 1983). In English, specific prepositions encode each of these path types. For example, source paths require prepositions such as ''from,'' ''out,'' ''off,'' and so on, and goal paths require ''to,'' ''into,'' ''onto,'' and so on.

Some linguists have observed that path expressions can be extended to expressions representing a variety of different conceptual domains, including manner of motion, transfer of possession, and change of state (Gruber, 1965). This observation has been captured formally by Jackendoff's (1983) Thematic Relations Hypothesis. For example, changes of state and changes of location are encoded in parallel structures, using the same lexical items: ''Brian went FROM sad TO happy'' engages the same structures and terms as ''Brian went FROM the car TO the store.'' These similarities suggest that languages encode source and goal paths at quite an abstract level, ranging over domains that are conceptually very different.

Similarly, the linguistic encoding of paths does not differentiate between events involving animate actors and those involving inanimate objects: ''The bird swooped OFF of the roof and INTO the pond'' engages the same structures and lexical items as ''The ball rolled OFF of a book and INTO the cup.'' Abundant evidence shows that human adults and young children reason differently about these two types of events (e.g., Luo & Baillargeon, 2005; Meltzoff, 1995; Premack, 1990; Woodward, 1998, 1999; Woodward & Sommerville, 2000). For example, an inanimate object, such as ''a ball,'' is only expected to move when contacted by another object and does not possess an intentional goal, whereas an animate object, such as ''a bird,'' is capable of self-propelled movement and can have an intentional goal. Yet despite these deep conceptual differences, language treats *the paths* in these motion events very similarly, across both semantic and syntactic structure (Jackendoff, 1983). This property holds across many other languages (see Levinson & Wilkins, 2006 for a detailed discussion of source and goal markings across several languages).

1.2. Asymmetries between source and goal paths in language

There is abundant evidence that the linguistic representations of source and goal paths show an asymmetry. One kind of evidence comes from formal studies in linguistics of the syntactic and semantic structure of paths: Goals and their paths tend to be unmarked in languages, whereas sources and their paths tend to be marked (Fillmore, 1997; Ihara & Fujita, 2000; Jackendoff, 1983). For example, in many languages, goal paths are encoded using the same elements that encode static places, but it is much rarer to find languages that encode source paths and static places with the same elements. Fillmore (1997) noted that the complement ''behind the sofa'' can be used either as a non-directional, locative place complement, or as a goal path complement, resulting in an ambiguous reading for sentences such as ''the cat ran behind the sofa'' (meaning, the cat ran *to* and behind the sofa). However, ''behind the sofa'' cannot be used as a source complement; the sentence can never mean ''the cat ran *from* behind the sofa.'' This meaning requires explicit marking with the source marker ''from.'' Nikitina (2009) proposes that evidence such as this places goals and sources at opposite ends of the semantic space (following Haspelmath, 2003). Also, goals contribute to telic readings of events (they are result states; e.g., Brian ran *to the store* in an hour, where ''in an hour'' modifies telic predicates), whereas sources contribute to atelic readings of events (they modify processes; e.g., Brian ran *from the store* for an hour, where ''for an hour'' modifies atelic predicates) (Filip, 2003; Markovskaya, 2006; Nam, 2004; but see Gehrke, 2005). Finally, in grammatical structure, goals tend to be arguments of the verb, whereas sources tend to be adjuncts (Nam, 2004).

Given the very different linguistic profiles of source and goal paths, it is perhaps not surprising that children and adults also show an asymmetry between source and goal paths in their use of language. Bowerman and colleagues reported that young children learning English, Korean, Dutch, and Tzotzil Mayan tend to apply source path terms (e.g., ''uit'' in Dutch and ''out'' in English) broadly across a wide variety of instances of separation, whereas children are more specific in their application of goal path terms (Bowerman, de León, & Choi, 1995), indicating that spatial terms marking goals are more finely differentiated than those marking sources (see also Meira, 2006; Papafragou, 2010; Regier & Zheng, 2007). In addition, Freeman, Sinha, and Stedmon (1980) reported that 3- and 4-year-old children found it easier to answer questions about the path of an object that moved ''to'' a landmark than ''from'' a landmark, suggesting that there might be a general ''allative'' bias; that is, young children might find it easier to encode motions toward a goal, rather than away from a source. Thus, a goal bias characterizes both production and comprehension in early language acquisition (for further evidence of a goal bias in production, see Clancy, 1985; Landau & Zukowski, 2003; Pléh, 1998).

Lakusta and Landau (2005) found extensive evidence for a goal bias in the way people describe motion events. In their study, children and adults were shown events including a source and a goal (e.g., the bird flew from the bucket into the pitcher) and were asked to tell the experimenter ''what happened.'' Participants (especially children) systematically and accurately included goal paths in the prepositional phrase more often than source paths. A goal bias was also found for other event types such as attachment/detachment, transfer of possession, and change of state. For example, participants tended to describe an event of a bear's nose turning from blue to yellow as ''the bear's nose turned *to yellow*'' rather than ''the bear's nose turned *from blue to yellow*.'' A goal bias persisted even when participants' attention was directed to the path by being supplied with a verb that selects for either a goal or a source path (e.g., ''give''/''get'' for transfer of possession events; ''hook''/''unhook'' for attach/detach events). Even in these cases, children, and sometimes adults, continued to include the goal but omit the source (see also Papafragou, 2010; see Ihara & Fujita, 2000 and Lakusta, Yoshida, Landau, & Smith, 2006 for evidence of a goal bias in Japanese).

In sum, the findings reviewed above suggest that goal and source paths are subject to different grammatical constraints, and that speakers chose to express them to different degrees. The goal bias is reflected in several syntactic and semantic phenomena, in the way these paths are treated in early language acquisition, and in the way that children and adults describe both motion and non-motion events. This latter set of findings is especially noteworthy. The observation that a goal bias extends to different event types (e.g., Motion, Attach/Detach, Transfer) is entirely consistent with the Thematic Relations Hypothesis (Gruber, 1965; Jackendoff, 1983) as discussed earlier in the Introduction; not only do distinct conceptual domains encode source and goal paths with similar syntactic and semantic structure, but the *preference* for goals over sources also appears to extend broadly throughout the linguistic system.

1.3. The current study

The breadth and robustness of a goal/source asymmetry in language raises the possibility that this asymmetry is rooted fully in non-linguistic representations of events. In fact, such a suggestion has been put forth by Regier, who argues that a goal bias in language might be explained by a general memory or attention bias to encode endpoints more robustly than starting points (Regier, 1996; Regier & Zheng, 2007). If so, this would suggest a strong case of homologous structure between language and non-linguistic thought—the way paths are attended to and remembered in events serves as the basis for their organization in language.

The evidence to date is consistent with this possibility; however, it is not conclusive. Although strong goal biases have been found in most studies of language, there are few studies that have systematically examined representations in non-linguistic tasks. One exception is a study by Lakusta, Wagner, O'Hearn, and Landau (2007), who found that prelinguistic infants preferentially encode the goal over the source in motion events involving an animate-like duck move from a source to a goal. Furthermore, Papafragou (2010) found evidence for a goal bias when testing how adults and 4- and 5-year-old children remember goal and source landmark objects in computer animated events depicting an animate figure move from one object to another object (e.g., a fairy flying from a flower to a tree). Papafragou (2010) also reported a goal bias when testing adults' and children's memory for goal and source spatial relations in events portraying a self-propelled inanimate object move to (or from) a goal (or source) reference object (e.g., a soccer ball moving onto a square) (see also Lakusta, 2005; Lakusta & Landau, 2007). A goal bias has also been reported by Regier and Zheng (2007), who tested discrimination of source and goal spatial relations. In this experiment, adults viewed pairs of joining events that sometimes differed in their end state (e.g., a hand placing a lid *on* a container vs. a hand placing a lid *in* a container) and separation events that sometimes differed in their starting state. The findings revealed that adults were better able to detect the differences in joining than separation, suggesting that adults' attention favored end states over starting states.

Note that in both the Papafragou (2010) and Regier and Zheng (2007) study, the events—like most events that have been used in studies of a goal bias in language—involved animate actors (or self-propelled inanimate objects) who carried out some action to achieve some goal. It is possible that this class of events highlights intentional goal-directed activity in a way to strongly bias people's representations of the actor's goal. By comparison, a non-intentional event involving inanimates (e.g., a ball rolling down an incline out of a can into a basket) might be much less susceptible to being represented in terms of the goal, or end state. Given that there is a deep conceptual distinction between animate–intentional events and inanimate-non-intentional ones, it is possible that a goal bias in non-linguistic thought may be strongly modulated by the animacy/intentionality of the figure that is moving. That is, a non-linguistic goal bias may be robust only for events involving motion by an animate figure undergoing a goal-directed action.

The main aim of the current study is to determine whether the goal bias observed in language studies also extends to non-linguistic representations—specifically, memory for source and goal paths. To the extent that a single set of principles dictates that there be a goal bias, both systems should show the same bias, and they should do so whether the figure is animate or inanimate.

We begin by examining performance on both a non-linguistic memory task (Experiment 1a) and a description task (Experiment 1b) using stimuli similar to those used by us in previous studies (Lakusta & Landau, 2005). We confined our stimuli to real-life events that could be described using manner of motion verbs (e.g., hopping, rolling, etc.). In these events, animate actors move from one physical object (source) to another (goal). The language data are meant to provide a replication of our earlier findings, and to serve as the comparison for the results of the memory task. As these events use animate actors, intentionality can easily be inferred by the viewer; in fact, one can easily infer that the individual is moving toward the endpoint for some reason. In later experiments, we will adjust the degree to which intentional movement toward the goal can be inferred, examining the degree to which the mapping between memory and language remains stable.

2. Experiment 1a—Look forward motion events

2.1. Participants

Participants were 14 Johns Hopkins undergraduates and 14 four-year-old children (4 males; mean age = 4 years, 6 months; range: 4 years, 1 month to 4 years, 11 months). For all the experiments reported in this study, adults were recruited through the Johns Hopkins Psychology subject pool; they received course credit for their participation. Children were recruited from local mothers' groups; they received a small toy for their participation.

2.2. Stimuli

Participants were shown 37 videotaped motion events. The events were comprised of an actor (male or female) moving in some way from one object (source) to another object (goal) (see Fig. 1). The events were 2.5 s long and all event components remained on the screen throughout the entire event. Sources and goals were real objects, such as a table, chair, and basket. Motions carried out by the actors included spinning, walking, hopping, running, rolling, lunging, crawling, skipping, and dancing. Left-right location of the source and goal were counterbalanced over events, as was the direction in which the actor moved.

Each of these 37 target events had a ''match.'' The matched event was either identical to the target event (N = 9), had a different source (N = 9), a different goal (N = 9), a different

Fig. 1. Clip from one of the events used in Experiments 1a and 1b (motion events involving actors). In this event, the man is hopping from the source (table) to the goal (ladder). Note that the actual stimuli used in all the experiments were movies, *not* static clips.

figure ($N = 5$), or a different motion ($N = 5$). The changes in figure and motion (filler trials) were included to increase the difficulty of the task. Changes in sources and goals were controlled such that the same set of changes was used for both cases. For example, an exchange of a TV for a cart was used twice, once for a source change and once for a goal change.

2.3. Procedure

The method builds on findings from change blindness studies suggesting that individuals fail to notice all the information contained in a scene (see Simons, 2000 for a review). Participants viewed an event (for 2.5 s), then the screen went black for 10 s, and then participants viewed the second event (i.e., the ''match'' event), after which they were asked to judge whether the two events were the same or different by circling ''same'' or ''different'' on their test sheet.

To interfere with linguistic encoding, participants were required to verbally shadow a sequence of numbers and words being played from the computer (e.g., Hermer-Vazquez, Spelke, & Katsnelson, 1999). Verbal shadowing began immediately before the event came on the screen and ended after the event finished playing. To further increase the complexity of the task for the adults, we asked people trivia questions during the 10-s delay between the end of the first event and the onset of the second in each pair. Pilot data suggested that this manipulation was necessary to prevent adults from performing at ceiling. Children were required to shadow, but they were not asked trivia questions during the delay period. Rather, during this time the experimenter said to the child, ''Remember, remember, remember, don't forget, don't forget.'' Pilot testing revealed that asking children even simple trivia questions resulted in long-winded answers that diminished the likelihood of their watching the second event in the pair.

Before the experiment began, participants received practice trials (four for adults, five for children). For adults, these included pairs of non-manner of motion events (e.g., teddy bear sitting on a table); two of the pairs were identical (hence ''same'') and two were different from each other (hence ''different''). For children, these included pairs of motion events similar to the test events (e.g., a girl crawling from a water bottle to a clothes rack); one was the same and four were different in goal, source, figure, or motion.

2.4. Results

Our main question was whether both adults and children would show a goal bias. Hence, we present the results for the adults and children in separate but parallel analyses.

Participants performed above chance (0.50) overall (for adults and children, respectively, Ms = 0.78, 0.60; ps < .01). Participants did not show any significant differences for events that had a change versus events that had no change (for adults and children, respectively, Ms = 0.77, 0.60 vs. Ms = 0.83, 0.59; ps > .10).

The main question was whether participants were able to detect goal changes better than source changes. Figs. 2 and 3 suggest that they were. This pattern was confirmed by comparing the proportion of correct responses for goal and source change trials, paired, two-tailed, $t(13) = 2.74$, $p < .05$, $d = 0.73$, $t(13) = 2.94$, $p < .05$, $d = 0.78$ for adults (Fig. 2) and children (Fig. 3), respectively. Ten of the 14 adults and 9 of the 14 children showed this pattern, two-tailed-Wilcoxon signed ranks test, $z = -2.39$, $p < .05$, $z = -2.36$, $p < .05$, for adults and children respectively. One adult and four children showed no asymmetry. Further, only the proportion of correct goal change trials significantly differed from chance (0.50); goal: $t(13) = 3.96$, $p < .05$; $t(13) = 2.60$, $p < .05$ and source: $t(13) = 1.03$, $p > .10$; $t\,(13) = -0.36$, $p > .10$, for adults and children, respectively.[1, 2]

For this experiment, as well as the remainder of experiments reported in this paper, the pattern of goal/source encoding was directly compared for the adults and children with 2 (goal, source) × 2 (adults, children) repeated measure ANOVAS. These yielded no significant interactions, ps > .05.

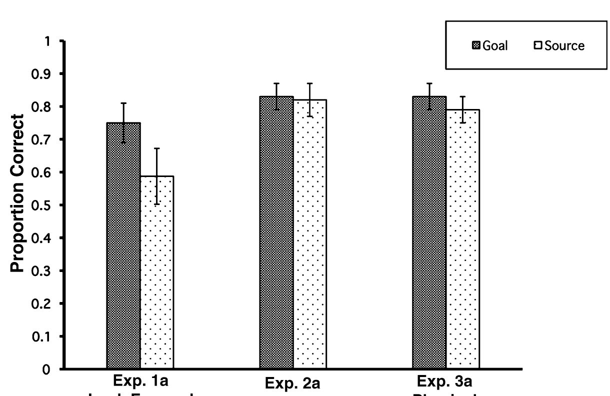

Fig. 2. Experiments 1a, 2a, and 3a. Average proportion correct (and SEs) of goal and source change trials for adults.

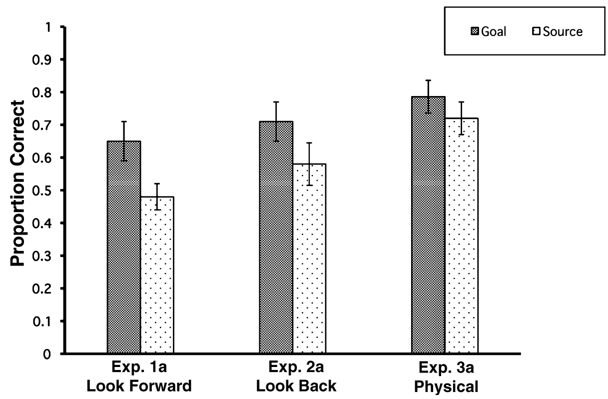

Fig. 3. Experiments 1a, 2a, and 3a. Average proportion correct (and *SE*s) of goal and source change trials for children.

2.5. Discussion

Both adults and children detected changes of goals in motion events better than changes in sources. This finding is consistent with the goal bias reported in Papafragou's (2010) study, which explored spatial memory for source and goal objects in computer animated motion events and Regier and Zheng's (2007) study, which explored attention to end states and starting states in attachment/detachment events. Our findings, in conjunction with the finding that pre-linguistic infants show a goal bias in their representations of motion events (Lakusta, Wagner, et al., 2007), provide support for the hypothesis that the goal bias observed in language is rooted fully in non-linguistic representations of events.

Although the events depicted in Experiment 1a were similar to those used in our previous work (Lakusta & Landau, 2005), they were not identical. To check that adults and children show the goal bias when linguistically describing these events, we next asked a separate group of participants to describe the same events used in the memory task. Although one might want to test the same subjects in the non-linguistic and language tasks, thereby seeing whether they have the same source/goal asymmetry in both cases, we opted to test independent groups of subjects since the non-linguistic task may easily bias the language task and vice versa. These language data were meant to provide a replication of earlier findings reporting that goal paths are included in people's descriptions more than source paths for manner of motion events (Lakusta & Landau, 2005).

3. Experiment 1b—Language of look forward motion events

3.1. Participants

Participants were 12 Johns Hopkins undergraduates and 12 four-year-old children (6 males; mean age = 4 years, 7 months; range: 4 years, 1 month to 4 years, 11 months).

3.2. Stimuli

Participants were shown 37 videotaped motion events (see Fig. 1). These events were the first event shown in each pair of events shown to participants in Experiment 1a.

3.3. Procedure

The method used was similar to that used by Lakusta and Landau (2005). Participants were told that they were going to watch short movies, and after viewing each movie, they were to tell the experimenter ''what happened.'' Adult participants received two practice trials, both that showed non-manner of motion events (e.g., a girl clapping). Unlike the adults, children received three practice trials that included motion events that were similar but not identical to the test events (e.g., woman lunging from pillows to a cart). Motion events were shown to the children during practice to acquaint the children with these types of events and increase the likelihood that they would describe the events with manner of motion verbs. For both the adults and children, the purpose of the practice trials was to acquaint participants with the method, without giving them specific feedback to encode the source and the goal. Lakusta and Landau (2005) did provide feedback during practice, and they found that adults supplied both goal and source path expressions at ceiling levels. To avoid this, feedback was not provided during practice in the current study. After the practice trials, participants proceeded to test. All responses were audiotaped and were later transcribed for analysis.

3.4. Results and discussion

Utterances were first coded for how people described the motion depicted in the events with respect to the source and the goal. Adults and children used manner of motion verbs over 90% of the time (e.g., he *ran* from the stool to the chair; *M*s = 0.93, 0.91, for adults and children, respectively).

Participants' descriptions were next analyzed for inclusion of goal and source. In this and all subsequent analyses, these were defined as a prepositional phrase complement of a verb (P + NP). Adults included the goal path (e.g., to the desk) more often than the source path (e.g., from the pillows; see Fig. 4); paired, two-tailed, $t(11) = 3.86$, $p < .01$, $d = 1.16$.[3] Individual subject analyses showed that all 12 adults showed a goal bias, two-tailed, Wilcoxon signed ranks test, $z = -3.06$, $p < .01$. Children also showed a goal bias, although the difference between goal and source path included was not significant (Fig. 5), paired, two-tailed, $t(11) = 1.61$, $p = .136$, $d = 0.49$. This is likely due to floor effects: Only three children actually included path information at all in their descriptions. All of these children included the goal and not the source (9 out of the 12 children encoded only the motion, stating, for example, ''she hopped''). Note that this pattern of manner of motion-only encoding for children was found only in this experiment. It was not found in Experiment 2b or in Experiment 3b of the current study, which included events that may have attracted more attention to the reference objects. This pattern was also not found in Lakusta and

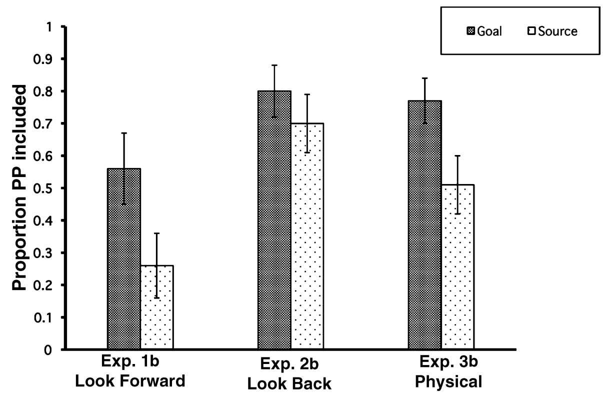

Fig. 4. Experiments 1b, 2b, and 3b. Average proportion Goal and Source PP included (and *SE*s) for adults.

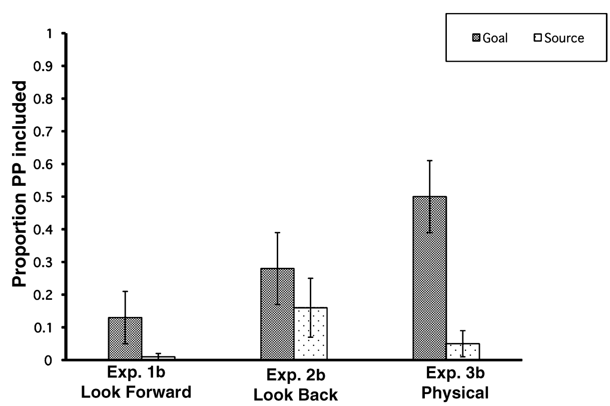

Fig. 5. Experiments 1b, 2b, and 3b. Average proportion Goal and Source PP included (and *SE*s) for children.

Landau (2005), who provided feedback to children during practice by encouraging them to specifically encode the goal and source.

What happened when participants did not encode source and/or goal reference objects in a PP? Considering the total number of responses for adults and children, we found that participants either simply omitted the source and/or goal objects altogether (*M* source = 0.58, 0.98, *SE* = 0.13, 0.01; *M* goal = 0.21, 0.79, *SE* = 0.09, 0.11, for adults and children, respectively), or mentioned them in another clause (e.g., ‘‘she jogged across the room and touched *the pillow*’’; ‘‘he stood up on *the blanket* and then walked over and touched *the wood thing*’’; *M* source = 0.15, 0.01, *SE* = 0.09, 0.01; *M* goal = 0.23, 0.08, *SE* = 0.08, 0.06, for adults and children, respectively). In this experiment and in Experiment 2b, there were no instances where participants used a preposition intransitively (e.g., he ran off).

In summary, when children or adults talked about elements of the path along which an actor moved, they showed a goal bias; that is, they encoded the goal in the PP more often than the source. These findings are consistent with Lakusta and Landau (2005), and they suggest that the manner of motion events we used also elicit a strong bias to linguistically encode the goal and its path over the source and its path. Thus, in both language and in non-linguistic memory (Experiment 1a), goals are encoded in preference than sources. Although this pattern is consistent with the idea of homologous representations for language and memory, it is not conclusive. In our events, we may have loaded the dice toward strong representation of goals, since we used animate actors who moved purposely toward the goal, strongly suggesting goal-oriented behavior. One possibility, therefore, is that the data from the language and non-language tasks mirrored each other simply because of the force of the events—driving the observer to encode them as goal-oriented. Would the asymmetry between language and non-linguistic thought remain stable if the intention in the event was modulated?

In the next two experiments, we address this possibility by carrying out modified replications of Experiment 1 with different types of events. In Experiment 2, we partially deconfounded the easily inferred intention of the actor (move to the goal) and the direction of movement (to the goal). In Experiment 3, we completely deconfounded these two variables by using stimuli that portray physical events—thereby removing animate intention but preserving direction of motion.

4. Experiment 2a: *Look back* motion events

4.1. Participants

Participants were 14 Johns Hopkins undergraduates and 14 four-year-old children (3 males and 11 females; mean age = 4 years, 6 months; range: 4 years, 1 month to 4 years, 11 months). None participated in Experiment 1a.

4.2. Design, stimuli, procedure

These were the same as for Experiment 1a, except that the actor looked back continuously toward the source, as he/she physically moved toward the goal (i.e., the endpoint object) (see Fig. 6). If the actor's perceived intentionality plays a strong role in which reference object is better remembered, then this manipulation should modulate the effects observed in Experiment 1a (in which the actor looked forward, toward the goal).

Note, in this Experiment, we continue to refer to the endpoint object of the actor's motion as ''goal'' and the starting point object of the actor's motion as ''source'' (i.e., we refer to the same objects as ''goal'' and ''source'' in Experiments 1 and 2). Whether the source is really an intentional goal as a result of the look back manipulation is an important question for future research; in the current study we sought only to modulate the goal bias effect with this manipulation.

Fig. 6. Clip from one of the events used in Experiments 2a and 2b (''Look Back'' motion events). In this event, the actor is hopping from the source (table) to the goal (ladder), *while looking back* at the source.

4.3. Results and discussion

Participants performed above chance (0.50) overall (for adults and children, respectively, Ms = 0.82, 0.60; ps < .01). Participants did not show any significant differences for events that had a change versus events that had no change (for adults and children, respectively, Ms = 0.81, 0.60 vs. Ms = 0.86, 0.62; ps > .10).

As shown in Figs. 2 (adults) and 3 (children), participants did not significantly differ in how well they detected goal and source changes; paired, two-tailed, $t(13) = 0.49$, $p > .10$, $d = 0.13$, $t(13) = 1.53$, $p > .10$, $d = 0.41$ for adults and children, respectively. Only six of the 14 adults and eight of the 14 children showed a goal bias; two-tailed, Wilcoxon signed ranks test, $z = -0.54$, $p > .10$, $z = -1.43$, $p > .10$, for adults and children, respectively. Four adults and three children showed no asymmetry.[4] Furthermore, proportion of goal and source changes judged correctly significantly differed from chance (0.50) for the adults: goal: $t(13) = 8.02$, $p < .05$ and source: $t(13) = 6.69$, $p < .05$. For the children, only the proportion of goal correct significantly differed from chance: goal: $t(13) = 3.65$, $p < .05$ and source: $t(13) = 1.22$, $p > .10$. Thus, as also suggested by the pattern of the means displayed in Fig. 3, children continue to show some evidence for an asymmetry in which they remember the goal better than the source. In fact, examination of the individual subject data for the look back events revealed that some children continued to show a goal bias despite the look back manipulation (see Fig. 7), suggesting that perhaps for these children the look back manipulation was not a strong enough cue to draw their attention away from the goal and toward the source (see also Einav & Hood, 2006 for evidence that children may have difficulty disengaging their attention when the moving figure is salient in the event).

In sum, unlike the pattern observed in Experiment 1a, adults, and some children, did not show a goal bias in memory when encoding events of an actor moving from a source to a

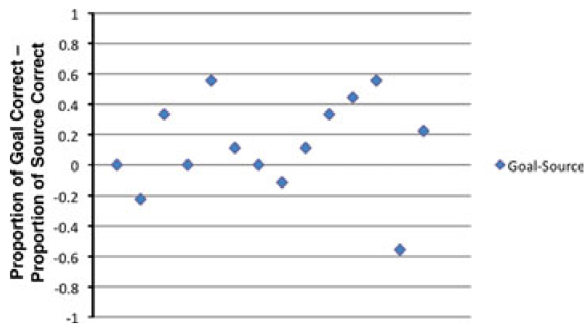

Fig. 7. Experiment 2b (Look Back) scatterplot of individual children. Proportion of goal correct minus proportion of source correct.

goal while looking back at the source. This suggests that the intentionality of the actor may strongly modulate goal and source encoding. In Experiment 2b, we explore whether the pattern of goal and source encoding in non-linguistic memory reflects the pattern of goal and source encoding in language.

5. Experiment 2b: Look back events—language

5.1. Participants

Participants were 12 Johns Hopkins undergraduates and 12 four-year-old children (6 males; mean age = 4 years, 4 months; range: 4 years, 1 month to 4 years, 10 months).

5.2. Design, stimuli, procedure

These were the same as for Experiment 1b, except that the actor looked back continuously toward the source, as he/she physically moved toward the goal (see Fig. 6).

5.3. Results and discussion

Adults and children used predominantly manner of motion verbs to encode the motion in the events with respect to the source and the goal (e.g., he *ran* from the stool to the chair; *M*s = 0.89, 0.74 for adults and children, respectively). When children did not use a motion verb, they usually encoded the event with only a verb of contact (e.g., ''she touched the pillow'').

Participants' descriptions were next analyzed for inclusion of goal and source. Adults did not differ in how often they included the goal path (e.g., to the desk) compared to the source path (e.g., from the pillows; see Fig. 4); paired, two-tailed, $t(11) = 1.39$, $p = .19$, $d = 0.42$.[5] However, children continued to show a goal bias, paired, two-tailed,

$t(11) = 2.38$ $p = <.05$, $d = 0.69$ (see Fig. 5). Individual subject analyses showed that six adults showed a goal bias and four adults showed a source bias; two-tailed, Wilcoxon signed ranks test, $z = -1.12$, $p = .26$. Two adults showed no difference between goal and source encoding. Six children showed a goal bias and no children showed a source bias, Wilcoxon signed ranks test, $z = -2.20$, $p < .05$. Six children showed no difference between goal and source encoding.

What happened when participants did not encode source and/or goal reference objects in a PP? Considering the total number of responses for adults and children, we found that participants either simply omitted the source and/or goal objects altogether (*M* source = 0.15, 0.77, *SE* = 0.06, 0.11; *M* goal = 0.12, 0.37, *SE* = 0.08, 0.13 for adults and children, respectively) or mentioned them in another clause (e.g., ''someone was touching some sort of *storage cabinet thing*''; ''he started at the desk…''; *M* source = 0.15, 0.07, *SE* = 0.08, 0.06; *M* goal = 0.08, 0.35, *SE* = 0.04, 0.12, for adults and children, respectively).

Overall, these findings suggest that when the gaze of the actor and the direction of the actor's motion are ''deconfounded,'' a goal/source asymmetry no longer robustly shows up in language for adults. These are the first findings, to our knowledge, that fail to find a goal bias in the language of events. We interpret this to mean that adults are sensitive to the actor's eye gaze and intention, and thus they focus their own attention on either getting *to* the physical goal (endpoint) or getting *away from* the physical source (starting point). This itself raises the question of how to define the source or goal in an event, and it suggests that this might vary depending on the type of event, a topic we return to in the General Discussion. Children are more likely to focus on the physical goal (endpoint of the path?), perhaps for the same reasons as those children who continued to show a goal bias in the non-linguistic memory task of Experiment 2a—the eye gaze cue may not have been strong enough to direct children's attention to the source. In any case, the intentional cues we provided did modulate the degree to which adults encode goal and source in language, but they did not have such a clear effect on children.

The findings from the adults lend even further support to the hypothesis of homologous structure between language and non-linguistic thought. Adults failed to show a robust goal bias in their memory of the look back events, and a separate group of participants showed a similar pattern in their descriptions of the look back events. Thus, the pattern of goal/source asymmetries observed in a non-linguistic task also appears in language.

In Experiment 3 we move to a stronger test of the generality of the goal bias and the extent of homologous structure of non-linguistic thought and language by portraying physical events, in which inanimate objects move from one object to another. These events preserve direction of motion from source to goal while removing any intentional component of the motion. Such events fall into an entirely different conceptual domain than events portraying motion by a clearly animate actor (Carey & Spelke, 1994). If there is a strong homology between language and non-linguistic representation of sources and goals, the two tasks should show similar patterns of goal/source encoding.

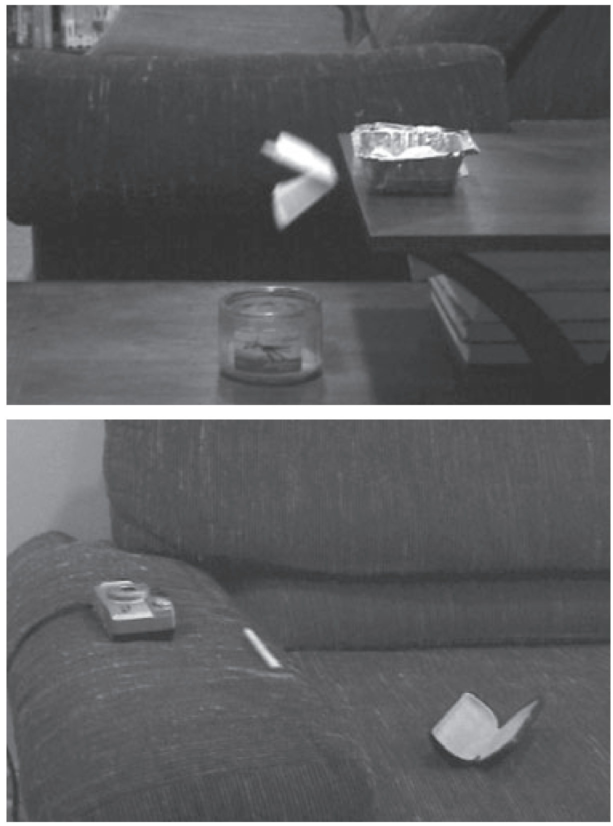

Fig. 8. Clips from two of the events used in Experiments 3a and 3b (motion events involving inanimate objects). In the first event, the paper blows from the source (container) to the goal (candle). In the second event, the pen rolls from the source (camera) to the goal (eyeglass case).

6. Experiment 3a: *Physical* motion events

6.1. Stimuli

Participants were shown 32 videotaped motion events comprised of an inanimate object rolling ($N = 16$) or blowing ($N = 16$) from one object (source) to another object (goal) (see Fig. 8). Sources and goals were real objects, such as a cup, folder, and remote control. The moving objects were objects that could be easily blown (e.g., tissue, leaf, paper) or rolled (e.g., pen, battery, film case) by an external force (a hairdryer positioned off screen). Note that we aimed to create physical events that were realistic—that could naturally be encountered in real life—thus the sources, goals, and figures were smaller than those used in Experiments 1a and 1b. To confirm that the motion would not be inferred as intentional, prior to conducting the experiment, we asked five adults to describe the events and coded their descriptions for the use of mentalistic language (see Heider & Simmel, 1945). Mentalistic language was not used, confirming that the motion appeared non-intentional.

Each of the 32 events had a ''match'' that was either identical to the target event ($N = 8$, 4 ''blowing'' and 4 ''rolling''), had a different source ($N = 8$, 4 ''blowing'' and 4 ''rolling''), a different goal ($N = 8$, 4 ''blowing'' and 4 ''rolling''), or a different figure ($N = 8$, 4 ''blowing'' and 4 ''rolling''). Unlike Experiments 1a and 1b, there were no filler trials that had different manners since the inanimate objects realistically moved via only one manner (rolling or blowing). This modification also resulted in the current experiment having a slightly different design than Experiment 1; the current experiment had 32 events while Experiment 1 had 37 events.

6.2. Procedure

The procedure was the same as that used for Experiments 1a and 1b.

6.3. Participants

Participants were 24 Johns Hopkins undergraduates and 14 four-year-old children (8 males; mean age = 4 years, 8 months; range: 4 years, 3 months to 4 years, 11 months). Note that initially we had a sample size of 14 adults, as in our other studies. However, with this sample size we observed a small trend in the data; we explored this trend by collecting data from 10 more adults. The results (reported below) remained the same, suggesting that the findings in this experiment do not appear to be related to sample size.

6.4. Results and discussion

Participants performed above chance (0.50) overall (for adults and children, respectively, Ms = 0.80, 0.69; ps < .01). Participants did not show any significant differences for events that had a change versus events that had no change (for adults and children, respectively, Ms = 0.78, 0.71 vs. Ms = 0.86, 0.70; ps > .10).

Figs. 2 and 3 show the proportions of correct responses for goal and source change trials. There were no reliable differences for adults or children, respectively, $t(23) = 1.03$, $p > .10$, $d = 0.21$, $t(13) = 1.20$, $p > .10$, $d = 0.32$. Only 11 of the 24 adults and eight of the 14 children were better at detecting goal changes than source changes; two-tailed, Wilcoxon signed ranks test, $z = -0.95$, $p > .10$, $z = -1.12$, $p > .10$, for adults and children, respectively. Seven out of the 24 adults and 2 out of 14 children showed no asymmetry.[6] Furthermore, both the proportion of goal and source correct significantly differed from chance (0.50); goal: $t(13) = 7.64$, $p < .05$, $t(13) = 5.74$, $p < .05$ and source: $t(13) = 7.37$, $p < .05$, $t(13) = 4.24$ $p < .05$, for adults and children, respectively.

Participants did not show a significant goal bias in memory when encoding events of an inanimate object moving from a source to a goal, suggesting that in non-linguistic cognition, a goal bias does not robustly show up for physical events. This further questions the generality of a goal bias in non-linguistic cognition and whether a goal bias in non-linguistic cognition can be *solely* explained as a general memory or attention bias to encode the endpoint over the starting point (Regier, 1996). Rather, as in Experiment 2a (Look back memory) features of the events (e.g., animacy/intentionality of the moving object) appear to modulate source/goal encoding in subtle ways.

In the final experiment, we explore how a separate group of adults and children describe the physical events portrayed in Experiment 3a. As in the previous experiments, by testing people's linguistic descriptions of these events we explore whether language follows the pattern we have observed for non-linguistic event representations.

If there is a perfect homology between language and non-linguistic representation of sources and goals, there should not be a goal bias in the language of physical events, just as there was no observed goal bias for non-linguistic representations of physical events.

7. Experiment 3b: Physical events—language

7.1. Participants

Participants were 12 Johns Hopkins undergraduates and 12 four-year-old children (5 males; mean age = 4 years, 6 months; range: 3 years, 11 month to 4 years, 9 months).

7.2. Design, stimuli, procedure

The procedure was the same as that used in Experiments 1b and 2b. The stimuli were the first event in each pair of movies used in Experiment 3.

7.3. Results and discussion

Adults and children overwhelmingly used manner of motion verbs to encode the sources and goals within the events (e.g., the chapstick *rolled* from an envelope onto a towel; *M*s = 0.97, 0.92, for adults and children, respectively). Participants' descriptions were next analyzed for inclusion of goal and source. Adults and children included the goal path (e.g., onto a folder) more often than the source path (e.g., off the plastic bag; see Figs. 4 and 5); paired, two-tailed, $t(11) = 3.30$, $p < .01$, $d = 1.00$, $t(11) = 4.04$, $p < .01$, $d = 1.16$ for adults and children, respectively.[7] Individual subject data revealed that 11 adults and 9 children showed a goal bias; two-tailed, Wilcoxon signed ranks test, $z = -2.94$, $p < .05$, $z = -2.67$, $p < .05$, for adults and children, respectively (one adult and three children showed no asymmetry).

What happened when participants did not encode source and/or goal reference objects in a PP? Considering the total number of responses for adults and children, we found that participants either simply omitted the source and/or goal objects altogether (*M* source = 0.37, 0.94, *SE* = 0.09, 0.04; *M* goal = 0.15, 0.49, *SE* = 0.06, 0.11 for adults and children, respectively), or mentioned them in another clause (e.g., ''the bill was next to *a baseball hat*''; ''…it stopped at *a stapler*''; *M* source = 0.125, 0.003, *SE* = 0.03, 0.003; *M* goal = 0.08, 0.01, *SE* = 0.03, 0.005, for adults and children, respectively). Unlike Experiments 1b and 2b, there were a few cases for the children where prepositions marking paths were used intransitively (*M* goal path = 0.003, *SE* = 0.003; *M* source path = 0.03, *SE* = 0.02). These were all cases were the reference objects were omitted (e.g., ''the book fell off'').

In sum, when adults and children described events depicting an inanimate object moving from a source to a goal, they encoded the goal in a PP more often than the source. This suggests that a goal bias in language does extend robustly to events involving motion by an inanimate. This contrasts with the pattern of goal/source encoding found in Experiment 3a, where a significant goal bias was *not* found for non-linguistic event representations (Figs. 2 and 3). These findings challenge the hypothesis that there is a direct and simple homology between non-linguistic thought and language; that is, there may not be a single set of principles dictating a goal bias in language and in non-linguistic event representations. In the discussion that follows, we consider how these two systems may map onto each other, and how they might diverge.

8. General discussion

The current study tested whether the goal bias that has been observed in language has its origins in non-linguistic representations of events. In three experiments, adults and children either remembered or described events that varied in animacy/intentionality of the actor. The three non-linguistic change detection tasks showed a range of results, with children and adults showing a goal bias for animate/intentional events (Experiment 1a), none for inanimate events (Experiment 3a), and a split pattern for animate events in which gaze cues to the actor's intention were pitted against the direction of motion (Experiment 2a). In the latter case, adults did not show a goal bias, while the pattern for children was mixed; some children continued to show a goal bias despite the look back manipulation, a difference possibly due to the differential weighting of the two cues (eye gaze, direction of motion) in representing the events. In the language tasks, adults showed a goal bias for the animate/intentional look forward events (Experiment 1b) and for the inanimate events (Experiment 3b), but not for the look back events (Experiment 2b), while the children showed a goal bias across all three experiments (see Table 1 for a summary of the results).

The first and third experiments provided a strong test of the homology between language and memory for sources and goals. Although the language task in both showed a goal bias, the change detection task showed this bias only when animate actors moved intentionally toward a goal. Is it possible that this difference can be explained by inherent differences in the events themselves (e.g., the difference in the physical size of the figure objects)? We believe this is unlikely for the following reasons. First, a *linguistic* goal bias was found for *both* the ''look forward'' and inanimate events. Second, a non-linguistic goal bias was not found for the ''look back'' events, which were nearly identical to the ''look forward'' events. And, third, using an entirely different method, Lakusta, Reardon, Oakes, and Carey (2007) showed that pre-linguistic infants show a strong goal bias for animate/intentional events, but not for inanimate events—the same pattern found with children and adults in the current study. Thus, although we think it is likely that the animacy/intentionality of the moving object in the physical events was the key feature responsible for the lack of an

Table 1
Summary of the results from the current study

	Experiment 1: Motion Events Involving an Actor (''look forward'')		Experiment 2: Motion Events Involving an Actor (''look back'')		Experiment 3: Motion Events Involving an Inanimate Object	
	Memory	Language	Memory	Language	Memory	Language
Adults	Goal bias	Goal bias	X	X	X	Goal bias
Children	Goal bias	Goal bias	Mixed pattern	Goal bias	X	Goal bias

asymmetry in memory between sources and goals, what is clear from the results of Experiment 3a is that the goal/source asymmetry does not robustly show up in physical events; which features of the event are responsible for modulating source/goal encoding in such events is a question left open for future research.

The presence of a robust goal bias in language but not in non-linguistic event representations suggests that, although there may be some grounding of a goal bias in cognition (as suggested by the similar pattern of results in the first experiment and, for adults, second experiment), the mapping is not as straightforward as has been previously suggested (Regier & Zheng, 2007). Rather, at least some of the pressure to encode goals in favor of sources may stem from properties of language, and not solely from properties of our memory representations of events. In the paragraphs below, we discuss the factors that may drive a goal bias in non-linguistic thought and in language, and we consider how non-linguistic event representations are mapped into linguistic ones.

8.1. Non-linguistic representations of source and goal

Children and adults were significantly better at detecting changes in goals than changes in sources for the animate, ''look forward'' events (Experiment 1a), but no such bias was found for adults, and some children, for the animate, ''look back'' events (Experiment 2a) or the inanimate events (Experiment 3a). The difference across these experiments was likely due to differences in the intentional structures of the events. Specifically, the events in Experiment 1 showed a human moving from the source (starting point) to the goal (endpoint), while looking at the goal. These events were likely to be construed as an intentional agent moving in a goal-directed fashion (in line with much research showing that eye gaze is a reliable indicator of one's intentions; e.g., Baron-Cohen, 1995; Tomasello, 1995). In Experiment 2, however, the goal (endpoint) was partially ''deconfounded'' with the actor's intentions by having the actor in the event *look back at the source* as he moved to the goal. Essentially, we provided competing cues to people, pitting direction of gaze against direction of motion. In Experiment 3, intention was completely removed from the event by using inanimate objects that were blown or rolled from one object to another object. The pattern of results suggests that the preferential encoding of goals shows up most strongly for events involving clear, goal-directed (intentional) motion by an agent, for both children and adults.

The importance of intention in the representation of goals likely has an early developmental origin. Recent evidence shows that pre-linguistic infants preferentially encode goals in events involving motion by animate-like objects (e.g., stuffed duck and self-propelled balloon with a face), but not in similar events involving inanimate objects (balloon) (Lakusta, Reardon, et al., 2007). Thus, the role of intention in modulating a goal bias seems to be a signature pattern of event memory that is continuous over development. The importance of intention also suggests that there should be a way to strengthen children's and adults' representations of sources: If the source generates strong intention and/or plays a strong causal role in an event, then people might remember it better than the goal. Examples that come to mind include a person running from a burning house to a neighbor's house, or a ball being shot out of a cannon into a barrel. We predict that such events would result in robust memory of the sources, even relative to the goals.

The current findings are consistent with, and extend, recent findings by Regier and Zheng (2007), showing that adults' perceptions of joining and separating events show an endpoint (goal) bias. Regier and Zheng point out that their events could result from ''attention to the intended *goals* of a human actor'' (p. 717). As they note, goals only become fully apparent at the endpoints of events, and a goal bias might be important for highlighting the endpoints/goals of human actions. Our findings are also consistent with the findings of Papafragou (2010), which showed a goal bias in children's and adults' memory for goal and source objects and spatial relations in computer generated motion events. Similar to our Experiment 1a (look forward memory) of the current study, Papafragou tested people's memory for goal and source objects with motion events involving an animate figure (e.g., a fairy) and she tested people's memory for source and goal spatial relations with events involving a self-propelled inanimate figure, thus raising the possibility that the intentions of the figure may have played a role in the observed goal bias. She states, ''As the present stimuli involved only animate agents (Experiment 1) or a self-propelled inanimate object (soccer ball; Experiment 2) it is natural to ask whether the results would change if one introduced inanimate, non self-propelled agents (e.g., a leaf, a piece of leather)'' (Papafragou, 2010, pp. 1087–1088). Our results from Experiment 3a (physical memory) suggest that they might; children and adults did not show a robust goal bias when the events portrayed physical events in which an inanimate object (e.g., tissue, pen) was blown or rolled from one object to another object. Thus, in sum, our results suggest that animate and intentional events are indeed represented in memory with a strong goal bias. However, an equivalent ''endpoint bias''—which would hold for inanimate events—does not show up robustly, at least with our stimuli and methods.

8.2. Linguistic representation of source and goal

Our results showed a strong bias among children and adults to encode the goal in preference to the source. Both goals and sources were predominantly encoded in prepositional phrases, the preferred structure for encoding paths in English. The robust nature of the goal bias in people's linguistic descriptions of motion events is consistent with our previous data (Lakusta & Landau, 2005), as well as abundant evidence from the linguistics literature that languages exhibit asymmetries in the way they encode the two kinds of paths (see Introduction).

The question motivating our studies was whether the pattern of asymmetry in language—shown in formal linguistic studies, and here, in children's and adults' language production—reflects a simple mapping from non-linguistic representation of events. Our findings suggest there is no such simple mapping, because factors that appear to affect people's memory representations of motion events do not *inevitably* affect their linguistic descriptions of those events.

The strong goal bias in language is likely to reflect in part the special nature of goals in human cognition; but it is also likely to reflect properties of language (the intermediate hypothesis presented in the Introduction). We have in mind an idea that centers around the notion of prominence hierarchies in language to explain the mapping between conceptual/semantic representations and syntax (Aissen, 2001; Dowty, 1991; Grimshaw, 1981; Pinker, 1989). One of the most well-studied instances of these cases is the mapping of the conceptual/semantic elements agents and patients into the syntactic positions of subject and object. Briefly, when agents and patients differ only minimally, the default mapping is to map agents into subject position (Aissen, 2001). But patients may become more prominent, for example, by being the topic of previous discourse (Aissen, 2001). It is the alignment of several hierarchies (conceptual/semantic, pragmatic, syntactic) that determines the mapping (see Fisher & Song, 2006, for an excellent discussion of the mapping of agents and patients into syntax).

This idea can be roughly extended to the case of goals and sources. As we have already reviewed in the Introduction, goals and goal paths may be more prominent than sources and source paths at the conceptual/semantic level (e.g., for a goal bias in infants see Lakusta, Reardon, et al., 2007; Lakusta, Wagner, et al., 2007; for a goal bias in semantic structure see Filip, 2003; Markovskaya, 2006; Nam, 2004). Even at the pragmatic/discourse level, goals may naturally be more prominent than sources. For example, an event that culminates in a goal presupposes some starting state (source), but not the reverse (Riemsdijk, 2007; Wexler, personal communication, May 3, 2007). What is less clear in the case of goals and sources is whether there is a distinction between goal and source PPs at the grammatical level (as there is between the syntactic subject and object). Do goal and source PPs (e.g., into x, out of x, to x, from x) differ in their grammatical status? For example, are goals arguments and sources adjuncts of manner of motion verbs (e.g., ''run'')? Do goal PPs show up as core syntactic arguments more than source PPs (e.g., are there more verbs of attachment, such as ''put,'' than detachment verbs, such as ''remove'')? If so, then the alignment of goal and source elements at the conceptual, pragmatic, and grammatical level may explain the mapping of goals and sources in language, and importantly it may explain the divergence between the non-linguistic and linguistic encoding of goals and sources in inanimate/non-intentional events.

Returning to our experiments, we speculate that the systematic encoding of goals across Experiments 1 (Look forward) and 3 (Physical) may have occurred because the goals in each case were more prominent than the sources at one or more levels. In the case of Experiment 1, this seems very clear. Animate actors moved purposefully in a direction away from a source and toward a goal. Conceptually, this type of event has everything going for it: It involves an animate-intentional actor whose movement reaches a clear endpoint. As with Dowty's (1991) analysis of what makes a good agent versus patient (sentient, volitional, and causal vs. inanimate and non-causal, respectively), we can think of the events in Experiment 1 as strongly biased toward the representation of a goal. In Experiment 1, the conceptual dice were loaded toward the goal, as shown by the bias among children and adults in both tasks. The situation differed for Experiment 2 (Look back), where adults did not show a goal (or source) bias in language and memory. This may not be surprising given that the look back events portrayed an animate figure *looking at the source* as he/she moved *toward the goal*. Thus, for these events the conceptual dice seem to be loaded toward both the source and the goal. For children, however, the look back manipulation may not have been a strong enough cue of the actor's intentionality, as shown by the persistence of a goal bias in language and, for some children, in memory.

By contrast, in Experiment 3, people described inanimate objects undergoing non-purposeful motion from point A to B. In this case, the events rank low in animacy and intentionality, but still have a source and goal—now perhaps better termed a ''starting point'' and ''endpoint''—which were roughly equally well represented in the memory task. In this case, the goal path—but not the source path—still surfaces in a PP (see Randall, van Hout, Weissenborn, & Baayen, 2004 for evidence that telicity—the boundedness of events—plays an important role in determining whether a verb is classified grammatically as unaccusative or unergative[8]). Perhaps this is similar to the case of mapping agent to subject and patient to object (Aissen, 2001); when these differ only minimally, the default is to map agents into subject position. Analogously, when source and goal differ only minimally, the default mapping is apparently to map the goal into the PP.

Although our hypothesis is speculative, it generates some interesting predictions. First, the general idea that the goal bias is the result of multiple prominence relations suggests that it should be possible to construct events in which the various levels conspire to make the source path more prominent than the goal path. Using the idea that a confluence of properties determines how ''good'' a source or goal is, one could construct events in which there are goals that are conceptually weak, and sources that are conceptually strong; language for these events should not show a goal bias, and it may even show a source bias. For example, starting points that are strongly causal (e.g., the girl ran out of the burning house and into her car) are likely to be highly prominent and might be expected to elicit source paths in preference to goal paths. And, in fact, if one accepts Jackendoff's (1990) ''two-tier'' analysis that agents and patients in transfer of possession events are also sources and goals, respectively, then sources/agents should be more prominent than goals/patients. Indeed, Lakusta and Landau (2005) found that throwing–catching events were systematically described by children and adults using the verb *throw* rather than *catch*, even though both throwing and catching were equally salient. People said ''the girl threw the ball to the boy'' rather than ''the boy caught the ball from the girl,'' choosing to code the girl as agent/-source and the boy as patient/goal rather than the reverse. Similar considerations apply to the other hierarchies we have discussed; one can imagine, for example, setting up situations in which the goal—but not source—is pragmatically presupposed and testing whether source paths now dominate.

The findings from the current study suggest that by the age of 4, children and adults look remarkably similar, differing only in their language of the ''look back'' events. This overall similarity suggests that ''proto-goals'' and ''proto-sources'' for children may be quite similar to those for adults, and thus there will be few developmental differences in how sources and goals are mapped into syntax. This is what one would expect given that the concepts of ''intentional agency'' and ''cause'' are well developed by this age. But to the extent that these concepts still need to mature, ''proto-goals'' and ''proto-sources'' may differ for children and adults—with different consequences for their language. As alluded to earlier, the difference in our ''look back'' task may be explained by the children's immature understanding of the actor's intentions in these events or their lower weighting of gaze cues, relative to direction of motion. A completely open question is the extent to which pragmatic/discourse hierarchies play a role in source/goal encoding over development.

In conclusion, we have found that the goal bias observed for the language of motion events is not fully rooted in non-linguistic event representations. Whereas the intentional structure of events strongly modulates the encoding of starting points and end points in non-linguistic thought, additional principles must be at work in linguistic encoding. The precise nature of these principles, how they align in language, and their nature early in development are questions left open for future research.

Notes

1. Note that a signal detection analysis taking into account the number of hits and false alarms was not performed on these data because, as described in the Methods section, in our design there were nine trials in which the pairs of events were identical to each other. Thus, the number of ''false alarms'' would be the same for the source and goal change trials in a signal detection analysis.
2. Detection of figure and motion (filler) changes was not of central concern to our thesis, and hence these changes were not controlled for salience as were goal and source changes. However, for the interested reader, adults were at ceiling for detecting both (Ms = 0.96, 0.94) and children were better at detecting figure changes than motion changes (Ms = 0.80, 0.53).
3. For adults, there were a few responses where a spatial location was encoded in a goal and/or source prepositional phrase (e.g., ''skipped *to the other side*''; Ms = 0.13, 0.03; SEs = 0.06, 0.02, for goal and source paths, respectively). When these PPs were included in the analysis above, the results remained the same—an asymmetry between goal and source PPs was observed; paired, two-tailed, $t(11) = 4.68$, $p < .05$.
4. As in Experiment 1a, we also report the proportion of correct figure changes (Ms = 0.81, 0.63) and motion changes (Ms = 0.74, 0.43), for adults and children, respectively.

5. As in Experiment 1b, for adults, there were a few responses where a spatial location was encoded in a goal/or source prepositional phrase (e.g., ''running *from one side to the next*''; *M*s = 0.04, 0.02; *SE*s = 0.04, 0.01, for goal and source paths, respectively). When these PPs were included in the analysis the results remained the same—no significant asymmetry between goal and source PPs was observed; paired, two-tailed, $t(11) = 1.80$, $p = .10$. Only one child encoded the spatial location in a goal PP (''He ran *to a different place*'').
6. For the curious reader, we also report the proportion of correct figure changes (*M*s = 0.73, 0.57), for adults and children, respectively.
7. For children and adults, there were a few responses where the physical context in which the event took place was encoded in a goal and/or source prepositional phrase (e.g., ''a battery fell *off the arm of the couch to the couch*''; *M*s goal paths = 0.18, 0.07, *SE*s = 0.07, 0.03; *M*s source paths = 0.29, 0.08, *SE*s = 0.07, 0.06, for adults and children, respectively). When these PPs were included in the analysis above, the results remained the same, that is, there was an asymmetry between goal and source PPs; paired, two-tailed, $t(11) = -1.81$, $p = .10$, $t(11) = -3.13$, $p < .05$, for adults and children, respectively. Note that the marginal effect for adults was possibly due to ceiling effects; adults encoded the actual goal object and/or furniture in a PP 95% of the time.
8. Interestingly, in the unaccusative/unergative case there are times where telicity is more prominent than agenthood and children are especially sensitive to the telicity of the event. For example, an analysis by Randall et al. (2004) shows that two semantic factors determine unaccusativity in Dutch: whether the conceptual representation has an actor and whether it is telic (bounded). Clauses that are atelic and have an actor (e.g., John danced around the room) are classified as unergative, whereas clauses that are telic and have an actor (e.g., John danced into the room) are classified as unaccusative. In the latter case, telicity ''outranks'' having an actor, making the clause unaccusative. Experimental data reported by Randall suggest that children as young as 4 years use this ''Telicity Linking Rule'' when classifying verbs (although, interestingly, their appropriate use of the ''Actor Linking Rule'' is much less clear; see Randall et al., 2004). The importance of telicity for children raises the possibility that the children in the current study continued to show a linguistic goal bias in Experiment 2b (look back events) because the goal continued to be the endpoint of the motion, thus making it highly prominent.

Acknowledgments

We gratefully acknowledge the assistance of David Strickland, and Whitney Street, who helped with data collection and Kathryn Yuschak who helped with coding of the language data. We thank the children and parents who participated in these studies, and special thanks to all our ''actors'' and ''actresses'' in the events. This research was part of the first author's dissertation at Johns Hopkins University. This research was supported by March of Dimes grants 01-87 and 04-46, and BCS grant 0117744 from the National Science Foundation.

References

Aissen, J. (2001). Markedness and subject choice in Optimality Theory. In G. Legendre, J. Grimshaw, & S. Vikner (Eds.), *Optimality-theoretic syntax* (pp. 61–96). Cambridge, MA: MIT Press.

Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind*. Cambridge, MA: MIT Press.

Bloom, P. (1999). The role of semantics in solving the bootstrapping problem. In R. Jackendoff, P. Bloom, & K. Wynn (Eds.), *Language, logic, and concepts* (pp. 285–309). Cambridge, MA: MIT Press.

Bowerman, M., de León, L., & Choi, S. (1995). Verbs, particles, and spatial semantics: Learning to talk about spatial actions in typologically different languages. In E. V. Clark (Ed.), *The Proceedings of the Twenty-seventh Annual Child Language Research Forum* (pp. 101–110). Stanford, CA: Center for the Study of Language and Information.

Carey, S., & Spelke, E. (1994). Domain-specific knowledge and conceptual change. In L. A. Hirschfeld & S. A. Gelman (Eds.), *Mapping the mind: Domain specificity in cognition and culture* (pp. 169–200). Cambridge, England: Cambridge University Press.

Clancy, P. M. (1985). The acquisition of Japanese. In D. I. Slobin (Ed.), *The crosslinguistic study of language acquisition: Vol. 1. The data* (pp. 373–524). Hillsdale, NJ: Lawrence Erlbaum Associates.

Dowty, D. (1991). Thematic proto-roles and argument selection. *Language*, *67*(3), 547–619.

Einav, S., & Hood, B. (2006). Children's use of the temporal dimension of gaze for preferring preference. *Developmental Psychology*, *42*(1), 142–152.

Filip, H. (2003). Prefixes and the delimitation of events. *Journal of Slavic Linguistics*, *11*(1), 55–101.

Fillmore, C. J. (1997). *Lectures on deixis*. Stanford, CA: CSLI Publications.

Fisher, C., Hall, G. D., Rakowitz, S., & Gleitman, L. (1994). When it is better to receive than to give: Syntactic and conceptual constraints on vocabulary growth. In L. Gleitman & B. Landau (Eds.), *The acquisition of the lexicon* (pp. 333–375). Cambridge, MA: MIT Press.

Fisher, C., & Song, H. (2006). Who's the subject? Sentence structure and verb meaning. In K. Hirsh-Pasek & R. Michnick-Golinkoff (Eds.), *Action meets word: How children learn verbs* (pp. 392–425). Oxford, England: Oxford University Press.

Freeman, N. H., Sinha, C. G., & Stedmon, J. A. (1980). The allative bias in three-year-olds is almost proof against task naturalness. *Journal of Child Language*, *8*, 283–296.

Gehrke, B. (2005). The prepositional aspect of Slavic prefixes and the goal-source asymmetry. In H. de Hoop & J. Zwarts (Eds.), *Proceedings of the ESSLLI workshop on Formal Semantics and Cross-Linguistic Data* (pp. 47–56). Edinburgh, Scotland: Heriot-Watt University.

Gleitman, L., Gleitman, H., Miller, C., & Ostrin, R. (1996). Similar' and similar concepts. *Cognition*, *58*, 321–376.

Grimshaw, J. (1981). Form, function, and the language acquisition device. In C. L. Baker & J. J. McCarthy (Eds.), *The logical problem of language acquisition* (pp. 165–182). Cambridge, MA: MIT Press.

Gruber, J. S. (1965). Studies in lexical relations. Doctoral dissertation, Cambridge, MA: MIT. Reprinted by Indiana University Linguistics Club, Bloomington, IN. Reprinted 1976 as part of *Lexical structures in syntax and semantics*. New York: North-Holland Publishing Company.

Haspelmath, M. (2003). The geometry of grammatical meaning: Semantic maps and cross-linguistic comparison. In M. Tomasello (Ed.), *The new psychology of language: Cognitive and functional approaches in language structure*, Vol. 2 (pp. 211–242), Mahwah, NJ: Lawrence Erlbaum Associates.

Hayward, W. G., & Tarr., M. J. (1995). Spatial language and spatial representation. *Cognition*, *55*, 39–84.

Heider, F., & Simmel, M. (1945). An experimental study of apparent behavior. *The American Journal of Psychology*, *57*, 243–259.

Hermer-Vaszquez, L., Spelke, E. S., & Katsnelson, A. S. (1999). Sources of flexibility in human cognition: Dual-task studies of space and language. *Cognitive Psychology*, *39*, 3–36.

Ihara, H., & Fujita, I. (2000). A cognitive approach to errors in case marking in Japanese agrammatism: The priority of the goal –ni over the source –kara. In A. Foolen & F. Van der Leek (Eds.), *Constructions in cognitive linguistics: Selected papers from the fifth international cognitive linguistics conference, Amsterdam, 1997* (pp. 123–140). Amsterdam: John Benjamins.

Jackendoff, R. (1983). *Semantics and cognition*. Cambridge, MA: MIT Press.

Jackendoff, R. (1990). *Semantic structures*. Cambridge, MA: MIT Press.

Lakusta, L. (2005). Source and goal asymmetry in non-linguistic motion event representations. Unpublished doctoral dissertation, The Johns Hopkins University.

Lakusta, L., & Landau, B. (2005). Starting at the end: The importance of goals in spatial language. *Cognition*, *96*, 1–33.

Lakusta, L., & Landau, B. (2007). Goal bias in language and in non-linguistic motion event representations. Poster presented at the Society for Research in Child Development, April, Boston.

Lakusta, L., Reardon, R., Oakes, L., & Carey, S. (2007). A goal bias in pre-linguistic thought and language: How strong is the homology? Paper presented at the Boston University Conference on Language Development, November, Boston.

Lakusta, L., Wagner, L., O'Hearn, K., & Landau, B. (2007). Conceptual foundations of spatial language: Evidence for a goal bias in infants. *Language Learning and Development*, *3*(3), 179–197.

Lakusta, L., Yoshida, H., Landau, B., & Smith, L. (2006). Cross-linguistic evidence for a Goal/Source asymmetry: The case of Japanese. Poster presented at the International Conference on Infant Studies, June, 2006, Kyoto, Japan.

Landau, B., & Hoffman, J. E. (2005). Parallels between spatial cognition and spatial language: Evidence from Williams syndrome. *Journal of Memory and Language*, *53*(2), 163–185.

Landau, B., & Jackendoff, R. (1993). ''What'' and ''where'' in spatial language and spatial cognition. *Behavioral and Brain Sciences*, *16*, 217–265.

Landau, B., Smith, L., & Jones, S. (1998). Object perception and object naming in early development. *Trends in Cognitive Sciences*, *2*(1), 19–24.

Landau, B., & Zukowski, A. (2003). Objects, motions, and paths: Spatial language in children with Williams syndrome. *Developmental Neuropsychology*, *23*(1 & 2), 107–139.

Levinson, S. C., & Wilkins, D. (eds.) (2006). *Grammars of space: Towards a semantic typology*. Cambridge, England: Cambridge University Press.

Luo, Y., & Baillargeon, R. (2005). Can a self-propelled box have a goal? Psychological reasoning in 5-month-old infants. *Psychological Science*, *16*(8), 601–608.

Markovskaya, E. (2006). Goal-source asymmetry and Russian spatial prefixes. In P. Svenonius (Ed.), *Working Papers in Linguistics, 33.2, Special Issue on Adpositions* (pp. 200–219). Nordlyd, Norway: Tromsø C.

Meira, S. (2006). Approaching space in Tiriyo grammar. In S. C. Levinson & D. Wilkins (Eds.), *Grammars of space: Towards a semantic typology* (pp. 288–235). Cambridge, England: Cambridge University Press.

Meltzoff, A. M. (1995). Understanding the intentions of others: Re-enactments of intended acts by 18-month-old children. *Developmental Psychology*, *31*(5), 838–850.

Munnich, E., Landau, B., & Dosher, B. A. (2001). Spatial language and spatial representation: A cross-linguistic comparison. *Cognition*, *81*, 171–207.

Nam, S. (2004). Goal and source: Asymmetry in their syntax and semantics. Paper presented at the Workshop on Event Structure, Leipzig, Germany.

Nikitina, T. (2006). Subcategorization pattern and lexical meaning of motion verbs: A study of the source/goal ambiguity. *Linguistics*, *47*(5), 1113–1141.

Papafragou, A. (2010). Source-goal asymmetries in motion representation: Implications for language production and comprehension. *Cognitive Science*, *34*, 1064–1092.

Pinker, S. (1989). *Learnability and cognition: The acquisition of argument structure*. Cambridge, MA: MIT Press.

Pléh, C. (1998). Early spatial case markers in Hungarian children. In E. V. Clark (Ed.), *The Proceedings of the Twenty-ninth Annual Child Language Research Forum* (pp. 211–219). Stanford, CA: Center for the Study of Language and Information.

Premack, D. (1990). The infant's theory of self-propelled objects. *Cognition*, *36*, 1–16.

Randall, J., van Hout, A., Weissenborn, J., & Baayen, H. (2004). Acquiring unaccusativity: A cross-linguistic look. In A. Alexiadou, E. Anagnostopoulou, & M. Everaert (Eds.), *The unaccusativity puzzle: Explorations of the syntax-lexicon interface* (pp. 332–370). New York: Oxford University Press.

Regier, T. (1996). *The human semantic potential: Spatial language and constrained connectionism*. Cambridge, MA: MIT Press.

Regier, T., & Zheng, M. (2007). Attention to endpoints: A cross-linguistic constraint on spatial meaning. *Cognitive Science*, *31*, 705–719.

Riemsdijk, H. C. van (2007). The case of source and goal: what determine case in german spatial PPs. Paper presented at Harvard Linguistics Theory Group, April, 2007, Cambridge, MA.

Simons, D. J. (2000). Current approaches to change blindness. *Visual Cognition*, *7*, 1–15.

Slobin, D. I. (1985). Crosslinguistic evidence for the language-making capacity. In D. I. Slobin (Ed.), *The crosslinguistic study of language acquisition: Vol. 2. Theoretical Issues* (pp. 1157–1256). Hillsdale, NJ: Lawrence Erlbaum Associates.

Talmy, L. (1983). How language structures space. In H. Pick & L. Acredolo (Eds.), *Spatial orientations: Theory, research, and application* (pp. 225–282). New York: Plenum Press.

Talmy, L. (1985). Lexicalization patterns: Semantic structure in lexical forms. In T. Shopen (Ed.), *Language typology and syntactic description* (pp. 57–149). New York: Cambridge University Press.

Tomasello, M. (1995). Joint attention as social cognition. In C. Moore & P. Dunham (Eds.), *Joint attention: Its origins and role in development* (pp. 103–130). Hillsdale, NJ: Lawrence Erlbaum Associates.

Waxman, S. R., & Booth, A. E. (2001). Seeing pink elephants: Fourteen-month-olds' interpretations of novel nouns and adjectives. *Cognitive Psychology*, *43*(3), 217–242.

Waxman, S. R., & Markow, D. B. (1998). Object properties and object kind: 21-month-old infants' extension of novel adjectives. *Child Development*, *69*(5), 1313–1329.

Woodward, A. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition*, *69*, 1–34.

Woodward, A. (1999). Infants' ability to distinguish between purposeful and non-purposeful behaviors. *Infant Behavior and Development*, *22*, 145–160.

Woodward, A., & Sommerville, J. A. (2000). Twelve-month-old infants interpret action in context. *Psychological Science*, *11*(1), 73–77.