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Children's Understanding of Directed Motion Events in an Imitation Choice Task

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Abstract

We investigated children's understanding of directed motion events using an *Imitation Choice* paradigm. Thirty-four children (mean age 33 months) watched a model act out an event containing a manner of motion (hopping or sliding), a motion path (up or down a ramp), and a goal (in or on a bowl). On the child's apparatus, the locations of the goal objects were different from the model so that the child had to choose whether to imitate the path or the goal of the model's event. Children's choice of which component to imitate therefore reflects how they prioritize these event components. Most children showed no bias to imitate the goal of the event, and instead preferred to imitate the model's path at the expense of the model's goal. However, children who spontaneously played with the goal objects during a free-play session showed a diminished path preference, choosing to imitate path and goal components equally often. We suggest that children's prioritization of information within an event depends on how that information is structured within the event itself.

Keywords

imitation; event representation; toddler; directed-motion event; goals

Imitation is an important tool of social learning that allows humans to replay an event that just occurred in the same way they witnessed it. It is also an important window onto children's representations: successful imitation requires a child to adequately represent the event in question. Moreover, for revealing how they represent and organize information, children's failures are as important as their successes. For example, a child who successfully imitates a model's ultimate goal while failing to imitate the model's process steps (a case of "emulation") most likely has a representation of the event that privileges or prioritizes the goal of the event. And indeed, the dominant finding in the literature is that infants and toddlers are goal-biased in their representations. However, generalizing from children's failures and omissions is not without difficulty. A child who fails too often may simply not have the ability to do the task; a child who fails too rarely may not make representative mistakes. In addition, there is the problem of interpreting null results: children might fail to do something for many reasons. Obviously, systematic patterns of success and failure can be quite meaningful – and many such patterns will be discussed below. However, the method adopted in this paper opts for a different solution, by forcing children to make choices.

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In the *Imitation Choice* method, children are asked to imitate a model with an apparatus that precludes exact imitation. For example, the model might make a doll go up a ramp and into a red bowl, while the child has his or her red bowl firmly fixed to the bottom of the ramp. Children must therefore choose whether to preserve the model's path of motion (going up the ramp) or the model's ultimate goal (getting in the red bowl). The dependent measure, therefore, is not what children fail to accomplish, but what they actively choose to do. In addition to using this new method, the experiment reported here will also test a type of event that has received relatively less attention in the literature – Directed Motion events. As shall be discussed further, these events are not themselves intrinsically biased towards their goals, and therefore provide a good domain in which to examine children's own potential biases. The aim of the experiment is to examine toddlers' representation of Directed Motion events and in particular, to probe the nature of children's bias towards goals.

Previous work looking at early representations of events has found that children and infants tend to be biased towards goals¹ in their event representations. For example, in Woodward (1998), 6 and 9-month-old infants were habituated to a hand grasping one of two toys, located on opposite sides of a stage. At test, the locations of the objects were switched and the infants looked longer when the hand maintained the same path but grasped a different toy (new goal) than when the hand changed paths but grasped the original toy (new path). These data suggest that for grasping events, goal information trumps path information in infants' representations. Adopting this paradigm to Directed Motion events, Lakusta, Wagner, O'Hearn and Landau (2007) showed infants a toy animal moving from one of two source objects to one of two goal objects. At test, the animal either moved from a different source object or moved to a different goal object. Results showed that 11-month-old infants would track the goal of an event, no matter how mundane the goal object was, but would track the source point of an event only when the source objects were made particularly salient. More generally, experiments aimed at testing the model of rational action proposed by Gergely, Csibra and colleagues (Csibra, Biro, Koos, and Gergely, 2003; Csibra, Gergely, Biro, Koos, and Brockbank, 1999; Gergely and Csibra, 2003) have found that by one year of age, infants regularly interpret path and manner components of an event as a function of the goal component.

Imitation work with older children has also found a bias towards goals. Young toddlers (two-years-old and younger) taught how to open a box with a special tool are more likely to emulate than imitate exactly, opening the box without respecting the particular process steps involved with the tool (Nielsen 2006). In the less functionally oriented mirror-game task, children were asked to imitate hand gestures, such as touching one's left ear with one's right hand. Children as old as 4 and 5 years made errors in this task, primarily errors that changed the gesture while preserving the goal – that is, they touched the correct ear but they used the wrong hand (Bekkering, Wohlschläger, and Gattis 2000, Gleissner, Meltzoff and Bekkering 2000). Perhaps most strikingly, children will sometimes posit a goal to an event even when they did not witness one. In Meltzoff (1995), eighteen-month-old infants were shown an adult trying to accomplish a task, such as putting beads in a jar, but failing to actually reach the goal. During the imitation phase, these infants imitated not what they had actually witnessed (a failed attempt) but the apparent intentional goal of the model (see also Bellagamba and Tomasello 1999 and Huang, Heyes and Charman 2006). Finally, within the realm of Directed Motion events, Carpenter, Call and Tomasello (2005) showed 12 and 18-month-olds a mouse either hopping or sliding (the manner) into one of two houses (the goal). Children preferentially imitated the goal dimension of the event, putting the mouse in the correct house but omitting the distinctive manner of motion.

¹Following Gattis (2002), we recognize that there is a difference between commonsense “goals” and “outcomes” or what linguists call “telos”. In this paper, the term “goal” will be used throughout to refer to the externally visible outcomes of the events in question and not to the relevant mental states involved. With this choice, we follow the dominant practice in the literature.

Although there appears to be a general bias towards goals, this does not mean that children and infants do not represent other elements in an event. For example, the results from studies in the rational action school (e.g., Gergely, Csibra and colleagues) suggest that some features of both manner and path dimensions must be encoded; at the very least, 12-month-old infants must notice whether or not they are goal directed. Thus, when either paths (Wagner and Carey, 2003) or manners (Wagner, submitted) were not goal-directed (as judged by adults), infants failed to track or predict the goal of an event. Similarly, Williamson and Markman (2006) found that 3-year-olds who spontaneously preferred to imitate a model's goal were still able to produce the antecedent actions when explicitly prompted to do so.

More strongly, there are situations when children can completely overcome their goal bias. One such situation is when there is no goal present – that is, when there is no specific external outcome present. In the infant domain, Pulverman, Sootsman, Golinkoff and Hirsh-Pasek (in press) showed that 16-month-old infants would track specific manner and specific path information in events that had no visible goals present. Similarly, in the mirror-game, Bekkering et al. (2000) found that children were more likely to match an action gesture (an ipsilateral or contralateral arm motion) when it was directed towards empty space than when it was directed towards a dot. Also, in Carpenter et al. (2005), young toddlers shown a Directed Motion event did imitate the manner of motion of the mouse when there were no houses for it to be directed towards. Thus, the goal bias does depend on there being some specific, external goal for children to be biased towards.

Another important class of situations that helps children overcome their goal bias is when the actions leading to the goal are specially motivated in some way. For example, Nielsen (2006) found that young toddlers were more likely to imitate a specific action with a tool to open a box if they saw that the tool was necessary, and that trying to open the box without the tool would not work. Similarly, Williamson and Markman (2006) found that 3-year-olds were more likely to imitate an unusual action if they were provided with an explanatory context for it. And, in a completely opposite approach, Gergely, Bekkering and Kiraly (2002) found that 14-month-olds infants were much more likely to imitate a particular manner of action (such as turning on a light with their head) when it was an apparently irrational way of accomplishing the goal. The fact that the model had so clearly made a choice for the irrational action when a more rational alternative was available served to motivate the use of the action. (See also Schwier, van Maanen, Carpenter and Tomasello 2006 for a similar result with 12-month-olds.)

While these cases successfully show that children care about more than just goals, they don't fundamentally undermine the idea that goals dominate children's representations. Infants and children seem to favor non-goal information only when that information is made particularly salient – either because the goal component is significantly downplayed (or absent altogether) or because the non-goal component is specially highlighted. This analysis is not new: it is essentially the same as the claim that children represent events hierarchically (e.g. Bekkering et al. 2000, Carpenter et al. 2005). Goals are at the top of children's hierarchy and non-goal information will be prioritized only to the extent that it is promoted in the hierarchy (or to the extent that goal information is demoted).

However, one potential criticism of many of the studies discussed above is that it may not be the children who were biased towards the goals so much as the events which were biased towards the goals. Many of the events involved a goal that included some sort of functional change in the environment, such as getting a box open or turning on a light. Such changes cannot be accomplished in a large variety of ways and so the antecedent processes involved are essentially derivable from the goal itself. Indeed, one of the central points of Gergely, Csibra and colleagues' theory of rational action (Csibra et al. 2003; Csibra et al 1999; Gergely and Csibra, 2003) is that infants can infer a dimension of an event so long as it is rationally consistent

with other situational evidence. For many events, the goal was a particularly informative anchor point; if one represented the goal, the remaining event components could essentially be derived for free. The reason goals are at the top of these event hierarchies is because goals are the most efficient means to represent these eventsⁱⁱ.

The experiment presented here will use a kind of event that is not intrinsically biased towards the goal: Directed Motion events. Directed Motion events are comprised of several distinct components. They require a FIGURE, which enacts the motion; a PATH or a direction for the motion to take; a MANNER or type of motion to be enacted; a SOURCE where the motion originates from; and a GOAL which the motion is directed towards. The goal is a critical component of a Directed Motion event because it is the goal that makes the event specially directed and distinguishes these events from simple motion events. However, other components, particularly Path and Manner, are equally important for making the event a motion event. Directed Motion events have been frequently discussed and analyzed in the linguistics literature (Jackendoff, 1990; Talmy, 1985) because they are one of the key event types that seem to help structure grammatical organization. Languages vary in how they preferentially encode the different event components noted above. English, for example, typically encodes manner information in main verbs (*hopping, skipping, jumping*) and path information in prepositional phrases (*over the river, through the woods*). By contrast, Spanish is more likely to code path information in the main verb (*entrar*, meaning to enter). Linguistic facts support the idea that the different components of Directed Motion events are psychologically distinct; they can at least be separated and combined for lexicalization in various ways within and across languages.

The components of Directed Motion events freely mix and match with one another. A goal destination of a store can be arrived at through a variety of manners of motions (e.g., driving, walking, flying), often via a variety of paths (e.g., straight down the highway, around the scenic road). In general, most goal destinations can be paired with many different manners and many different paths to create a plausible and appropriate Directed Motion event. This contrasts with other event types. For example, for creation events, there are typically only a very limited number of processes that will reasonably achieve the goal, and the processes tend to be specific to a particular goal. That is, there are not that many ways to make a sandwich, and very few, if any, of those are plausible means for making a house. Directed Motion events are not so closely tied to specific causal sequences and this makes them more flexible with respect to how their component parts can interact.

This flexibility means that Directed Motion events are not particularly helpful for inferences of the sort used in the rational action theory. Beyond some very general constraints (e.g., swimming is a bad manner of motion to use on land), manners, paths and goals are largely independent of each other. Knowing that I have ended my journey at the store tells you nothing about how I got there: nothing about the specific manner of motion used (driving, walking, cartwheeling) nor about the specific path (straight shot, round-about maneuvering). A special focus on the goal of the event will not help one derive the remaining event dimensions, beyond knowing that they were directed towards the goal. Directed Motion events are therefore inherently less biased towards goals and more revealing about potential biases that children bring to an event. There is some reason to believe that infants may extend their goal bias to these events: Carpenter et al. (2005) used Directed Motion events and found that infants preferentially enacted the goal of the event. Their study is not wholly compelling, however, as

ⁱⁱThis objection cannot be leveled at all previously used events in this domain, in particular, the mirror game (Bekkering et al. 2000, Gleissner et al. 2000) does not involve any functional changes. However, children's error rates (that is, their incorrect imitation of the ipsi- or contra-lateral hand motions) are not that high in this game, topping out at around 25%.

their goals (houses) had high socio-functional salience which may have independently drawn the infants' attention.

The aim of the current study is to examine children's event representations with events that provide an unbiased test of their abilities. Will toddlers continue to demonstrate a goal bias with Directed Motion events, which are not inherently goal biased, and even when the goal is not socio-functionally relevant? Our method for testing this question is the Imitation Choice paradigm, which incorporates the most helpful qualities of the imitation and looking-time paradigms.

Looking-times studies such as those described previously (e.g., Woodward 1998, Csibra et al. 1993) allow each component of the event to be analyzed individually. Infants are habituated to a complex event; test trials consist of events that are minimally different from the habituation event – typically, they are different along only a single dimension. Infants' representation of the initial event is inferred from their pattern of looking during test trials: whichever changed dimension causes infants to recover their interest in the display is presumed to have been part of their original representation. For example, in Woodward (1998), infants were habituated to a hand reaching for a particular object in a particular location. The test trials showed a reaching event that differed either along the object dimension (a new object in the old location) or along the location dimension (an old object in a new location). Infants increased their looking times to the change in the object dimension which allowed the inference that the object was critical to their original representation of the reaching event.

There is great precision in the looking-time methodology, since the events must be manipulated dimension by dimension. However, the passive nature of the behavioral measure – looking times – means that the representations that support the behavior do not have to be particularly robust. By contrast, the imitation studies provide an active measure of the child's interpretation. To imitate an event, toddlers must be able to represent it, remember it, and also reproduce it. Performance in such a task reflects deep and robust processing by the child. The drawback to imitation tasks is that the response is very open-ended. Completely veridical imitation indicates that a child represents all components of an event, but cannot tell us which elements they prioritize. When children omit components of an event, we are faced with interpreting a null result: it could mean that the children have a weaker representation of the omitted element, but it might also simply reflect difficulty in coordinating and executing actions.

The Imitation Choice task combines the dimension by dimension manipulation of the looking time studies with the robust processing necessary for an imitation task. The task involves two phases. In the Direct Imitation phase, the child is asked to directly imitate a simple Directed Motion event. For example, the child might be shown a doll hopping (manner) up a ramp (path) and jumping into a red bowl (goal). He or she would then be handed the toys and asked to perform the same event. The purpose of this phase is to insure that the child has the motor coordination and representational skills to complete a full event. In the second phase -- the Imitation Choice phase – the child and the model work on parallel sets of toys and the child's set is configured to prevent direct imitation. For example, the model might enact the event just described, but the child's toys would have the identical bowl firmly fixed at the bottom of the ramp instead of the top. In this case, both the model's path (up) and the model's goal (the red bowl) cannot be preserved in a natural enactment. The children must therefore choose which event dimension they wish to enact and which they wish to sacrifice.

If children are truly goal biased in their analysis of events, then we expect them to preserve the goal dimension of the event at the expense of the path dimension. By contrast, if children are sensitive to the way in which event dimensions interact in Directed Motion events, we expect their choices to vary more randomly as both path and goal should be equally important to them.

The age of the children studied (mean age of around two and half years old) places them squarely within the midst of the age at which children have previously shown a goal bias in other events – other studies have examined children younger than these participants (e.g., Bellagamba and Tomasello 1999), older than them (e.g., Bekkering et al 2000) and approximately the same age as them (e.g., Carpenter et al. 2002; Huang et al. 2006).

Methods

Participants

A total of 34 children participated with a mean age of 33.6 months (ranging from 24.2 months to 44.1 months). Half the children were girls ($N = 17$) and half were boys. Children were brought into an on-campus lab and tested individually. All children were from a moderately large Midwest city; the overwhelming majority of them were Caucasian and from a mid to high socio-economic background.

An additional 28 children participated but were not included in the analyses below. Twelve of these children were excluded for general refusal to participate: ten children completed fewer than 2 trials in the first phase of the study (Direct Imitation) and two completed fewer than 2 trials in the second phase (Choice Imitation). Thirteen children did attempt all four trials in the Direct Imitation phase but they were unable to accurately imitate at criterial levels (the criteria was an average of two event components per trial and these children imitated on average 1.3 components). An additional 3 participants were excluded because of experimenter error. This attrition rate is comparatively high, but it largely reflects difficulties in working with the younger children: the mean age of all excluded participants was 29.3 months.

Apparatus

Directed motion events were enacted with a figure (toy monkey) on a foam-core ramp (12.4" long, 10.8" wide, $\times$ 8.5" high). The ramp contained a slide, which provided two paths, up and down. At the top and bottom of the ramp were two small plastic bowls which served as goal objects. One was placed upright (so the figure would fit inside it) and the other was placed upside down (so the figure could be placed on top of it) and they differed in color. A single ramp was used in the Direct Imitation phase (see Figure 1) and two ramps were used in the Imitation Choice phase (see Figure 2). The Choice ramps differed in that on one apparatus, an upright red bowl was on the bottom of the ramp and an upside-down orange bowl was at the top, while on the other apparatus their locations were reversed.

Procedures

The study was conducted on a child's sized table or on the floor. Sessions began with a three minute free play session involving one ramp and the toy figure. During this time, children were allowed to interact with the toys however they wished.

Direct Imitation—Following free play, the child was introduced to "George" (the toy doll) and told he or she would watch George do something on the playground (the ramp) and then it would be his or her turn to make George do the same thing on the same playground. For each trial, the experimenter acted out a Directed Motion event with a distinctive Path (up or down the slide), Manner (hopping or sliding), and Goal (placing the monkey into or onto one of the two goal objects). The doll was removed from the Goal object after a few seconds so that the amount of time spent on the Goal component was approximately the time spent as that spent on the other components. Participants were encouraged to imitate after watching the Experimenter's model the first time, but were allowed to watch the model up to 3 times if they were inattentive or reluctant to participate. Encouragement consisted of saying "it's your turn" and to "show me with George." At no time during this phase (or in the Imitation Choice phase)

did the experimenter ever describe the actions or goals of the doll. Each participant received four trials, which included all of the possible Manner/Path/Goal configurations (see Table 1). The order of the trials was counterbalanced between participants.

Imitation Choice—Following the Direct Imitation phase, the two new ramps used for the Choice phase were introduced. The experimenter acted out Directed Motion events on one apparatus as before and participants were then told to take their turn on their own ramp. As in the Direct Imitation phase, children were allowed to watch the model 3 times, but were encouraged to imitate after the first example. Encouragement consisted of saying “it’s your turn” and “show me on your playground.” After completing all four possible combinations of Manner/Path/Goal, the experimenter and child exchanged ramps and an additional four trials were conducted. The order of the trials was counterbalanced across participants.

Participants were not allowed to begin their imitation until after the experimenter had completed her event (including removing the doll from the Goal object). For some participants, this required the Experimenter to hold on to the child’s doll during the modeling phase so they were certain to see the entire event.

Coding

All sessions were videotaped and coded off-line. The footage from individual trials was spliced so that each child’s enactment was separated from the experimenter’s model. Coders viewed only the children’s enactments and were therefore completely blind to the particular event that had been previously demonstrated. Trials were coded for the Manner, Path, and Goal that each child used in his or her enactment. The Manner was coded as *hopping* if the figure broke contact with the surface of the ramp and as *sliding* if the figure maintained contact with the ramp. The Path was coded as *up* the child moved toy up the ramp and as *down* if the child moved the toy down the ramp. The Goal was coded as the object at which the child placed the doll. When necessary, components could also be coded as *omitted*, when the child failed to include either version of the component (for example, Path and Manner components were coded as *omitted* if the child simply placed the doll in/on a Goal object); components could also be coded as *multiple* when a child serially enacted more than one version of the component (for example, the Goal component was coded as *multiple* if the child first placed the doll in the red bowl then immediately placed it on the orange bowl).

A second coder, blind to the experimenter’s model as well as to the first coder’s assessment coded 20% of the trials distributed randomly across all participants. The two coders agreed on the Manner codes 93% of the time ($Kappa = .87$), on the Path codes 93% of the time ($Kappa = .87$), and on the Goal codes 97% of the time ($Kappa = .93$).

Results

Free play session—The children’s spontaneous play during the initial free-play session was analyzed to see if there were any a priori biases towards enacting any of the event components. A total of 68% ($N = 23$) of the children spontaneously enacted any of the components that would later be used in the study. These participants clearly showed a goal bias: 82.6% ($N = 19$) of them included play with a goal object, either placing the doll in or on one of the bowls.

Direct Imitation—All participants completed all four trials of the Direct Imitation phase and imitated an average of 2.69 components (out of a possible maximum of 3 components). As noted previously, participants were included in the analysis only if they were able to imitate on average a minimum of two event components in this phase. Two components was deemed a minimal standard to insure that children’s behavior in the next phase actually represented a meaningful choice between components. Children failed to match the experimenter on the three

components approximately equally often: they failed to match Manner on 9.6% of trials, Path on 13.3% of trials and Goal on 12.6% of trials. The majority of these failures (54.2%) were omissions: children did not act out the component at all. Overall, the participants were capable of imitating all the elements in the Directed Motion event when the imitation was a straightforward replication of the model.

Choice Imitation—The Imitation Choice phase was designed to keep children from being able to imitate all three components; in particular, participants had to choose between the Path and Goal components. Participants completed an average of 7.6 (out of 8) of the Imitation Choice trials. There were four possible patterns of choice behavior: Children could match both the Path and Goal components (and fail to respect the “flow” of the event), they could fail to match both the Path and Goal components (effectively ignoring the model), they could match the Path component at the expense of Goal (the Goal might be omitted, the opposite Goal might be chosen, or multiple Goals might be chosen), or they could match the Goal component at the expense of Path (the Path might be omitted, the opposite Path might be chosen, or multiple Paths might be chosen). The percentage of trials conforming to each type of pattern is shown in Table 2. In general, children appear to prefer to preserve the Path component at the expense of the Goal component.

We also calculated a more stringent measure of Path and Goal choices, including only those trials on which children correctly matched the first component and also enacted the opposite value of the other component. That is, the stringent Path at the expense of Goal code required children to both match the experimenter’s Path component and act out the opposing Goal component. Using this stronger criterion, children chose Goal at the expense of Path on 16.9% of trials and Path at the expense of Goal on 31.9% of trials. Although only the analyses using the more liberal criterion are being reported, all analyses examining children’s Path preference were also conducted using the more stringent criterion as well. In all cases, findings that were significant via the liberal criterion were also significant via the stringent criterion.

Looking more in depth at individual preferences, we calculated a Path Preference score for each child. Each trial was scored as +1 if it demonstrated the Path at the expense of Goal choice described above, as −1 if it demonstrated the Goal at the expense of Path choice described above, and as 0 if it demonstrated either of the other choices. Positive scores, therefore, reflect a preference for Path while negative scores reflect a preference for Goal. The mean Path preference score was .22 (std = .45) and the score for each child is plotted on Figure 3. The Path preference score was found to be significantly higher than a score of 0 (no preference at all): $t(33) = 2.9$, $p < .007$ (Cohen’s d effect size = 1.01). In addition, a binomial test was run to see if more children overall showed a Path preference compared to a Goal preference. Overall, 70% of the children showed some degree of Path bias (i.e., had a positive Path bias score) which is significantly more than a chance score of 50% ($p < .043$).

We next considered several factors that might have influenced children’s preference in this task. Across the experiment, children’s preference did not change: the average Path Preference score for the first four Choice trials was .21 and for the second four Choice trials was .17 (a paired t-test comparing those means was not significant, $p > .6$). Moreover, the age of the participant did not influence the strength of the Path preference. A correlation on participants’ age (in months) and Path preference score was not significant (Pearson’s Correlation $p > .16$). Children’s performance was partially influenced by the specific values of the components being acted out. For Path, children were slightly more likely to match the experimenter when asked to imitate a Down Path (60%) than an Up Path (47%); however, a paired t-test comparing the average rate of matching the path for each of these paths showed this difference was not significant. For Goal, children were significantly more likely to match the experimenter when the Goal was the Red bowl/In action (43%) than when it was the Orange bowl/On action (24%)

($t(33) = 3.6, p < .001$; Cohen's $d = 1.25$). However, as all combinations of the particular paths and goals were used across trials, this difference cannot account for the general Path preference.

One possible worry (raised by reviewers) was that children may not have noticed the differences in the two ramps in the Choice task: children may have shown the Path preference because they did not see any differences between the two Goals. Children's ability to discriminate between the Goals, and between the different ramps, was assessed in several ways: Children's explicit mentioning of the differences (e.g., "Yours is different from mine"), implicit signaling of the differences (e.g., one child carefully pointed from his red bowl to the experimenter's and then repeated the sequence for the orange bowls), children's ability to label the different colors of the bowls, and children's hesitations just before placing the doll at a goal (for example, a few children confidently began their enactment of the event's path and then hesitated before completing the event as if they were confused by where they had ended up). A total of 29 participants (85%) did at least one of these behaviors, suggesting that they really did notice the difference between the ramps. Moreover, participants who explicitly mentioned the difference ($N = 8$) between the goals showed an equivalent Path preference to those who did not; nor was there any difference in Path preference score between participants who labeled the different colors of the Goals ($N = 19$) and those who did not. In short, it appears that children truly did notice the difference between the ramps in general, and to the extent they may not have, it does not explain the Path preference.

However, noticing the difference between the Goal objects may not have been enough to counter-act the Path preference. Perhaps children needed to actually interact with the Goals in order for them to have a strong influence. As noted above, 19 of the participants interacted with the Goal objects during the free-play session prior to the study itself. A one-way ANOVA was conducted with Path preference score as the dependent variable and whether or not the child free-played with the Goals as the independent variable. The results showed a significant difference: $F(1,32) = 7.4, p < .011$, Cohen's $d = .971$. Children who had played with the Goal objects prior to the study had a much lower Path preference score (.05) compared to children who did not play with the Goal objects (.43). Concrete experience with the Goal objects, therefore, does seem to influence children's choices in imitation.

Finally, an analysis of the Manner component was conducted. In contrast to Path and Goal, Manner could always be accurately imitated despite the differences in the ramps, and participants accurately did so 75% of the time. A paired t-test comparing the average rate of matching each manner found no significant difference between their imitation rates of Hopping (73%) and Sliding (78%). Because Manner could co-occur with the other components, we looked to see if accurate imitation of Manner correlated with the choice to imitate either Path or Goal. A positive correlation was found between Manner and Path ($r = .421, p = .013$): Participants were more likely to correctly imitate Manner when they also imitated the Path than when they also imitated the Goal.

Discussion

Are young children biased to think about events in terms of goals? The data presented here suggest that they are not. In this experiment, children were forced to choose whether to preserve the path component of a Directed Motion event or the goal component of the event. Children were not biased to specially preserve goal information; indeed they were significantly more likely to imitate the path component at the expense of the goal.

We suggested at the outset that Directed Motion events should lead to less goal bias in general because of the nature of those events. In functionally oriented events, such as using a tool or opening a box, the goal state has a special status: the process steps are in the causal service of

making the goal happen, and representing a goal implies a particular sequence of actions. However, in Directed Motion events, that causal connection is much looser: the motions must get one to the goal, but their specifics are largely irrelevant. Representing the goal of a Directed Motion event implies very little about the path and manner used to get there. Functionally oriented events place goals at the top of an event representation hierarchy; Directed Motion events may be intrinsically more egalitarian with respect to the representation of the various event components.

One contributing force to the goal bias in children's event representations, therefore, may be that focusing on the goal is often a very efficient way to represent the whole because the goal itself implies much of what came before it. By using a familiar type of event for which that is simply not true, we predicted that children's bias would fade as well. Our results in general support this hypothesis: the children in our experiment did not show a goal bias. However, this hypothesis does not obviously predict one of our central findings, namely, the fact that the children showed an overall bias towards the path information. As discussed in the introduction, previous work has found two main situations in which children prefer a non-goal interpretation: when the goal is absent (i.e., there is no visible external outcome of the action) as in Bekkering et al. (2000) and Pulverman et al. (in press); and when the non-goal is specially highlighted as in Gergely et al. (2002), and Williamson and Markman (2006). We consider next whether one of these situations holds in the current experiment.

It is certainly not the case that the goals were removed entirely. The bowls at either end of the ramp were the most colorful objects on the apparatus and the doll interacted with them on every trial. Most children were able to label the color difference between the bowls and several children spontaneously discussed the different placement of the goal objects on their board and the experimenter's board. The children were clearly aware of the presence of the objects as well as the relevant differences in the objects used across the study. However, we did intend for these goals to be less salient than the socio-functionally relevant goals (houses) used in the Directed Motion events in Carpenter et al. (2005). It is possible that we over-shot and that while our objects were salient enough to be noticed, they were not salient enough to serve as proper goals. One piece of evidence that supports this possibility is the fact that children who chose to interact with the goal objects during the initial free-play session did not show a path bias. Personal experience with the objects, therefore, appears to influence how children integrate them into the event. Notice, however, that children who played with the objects did not in general show a bias towards the goals: instead, they were equi-potential between the goal and path options, imitating path at the expense of goal on some trials and on other trials imitating goal at the expense of path. This fact suggests that Directed Motion events themselves may be intrinsically biased towards a path interpretation; special emphasis of some sort (either from personal experience or from social relevance) is needed to shift these events towards their goals. Contrary to our hypothesis, these events are not neutral with respect to goals, they are in fact biased away from them.

It seems possible, therefore, that these events specially highlight path information in some way. One potential way that Directed Motion events might highlight the path is the fact that the path always comes first: by definition, the goal is the end of the event and the path must precede it. This explanation, however, seems doubtful. Across all the studies looking at children's understanding of goals, it is always the case that processes, paths, and means precede the goal; this follows logically from the fact that causes precede effects. If precedence was the root cause of the current path bias, then the literature should be rife with process biases in all sorts of situations instead of the goal biases more commonly found. Moreover, there is a way to explicitly test this possibility with Directed Motion events, by using source objects instead of goal objects (cf Lakusta et al. 2007). Instead of modeling an action path to a specific goal object, one could model a doll starting at a specific source object and then moving along an

action path (stopping at the end of the trajectory but not at a specific object); thus, source precedes path. If precedence was critical, we would expect the path bias to disappear in favor of a Source bias. Preliminary data from a study of just this sort do not appear to show such a bias; indeed the path bias still seems to dominate children's responses.

A more promising possibility stems from the finding that there was a correlation between successful imitation of the manner and the choice to imitate path over goal. The manner component of the event (hopping or sliding) could be successfully imitated on all trials, regardless of whether the child opted to imitate the path or goal, but children did better with manner when they opted to match the experimenter's path. It should probably not be surprising that there is a tighter link between path and manner than between manner and goal; although path and manner information are independent from each other, they do occur simultaneously within the event. Children may not, therefore encode them in a completely independent fashion. The temporal link between manner and path components may lead to a highlighting of the path. Children who choose to imitate path are effectively choosing two components at the expense of goal, because the path choice facilitates their ability to correctly imitate the manner component. This perspective brings these data in line with the initial hypothesis. If one of the reasons children are goal biased in more functionally oriented events is because the goal effectively captures more information, then we should expect the path bias with Directed Motion events because that's the choice that preserves the maximal amount of information in the event.

The results found here suggest that both the structure of the information within an event as well as children's prior experiences with particular event elements shape children's understanding, as measured by how they prioritize the event's components. Previous work in general has found that children tend to be biased towards goals, but we have argued that this bias reflects the nature of the events used, rather than the nature of the children. The Directed Motion events examined in this study structure information rather differently than the functionally-oriented events often used, and as a consequence, we found children biased away from goal and towards path. However, we also found this bias itself to be attenuated by children's own experiences: children who spontaneously played with the goals showed no preference between path and goal information. Further studies will be needed to tease apart how these factors influence and interact with each other, and the imitation choice task is a promising paradigm in which to investigate these questions further.

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References

- Bekkering H, Wohlschläger A, Gattis M. Imitation of gestures in children is goal-directed. *The quarterly Journal of Experimental Psychology* 2000;53A(1):153–164. [PubMed: 10718068]
- Bellagamba F, Tomasello M. Re-enacting intended acts: Comparing 12- and 18-month olds. *Infant Behavior and Development* 1999;22(2):277–282.
- Carpenter M, Call J, Tomasello M. Twelve- and 18-month-olds copy actions in terms of goals. *Developmental Science* 2005;8(1):F13–F20. [PubMed: 15647059]
- Csibra G, Biro S, Koos O, Gergely G. One-year-old infants use teleological representations of actions productively. *Cognitive Science* 2003;27(1):111–133.
- Csibra G, Gergely G, Biro S, Koos O, Brockbank M. Goal attribution without agency cues: The perception of "pure reason" in infancy. *Cognition* 1999;72(3):237–267. [PubMed: 10519924]
- Gattis, Meredith. Imitation is mediated by many goals, not just one. *Developmental Science* 2002;5(1): 27–29.

- Gergely G, Bekkering H, Kiraly I. Rational imitation in preverbal infants. *Nature* 2002;415(6873):755. [PubMed: 11845198]
- Gergely G, Csibra G. Teleological reasoning in infancy: The naive theory of rational action. *Trends in Cognitive Sciences* 2003;7(7):287–292. [PubMed: 12860186]
- Gleissner B, Meltzoff AN, Bekkering H. Children's coding of human action: Cognitive factors influencing imitation in 3-year-olds. *Developmental Science* 2000;3(4):405–414.
- Huang C, Heyes C, Charman T. Preschoolers' behavioural reenactment of "failed attempts": The roles of intention-reading, emulation and mimicry. *Cognitive Development* 2006;21:36–45.
- Jackendoff, R. *Semantic structures*. Cambridge: MIT Press; 1990.
- Lakusta L, Wagner L, O'Hearn K, Landau B. Conceptual foundations of spatial language: Evidence for a goal bias in infants. *Language Learning and Development* 2007;3(3):1–19.
- Meltzoff AN. Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. *Developmental Psychology* 1995;31(5):838–850.
- Nielsen M. Copying actions and copying outcomes: Social learning through the second year. *Developmental Psychology* 2006;42(3):555–565. [PubMed: 16756445]
- Pulverman; Sootsman; Golinkoff; Hirsh-Pasek. Infants' nonlinguistic processing of motion events: One-year-old english speakers are interested in manner and path; *Proceedings of the Stanford Language Conference*; (in press)
- Schwier C, van Maanen C, Carpenter M, Tomasello M. Rational imitation in 12-month-old Infants. *Infancy* 2006;10(3):303–311.
- Talmy, L. Lexicalization patterns: Semantic structure in lexical forms. In: Shopin, T., editor. *Language typology and syntactic description: Grammatical categories and the lexicon*. Cambridge, UK: Cambridge University Press; 1985.
- Wagner L, Carey S. 12-month-olds represent probable endings of motion events. *Infancy* 2005;7(1):73–83.
- Wagner L. Infants' goal-tracking with directed motion events. (submitted)
- Williamson RA, Markman EM. Precision of imitation as a function of preschoolers' understanding of the goal of the demonstration. *Developmental Psychology* 2006;42(4):723–731. [PubMed: 16802904]
- Woodward AL. Infants selectively encode the goal object of an actor's reach. *Cognition* 1998;69(1):1–34. [PubMed: 9871370]

Figure 1.
Apparatus used during Direct Imitation trials.

Figure 2.
Apparatus for experimenter and participant used during Imitation Choice trials.

Figure 3.
Average Path Preference Score for Each Participant. Positive scores indicate a preference for Path over Goal, and negative scores indicate a preference for Goal over Path.

Table 1

The possible combinations of event components in the Direct Imitation phase. Note that in the Imitation Choice phase, the yellow bowl was exchanged with an orange bowl.

Manner	Path	Goal
Hop	Up	On Red Bowl
Slide	Up	On Red Bowl
Hop	Down	In Yellow Bowl
Slide	Down	In Yellow Bowl

Table 2

The percentage of trials across all children that conformed to the different possible patterns in the Imitation Choice phase. A Plus sign indicates that the participant correctly matched that component of the model; a Minus sign indicates that the participant did not match the model (either through an omission or a reversal).

Path Component	Goal Component	Pattern Type	Percentage of Trials
+	+	Matching both: Failure to respect event 'flow'	6.9%
-	-	Matching neither: Ignoring the model	21%
+	-	Matching Path at the expense of Goal	46.5%
-	+	Matching Goal at the Expense of Path	25.4%