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Authors
Mukherji, Mohit
Dillon, Moira Rose

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Taking the C-nic Route: Object-Directedness and Path, Not Efficiency, Shape Adults' Word Extension

Mohit Mukherji (mohit.mukherji@nyu.edu)
Department of Psychology, New York University

Moira R. Dillon (moira.dillon@nyu.edu)
Department of Psychology, New York University

Abstract

What intuitions guide adults in extending the meanings of new words? Are these intuitions consistent with prelinguistic sensitivities operative in infancy? Across two preregistered experiments, adult participants saw simple grid-world environments in which characters moved in a "C" path efficiently (or not) to an object (or not). These events were labeled with a novel verb or noun. Participants were asked whether that word applied to new events varying in object-directedness, path, and efficiency. By contrast to infants' focus on efficiency, adults instead focused on object-directedness and path, and they did so similarly for both verbs and nouns. Language might thus build on universal, prelinguistic assumptions of goal-directedness and efficiency to specify what goal an agent might have (e.g., object- vs. location-directed) as well as how an agent might achieve that goal (e.g., this vs. that kind of path), ultimately restricting the hypothesis space for action understanding and supporting learning.

Keywords: action understanding; language acquisition; lexical semantics; word learning; language and thought.

Introduction

From early in development, human infants are keenly sensitive to the goals and efficiency that guide others' actions. For example, given a short period of familiarization, pre-reaching 3-month-old infants can learn that another agent's reaching behavior is indicative of their having a particular *goal* (Woo et al., 2024). And, when 3-month-old infants watch another agent reach over a barrier to touch and turn on a light, they expect that agent to reach for and touch the light using a new and direct *efficient* path after the barrier is removed (Liu et al., 2019). Indeed, infants' expectations about the goals and efficiency of other agents' actions are cornerstones of human prelinguistic action understanding (Gergely & Csibra, 2003; Stojnić et al., 2023; Woodward, 2009).

Adults' commonsense action understanding also follows these same principles (e.g., Jara-Ettinger et al., 2016). For example, when adults see a single animated character perform a series of coordinated actions on simple objects in a minimal environment, they interpret these actions as goal-directed and efficient, e.g., the character is gathering and rearranging the objects. When adults instead observe the character performing these same actions but there are no objects present, they attribute a different goal to the actions, e.g., they think the character is "dancing" (Schachner & Carey, 2013).

Intuitions to prioritize goal-directedness and efficiency when interpreting others' actions may thus be present and active throughout the human lifespan, guiding commonsense — but often tacit — action understanding. What happens, then, when actions and/or the agents participating in those actions get labeled? Does language also focus on the prelinguistic principles of goal-directedness and efficiency? If so, how?

On the one hand, some language, like spatial prepositions, may more or less directly lexicalize infants' prelinguistic sensitivities (Spelke, 2022; Strickland, 2017). For example, young infants are sensitive to certain spatial relations, like tight and loose containment, that get lexicalized in some of the world's languages (Hespos & Spelke, 2004). Verbs and nouns may also capture some of infants' prelinguistic sensitivities by indirectly pointing to those sensitivities through the content captured by everyday vocabulary (Dillon, 2024; Lin & Dillon, 2024; Mukherji & Dillon, in review; Strickland, 2017). On the other hand, language might instead focus on those aspects of our experiences that are not captured by our prelinguistic knowledge. For example, while young children's and adults' nonlinguistic memories of physical events do not prioritize the goal of such events, young children's and adults' descriptions of such physical events do (Lakusta & Landau, 2012).

In the present study, we thus ask whether and how adults might extend the meanings of verbs and nouns by focusing on the goals and efficiency of agents' actions. To do so, we vary the object-directedness and paths of agents' actions because variation in these two types of information can indicate different kinds of goals, e.g., object-based goals vs. movement-based goals (Schachner & Carey, 2013; Yasuda et al., 2025). We also consider how verbs and nouns might capture the efficiency of agent's actions apart from any specific path, reflecting infants' robust expectation that agents modify their paths to achieve efficient, goal-directed action (Gergely et al., 1995; Liu et al., 2019; Liu & Spelke, 2017; Stojnić et al., 2023; Woodward, 2009).

Experiment 1 focuses on verbs. Verbs in languages like English tend to highlight the object-directedness of an action

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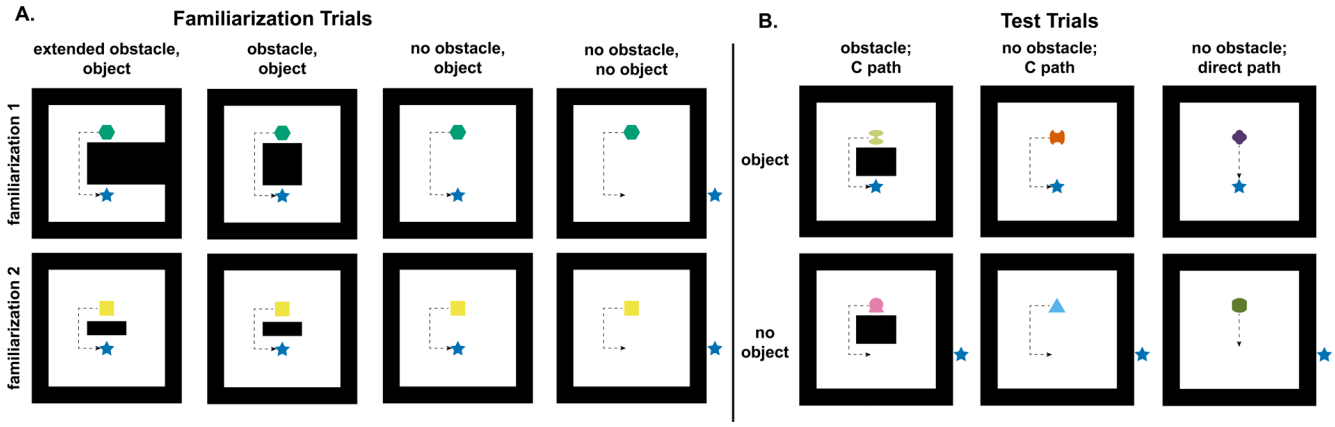


Figure 1: Stimuli for Experiments 1 (verbs) and 2 (nouns). Schematics of familiarization trials for the four between-participant conditions are shown in **1A**. Participants in all conditions saw the six test trials shown in **1B**.

(e.g., *take*, *gather*), the path taken (e.g., *zig-zag*, *beeline*), or the manner of motion (e.g., *spinning*, *jumping*). Across languages, almost no verbs encode the efficiency of actions in their root meaning (e.g., *meander*; Talmy, 1985). Since action efficiency is not robustly encoded by verbs, we thus predict that novel verb extensions will reflect the object-directedness and paths of actions more than their efficiency.

Experiment 2 focuses on nouns, investigating the possibility that adults might attend to efficiency more when extending nouns than verbs since nouns do not typically encode object-directedness, path, or manner.

Experiment 1

We presented adult participants with a word-extension task, following Landau et al. (1988). Across four conditions, different groups of participants first saw two videos of different characters —represented by different simple shapes in different colors — move along similar "C" paths in a grid-world environment (**Figure 1**). The conditions differed by the object-directedness and efficiency of the characters' actions. In all conditions, the videos included the same audio, describing the action with a novel verb, "This is *wugging*." Participants then saw six test trials, which presented new characters and varied the object-directedness, path, and efficiency of the characters' actions. Participants were asked whether the novel verb applied to each of these events, "Is this *wugging*?".

Following prior studies with infants and adults, we used highly minimal displays presenting simple shapes moving in a 2D grid world. These stimuli allowed us to best engage intuitions about agents and their actions based on agents' behaviors as opposed to their physical cues like eyes or hair (e.g., Heider & Simmel, 1944; Stojnić et al., 2023).

Methods

Our design, methods, and analysis plan were preregistered prior to data collection on the Open Science Framework (OSF): https://osf.io/xz6qy.

Participants Ninety-six native English-speaking adults were randomly assigned to one of the four conditions (24 per condition). Following preregistered criteria, an additional 24 adults were excluded for: failing a catch question (6; see **Procedure**); taking longer than 15 minutes to complete the experiment (8); or for answering "no" to all test trials (10). Participants were recruited on Prolific and completed the experiment online and asynchronously on Qualtrics.

Materials Participants in each condition saw two familiarization videos and six test videos. The familiarization videos presented different characters (a green hexagon or a yellow square) that moved along either a tall or short "C" path in a 2D grid world (**Figure 1**). Each video was presented with two instances of pre-recorded audio including the novel verb, one which started before the character's movement began, "Look! Here is *wugging*," and the other which started after the character's movement ended, "See? It's *wugging*." The first familiarization video lasted 24s, and the second familiarization video lasted 22s.

Across the four conditions, the familiarization videos varied in the object-directedness and efficiency of the characters' actions (**Figure 1A**). In the *extended obstacle, object* condition, the characters moved along the only efficient path available around an obstacle to a goal object, a star, changing its color on contact (after Liu et al., 2019). After touching the object, the characters moved along the same path back to their starting position. In the *obstacle, object* condition, the characters moved efficiently around the left side of an obstacle, one of the two efficient paths to the star, touched it to change its color, and moved back to their starting position. In the *no obstacle, object* condition, the characters moved along the same path as in the other conditions, but now that movement was inefficient because there was no obstacle present. Finally, in the *no obstacle, no object* condition, the characters simply moved along the "C" path and back to their starting position. There was no obstacle present, and the star was located outside of the border of the grid world and did not change color.

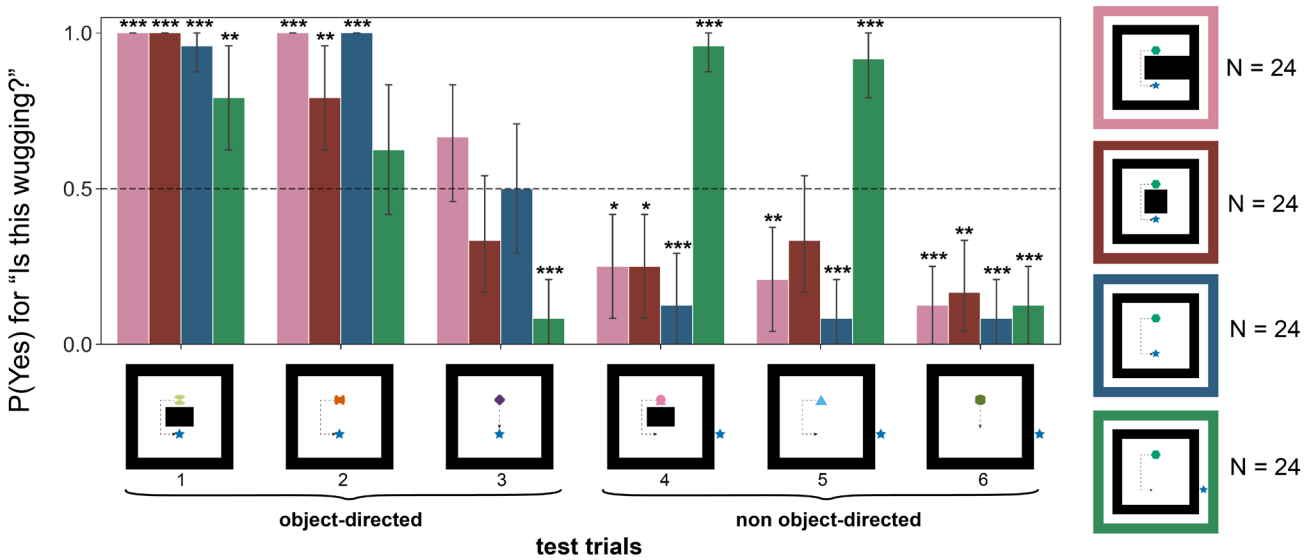


Figure 2: Results of Experiment 1 (verbs). Error bars represent bootstrapped 95% confidence intervals. * $p < .05$, ** $p < .01$, *** $p < .001$.

Participants across conditions saw the same six test trials, which presented new characters of different shapes and colors. The test trials varied the object-directedness, path, and efficiency of the characters' actions (**Figure 1B**). Each test video included two instances of pre-recorded audio, one which started before the character's movement began ("Look!") and the other which started after the character's movement ended ("Is this *wugging*?"). The "C"-path test trials lasted 14s, and the direct-path test trials lasted 8s.

Procedure Participants saw the two familiarization videos in a fixed order. Then, participants answered a catch question, in which they were asked with written text what novel word they just heard from the following fixed-order list: *blicketing*; *snuzzing*; *lorping*; *wugging*; or ***other (please type in a response)***. Participants then saw the six test videos presented in pseudo-random order such that each trial appeared in each ordinal position an approximately equal number of times. Before each test video, participants saw a shortened version of one or the other familiarization video with the text, "Here is *wugging*." as a reminder. They responded to each test video using a mouse click to indicate their 'yes' or 'no' response to the question, "Is this *wugging*?". Participants received no feedback on their responses to the catch or test questions. Finally, participants were asked two debriefing questions: "What do you think *wugging* is?"; and "Did you use any strategy to answer the questions? For example, how did you decide what *wugging* is?".

Results

Our preregistered analysis (https://osf.io/5wsh8/) focused on whether participants extended novel verbs differently across conditions as well as whether participants focused on the characters' object-directedness, path, and efficiency. We conducted mixed-model logistic regressions with participants' responses (yes vs. no) as the dependent variable and participant as a random-effects intercept. We obtained *p*-values using Wald Chi-Square tests run on the results of each regression.

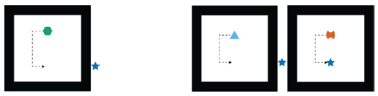
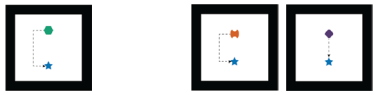
Figure 2 shows the proportions of participants' yes/no responses for each test trial for each condition and includes the significance value for each trial for each condition, evaluated against chance (.50). We found that participants in all conditions extended the novel verb to the test trial that matched their condition in terms of the presence vs. absence of a goal object and the presence vs. absence of an obstacle, suggesting that participants understood the task.

Second, for each condition, we conducted a regression that added test trial as a fixed effect. Because our planned models failed to converge, we used a Bayesian binomial logistic regression to estimate our coefficients (Gelman et al., 2008). We found that participants' responses differed across the test trials in each condition (*extended obstacle, object*, $\chi^2(5) = 95.52$, $p < .001$; *obstacle, object*, $\chi^2(5) = 63.98$, $p < .001$; *no obstacle, object*, $\chi^2(5) = 108.68$, $p < .001$; and *no obstacle, no object*, $\chi^2(5) = 46.79$, $p < .001$). Third, we conducted a regression with Bayesian estimation that included condition and test trial as fixed effects. We found main effects of condition ($\chi^2(3) = 14.16$, $p = .003$) and test trial ($\chi^2(5) = 102.14$; $p < .001$) as well as an interaction between condition and test trial ($\chi^2(15) = 133.03$, $p < .001$), indicating that participants responded differently to the test trials across conditions.

We then directly tested for any effects of object-directedness, path, and efficiency on participants' responses using targeted pairwise contrasts within and across the: *obstacle, object*; *no obstacle, object*; and *no obstacle, no object* conditions. The results of these contrasts are presented in **Table 1**. First, and most strikingly, we found no difference

in participants' extension of a novel verb based on efficiency: Participants in the conditions in which the character took a "C" path to an object extended the verb to other cases in which the character took a "C" path to an object, regardless of whether that path was efficient (based on the presence vs. absence of an obstacle; rows 1–2). In addition, participants in the *obstacle, object* condition, who saw the character take a "C" path to an object around an obstacle, did not extend the verb to a character who moved directly to an object when there was no obstacle (row 3). These results run in stark contrast to the robust literature finding that infants predict that goal-directed agents will take new and efficient paths to objects after an obstacle is removed (e.g., Gergely et al., 1995; Liu & Spelke, 2017; Stojnić et al., 2023).

Table 1: Pairwise contrasts for Experiment 1 (Verbs).

Condition	Test Trial	*p*-value
		.453
		.402
		.001
		< . 001
		.047
		< .001
		< .001

Further pairwise contrasts revealed that the object-directedness of agents' actions affected whether participants extended the novel verb: Participants in the *no obstacle, object* condition extended the verb more to the "C" path trial that was vs. was not object-directed (row 4), and participants in the *no obstacle, no object* condition extended the verb more to the "C" path trial that was not vs. was object-directed (row 5).

Additional paired contrasts revealed that the character's path also affected whether participants extended the novel verb when the actions otherwise matched in object-directedness (rows 6 and 7).

Finally, in an additional, unplanned analysis, we sought to evaluate the overall effects of object-directedness, path, and efficiency across all four conditions and all six test trials. We coded each test trial for whether it matched (1) or did not match (0) each familiarization condition in terms of the presence vs. absence of an object goal, the presence vs. absence of the "C" path, and the presence vs. absence of efficient action. We then conducted a regression including these three variables as fixed effects, again using participant responses as the dependent variable and including a random-effects intercept for participant. We found main effects of object-directedness ($\chi^2(1) = 7.65$; $p = .006$) and path ($\chi^2(1) = 12.38$; $p < .001$) but no main effect of efficiency ($\chi^2(1) = 1.20$; $p = .273$). We also found an interaction between object-directedness and path ($\chi^2(1) = 4.92$; $p = .027$) but no interactions between object-directedness and efficiency ($\chi^2(1) = .15$; $p = .701$) or path and efficiency ($\chi^2(1) = 1.98$; $p = .159$).

Discussion

In a verb-extension paradigm presenting minimal displays, adults focused on the object-directedness and path of an agent's actions, not on action efficiency. This focus is strikingly different from infants' prioritization of efficiency over path in evaluating agents' goal-directed actions.

It is possible that English-speaking adults' extensive experience with verbs that encode paths might have driven them to focus on path over efficiency in Experiment 1. If so, then asking adults to extend novel noun labels, which do not typically encode paths, might allow adults to consider agents' efficiency more, perhaps better reflecting enduring principles of early action understanding. Noun labels may also focus adults' attention more to agents themselves such that they might consider efficiency as a property of a certain category of people (Rhodes & Mandalaywala, 2017). Experiment 2 tests this possibility.

Experiment 2

Methods

Our design, methods, and analysis plan were preregistered prior to data collection on the OSF: https://osf.io/78pyb and https://osf.io/suaw2.

Participants As in Experiment 1, 96 native English-speaking adult participants were randomly assigned to one of the four conditions. Following preregistered criteria, an additional 31 were excluded for: failing an attention check (4); taking longer than 15 minutes to complete the study (6); answering 'yes' to all questions (2); or answering 'no' to all questions

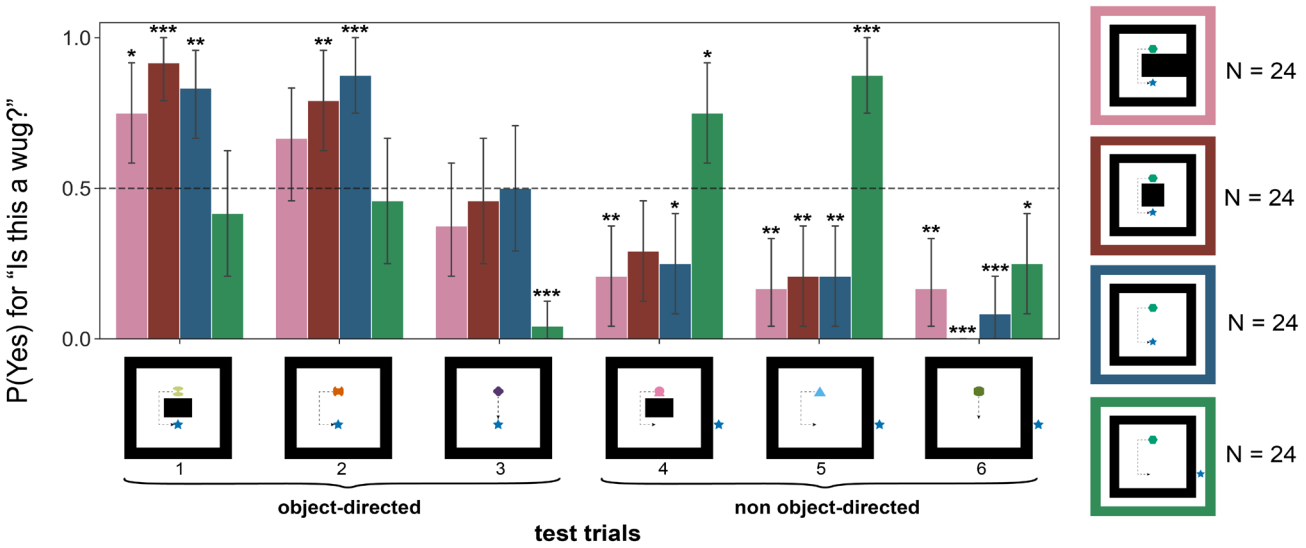


Figure 3: Results of Experiment 2 (nouns). Error bars represent bootstrapped 95% confidence intervals. * $p < .05$, ** $p < .01$, *** $p < .001$

(19). Participants were recruited on Prolific and completed the experiment online and asynchronously on Qualtrics.

Materials & Procedure The stimuli were identical to those of Experiment 1, except that participants heard a novel noun (*wug*) instead of a novel verb, "Look! Here is a *wug*." At test, they were asked, "Is this a *wug*?". The procedure was otherwise identical to that of Experiment 1.

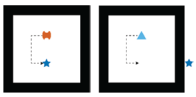
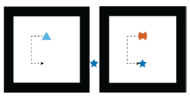
Results

Our analysis (osf.io/5wsh8/) followed that of Experiment 1. **Figure 3** shows the proportions of participants' yes/no responses for each test trial for each condition and includes the significance value for each trial for each condition, evaluated against chance (.50). As in Experiment 1, participants in all conditions extended the novel noun to the test trial that matched their condition in terms of the presence vs. absence of a goal object and the presence vs. absence of an obstacle, suggesting that participants understood the task.

As in Experiment 1, participants' responses differed across the test trials in each condition (*extended obstacle, object*, $\chi^2(5) = 26.24$, $p < .001$; *obstacle, object*, $\chi^2(5) = 24.05$, $p < .001$; *no obstacle, object*, $\chi^2(5) = 33.86$, $p < .001$; and *no obstacle, no object*, $\chi^2(5) = 28.12$, $p < .001$). Our regression including condition and test trial, moreover, revealed main effects of condition ($\chi^2(3) = 10.54$; $p = .015$), test trial ($\chi^2(5) = 44.65$; $p < .001$), and an interaction between condition and test trial, ($\chi^2(15) = 85.08$, $p < .001$), again suggesting that participants responded differently to the test trials across conditions.

Our targeted pairwise comparisons to test for any effects of object-directedness, path, and efficiency were also consistent with Experiment 1 (**Table 2**). Efficiency did not affect noun extension (rows 1–3), but object-directedness (rows 4–5) and path (rows 6–7) did.

Table 2: Pairwise contrasts for Experiment 2 (Nouns).

Condition	Test Trial	*p*-value
		.400
		.473
		.002
		< . 001
		.002
		.005
		< .001

Next, to test whether participants' responses differed when extending verbs (Experiment 1) versus nouns (Experiment 2), we conducted a preregistered regression including experiment, condition, and test trial as fixed effects. We found main effects of condition ($\chi^2(3) = 10.28$, $p = .016$) and test trial ($\chi^2(5) = 44.96$, $p < .001$) but no main effect of experiment ($\chi^2(1) = 0.83$, $p = .364$). We also found an interaction between condition and test trial ($\chi^2(15) = 79.66$, p

< .001) but no other interactions (*p*s > .396). These results suggest that adults extended novel verbs and novel nouns similarly across the two experiments.

Our unplanned analysis of the overall effects of object-directedness, path, and efficiency was also consistent with Experiment 1: We found main effects of object-directedness ($\chi^2(1) = 10.97$, $p < .001$) and path ($\chi^2(1) = 6.94$, $p = .008$) but no main effect of efficiency ($\chi^2(1) = .16$, $p = .692$) and no interactions (*p*s > .687). After adding experiment to this model as a fixed effect, we again found main effects of object-directedness ($\chi^2(1) = 12.09$, $p < .001$) and path ($\chi^2(1) = 7.87$, $p = .005$) but no main effect of experiment ($\chi^2(1) = .16$, $p = .690$) and no interactions (*p*s > .151).

As discussed below, the similarity of the results for verbs and nouns is surprising. To address the possibility that adults may not have been responding in any way that was specific to the word class probed by each experiment, we explored adults' responses to the debriefing questions in an unplanned analysis. To do so, we coded their responses based on whether (1) or not (0) they mentioned: the character (*agent*); the character's starting position (*source*); the character's ending position (*goal*); or the character's trajectory or any directional terms (*path*). We then evaluated in separate logistic regressions whether there were differences in these mentions across experiments. Consistent with the information typically encoded by verbs vs. nouns, adults mentioned *path* ($\chi^2(1) = 3.40$, $p = .065$) and *source* ($\chi^2(1) = 9.44$, $p = .002$) more in the verb vs. noun experiment, but *agent* more in the noun vs. verb experiment ($\chi^2(1) = 38.26$, $p < .001$). There were no differences in the mentions of *goal* ($\chi^2(1) = 2.54$, $p = .111$) across experiments. These results suggest that the similarity between adults' responses across experiments is unlikely to be attributable to their not meaningfully engaging with the experiments' manipulations.

General Discussion

When extending the meanings of verbs and nouns describing the simple events in the present experiments, adults used information about an action's object-directedness and path, not its efficiency. This result contrasts with both infants' focus on efficiency when interpreting others' actions (Gergely et al., 1995; Liu et al., 2019) and adults' commonsense reasoning about the goals of others' actions when those actions are not labeled (Jara-Ettinger et al., 2016; Schachner & Carey, 2013).

Why might adults focus on object-directedness and path, but not efficiency, when extending the meanings of novel words? One possibility is that language introduces a different way to interpret actions that is discontinuous with infants' action understanding. This possibility would challenge the idea that early action understanding remains present and active throughout the lifespan (Dillon, 2024; Spelke, 2022). A second possibility is that adults' experience with words that encode paths might drive them to focus on path over efficiency, although this possibility seems more suited to verb learning than noun learning, since nouns in English do not encode paths. A third possibility is that a focus on object-directedness and path does not leave behind infants' prelinguistic knowledge but rather builds on it to further specify an agent's goal. In particular, if goal-directedness and efficiency are tacitly assumed, then language that focuses instead on object-directedness and path can effectively specify what goal an agent might have (e.g., object, location, movement) as well as how an agent might achieve that goal (e.g., this vs. that kind of path/movement). If language plays this role, it might be especially helpful for linking specific actions to specific goals, something which infants likely learn (Skerry et al., 2013; Woo et al., 2024; Woodward, 2013). One way to further test this possibility in the present context is to contrast an object-based goal with a location-based goal (the present experiments always had the agent return to its starting location at the end of the action) and assess whether adults vary their word extension based on these two types of goals.

Along similar lines, if efficiency is assumed, then language that focuses on path provides useful additional information. For example, a particular path can indicate a movement-based or social goal to both infants (Powell & Spelke, 2018; Yasuda et al., 2025) as well as adults (Schachner & Carey, 2013). And in the presence of a goal object, a particular path can indicate both an object-based goal as well as social goal, as in a ritualistic action, which older infants can appreciate (Liberman et al., 2018). Language may thus facilitate the interpretation of such events as directed towards social goals, object goals, or both, ultimately supporting social learning. Future studies might thus explore whether providing infants with labels for events like those used in the present experiments might change their expectations about agents' goals and efficiency.

Finally, ruling out a purely pixel-based similarity account (which could not explain object-directedness as a factor supporting word extension) as well as an account suggesting that adults simply did not engage with the experiments' different manipulations (which is unlikely given the results of the debriefing data analysis), it is possible that adults' focus on object-directedness and path emerges as soon as there is any explicit representation of an agent's actions, explaining our similar results for verbs and nouns. Since inferences about goal-directedness and efficiency are implicit and automatic, explicit attention to or labeling of such events might highlight other information. Future studies might thus examine whether and how that explicitness might be achieved, whether uniquely through labeling language (e.g., Landau et al., 1988) or through kind-based judgments (e.g., Diesendruck & Bloom, 2003) or other ways of eliciting explicit attention that do not require language (e.g., Lin & Dillon, 2024).

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