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Evaluating actions: Do young children prefer actions completed efficiently over those completed inefficiently?

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Abstract

Efficiency informs perceptions and expectations of people's actions from early in life. We examined whether young children aged three and four consider efficiency when evaluating how well agents completed goals. In three experiments, we showed children scenarios where two characters each walked to target objects, and then asked children which character did a better job. In the first experiment, children appeared to consider efficiency. They more often chose a character who took a direct path over one who took an indirect path, but only when the latter character could have taken a shorter path. Two follow-up experiments, though, failed to replicate this pattern and the success in the initial experiment could be explained in terms of the features of the paths (not strictly related to efficiency) used in that experiment. The findings suggest, then, that three- and four-year-olds do not yet use efficiency to normatively evaluate actions. We consider two alternative explanations for this.

Keywords: efficiency; constraints; goals; theory of mind; cognitive development

Introduction

We examine whether preschoolers aged three and four prefer actions that are completed efficiently over actions that are completed inefficiently. More specifically, we ask whether children judge that an agent does a better job in walking to a target object if the route taken by the agent is efficient rather than inefficient. Investigating this question has the potential to advance knowledge both about how young children recognize and think about efficiency and about the normative standards they use to evaluate goal directed actions.

A growing body of literature suggests that considerations of efficiency are important from infancy onward. One major launching point for this research was seminal work suggesting that one year old infants (i.e., aged 12-months) consider efficiency when attributing intentionality and the capacity for goal-directed actions to an agent (Gergely, Nádasdy, Csibra, & Bíró, 1995). In this that experiment, an agent took the shortest and most efficient path to its goal by jumping over a wall to reach a target. After, infants' looking time data suggested they expected the agent to take a novel, but still efficient, action in the future: With the wall removed, infants expected the agent to go straight to the target, rather than jump. By contrast, infants did not expect this if the agent's initial actions were not rational and efficient — if the agent initially jumped for no reason when approaching the target. Since then, much other work has continued to suggest that infants are sensitive to considerations of efficiency when interpreting actions (e.g., Csibra, Gergely, Bíró, Koos, & Brockbank, 1999; Liu & Spelke, 2017; Phillips & Wellman, 2005; Scott & Baillargeon, 2013; Skerry, Carey, & Spelke, 2013).

Turning to research on young children – research that typically examines responses to verbal questions rather than looking times – many findings also suggest sensitivity to efficiency. When children are aged four years and older, they predict that an agent will take the shorter path to a goal over a longer one (Gönül & Paulus, 2021; also see Schuwerk & Paulus, 2016), although children at three years old do not share this expectation. At this age, children also expect others should choose simple tasks over difficult ones to receive a reward (Bennett-Pierre, Asaba, & Gweon, 2018). When children are around five or six, they also expect that an agent will be more likely to retrieve an object from a short hill that is comparatively easy to climb than from a higher one that is more difficult to climb (Sehl, Friedman, & Denison, 2021), and they likewise use cost-benefit analyses (which are closely linked with efficiency) when determining which of two objects an agent prefers (Jara-Ettinger, Gweon, Tenenbaum, & Schulz, 2015) and when making other social inferences (Chu & Schulz, 2023; Jara-Ettinger, Floyd, Tenenbaum, & Schulz, 2017; Leonard, Bennett-Pierre, & Gweon, 2019). For example, when children aged three and four are faced with two artifacts that are both well suited for performing a function and are asked which was *designed* to perform that function, they are more likely to indicate an artifact that does not have any extra or unnecessary parts over an artifact that does have extra parts—that is, they prefer artifacts with more efficient designs (Kelemen, Seston, & Saint Georges, 2012).

The work described so far has mostly examined inferences connected with infants' and children's expectations of efficiency and their detection of efficiency. Adults, though, also consider efficiency in normative ways. They sometimes indicate that agents and things which operate efficiently are preferred to ones which are inefficient. For instance, all else being equal, adults think that if a goal can either be achieved by using one chemical compound or by using two different

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compounds, it is more appealing to use one (e.g., Sehl, Denison, & Friedman, 2024; also see Sehl, Friedman, & Denison, 2022). Some work on infants also suggests social preferences for efficient over inefficient agents. On seeing one agent efficiently approaching a goal item and another agent inefficiently approach a goal item, infants at 15 months expect an observer to be more likely to approach the efficient agent (Colomer, Bas, Sebastian-Galles, 2020).

Work on children has looked at the related question of whether they use efficiency to infer competence. One study found that children aged 4 and 5 do this (Leonard et al., 2019). For instance, children at these ages judge that a person who quickly builds a block tower is better at this task than a person who takes longer to build an identical looking tower. This kind of judgment differs, however, from normative judgments about who did a better job. Such judgments involve thinking about whether a person who *chose* to accomplish a goal in the most efficient way possible did a better job, or used a better approach, than a person who chose to accomplish the goal in a less efficient way. This was the kind of judgment we investigated.

We conducted three experiments on children aged three and four. In our experiments, children saw scenarios about characters who had to go to target objects. For instance, each character had to go to their water bottle. One character always took a direct path, which was maximally efficient. The other character took a longer circuitous path. This long path was sometimes inefficient as the character could have taken the shorter path, and here preferences for efficiency should lead children to prefer the character taking the shorter path. Other times, though, the longer path was also efficient because obstacles prevented the character from taking a direct route. Here a preference for efficiency should not lead children to select the character with the shorter path as doing a better job.

Experiment 1

Methods

Participants We tested 80 children aged three and four (mean age = 3 years 11 months, range = 3 years 0 months to 4 years 11 months; 45 girls and 35 boys). Of these children, 73 were tested in-person at childcare centers and schools in the Waterloo (Ontario) region. This region is predominantly middle class and approximately 79% of residents are White; Chinese and South Asians are the predominant visible minorities. The remaining seven children were tested online in a Zoom call.

Procedure When tested in person, children were shown images on a laptop computer. When children were tested over Zoom, the experimenter shared their screen. The experiment began with two warm-up trials. In these warm-up trials, children saw two colored boxes. A fish appeared in one and children were asked to indicate where it was located ("So what color box is the fish in?"). Boxes using the same two colors (yellow and orange) were used in both warm-up trials and in all the subsequent test trials. Although we included these trials for all children, they only really mattered for children tested over Zoom, since they could only choose between characters in the main experiment by saying the color of the box around the character they wanted to select.

Next, children completed four test trials; see Figure 1. In each trial, two characters were shown in separate fields, and each character had to walk to an object in their field (e.g., "*Here are two kids. The kids have to get to the watering cans.*"). Across the four trials, these objects were water bottles, backpacks, umbrellas, and watering cans. Children saw the route each character took to go to the object in their field (e.g., "*And look! They got to their watering cans*"). One character walked straight to the desired object while the other character walked in a longer winding path.

The experiment used a within-subjects design, manipulating trial type. There were two types of trials, constraint and no-constraint, with two test trials of each type. In all trials, the character who went directly to the object took the shortest possible path. Hence, this character's route was always efficient. The efficiency of the character who took a longer path, however, differed across the two types of trials. In constraint trials, this character's winding path was also efficient. Obstacles like dense bushes and boulders prevented the character from walking directly to the object. Hence, taking a winding path was the shorter available way of getting to the object. In the no-constraint trials, by contrast, the winding path was inefficient. There were no obstacles between the character and the desired objects, which meant that taking a winding path was unnecessary as the character could have directly gone to the object. At the end of each trial, children were asked a forced-choice question: "*Which kid did a better job?*".

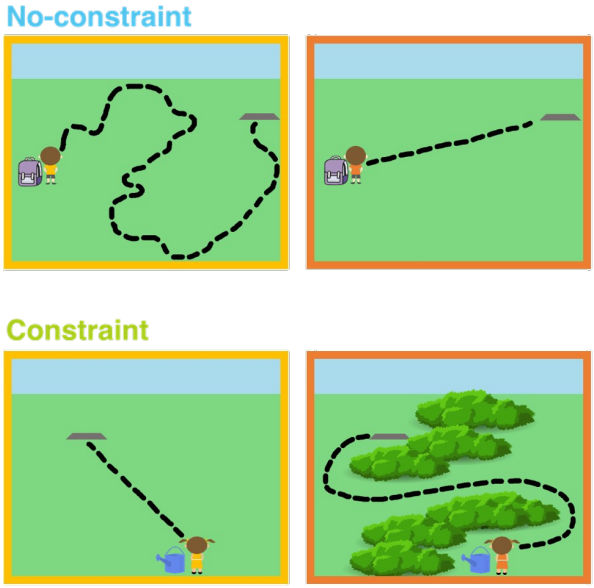

Figure 1: Sample stimuli from two test trials in Experiment 1. The top panel shows a no-constraint trial with backpacks, and the bottom panel shows a constraint trial with watering cans. Here, the winding route (character on the right) is efficient because the bushes prevented a shorter path to the object.

Results

In all experiments, choices of the character who took the shorter path were scored as 1 and choices of the character who took the longer winding path were scored as 0. Responses were analyzed using a generalized estimating equation (GEE) model (binary logistic, independent correlation matrix) with trial type (constraint, no-constraint), question (better, fun), and age in months (mean centered) as predictors; see Figure 2. For all analyses, we ran the model in R using the *geepack* package (Højsgaard et al., 2006) and passed the results to the joint_tests function in the *emmeans* package (Lenth et al., 2019) to yield a Type 3 analysis.

This analysis yielded a main effect of trial type, χ^2 (1) = 20.99, p < .001: Children were more likely to select the character who took the shorter path in the no-constraint trials than in constraint trials. The other effects were not significant: There was no main effect of age, χ^2 (1) = 0.33, p = .566, and there was also no interaction between trial type and age, χ^2 (1) = 0.93, p = .335.

We also conducted single-sample tests against chance to test whether children mostly chose one character over the other; these tests were conducted using intercept-only models. In no-constraint trials, children chose the character who took the shorter path significantly more often than they chose the character who took the longer winding path, p < .001. In constraint trials, children were no more likely to choose one character over the other, p = .215.

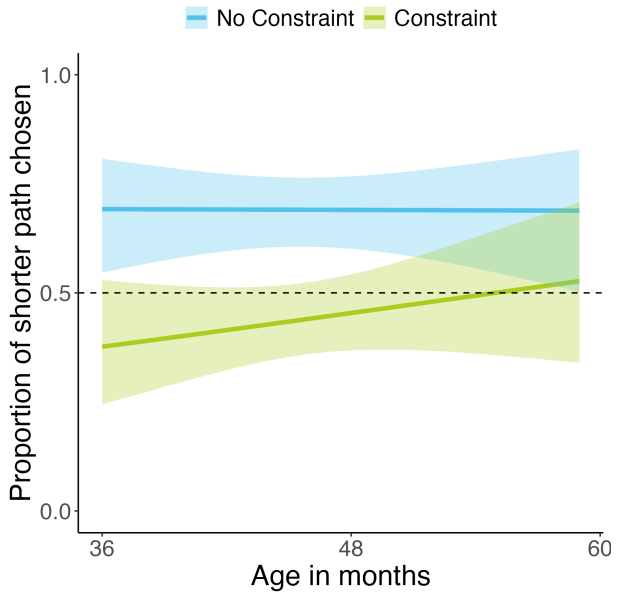

Figure 2: Results from Experiment 1 showing the proportion of children selecting the character who took the shorter path when asked which character did a better job. All plots show the regression lines and 95% confidence intervals predicted from the GEE models.

Discussion

Children appeared to be sensitive to efficiency. In the no-constraint trials – where taking a longer route was inefficient because they character could have taken a shorter path – children indicated that the character who took the shorter path did a better job. In constraint trials – where both characters took the shorter path available to them – children did not show this preference and instead chose both characters at similar rates.

Given these findings, we wanted to be sure that children's pattern of responses truly indicated their assessments of which character did a better job. One concern was that the winding routes differed across the no-constraint and constraint trials: The routes in the no-constraint trials were more complex and wavering, whereas those in the constraint trials were smoother (see Figure 1). This raised the concern that our findings might be explained by children simply having a preference for smoother paths over less smooth ones. We addressed this in the next experiment by adjusting the winding paths so that they were similar across both trial types.

In the next experiment, we also wanted to examine whether children's sensitivity to efficiency could also drive other judgments, besides assessments of which character did a better job. To examine this, we attempted to replicate the results with one group of children, while having another group of children see the same kinds of scenarios but respond to a different test question. Rather than having these latter children evaluate which character did a better job, we instead asked them to judge which character had more fun. Rather than seeing greater efficiency as indicative of fun, children may see inefficiency as a cue to it (Chu & Schulz, 2023; also see Schachner & Carey, 2013 for work in adults).

Experiment 2

Methods

Participants We tested 81 children aged three and four (mean age = 3 years 11 months, range = 3 years 0 months to 4 years 10 months; 37 girls and 44 boys). Of these children, 72 were tested in-person at childcare centers and schools in the Waterloo (Ontario) region. The remaining nine children were tested online in a Zoom call. We also tested two other 3-year-olds. They could not be included in the analysis because they did not respond to any of the test questions.

Procedure Children were tested as in the first experiment with the experimenter showing pictures on a laptop computer (live testing) or by screen-sharing (Zoom testing). Also as before, testing began with two warm-up trials, and then moved to four test trials (see Figure 3), where two characters were shown in separate fields, and each had to walk to an object in their field. As before, across the four trials, these

objects were water bottles, backpacks, umbrellas, and watering cans.

The scenarios differed from those in the first experiment in two ways. First, we modified the slides so that the smoothness of the winding paths was consistent across the no-constraint and constraint trials. We also used a slightly different testing script. Here is the wording from one trial: "*Here are two kids. The kids have to get to the watering cans. Let's see how they get to the watering cans.*"

This experiment used a 2X2 factorial design. As before, trial type (constraint and no-constraint) was manipulated within-subjects with two test trials of each type. Again, the character who walked straight was always efficient, while the character who took the longer winding path was efficient in constraint trials and inefficient in no-constraint trials.

The between-subjects factor was test question: At the end of each trial, children were asked either about which character did a better job ("Which kid did a better job?"), or about which character had more fun ("Which kid had more fun?").

Results

Responses were analyzed using a GEE model (binary logistic, independent correlation matrix) with trial type (constraint, no-constraint), question (better, fun), and age in months (mean centered) as predictors; see Figure 4.

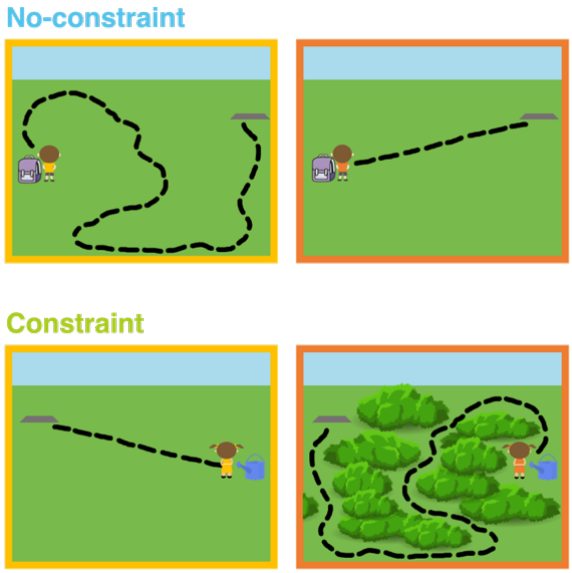

Figure 3: Sample stimuli from Experiment 2. The top panel shows a no-constraint trial and the bottom panel shows a constraint trial. In contrast Experiment 1, the winding paths were matched for smoothness. Indeed, both trials use the *same* paths; the paths are flipped horizontally or vertically across the two trial types.

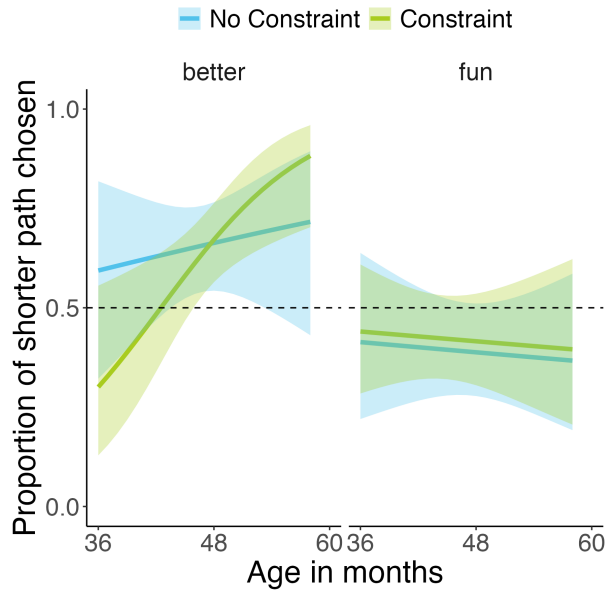

Figure 4: Results from Experiment 2, showing the proportion of children choosing the character who took the shorter path when asked who did a better job (left) or who had more fun (right).

This analysis yielded a main effect of question type, χ^2 (1) = 15.18, p < .001: Children were more likely to select the short-path character when they were asked about who did better compared with when they were asked about who had more fun. All other effects were not significant: There was no main effect of trial type, χ^2 (1) = 0.03, p = .869, no main effect of age, χ^2 (1) = 2.09, p = .149, no significant two-way interaction between trial and age, χ^2 (1) = 2.46, p = .117, between trial and question, χ^2 (1) = 0.14, p = .710, or between age and question, χ^2 (1) = 3.27, p = .071, and likewise no significant three-way interaction, χ^2 (1) = 2.41, p = .121.[1]

We also conducted single-sample tests against chance using intercept-only models to test whether children mostly chose one character over the other. When children were asked about which character did a better job, they mostly chose the character who took the shorter path, p = .001. By contrast, when children were asked about which character had more fun, they mostly chose the character who took the longer winding path, p = .044.

Discussion

To our surprise, and in contrast with the results of the first experiment, children were insensitive to efficiency both when they judged which character did a better job and when they judged which character had more fun. The difference in results across the experiments could stem from the methodological differences between the experiments, or alternatively could reflect sampling error—for instance,

[1] We also ran several exploratory analyses following up on these null findings but they also did not reveal any significant effects of trial type. Trial type remained non-significant when age was binned by years (3-year-olds versus 4-year-olds), when the data was filtered to only include 4-year-olds and age was removed from the model, and when analysis was restricted to children asked about which character did a better job.

perhaps the children sampled in the first experiment were, for unknown reasons, unusually precocious. To get a clearer understanding, we conducted another experiment to investigate whether children consider efficiency in evaluating actions, while also trying to make the scenarios easier for children to follow.

Experiment 3

Methods

Participants We tested 80 children aged three and four (mean age = 3 years 10 months, range = 3 years 0 months to 4 years 11 months; 35 girls and 45 boys). Of these children, 75 were tested in person at childcare centers and schools in the Waterloo (Ontario) region. The remaining six children were tested online.

Procedure As in the previous experiments, the experimenter showed pictures on a laptop computer (live testing) or by screen-sharing (Zoom testing). Testing again began with two warm-up trials, and then moved to the four test trials. This experiment used the same 2 X 2 design as the previous experiment, with trial type (constraint, no-constraint) as a within-subjects factor and question (better, fun) as a between-subjects factor.

In an attempt to make the procedure easier and more engaging for children, the trials were administered differently than before. At the beginning of each trial, children were first introduced to the characters and told that each had to get their possessions (e.g., "*Here are two more kids. The kids have to get to their watering cans*.") The experimenter next indicated the character on the left, explaining that children would see this character get their item ("*First, we'll see how the kid in the yellow box gets their watering can.*"). Children then watched an animation of the character going to the object. The experimenter then introduced the character on the right ("*Next, we'll see how the kid in the orange box gets to their watering can.*"), and children also saw an animation of this character going to their object. In contrast with the procedure in the previous experiments, the slides did not include a dotted line showing the path; children only saw each character move and nothing else. As before, each trial ended with the test question, either "*Which kid did a better job?*" or "*Which kid had more fun?*".

Results

Responses were analyzed using a GEE model (binary logistic, independent correlation matrix) with trial type (constraint, no-constraint), question (better, fun), and age in months (mean centered) as predictors; see Figure 5.

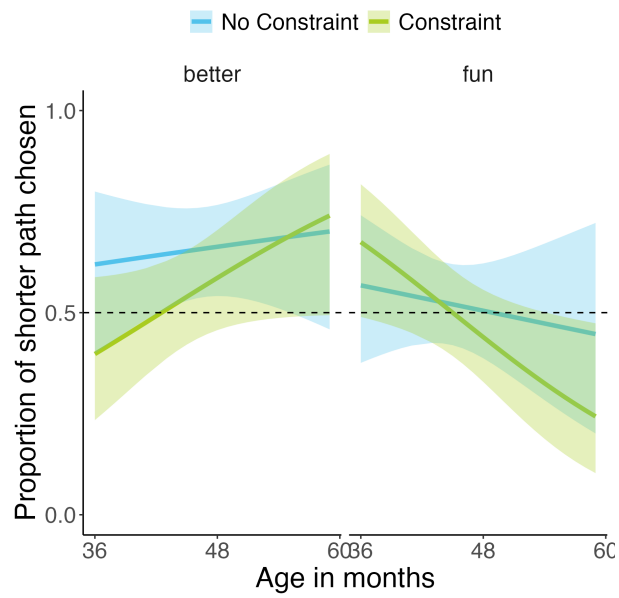

Figure 5: Results from Experiment 3, showing the proportion of children choosing the character who took the shorter path when asked who a better job (left) or who had more fun (right).

The analysis yielded only one significant effect—the two-way interaction between age and question, χ^2 (1) = 5.51, p = .019. However, breaking this interaction down yielded non-significant effects. When children judged who did a better job, older children were marginally more likely than younger ones to choose the character who took a shorter path, p = .087, whereas when children judged who had more fun, older children were marginally more likely than younger ones to choose the other character, p = .089.

All other effects were non-significant. The main effects of trial type, χ^2 (1) = 1.78, p = .182, question, χ^2 (1) = 3.64, p = .056, and age, χ^2 (1) = 0.09, p = .769. The two-way interaction between trial and question, χ^2 (1) = 0.28, p = .598, and between trial and age, χ^2 (1) = 0.03, p = .854. And finally, the three-way interaction between trial type, age, and question, χ^2 (1) = 2.62, p = .106.

Discussion

We again failed to replicate the findings from the first experiment. As in the previous experiment, children showed no sensitivity to whether characters completed goals efficiently or inefficiently. Overall, performance was noisier than both previous experiments, as this time we found only limited evidence of children responding differently on the basis of whether they were judging which character did a better job or which had more fun.

General Discussion

In three experiments, we examined whether 3- to 4-year-olds consider efficiency when evaluating the methods individuals use to complete goals. Children's responses in the first experiment suggested that children preferred efficiency. Children saw one character reach a goal by taking a short path and another character reach a goal by taking a longer path. When asked which character did a better job, they mostly chose the character who took the short path, but only when the other character could have taken a more efficient path. When both characters took the shortest path available to them, children chose them at similar rates.

The second experiment followed up on a potential concern with the stimuli used in this first experiment: The paths taken by the character who took the longer route were smoother in the trials where this character faced obstacles (and could not take a shorter and more efficient route), compared with the paths in the trials where there were no obstacle (meaning a shorter route and more efficient route was available). This experiment also compared two kinds of judgments—assessments of which character did a better job in completing their goal, and assessments of which character had more fun. In contrast with the first experiment, children were now insensitive to efficiency. They responded similarly regardless of whether the character taking the longer route took the most efficient path available. At the same time, children were sensitive to the test question they were asked. They preferentially chose the character who took the shorter path when assessing who did a better job, and preferentially chose the other character when assessing who had more fun.

In the third experiment, we animated the stories to try to make them clearer and more engaging for children. However, we again failed to replicate the finding from the first experiment, as children continued to respond with no sensitivity to efficiency. Evidence that they differentiated between the two test questions was also somewhat weaker. It is likely that our attempts to make the task clearer for children had an effect opposite to what we intended. Perhaps animating the two stories made it harder for children to remember what each character had done.

Overall, these findings suggest that children aged three and four do *not* use efficiency to evaluate goal-directed actions, at least with the kinds of scenarios we explored. Although follow-up studies will be needed, for now we believe children's success likely resulted because of the oversight in creating the stimuli which we discussed above — namely that the long indirect paths looked notably different in trials with obstacles than in trials without obstacles (i.e., they were smoother in the former than the latter).

Why then did children *not* use efficiency to guide their assessments? One explanation is that although participants were attuned to efficiency in our tasks, children at this age do not yet think that it is better to pursue goal-directed actions efficiently rather than inefficiently. On this view, children might have shown sensitivity or awareness if asked to make some other judgment—for instance, if they were asked to indicate which of two paths an agent would be more likely to take. This might be expected to the extent that many previous studies suggest that young children and even infants do appear to expect individuals to behave rationally (as reviewed in the Introduction). It could be suggested, for instance, that preferences for efficiency are a product of socialization and enculturation.

Another possibility, though, is that children did not register the distinction between efficiency and inefficiency as manipulated in our experiments. To recognize actions as inefficient in our scenarios, children likely had to recognize that agents taking winding paths with no obstacles could have taken more direct paths to their goals. Similarly, to recognize actions as efficient children likely had to recognize that other agents (both those taking direct paths and those forced to take winding paths because of obstacles) could not have taken a shorter path. These judgments implicate counterfactual reasoning – in this case, the recognition of whether routes other than the one taken could have been possible. Much research suggests that young children often struggle with counterfactual reasoning, and this could explain children's difficulty with our tasks (e.g., Beck, Robinson, Carroll, & Apperly, 2006; Kominsky, Gerstenberg, Pelz, Sheskin, Singmann, Schulz, & Keil, 2021; Nyhout, Henke, & Ganea, 2019; for reviews see Beck & Riggs, 2014 and Nyhout & Ganea, 2019a). Some work has found that children at age 4 succeed with counterfactuals, and with recognizing that agents could have done otherwise (e.g., Kushnir, Gopnik, Chernyak, Seiver, & Wellman, 2015; Nyhout & Ganea, 2019b). But in those tasks, children were explicitly asked about the alternative possibilities, and 4-year-olds might be less likely to consider counterfactuals if not explicitly asked. One direction for future research, then, might be to explicitly ask children if agents could have taken a shorter route, before having them judge which did a better job.

Beyond this, it could also be that some of children's difficulty arose from our test question, "*Which kid did a better job?*". It could be that children felt conflicted about which agent to choose, because although one was more efficient, the other did more (i.e., travelled a longer distance) and this exertion of effort could seem praiseworthy. It might be helpful for future research to assess children using another test question, like "*One of the kids should get a sticker. Which kid should get it?".* That said, if children see traveling longer distances as warranting praise, they might continue to feel conflicted. Another approach then might be to hold distance constant while manipulating efficiency by having one agent's path constrained by obstacles and the others' unconstrained. We have conducted studies using this approach, and although we found success in older children, those aged 3 and 4 continued to struggle.

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