Does normality influence children's causal selections?

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Abstract

Our expectations about what normally occurs influence our explanations. In conjunctive causal structures, people tend to select the more *abnormal* cause. This tendency reverses in disjunctive structures, and people select the *normal* cause. It is currently unknown how these tendencies develop, and what factors contribute to their emergence in childhood. Across three experiments, we tested adults (n = 179) and 5- to 7-year-olds (n = 96) on two tasks where an abnormal and normal factor jointly caused an outcome. Experiments 1 and 2 revealed that while adults' explanations varied according to the causal structure, children exclusively chose the normal cause, regardless of causal structure. Using a task with an intuitive and explicit causal mechanism, Experiment 3 found that children were more likely to select the abnormal cause in the conjunctive case than in previous experiments. This suggests that intuitions about causal mechanisms may facilitate adult-like judgments. We consider potential explanations, including the role of counterfactual reasoning.

Keywords: causal selection; explanations; normality; counterfactuals; cognitive development

Introduction

Imagine that, to enjoy a good cup of coffee, Cooper needs *both* sugar and cream. With only sugar or only cream, Cooper would not enjoy his coffee. The kitchen in Cooper's office always has sugar, but there is rarely cream, so it is normal for Cooper to unhappily have his coffee with sugar alone. If one morning Cooper is blissfully able to enjoy his coffee with *both* sugar and cream, which ingredient better explains his happiness? In cases like this, adults tend to select the unexpected, or *abnormal* cause (cream) as the better explanation, compared to the normal event (see for a review, Willemsen & Kirfel, 2019). In fact, research across areas of cognitive science shows that our expectations about what normally occurs influence our explanations of events (Hart & Honoré, 1959; Henne et al., 2021; Hilton & Slugoski, 1986; Hitchcock & Knobe, 2009; Kahneman & Miller, 1986).

Critically, the *structure* of a causal system—how causes relate to each other and to effects—interacts with our expectations of normality to influence our causal judgments (e.g., Icard et al., 2017; Kominsky et al., 2015). In the current paper, we are specifically concerned with common effect structures, where two causes come together to create a joint outcome. *Conjunctive* common effect structures occur when both causes together are necessary for the effect. *Disjunctive* common effect structures occur when either cause is sufficient, and the outcome is overdetermined.

As noted above, prior work has found that when multiple events are necessary for an outcome (conjunction), people tend to find the *abnormal* cause to be more explanatory, or "more causal." However, this tendency *reverses* when either cause is sufficient for the effect (disjunction), and people select the *normal* event instead (e.g., Henne et al., 2019; Kominsky et al., 2015; Kirfel et al., 2022; O'Neill et al., 2024). For example, imagine that for Cooper's colleague, Diane, having *either* sugar or cream in her coffee is sufficient to make her happy. She enjoys her coffee with only sugar, only cream, or both – and only dislikes a black cup of coffee. Again, the office kitchen always has sugar, but rarely has cream, so it is normal for Diane to happily have her coffee with only sugar. If one morning Diane has her coffee with *both* sugar and cream, which ingredient better explains her happiness? In overdetermined disjunctive cases like this, people tend to select the *normal* cause (sugar) as the better explanation. The influence of the abnormal cause (cream) is virtually negligible here, as the normal event can make the outcome happen on its own. In short, the influence of normality on causal selection depends on the causal structure.

Various accounts have interpreted this interaction as resulting from implicit counterfactuals in causal selection (e.g., Fazelpour, 2021; Halpern & Hitchcock, 2015; Icard et al., 2017; Quillien & Lucas, 2023). For example, Icard et al. (2017) formulated a measure of causal strength indicating that normal and abnormal causes are selected in terms of their necessity and sufficiency across counterfactual alternatives. This measure includes the probabilities of each event (i.e., how normal it is for an event to occur) and the causal structure under which they operate. Specifically, the counterfactual in which the abnormal event *did not* occur highlights the effect of the abnormal cause. In disjunctive causal structures, the normal event is sufficient to create the outcome, and the abnormal event is not necessary. In other words, even if the abnormal event had not occurred, the outcome would still have happened. In conjunctive structures, although both events are necessary for the outcome, the normal event is insufficient on its own. Here, the sufficiency of the normal event is equivalent to the probability of the abnormal event: if the abnormal event had not occurred, the outcome would not have happened. According to Icard and colleagues, this "inflates" the strength of the abnormal event.

Such formalisms explain these patterns of causal selection computationally. But it remains unclear how these tendencies emerge and develop. The present paper asks whether children, like adults, combine information about causal structure and normality when forming explanations. What factors of the causal process might influence children's judgment?

There is very little research exploring whether and when normality influences causal selection in children, or what factors contribute to its development. To our knowledge, only one prior study has investigated children's abnormal selection bias in conjunctive structures. This work presents children with a social and moral setting (Samland et al., 2016), using a modified version of "the pen vignette" (Knobe & Fraser, 2008). Here is a shortened adaptation: *We have ten pens. Rules are that hedgehogs are not allowed to take any pens, but bears are allowed. When a bear and a hedgehog take five pens each, no pens remain! The question is: "Who caused the problem, the hedgehog, or the bear?"*

Samland et al. (2016) found that both adults and 5-year-olds tend to choose the norm-violating (abnormal) agent as the cause of the problem—the hedgehog who broke the prescriptive rule—even though both agents contributed to the outcome equally. This implies that prescriptive norm violations guide causal judgments in both children and adults (see also, Samland & Waldmann, 2016). However, in moral norm violation scenarios like this, the norm-violating agent serves as a particularly attractive pragmatic choice. Since the outcome is represented as a "problem," people may simply match this negative event with the agent who broke a rule, without considering the necessity of the other agent or the causal structure of the events. Moreover, 5-year-olds' judgments were unchanged by the agent's epistemic state. That is, even when the norm-violating agent was ignorant of the rule they were breaking, children, but not adults, continued to attribute the outcome to that agent. This further suggests that children might default to blaming the norm-violator without considering other relevant factors (see also, Proft & Rakoczy, 2018).

These findings relate the normality biases to social and moral reasoning, where attributions of blame, responsibility, or accountability might underlie causal selection (Alicke et al., 2011; Samland & Waldmann, 2016; Sytsma et al., 2012). However, recent work with adults has found that normality also influences our judgments in non-agentive and non-moral paradigms; even physical collision events between inanimate objects can elicit biased causal judgments (Henne et al., 2021; Gerstenberg & Icard, 2020). These biases therefore not only appear with prescriptive norms (i.e., what one ought to do), but also with statistical norms (i.e., what is more likely), and norms of proper functioning (i.e., how a machine should operate) (Gill et al., 2022; Kirfel et al., 2022; Kominsky & Phillips, 2019). These biases are also implicit in the way we communicate causality to others, and people infer causal structure or event normality according to which causes were mentioned in explanations (Kirfel et al., 2022). Considering these findings, accounts that emphasize the role of relevant counterfactuals and causal strength (e.g., Icard et al., 2017; O'Neill et al., 2024; Quillien & Lucas, 2023) may provide a more comprehensive explanation of the interactions between normality and causal selection than sociomoral accounts.

It is currently unknown whether children would also show biased causal judgments in the absence of prescriptive, moral rules. It is plausible that normality biases are initially rooted in sociomoral development, such that causal selection is a function of moral judgments (Samland & Waldmann, 2016; Samland et al., 2016), and are only later generalized to non-agentive and non-moral situations.

On the other hand, it is also possible that these biases emerge as a result of domain-general processes underlying early causal inference. In line with this proposal, there is a large body of developmental work that has established that children can rationally select causes (e.g., Gopnik et al., 2004; Goddu & Gopnik, 2024), infer probabilities and likelihoods from evidence (e.g., Bonawitz et al., 2014; Denison et al., 2013), understand complex causal structures (e.g., Koskuba et al., 2018; Lapidow & Walker, 2020; Rett al., 2025), and reason counterfactually starting around age 4 or 5 (Nyhout & Ganea, 2019; cf. Kominsky et al., 2021; McCormack et al., 2018; Nyhout et al., 2019). Furthermore, preschoolers engage in greater amounts of explanation when outcomes are inconsistent with their expectations (e.g., Legare, 2012; Legare et al., 2010), suggesting that the normality of an event (i.e., "what is supposed to happen") may guide explanation.

If children can take both normality and causal structure into account, their causal explanations for conjunctive and disjunctive events should be asymmetrical, even when conditions are non-agentive and non-moral. Alternatively, if children's causal selection is influenced by norms that concern social and moral violations, their explanations should not necessarily show this adult-like asymmetry in non-agentive contexts.

The Present Study

The present study investigates the influence of statistical normality expectations on causal selection in children and adults across three experiments that use non-agentive, non-moral paradigms (Figure 1). We created two distinct but analogous tasks, with different causal mechanisms. In both tasks, two objects jointly cause an outcome, representing common effect structures. The objects functioned probabilistically, determining which events were normal (more likely) and abnormal (less likely) to occur. Statistical normality, in this sense, is about the likelihood of each individual cause, rather than the likelihood of the joint outcome occurring.

In conjunctive structures, both events were necessary (i.e., "A *and* B cause C"). In disjunctive structures, either event was sufficient (i.e., "A *or* B cause C"), and the outcome was overdetermined. Test trials either had (1) an achieved outcome with both of the objects working, or (2) an omitted outcome with neither of the objects working. In test trials, participants selected between two causes: one normal, and one abnormal. We opted for a forced-choice paradigm over individual ratings to make the task more understandable for young children. These two-option forced-choice questions were adapted from previous adult studies (e.g., Gerstenberg & Icard, 2020; Kirfel et al., 2022; 2024).

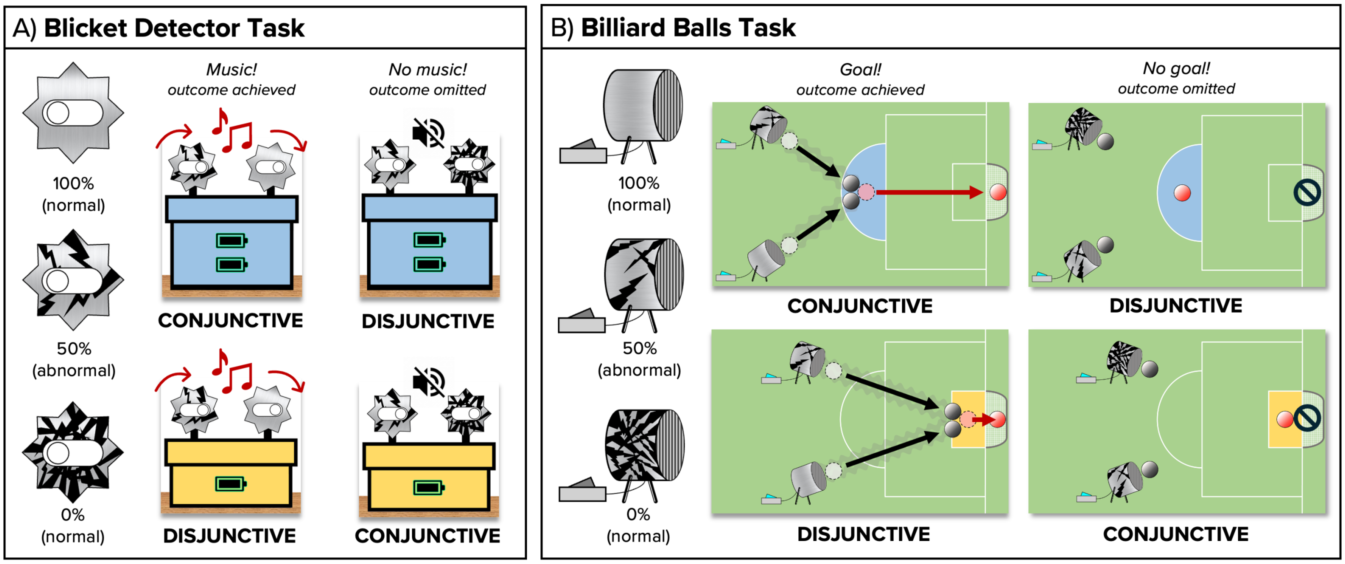

Figure 1: Experimental tasks. (A) The blicket detector task used in Experiment 1. Experiment 2 used the same blicket detector paradigm, but with 75% and 25% probability stars. (B) The billiard balls task used in Experiment 3.

Across all experiments, conditions, and age groups, we hypothesized that the abnormal cause would be selected to explain the outcome in conjunctive structures, and the normal cause would be selected to explain the outcome in disjunctive structures. All data was collected between January 2024 and September 2024. All experiments were pre-registered on AsPredicted.org [link].

Experiment 1

In Experiment 1, we used a "blicket detector" paradigm, displaying a novel causal system with a hidden causal mechanism (e.g., Gopnik & Sobel, 2000) (Figure 1A).

Method

Participants The final sample included 32 children (six 5-year-olds, nineteen 6-year-olds, seven 7-year-olds) recruited through in-lab appointments or museum and preschool visits (M_{age} = 6.50 [5.56; 7.96 years], SD_{age} = 0.67, 14 females) and 51 adults recruited through Prolific (M_{age} = 37.41 [20; 75 years], SD_{age} = 13.20, 24 females, 24 males, 3 non-binary). Three children were excluded for failing to complete the task (n = 2) or failing attention check questions (n = 1). Fifteen adults were excluded for taking longer than 1.5 SDs above average to complete the task (n = 7) or failing attention check questions (n = 8). All participants were English speakers based in the United States. Adults were compensated with $12.00/hour, children received a small prize.

Design & Procedure We employed a 2 (causal structure: conjunctive or disjunctive) × 2 (outcome: music or no music) between-subjects design. All participants were randomly assigned to one of four conditions. All experimental stimuli were created and animated using Microsoft PowerPoint. The adults were tested online through Qualtrics, where they watched videos depicting the task. The children were tested in-person where an experimenter moderated the PowerPoint presentation on an Apple iPad.

The blicket detector task included spinning "stars" that differed in their probability of functioning (conveying statistical and proper functioning norms). When the stars were "turned on," they would either spin or fail to spin, depending on the trial. Stars that "got broken" had cracks on their surface and were less likely to function. Each star was introduced individually in the following order: the 100% star spun 4/4 times, the 0% star spun 0/4 times, and the 50% star spun 2/4 times in a No-Yes-Yes-No order. To check comprehension, children were asked which star "always" works and which star "never" works, and adults were asked to order the stars by most likely to spin to least likely. Critically, in contrast to previous studies, participants were not explicitly told the likelihoods. Instead, they inferred this statistical normality information by observing each object behave four times.

The stars were then placed on top of "music boxes," which played music when they were "powered up" by spinning stars (Figure 1A). Participants were introduced to either the big music box, or the small music box. Then, participants observed pairs of 100% and 0% stars placed on two pegs on top of the box. The big music box required *both* stars to spin to play music, and only activated when two 100% stars were placed on top. The small music box required *at least one* star to spin to play music, and activated when two 100% stars were placed on top or when one 100% star was paired with a 0% star. Participants were shown combinations where the 0% star was placed on the left and right sides to avoid inferences about the causality of each peg. Participants were then asked hypothetical questions about whether the box would play music with combinations of 100% and 0% stars. Only the participants who correctly answered all comprehension check questions were included in analyses.

During the test trial, participants saw one of two outcomes. In the *music* outcome, a 100% and a 50% star were placed on the box. When turned on, both stars spun, making the box play music. Here, the 100% star was normal, and the 50% star was abnormal (because it is less expected to spin). In the *no music* outcome, a 0% and a 50% star were placed on the box. When turned on, neither star spun, and the box did not play music (i.e., causal omission). Here, the 0% star was normal, and the 50% star was abnormal (because it is less expected to fail to spin). Then, participants were asked to explain the outcome. Children were asked "Why did the box [not] play music? Was it because this star spun [did not spin]? Was it because this star spun [did not spin]?" (pointing to each star, in turn). Adults were asked to choose between two statements that better described the outcome: "The box played music [did not play music] because the star on the left/right spun [did not spin]."

Critically, the outcomes determined causal structure. When music played, the big box represented a conjunctive structure, as it required both stars to function; and the small box represented an overdetermined disjunctive structure, as it required at least one star to function. In contrast, when no music played, the big box represented an overdetermined disjunctive structure, as it required at least one star to fail to spin to cause this outcome; and the small box represented a conjunctive structure, as it required both stars to fail to spin. Therefore, the same music box could represent either causal structure, depending on the outcome and the explanandum.

Results & Discussion

Figure 2A shows participants' selections. A binomial logistic regression revealed that, in line with prior research, adults' causal selections differed by causal structure (conjunctive vs. disjunctive), $\beta = 2.79$, $SE = 0.75$, $z = 3.72$, $p < .001$; but not by outcome (music or no music), $\beta = 1.28$, $SE = 0.75$, $z = 1.71$, $p = .087$. Further, binomial tests compared the proportion of selections to chance (50%). In conjunctive structures, adults selected the *abnormal cause* more often than chance, 78%, $p = .003$, *95% CI:* [61%, 100%]. In disjunctive structures, adults selected the *normal cause* more often than chance, 79%, $p = .003$, *95% CI:* [62%, 100%].

Unlike adults, 31 of 32 children selected the *normal cause*, regardless of causal structure or outcome, with no differences across conditions (ps > .1). It is worth noting that 24 of 36 children initially answered the question by ignoring the forced-choice and spontaneously saying, "Both." Although this is a technically correct answer, experimenters prompted further by saying, "If you had to choose *one*, which one made the box [not] play music?" After this additional prompt, all children selected one cause.

Results of Experiment 1 demonstrate that the novel blicket detector design elicited the expected asymmetrical normality bias in adults, but not in children. This finding is inconsistent with previous developmental work that found that children show an abnormal selection bias under conditions of prescriptive normality (Samland et al., 2016). Based on the results of Experiment 1, it is therefore possible that these biases initially emerge in sociomoral contexts with prescriptive norms (Samland et al., 2016; Samland & Waldmann, 2016), and that 5- to 7-year-olds have not yet begun to generalize to non-agentive situations. Alternatively, it is possible that children had a general preference to select deterministic (100% or 0%) over probabilistic causes (50%), without considering causal structure. In line with this, some prior work suggests that 4-year-olds tend to expect causes to work deterministically, and often avoid attributing causality to stochastic causes (Schulz & Sommerville, 2006; cf. Kushnir & Gopnik, 2005). To rule this out in Experiment 2, we did not present a deterministic option in test trials.

Experiment 2

In Experiment 2, we modified the blicket detector task, asking children to select between two probabilistic causes (instead of having a deterministic option), where the abnormal cause had a 25% probability of working or failing.

Method

Participants The final sample included 32 children (eight 5-year-olds, thirteen 6-year-olds, eleven 7-year-olds) recruited through in-lab appointments or museums ($M_{age} = 6.63$ [5.04; 7.88 years], $SD_{age} = 0.87$, 17 females) and 55 adults recruited through Prolific ($M_{age} = 39.85$ [19; 72 years], $SD_{age} = 15.43$, 28 females, 24 males, 3 non-binary). Four children were excluded for failing attention checks ($n = 3$) or parent interference ($n = 1$). Sixteen adults were excluded for taking longer than 1.5 SDs above average to complete the task ($n = 7$) or failing attention check questions ($n = 9$). All participants were English speakers based in the United States, and were compensated as in Experiment 1.

Design & Procedure Experiment 2 followed a similar design and procedure as Experiment 1, except that in the test trials, we used pairs composed of a 75% star (3/4 times) and a 25% star (1/4 times), instead of the 50% star paired with the 100% or 0% stars. This allowed us to test the outcome achieved (music) and omitted (no music) conditions using the same pairs of objects, and ruling out any preference for deterministic stars.

When both stars spun and music played, the 75% star was normal (i.e., more expected to spin) and the 25% star was abnormal (i.e., less expected to spin). When the outcome failed to occur, neither star spun and no music played, the 75% star was abnormal (i.e., less expected to fail), and the 25% star was normal (i.e., more expected to fail).

Results & Discussion

Results of Experiment 2 were similar to Experiment 1 (Figure 2B). Again, adults' causal selections differed by causal structure (conjunctive vs. disjunctive), $\beta = 2.55$, $SE = 0.69$, $z = 3.68$, $p < .001$; but not by outcome (music vs. no music), $\beta = 0.66$, $SE = 0.67$, $z = 0.99$, $p = .324$. Binomial tests showed

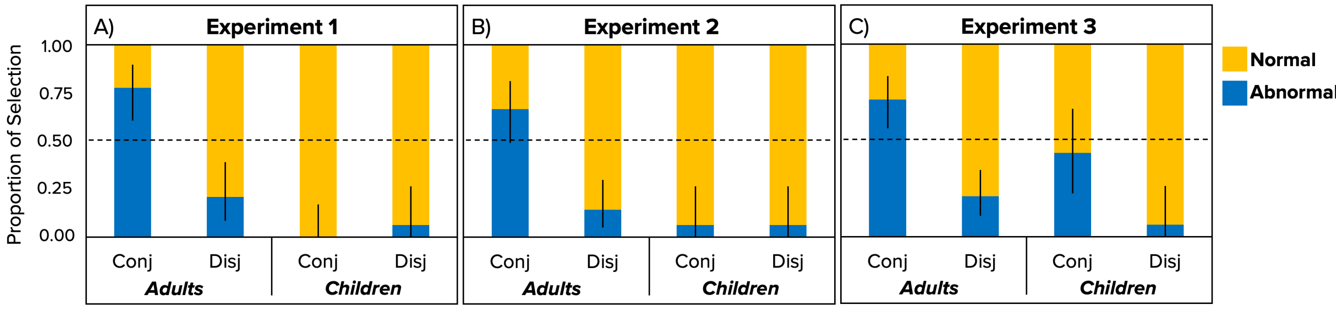

Figure 2: Proportion of selecting the normal or the abnormal cause across all experiments, according to causal structure. The dashed line marks the chance-level at 0.50. The error bars indicate 95% confidence intervals. "Conj" = conjunctive, "Disj" = disjunctive.

that in conjunctive structures, adults did not select the *abnormal cause* more often than chance, but trended in the predicted direction, 67%, $p = .061$, *95% CI:* [49%, 100%]. In disjunctive structures, adults selected the *normal cause* more often than chance, 86%, $p < .001$, *95% CI:* [70%, 100%].

Again, the overwhelming majority of children (30 of 32) selected the *normal cause*, regardless of causal structure or outcome, with no differences across conditions (*p*s > .1). Similar to Experiment 1, 16 of 36 children initially answered the question saying, "Both," before being prompted to select just one.

These results demonstrate that children's tendency to select the normal cause is unlikely to be due to a preference for the deterministic cause. Another possibility may be that children in Experiments 1 and 2 matched the efficacies of causes to the outcomes. That is, when the outcome occurred, children selected the object that functioned most of the time (100% or 75% stars). Similarly, when the outcome failed to occur, children selected the object that malfunctioned most of the time (0% or 25% stars). Indeed, *correspondence* theories posit that people are more likely to select the abnormal cause when the effect is abnormal (i.e., exceptional events cause exceptional outcomes), and the normal cause when the effect is normal (Gavanski & Wells, 1989; Harinen, 2017). It is therefore plausible that children used a similar, but simpler heuristic that led them to select normal causes.

The results of Experiments 1 and 2 are consistent with the idea that sociomoral concerns underlie the emergence of biased causal judgments (Samland et al., 2016; Samland & Waldmann, 2016). However, as noted in the introduction, other accounts posit that counterfactual alternatives play an important role in inflating the strength of the abnormal cause in conjunctive structures (e.g., Icard et al., 2017; Quillien & Lucas, 2023). If children failed to consider the relevant counterfactual in these tasks, they may have defaulted to matching causes with effects, leading to the overwhelming tendency to select the normal cause.

In Experiment 3, we test the hypothesis that children's ability to simulate relevant counterfactual alternatives may depend on their capacity to represent the underlying *causal mechanism* (e.g., Keil, 2022; Kelemen, 2019). To do this, we exchanged the blicket detector paradigm used in previous experiments—which provides no explicit mechanistic. information—for an analogous task with a transparent causal mechanism that is more likely to recruit children's intuitive understanding of physics. Given that Experiment 2 ruled out a preference for deterministic causes, Experiment 3 only included causes with 100%, 50%, and 0% probabilities.

Experiment 3

Experiment 3 had a "billiard balls" paradigm, designed to be conceptually analogous to the blicket detector task (Figure 1), and akin to prior adult work examining normality influences on causal selection (Henne et al., 2021; Gerstenberg & Icard, 2020; Kirfel et al., 2022). Similar paradigms have been used in the past to test causal and counterfactual reasoning in preschoolers (e.g., Kominsky et al., 2021; Ozdemir et al., 2023). This task employed collision events, where the processes and the mechanism of causation were visible and easily understandable. We test whether these features aid children's simulation of relevant counterfactuals, leading to an adult-like bias.

Method

Participants The final sample included 32 children (ten 5-year-olds, twelve 6-year-olds, ten 7-year-olds) recruited through in-lab appointments or museums (M_{age} = 6.52 [5.18; 7.92 years], SD_{age} = 0.80, 16 females) and 73 adults recruited through Prolific (M_{age} = 39.18 [18; 73 years], SD_{age} = 14.69, 40 females, 30 males, 3 non-binary). Two children were excluded for failing attention check questions ($n = 1$), or experimenter error ($n = 1$). Eleven adults were excluded for taking longer than 1.5 SDs above average to complete the task ($n = 4$) or failing attention check questions ($n = 7$). All participants were English speakers based in the United States, and were compensated as in Experiment 1.

Design & Procedure Experiment 3 paralleled Experiment 1, except that the spinning stars were replaced with "fans" that could push the balls placed in front of them (Figure 1B). Fans and gray balls were presented on one end of a soccer field with a red ball placed far from the goal (blue zone), or close to the goal (yellow zone). These compositions reflected a causal structure that is analogous to the big and the small music boxes used in the previous experiments.

During the test trial, participants saw one of two outcomes. In the *goal* outcome, both the 100% and the 50% fan worked, pushing the gray balls to hit the red ball, making a goal. In the *no goal* outcome, neither the 0% or the 50% fan worked, and no goal occurred. The 100% and the 0% fans were normal, and the 50% fan was abnormal. Then, participants were asked to explain the outcome. Children were asked, "Why did a goal [not] happen? Was it because this fan worked [did not work]? Was it because this fan worked [did not work]?" (pointing to each fan, in turn). Adults were asked to choose between two statements that better described the outcome: "A goal happened [did not happen] because the fan on the top/bottom pushed [did not push] its ball."

Results & Discussion

Figure 2C shows participants' selections. As in previous experiments, adults' causal selections differed by causal structure (conjunctive vs. disjunctive), $\beta = 2.34$, $SE = 0.57$, $z = 4.09$, $p < .001$; but not by outcome (goal vs. no goal), $\beta = 0.45$, $SE = 0.57$, $z = 0.79$, $p = .426$. In conjunctive structures, adults selected the *abnormal cause* more often than chance, 71%, $p = .008$, *95% CI:* [56%, 100%]. In disjunctive structures, adults selected the *normal cause* more often than chance, 79%, $p < .001$, *95% CI:* [65%, 100%].

Critically, in contrast to Experiments 1 and 2, children in this experiment showed the hypothesized asymmetry in their explanations. Like adults, children's selections also differed by causal structure (conjunctive vs. disjunctive), $\beta = 2.52$, $SE = 1.16$, $z = 2.16$, $p = .031$; but not by outcome (goal vs. no goal), $\beta = 0.84$, $SE = 0.93$, $z = 0.89$, $p = .370$. In conjunctive structures, children's selections did not differ from chance, 43% abnormal selection, $p = .773$, *95% CI:* [23%, 100%]. In disjunctive structures, children selected the *normal cause* more than chance, 94%, $p < .001$, *95% CI:* [73%, 100%]. There were no differences between ages (ps > .1). Similar to the previous experiments, 20 of 36 children initially answered the question saying "Both," before being prompted to select one.

Although children tended to select the normal cause overall, these findings show that children *can* select the statistically abnormal cause in a manner that is similar to adults, in conditions that have no agents, morality, or prescriptive rules.

General Discussion

In Experiments 1 and 2, using a blicket detector task, we found that 5- to 7-year-old children defaulted to privilege the normal cause, whereas adults' explanations were sensitive to differences in causal structure. Children's tendency to privilege the normal cause across experiments might relate to our operationalization of statistical normality in terms of more or less "broken" objects (see *norms of proper functioning*, e.g., Gill et al., 2022). In line with correspondence accounts (e.g., Harinen, 2017), children may have matched "less broken" objects with achieved outcomes, and "more broken" objects with omitted outcomes, leading them to select these normal causes more frequently. Furthermore, the difference in causal selection between children and adults might be related to differences in causal priors, where young children have been shown to be more adept than adults at inferring conjunctive hypotheses from evidence (e.g., Gopnik et al., 2017; Lucas et al., 2014). Future research should investigate whether these differences might underlie the developmental differences we report.

In Experiment 3, using a billiard balls task, we found that children showed the same asymmetrical bias as adults, with more children selecting the abnormal cause in conjunctive structures. This provides evidence that children's causal judgments are *not* fully explained by sociomoral reasoning. Instead, when observing events with a visible causal mechanism, children are able to integrate information about statistical normality and causal structure.

In line with counterfactual accounts of the normality bias in adults (e.g., Icard et al., 2017; Quillien & Lucas, 2023), children's judgments may have been facilitated by their ability to simulate alternative outcomes. We hypothesize that—by providing mechanistic information—the paradigm used in Experiment 3 may have supported this nascent ability. Knowledge about mechanisms has long been argued to play a critical role in both children's and adults' causal reasoning (e.g., Johnson & Ahn, 2017; Keil, 2022; Shultz, 1982; Walsh & Sloman, 2011). However, additional work is necessary to assess whether and how this information supports early counterfactual reasoning.

Relatedly, recent computational models of causal judgments posit an important role for intuitive theories in counterfactual simulation (Gerstenberg et al., 2021; Gerstenberg, 2024). It is possible, therefore, that the billiard balls task used in Experiment 3 supported children's use of an internal "physics engine" to simulate causal outcomes (Battaglia et al., 2013). Again, additional work is needed to pull these potential explanations apart.

Finally, given that over half of the children across studies spontaneously attributed the outcome to "both" causes instead of selecting one, our forced-choice design may have not fully captured children's reasoning in these tasks. Importantly, however, children were equally likely to provide this response across conditions, and there was no difference in final responses between children who did or did not first respond "both" (ps > .1). This implies that initially ignoring the forced-choice might not be relevant for children's final causal selection. Additionally, given that adults' responses in the current tasks were consistent with prior work using causal ratings, acknowledging both causes might be unlikely to impact the bias.

In conclusion, building on previous philosophical, psychological, and computational work examining how our expectations of normality influence causality, the present study is an initial step toward uncovering how our tendencies in causal selection emerge, emphasizing the role of intuition and mechanism in children's developing understanding of the causal world.

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