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Children affirm the possibility of improbable events when they are similar to a known event

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Abstract

Children often judge that strange and improbable events are impossible, whereas adults usually accept the possibility of such events. This shows that children's reasoning about possibility is immature, but it remains unclear how children reason about the possibility of improbable events. We explore whether children use a novel event's similarity to a known event to infer whether the event can happen. We told 4- to 6-year-olds (N=120) either ordinary or improbable facts and then asked if a related improbable event was also possible. The facts contained no causal information that could be extended to the occurrence of a similar event. Children who heard improbable facts more often agreed that similar improbable events were possible than children who heard ordinary facts. This suggests that the mere knowledge that an event can happen influences children's beliefs about the possibility of other unfamiliar-but-similar events.

Keywords: possibility; causality; improbable events; availability heuristic; conceptual development

Introduction

Understanding what is possible is an important ability. It allows us to anticipate events, plan our behavior, and structure our lives. People would not install smoke detectors if they viewed a fire in their house as an impossibility, and would not plan trips to overseas countries if they knew of no way to get there. Mistaken possibility judgments can be costly. Mistakenly believing that impossible events can occur can lead people to waste resources on goals that can never be realized (e.g., perpetual motion) and to place their hopes in interventions that can never be realized (e.g., homeopathy). But mistakenly concluding that possible outcomes could never happen also has problems. For example, it could lead people to give up on looking for inventions and solutions that are potentially within reach.

We can easily dismiss certain events as *impossible* by referencing our principled knowledge of how the world works. For instance, there are certain physical and biological laws that we intuitively know to be inviolable; solid objects cannot float in the air, and animals of one species cannot give birth to offspring of a different species. Even preschoolers acknowledge that these things are impossible (Sobel, 2004), and believe that magic would be required to bring about events that violate their basic physical and biological

intuitions (Johnson & Harris, 1994; Rosengren & Hickling, 1994; Rosengren, Kalish, Hickling, & Gelman, 1994).

But young children's understanding of possibility is far from mature, as they often dismiss the possibility of events that *can* happen. Drinking onion juice and painting polka dots on a plane are strange and unfamiliar events, but their occurrence does not violate any real or intuitive causal principles. Yet young children often judge these events to be almost as impossible as walking through a brick wall or travelling back in time (Shtulman & Carey, 2007). Children become more likely with age to accept the possibility of unfamiliar events, but it is only in adulthood that people generally accept such events as possible.

This early skepticism towards the possibility of unfamiliar events has been demonstrated across a variety of events and study designs (Bowman-Smith, Shtulman, & Friedman, 2019; Cook & Sobel, 2011; Goulding & Friedman, in press; Lane, Ronfard, & El-Sherif, 2018; Lane, Ronfard, Francioli, & Harris, 2016; Nancekivell & Friedman, 2017; Nolan-Reyes, Callanan, & Haigh, 2016; Shtulman, 2009; Shtulman & Phillips, 2018; Weisberg & Sobel, 2012). Children's skepticism towards these unfamiliar events is also reminiscent of findings showing that they often appear to view social norms and conventions as laws that cannot be changed (e.g., Browne & Woolley, 2004; Chernyak, Kushnir, Sullivan, & Wang, 2013; Kalish, 1998; Komatsu & Galotti, 1986; Levy, Taylor, & Gelman, 1995; Lockhart, Abrahams, & Osherson, 1977; Miller, Custer, & Nassau, 2000). Both lines of work reveal that young children are remarkably hesitant to endorse the possibility that people can engage in uncommon or unorthodox behaviours.

Children's skepticism that improbable events can happen has also proven quite robust to manipulation. Children persist in denying that improbable events can happen after they provide realistic-sounding explanations for how the events could happen (Nancekivell & Friedman, 2017), and even after they are explicitly told that events can happen (Lane et al., 2018). Likewise, although children are somewhat less likely to deny the possibility that improbable events can happen when they consider the events happening in a distant location, this manipulation does not lead children to affirm these events can happen at chance rates (Bowman-Smith et al., 2019).

Why do young children deny the possibility of improbable events? Here we outline two alternative accounts for this puzzling phenomenon—one claims that children’s possibility denials stem from the causal-historical reasoning, while the other claims it stems from a memory-based heuristic. We then present an experiment that provides preliminary support for the second account.

The Causal-Historical Account

One potential explanation is that this phenomenon stems from limits in children’s ability to infer or reflect on how certain outcomes might arise. When asked about whether an event or outcome is possible, children might attempt to consider the circumstances that would allow it to occur (Shtulman & Carey, 2007). Further, if they fail to think of an appropriate set of circumstances, this may lead them to deny that the event can happen. For instance, children may dismiss the possibility of drinking onion juice simply because they are unable to imagine *how* it could be made or obtained.

On this view, children do not reason about possibility by using general knowledge of real-world principles, but instead rely on more specific knowledge of how each event could happen. However, some findings call this account into question. As mentioned above, when children are asked to generate their own explanations for improbable and impossible events, they often provide realistic explanations but still deny the events are possible (Nancekivell & Friedman, 2017; Woolley & Cornelius, 2017). So, it is unlikely that children rely exclusively on this sort of circumstantial reasoning to determine whether unfamiliar events can happen.

The Memory-Based Similarity Account




An alternative explanation for children’s reluctance to endorse the possibility of unfamiliar events is that children use the familiarity of an event to determine whether it is possible. It is perhaps obvious how this account would apply to an event that is entirely familiar to a child: if they have

encountered it, it can happen. However, children may also use familiarity to infer the possibility of an *unfamiliar* event by determining whether it is sufficiently *similar* to a familiar event (Woolley & Ghossainy, 2013). For instance, adults may infer that a person could drink onion juice because they know of people who have consumed other strange concoctions like kale or pickle juice—and they may make this inference in the absence of any causal knowledge about *how* such a beverage is prepared. And young children may deny that this same event is possible because they have yet to encounter or hear of people drinking strange beverages. On this view, people may rely on a strategy akin to an availability heuristic to decide whether an event can occur (Bowman-Smith, Shtulman, & Friedman, 2019; Tversky & Kahneman, 1973). If an event is sufficiently familiar to a known event, it is deemed possible; if it is dissimilar, it is not.

This similarity account may explain why children view improbable events as more possible in distant countries than at home (e.g., having a pet zebra), as they may know that distant countries engage in similar practices that are strange and largely unfamiliar to them (e.g., having a pet camel, from the perspective of a Canadian child; Bowman-Smith et al., 2019). It may also explain why children view more events as possible in dreams and stories, as they know that these fictional worlds are often filled with similarly strange and even impossible events (Goulding & Friedman, in press). Further, Shtulman (2009) found that children became more likely with age to both encounter improbable events and to judge them as possible, which supports the suggestion that mere exposure to strange events can lead children to judge that other strange events can happen. However, this similarity account has not been directly tested.

The Current Experiment

Here we explore whether children consider an unfamiliar event’s similarity to a familiar event when inferring whether an unfamiliar event is possible. If children judge possibility by relying on an availability heuristic that searches for

| | | |
|--|--|---|
|  |  | <ol style="list-style-type: none"> 1) pet [elephant/dog] 2) drink [broccoli/orange] juice 3) wear [pajamas/suit] to work 4) have [striped/white] plane 5) eat [pickle/strawberry] popsicle 6) have [shoe-/square-] shaped house |
| <p><i>“Here’s a person, and they have a pet [elephant/dog]. See? This [elephant/dog] is actually their pet!”</i></p> | | |
|  | | <ol style="list-style-type: none"> 1) pet zebra 2) drink cauliflower juice 3) wear costume to work 4) have polka dot plane 5) eat onion popsicle 6) have mug-shaped house |
| <p><i>“So, could a person also have a pet zebra?”</i></p> | | |

instances of similar events, they may often agree that unfamiliar-but-similar events are possible. However, if children primarily infer possibility by using principled or circumstantial knowledge, then merely knowing *that* a similar event happened—but not *how* it happened—should have little influence on whether an event is judged possible.

To this end, we conducted an experiment, where children aged four to six years were questioned about whether a variety of improbable events can happen. Before asking children about each event, we first told them about a related event which was itself either improbable or ordinary. For example, children were asked whether a person could have a pet zebra, either after being told about a person who has a pet elephant or after being told about a person who has a pet dog. The similarity account predicts that telling children about the related improbable event should make them more likely to affirm the target event can happen. Crucially, this prediction does not follow from the claim that children judge whether events are possible by asking how they could arise. Telling children that a person can have a pet elephant informs them about an event similar to having a pet zebra. But it does not tell children about the circumstances that would cause either event to transpire.

Methods

Participants

We tested 120 4- to 6-year-olds: 40 4-year-olds ($M_{\text{age}} = 4;5$ [years;months], range = 4;0 to 4;11), 40 5-year-olds ($M_{\text{age}} = 5;6$, range = 5;0-5;11), and 40 6-year-olds ($M_{\text{age}} = 6;6$, range = 6;0 to 6;11). At each age-in-years, we randomly assigned 20 children to each between-subjects condition. All children were seen individually, and tested in a quiet area of their school.

Materials and Procedure

Children were shown photos on a laptop, with accompanying narrations from the experimenter; see Figure 1 for an illustration of the procedure. Children completed six trials. In each trial, they heard facts about people and were shown a photo demonstrating that the fact was true. Children completed the trials in one of two between-subjects conditions. In one condition the facts were improbable, and in the other condition they were ordinary. After hearing each fact, children were asked if a related improbable event was also possible. For example, children were either shown and told that a person could have a pet elephant (improbable) or dog (ordinary) and then asked, “So, could a person also have a pet zebra?”

The similarity account predicts that children who hear improbable facts will judge more improbable events to be possible than children who hear ordinary facts, as the mere possibility of each improbable event may suggest that a similar improbable event is also possible. Conversely, a causal reasoning account does not predict obvious differences in children’s judgements after hearing improbable or ordinary facts, as neither fact-type includes

causal knowledge that children can potentially extend to the occurrence of the improbable events.

Results

We analyzed the data using a generalized estimating equations models (binary logistic) with independent covariance matrices. The analysis was performed using “geepack” for R (Halekoh, Højsgaard, & Yan, 2006). We entered fact-type (improbable, ordinary) and age-in-months (mean-centered and entered as a covariate) as predictors of children’s judgements about whether improbable events were possible.

The model revealed a main effect of fact-type, Wald $\chi^2(1) = 9.59$, $p = .002$, and a main effect of age, Wald $\chi^2(1) = 13.65$, $p = .002$, but these effects were qualified by an interaction, Wald $\chi^2(1) = 6.43$, $p = .011$.

We explored this interaction by analyzing the effect of age separately for each fact-type. At all ages, children made similar judgements about whether improbable events were possible after hearing improbable facts, Wald $\chi^2(1) = 0.01$, $p = .931$, but were less likely with age to agree that improbable events were possible after hearing ordinary facts, Wald $\chi^2(1) = 13.65$, $p < .001$. As seen in Figure 2, younger children often agreed that improbable things could happen after hearing any type of fact. Older children often agreed that improbable things could happen after hearing improbable facts, but often denied that they could happen after hearing ordinary facts.

We further characterized our results with single-sample tests against chance for each age group (4, 5, 6). At age 4, children mostly agreed that improbable events could happen after hearing any fact, $ps = .003$. At ages 5 and 6, children mostly agreed that improbable events could happen after hearing improbable facts, $ps \leq .003$, and mostly denied that improbable events could happen after hearing ordinary facts, $ps \leq .016$.

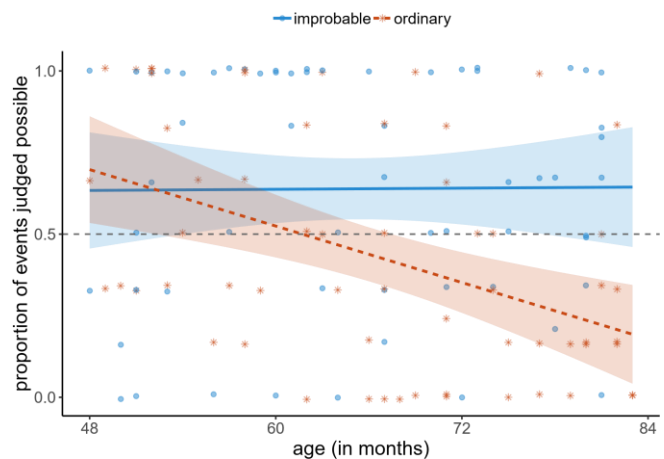


Figure 2: Scatterplot showing proportion of improbable events judged possible by each child as a function of their age in months. Bands show 95% confidence intervals. Points are jittered slightly to decrease overplotting.

Discussion

We found that children judged more improbable events as possible when they heard a similar strange fact than when they heard a related, but dissimilar, ordinary fact. This difference was subject to an interaction with age. Although the effect of fact-type was not apparent in 4-year-olds, it was in older children aged five and six. We first describe the relation of these findings to other work in this area, and then discuss its theoretical implications.

Relation to Previous Work

To our knowledge, these results are the first to reveal a manipulation leading young children to affirm that improbable events can happen in real life. As reviewed in the Introduction, several recent experiments investigated other manipulations, and some attenuated children's denials to a degree. For instance, one paper found that children were less likely to deny that these events could happen in another country (Bowman-Smith et al., 2019) and another found that denials were less likely after children were explicitly told that the events could happen (Lane et al., 2018). However, these manipulations did not shift children from denying that some improbable could happen to affirming this.

The finding that merely telling children about *similar* improbable circumstances had this effect may be surprising given recent findings suggesting that children do not affirm the events even after receiving testimony that those very events are possible (Lane et al., 2018). Further research will be needed to follow up on this surprising pattern. For now, one explanation is that affirming a fact and then immediately asking children about whether it is true could lead children to doubt that the experimenter themselves believed it. At the same time it is important to acknowledge that, as was done with other studies investigating manipulations that could lead children to acknowledge that improbable events can happen, it will be important to test whether our manipulation would lead children to affirm that totally impossible events can happen. If the manipulation had this effect, it would raise the possibility that the experimental design made children feel pressured to affirm that unusual events can happen, perhaps by making children feel like they were playing a sort of call-and-response game in which the experimenter says a strange thing and they respond in kind.

Surprisingly, we found that 4-year-olds were likely to affirm that improbable events could happen after hearing both improbable and ordinary facts. Further, children who heard ordinary facts were less likely with age to affirm the possibility of improbable events, whereas children who heard improbable facts often affirmed that improbable events could happen at all ages. This may give the impression that the inverse of our favored interpretation is true, such that hearing ordinary facts manipulated 5- and 6-year-olds into *denying* that improbable events could happen. However, children have been continually shown to deny the possibility of these kinds of events when no manipulation is administered (e.g., Shtulman, 2009; Lane et al., 2016), and manipulations designed to reduce their skepticism often fail or produce

weak effects (e.g., Bowman-Smith et al., 2019; Lane et al., 2018). We therefore think it unlikely that the ordinary facts did most of the work here, though more must be done to understand why 4-year-olds in this experimental paradigm so often agreed that improbable events could happen.

Theoretical Implications

Although further work is needed, our findings provide insight into how children reason about what is possible. Previous work has shown that children often deny that strange and improbable events can happen, but the source of their denial has remained unclear (Lane, Ronfard, Francioli, & Harris, 2016; Nolan-Reyes, Callanan, & Haigh, 2016; Shtulman & Carey, 2007; Shtulman & Phillips, 2018). One proposed explanation is that the improbable events in question are often too dissimilar from children's own experiences, and that they might be more willing to endorse the possibility of unlikely events that are similar to events they know (Woolley & Ghossainy, 2013). Our experiments served as the first direct test of this similarity account.

We manipulated children's knowledge by showing them depictions of improbable events and informing them that the events really happened, and found that this knowledge made them likely to judge that similar improbable events can also happen. This suggests that children may reason about possibility by using an availability heuristic that calls to mind occurrences of either the target improbable event or a similar event (Bowman-Smith et al., 2019; Tversky & Kahneman, 1973). The findings suggest that children will judge an event possible if they can recall another event that is sufficiently similar to it. However, whether children spontaneously search their memories for similar events when inferring possibility remains an open question.

It will also be important to discover how children determine whether an event is *sufficiently* similar to a target event. The fact and event pairings used here were designed to be thematically similar; for instance, elephants and zebras were paired because they are both large exotic animals that are not dangerous predators, and so perhaps pose similar barriers to being pets. But there are many respects in which two events can be construed as similar beyond general thematic relation (see Medin, Goldstone, & Gentner, 1993). Indeed, the mere improbability of one event may suggest that improbable outcomes are generally possible within the same context, despite the outcomes bearing little resemblance to each other beyond their unlikelihood. For instance, children who heard that a person could have a pet elephant might also agree that a person could have a pet jellyfish. Future work should explore how children decide whether two events are similar when inferring possibility, and how far this similarity heuristic extends.

Importantly, we did not provide children with information about the circumstances or causal principles that would have allowed any of the improbable or ordinary events to occur. Children therefore had no new causal information to deploy when inferring the possibility of the target impossible events. Yet children still inferred that more improbable events could

happen after merely hearing and seeing that a similar improbable event was possible. These findings contrast sharply with the suggestion that children infer possibility by identifying circumstances that would allow an event to occur (Shtulman, 2009; Shtulman & Carey, 2007). On this view, knowledge that an improbable event *can* happen should have little influence on children's beliefs about possibility in the absence of further information about *how* the event could have arisen. While our findings do not address this account as a strategy for inferring possibility, they nevertheless show that children's beliefs about possibility are not fully tied to their knowledge of how events can occur.

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