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A similarity heuristic in children's possibility judgments

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Abstract

Children often judge that strange and improbable events are impossible, but the mechanisms behind their reasoning remain unclear. This paper ($N = 250$) provides evidence that young children use a similarity heuristic that compares potential events to similar known events to determine whether events are possible. Experiment 1 shows that 5-6-year-olds who hear about improbable events go on to judge that similar improbable events can happen. Experiment 2 shows that 5-6-year-olds more often affirm that improbable events can happen if told about related improbable events than if told about unrelated ones. Finally, Experiment 3 shows that 5-6-year-olds affirm the possibility of improbable events related to known events, but deny that related impossible events can happen.

Keywords: possibility; availability heuristic; extraordinary events

A similarity heuristic in children's possibility judgments

“How many things have been denied one day, only to become realities the next!”

—Jules Verne, *From the Earth to the Moon*

At the turn of the 20th century, a group of French artists produced a series of postcards depicting a vision of what France might look like in the year 2000 (Côté et al., 1910). Their optimistic predictions included flying firemen equipped with wings, a robotic barber, and a long-distance communication device that would allow people to see projections of each other. Almost all of their predictions rested on the advent of technologies that did not yet exist. Yet a cursory glance at the postcards reveals their predictions were fairly limited in scope, and clearly guided by new and familiar technologies like gliders, electricity, and the telephone. The artists likely felt that since these strange and wonderful technologies had recently fallen into the realm of possibility, perhaps similar strange and wonderful things were possible, too.

Here we explore whether a similar intuition drives 4- to 6-year-old's beliefs about what is possible. Specifically, we test whether their knowledge of what *has* happened guides their inferences about what *can* happen, and does so even when the circumstances that would enable events remain mysterious or unclear. This investigation will help us understand the puzzling yet robust finding that children often deny the possibility of improbable events. Drinking onion juice and painting polka dots on a plane are strange and uncommon acts, but they are possible nonetheless. Yet in contrast with adults, 4- to 8-year-olds often judge these events to be almost as impossible as walking through a brick wall or travelling back in time (Shtulman & Carey, 2007). This early skepticism towards the possibility of improbable events has been demonstrated across a variety of events and study designs (e.g., Lane, Ronfard, Francioli, & Harris, 2016; Nolan-Reyes, Callanan, & Haigh, 2016; Shtulman & Phillips, 2018).

The similarity heuristic in children's judgements of possibility

One way that children may judge whether events are possible is by using a similarity heuristic. When hearing about an event or outcome, children may search their memory for instances of similar events. If this memory search is successful, children conclude the event can happen. But if the search returns no events similar enough to the target event, children may deny that the event is possible. For ordinary events and circumstances, similar events should be easy to find. For instance, a child who has seen brick houses may also agree that a person could build a house out of stones—even if they have never seen or heard about a stone house—simply because both events are similar enough that the possibility of one suggests the possibility of the other. For improbable events, recalling similar events will be more difficult. After all, improbable events are, by nature, exceedingly rare. So, children may deny the possibility of drinking onion juice and painting polka dots on a plane because they cannot recall sufficiently similar events.

The similarity heuristic can be viewed as a variant of the availability heuristic (Tversky & Kahneman, 1973) for inferring whether events can occur (Bowman-Smith, Shtulman, & Friedman, 2018). It is also consistent with suggestions that familiarity underlies children's possibility judgments, though this has not been directly investigated (Shtulman & Carey, 2007; Shtulman, 2009; Woolley & Ghossainy, 2013).

An important feature of the similarity heuristic is that it allows children to judge whether an event is possible without ever considering the circumstances that would enable or prevent its occurrence. This contrasts with the assertion that children judge an event to be possible only if they can identify circumstances that would allow it to occur (Shtulman & Carey, 2007). For instance, children may dismiss the possibility of drinking onion juice simply because they are

unable to imagine *how* such a juice could be made. However, when 5- to 9-year-olds are asked to generate their own explanations for extraordinary events, they often provide realistic explanations while still denying that 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 improbable events can happen.

We are not suggesting, though, that children do not use any sort of causal reasoning when inferring possibility. Indeed, children consistently reject the possibility of truly impossible events (Cook & Sobel, 2011; Lane, Ronfard, & El-Sherif, 2018; Shtulman, 2009), likely because these events violate either learned or intuitive principles that guide children's real-world beliefs. For instance, from age 4 children know that solid objects cannot float in the air, and animals of one species cannot give birth to offspring of a different species. They use knowledge of these principles to conclude that specific events are impossible (Schult & Wellman, 1997; Sobel, 2004), and believe that magic would be required to bring about events that violate these principles (Johnson & Harris, 1994; Phelps & Woolley, 1994; Rosengren & Hickling, 1994; Rosengren, Kalish, Hickling, & Gelman, 1994). We should therefore expect children to reject the possibility of impossible events, even if they can recall superficially similar events.

We investigated the similarity heuristic across three experiments. Experiment 1 compares 4-6-year-olds' possibility judgements for improbable events after hearing improbable or ordinary facts that are related to the test events. Experiment 2 compares 5-6-year-olds' possibility judgements for improbable events after hearing improbable facts that are related or unrelated to the test events. Finally, Experiment 3 compares 5- 6-year-olds' possibility judgements for both improbable and impossible events after hearing improbable facts that are related to the test events.

Experiment 1

Method

Participants. We tested 120 4- to 6-year-olds ($M = 5;6$ [years;months], range = 4;0-6;11, 62 girls). In this experiment and the next one, we aimed to test 20 children per age-in-years per between-subjects condition, and randomly assigned equal numbers of children at age-each-in-years to each condition. We determined this sample size as it has sufficed to reveal significant effects in past work in this area of research (e.g., Bowman-Smith et al., 2018; Lane et al., 2018).

Children were recruited and individually tested at childcare centers and elementary schools. Demographics were not formally collected, but most children were from middle-class families in the region of Waterloo (Ontario, Canada). Approximately 85% of residents in this region are Caucasian, and the largest visible minority groups are of Chinese and South Asian descent. All studies received approval from the Office of Research Ethics at the University of Waterloo.

Materials and procedure. In all experiments, children were shown photos on a laptop computer, with accompanying narrations from the experimenter; see Figure 1 for an illustration of the full procedure for each experiment. 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?”

	facts	events
Exp 1	<p>Here's a person, and they have a pet [elephant/dog]. See? This [elephant/dog] is actually their pet!</p> <p>drink [broccoli / orange] juice wear [pajamas / suit] to work have [striped / white] plane eat [pickle- / strawberry-] flavored popsicle have [shoe- / square-] shaped house</p>	<p>So, could a person also have a pet zebra?</p> <p>drink cauliflower juice wear costume to work have polka dot plane eat onion-flavored popsicle have mug-shaped house</p>
Exp 2	<p>Here's a person, and they have a pet elephant. See? This elephant is actually their pet!</p> <p>drink broccoli juice wear pajamas to work have striped plane eat pickle-flavored popsicle have shoe-shaped house</p>	<p>So, could a person also have a [pet zebra/polka dot plane?]</p> <p>[drink cauliflower juice/eat onion-flavored popsicle] [wear costume to work/have mug-shaped house] [have polka dot plane/have pet zebra] [eat onion-flavored popsicle/drink cauliflower juice] [have mug-shaped house/wear costume to work]</p>
Exp 3	<p>Here's a person, and they have a pet elephant. See? This elephant is actually their pet! So now I have some questions for you.</p> <p>drink broccoli juice wear pajamas to work have striped plane</p>	<p>Could a person also have a pet zebra? Could a person also have a pet unicorn?</p> <p>drink cauliflower juice & drink lightning juice wear costume to work & wear cloud to work have polka dot plane & have invisible plane</p>

Figure 1. Sample stimuli and scripts for all experiments, as well as a full list of the facts and events used in each. The full set of stimuli can be viewed [here](#). Children in Experiments 1 and 2 saw a photo related to each test question, whereas children in Experiment 3 saw only a blank screen at test. Trials were administered in the order listed, or in the reverse order. For Experiment 3, improbable (i) and impossible (I) events were asked about in two orders: iIiI and IiIi.

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 the improbable facts may suggest that similar improbable events are also possible.

Results

In all experiments, the main confirmatory analyses used generalized estimating equations models (binary logistic) with independent covariance matrices performed using “geepack” for R (Halekoh, Højsgaard, & Yan, 2006); any post-hoc pairwise comparisons were performed using the “emmeans” package for R (Lenth, Singmann, Love, Buerkner, & Herve, 2019). Although we did not pre-register the analyses, we used the same analytic approach we have taken in other recent papers using similar designs (e.g., Goulding & Friedman, 2020; Thorburn et al., 2020). The data for all experiments can be found [here](#).

We entered fact-type (improbable, ordinary) and age-in-months (mean-centered) as predictors of children’s judgements about whether improbable events were possible; see Figure 2. We found a main effect of fact-type, Wald $\chi^2(1) = 9.59, p = .002$, and a main effect of age, Wald $\chi^2(1) = 13.65, p < .001$, but these effects were qualified by an interaction, Wald $\chi^2(1) = 6.43, p = .011$. This interaction resulted because although affirmations of improbable events did not vary with age for children who heard about improbable facts, Wald $\chi^2(1) = 0.01, p = .931$, they declined with age for children who heard about ordinary facts, Wald $\chi^2(1) = 13.65, p < .001$. Also, both 5- and 6-year-olds more often agreed that improbable events could happen after hearing improbable facts than after hearing ordinary facts, Wald $\chi^2(1) = 4.78, p = .029$ and Wald $\chi^2(1) = 12.30, p < .001$, but this effect was absent for 4-year-olds, Wald $\chi^2(1) = 0.00, p = 1.000$.

Figure 2. Scatterplots with trendlines showing the proportion of improbable events judged possible by each child as a function of their age in months in Experiment 1. Children heard either improbable or ordinary facts before judging each event. The left panel shows the full data; the right panel shows the data with children 4.5-years and younger removed. Bands show 95% confidence intervals. Points are jittered slightly to decrease overplotting.

We also examined whether responses within each age group differed from chance. At each age, children mostly agreed that events could happen after hearing improbable facts, $p_s \leq .003$. At age 4, children also mostly agreed that events could happen after hearing ordinary facts, $p = .003$. However, 5- and 6-year-olds mostly denied that events could happen after hearing ordinary facts, $p_s \leq .016$.

We were surprised that 4-year-olds who heard about ordinary facts mostly went on to affirm the possibility of improbable events, as previous studies have generally found that 4-year-olds deny these events can happen (Lane et al., 2018; Shtulman & Carey, 2007, Experiments 1-3; Weisberg & Sobel, 2012). This said, there is some uncertainty about how 4-year-olds view

improbable events. Most studies have not reported 4-year-olds' results separately from those of older children (e.g., Lane et al., 2016; Lane et al., 2018; Shtulman, 2009; Shtulman & Philips, 2018) and some findings suggest these children may sometimes affirm that improbable events can happen (i.e., Shtulman & Carey, 2007, Experiment 4; Shtulman & Philips, 2018).

We therefore conducted further exploratory analyses to better understand these findings; these analyses are reported in the Supporting Information. These analyses revealed that the fact-type x age interaction, as well as the high rate of agreement among 4-year-olds, was driven entirely by children aged 4-and-a-half and younger; this effect can be seen by comparing the trendlines in Figure 2. This youngest age-group exhibited a reverse pattern of responding relative to other age-groups, as they alone judged that more things could happen after hearing ordinary facts than improbable facts. When this youngest age-group was excluded from our main analysis, we found a main effect of both fact-type and age, $ps < .017$, but no interaction, $p = .516$. Children more often affirmed the possibility of events after hearing improbable than ordinary facts, and denied the possibility of more events with age.

This overall effect of condition speaks to the efficacy of our manipulation, and is consistent with children's use of a similarity heuristic for inferring possibility. However, the overall age-related decline in possibility judgments seen here contrasts with age-related increases in agreement observed in other studies (e.g., Shtulman & Carey, 2007). This suggests that our experimental design (i.e., telling children facts before asking for possibility judgments) presented demands that may have shifted children away from their baseline judgments. These task demands also seemingly affected younger children more strongly than older children, and may account for the surprising pattern of responding observed in our youngest participants.

However, one could worry that children's apparent use of a similarity heuristic is *also* explained by demands inherent in the task we used to investigate it. Specifically, one could worry that children were simply matching improbable facts to improbable events without explicitly considering the similarity between the two. In the next experiment, we address this concern by telling children about improbable facts and events that are either related or unrelated to each other. If children use a similarity heuristic to infer possibility, they should affirm the possibility of improbable events more often if they learn about related improbable events than unrelated improbable events. However, if they are merely responding to task demands, and simply matching improbable-to-improbable, we should observe similar rates of agreement across conditions.

We conducted this experiment on 5- and 6-year-olds only. We excluded 4-year-olds because their performance in Experiment 1 was qualitatively different from that of older children, and likely an artifact of our experimental design. Conversely, the performance of the 5- and 6-year-olds was similar to what has been observed in previous experiments (e.g., Bowman-Smith et al., 2018; Lane et al., 2016) which also found that children in this age range mostly deny that improbable events can happen. Further, investigating 5- and 6-year-olds serves as a conservative test of the similarity heuristic, as the results of Experiment 1 showed them to be the least likely to agree that events can happen within this paradigm.

Experiment 2

Method

Participants. We tested 80 5 and 6-year-olds ($M = 6:0$, range = 5;0-6;11, 38 girls). One additional child did not respond to our questions was therefore replaced.

Materials and procedure. Children completed six trials in one of two between-subjects conditions; see Figure 1. In each trial, they heard improbable facts about people and were shown a photo demonstrating that the fact was true. In one condition, they were then asked about the possibility of a related improbable event. For example, children were told and shown that a person could have a pet elephant and then asked: “So, could a person also have a pet zebra?” This condition served as a replication of the improbable-fact condition from Experiment 1. In the other condition, they were instead asked about the possibility of an unrelated improbable event. This condition featured the same facts and events as the related-event condition, but with the pairings shuffled so that the facts were no longer related to the succeeding events. For example, children were told and shown that a person could have a pet elephant and then asked: “So, could a person also have a polka dot plane?”. A consequence of simply rearranging the items from Experiment 1 is that children would inevitably judge the possibility of events related to facts presented in previous trials. We therefore blocked the items such that children’s first three judgments were unrelated to the presented facts, whereas their final three judgments were related to facts presented in the first three trials.

The similarity account predicts that children who hear related facts will judge more improbable events to be possible than children who hear unrelated facts, as only facts that are sufficiently related to the improbable events should be informative about their possibility. Crucially, this difference should be more apparent in children’s first three possibility judgments, as their last three judgments will be informed by previously presented facts regardless of whether they saw related or unrelated fact-event pairings. Conversely, if children are simply affirming improbable events as possible after hearing any other improbable event, we should find no difference between the influence of related and unrelated facts.

Results

We entered relation (related, unrelated), item-block (first three trials, last three trials), and age-in-months (mean-centered) as predictors of children's judgements about whether improbable events were possible; see Figure 3. There was a main effect of relation, Wald $\chi^2(1) = 15.18$, $p < .001$, as children more often affirmed that improbable events could happen after hearing related rather than unrelated facts. There was also a main effect of item-block, Wald $\chi^2(1) = 28.75$, $p < .001$, as children more often affirmed that improbable events could happen in the last block than in the first block. However, these main effects were qualified by an interaction, Wald $\chi^2(1) = 17.04$, $p < .001$. There was no main effect of age, Wald $\chi^2(1) = 0.01$, $p = .923$, and age did not interact with any other factor, $ps \geq .180$.

Figure 3. Scatterplot with trendlines showing the proportion of events judged possible by each child as a function of their age in Experiment 2. Children heard either related or unrelated facts before judging each event. Bands show 95% confidence intervals. Points are jittered slightly to decrease overplotting.

We next analyzed the effect of relation separately within each item-block. For the first item-block, there was a main effect of relation, Wald $\chi^2(1) = 14.86$, $p < .001$, as children who heard about related facts and events were more likely to say that the events were possible than children who heard about unrelated facts and events. This effect was not observed in the last item-block, Wald $\chi^2(1) = 0.04$, $p = .849$, as children's judgments did not differ across related and unrelated fact-event pairings.

Finally, we examined whether children's responses within each item-block and relation differed from chance. For the first item block, children who heard about related facts and events mostly agreed events could happen, $p < .001$, whereas children who heard about unrelated facts and events mostly denied events could happen, $p < .001$. For the last item-block, children mostly agreed that events could happen after hearing both related and unrelated facts, $ps \leq .017$.

In sum, children were more likely to affirm that improbable events could happen after hearing about related improbable events than after hearing about unrelated ones. This shows that children consider their knowledge of what has happened to be informative about the possibility of sufficiently similar events, but not other unrelated events. The findings also suggest that children in Experiment 1 were not simply matching improbable facts to improbable events, and that their performance is better explained by the use of a similarity heuristic than the presence of task demands.

In our final experiment, we test whether children's use of the similarity heuristic is constrained by deeper principles about what is impossible. We do this by asking children about improbable and impossible events that are both related to a given fact. This experiment also further explores the role of task demands by testing whether our manipulation would lead children to affirm the possibility of truly impossible events.

Experiment 3

Method

Participants. We tested 50 5-6-year-olds ($M = 6;1$, range = 5;0-6;11, 23 girls). We aimed to test 20 children per age, but inadvertently tested an additional 10 6-year-olds. All children are included in our analyses.

Materials and procedure. In four trials, children heard improbable facts and were shown a photo demonstrating that each fact was true. After hearing each fact, all children were asked whether two related events were also possible. One of the events was improbable, and the other was impossible. For example, children were told and shown that a person has a pet elephant and then heard: “OK, now I have some questions for you. Could a person also have a pet zebra? Could a person also have a pet unicorn?”.

Results

We entered event-type (improbable, impossible) and age-in-months (mean-centered) as predictors of children’s judgements about whether the events were possible; see Figure 4. We found a main effect of event-type, Wald $\chi^2(1) = 29.92$, $p < .001$, as children more often affirmed that improbable events could happen than impossible events. There was no main effect of age, Wald $\chi^2(1) = 2.55$, $p = .110$, but there was an interaction between age and event-type, Wald $\chi^2(1) = 5.51$, $p = .019$. Exploring the effect of age within each event-type revealed no significant effects, $ps \geq .110$. However, the interaction occurred because the effect was larger in 6-year-olds, $p < .001$, $OR = 0.08$, than in 5-year-olds, $p < .001$, $OR = 0.20$.

Figure 4. Scatterplot with trendlines showing the proportion of events judged possible by each child as a function of their age in Experiment 3. Children heard improbable facts before judging the possibility of related improbable and impossible events. Bands show 95% confidence intervals. Points are jittered slightly to decrease overplotting.

Finally, we examined whether children's responses for each event-type differed from chance. Both 5- and 6-year-olds mostly agreed that improbable events could happen, $ps < .013$, and mostly denied that impossible events could happen, $ps < .001$.

These findings show that children more often affirmed the possibility of improbable rather than impossible events despite both events being related to a learned fact.

General Discussion

Children judged that improbable events could happen when they were told that similar events had occurred. In Experiment 1, 4.5- to 6-year-olds more often affirmed that improbable events could happen after hearing about related improbable events than related ordinary events. In Experiment 2, 5- to 6-year-olds were more likely to affirm that improbable events could happen if told about related improbable events than if told about unrelated ones. Finally, in Experiment 3, 5- to 6-year-olds affirmed the possibility of improbable events, but not impossible ones, after hearing about related improbable events. These results are the first to reveal a manipulation leading young children to mostly affirm that improbable events can happen. Recent experiments investigated other manipulations that attenuated children's denials to a degree (Bowman-Smith et al., 2019; Lane et al., 2018), but without bringing children to affirm that improbable events could happen.

These findings suggest that the similarity heuristic is an important strategy 4.5- to 6-year-olds use to judge whether events are possible. This is consistent with the suggestion that children often reject the possibility of improbable events because the events are too dissimilar from children's own experiences (Shtulman & Carey, 2007; Woolley & Ghossainy, 2013). Our experiments offer the first direct support for this account. Importantly, though, children mostly denied the possibility of impossible events, even after being told about similar improbable events. These denials fit with recent findings showing that children deny that impossible events are possible even after being told that the events themselves actually happened (Lane et al., 2018; Danovitch & Lane, 2020). Also, while children's judgments for impossible events were not at floor, they were comparable to those of other studies where children of similar ages judged whether impossible events could happen (e.g., Lane et al., 2018; Shtulman & Phillips, 2018).

This shows that besides considering similarity, children's judgments were constrained by awareness of deeper principles making certain outcomes impossible (Schult & Wellman, 1997; Sobel, 2004).

Crucially, we did not provide children with information about the circumstances or causal principles that would have allowed any of the events to occur. For example, we did not tell them how a person could acquire or accommodate a pet elephant. Children therefore had no new causal information to deploy when inferring the possibility of the target impossible events, like having a pet zebra. So our findings are not explained by 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.

We investigated young children's tendency to deny that improbable events can happen. Interestingly, children at the same ages also often deny that it is possible for people to violate moral rules and social conventions (e.g., Chernyak et al., 2013; Shtulman & Phillips, 2018). Children in this age range also respond to improbable events as if they involved moral transgressions—they judge story characters who behave oddly as doing wrong and deserving punishment (Shtulman & Phillips, 2018). Together these findings suggest that children may represent immoral actions, unconventional actions, and improbable events similarly, or even as categorically the same (also see Phillips & Cushman, 2017, and Shtulman & Tong, 2013 for related findings from adults).

The similarity heuristic might help explain why violations of moral rules and social conventions are sometimes deemed impossible. Improbable events, immoral actions, and

violations of social conventions are abnormal (Shtulman & Philips, 2018). Given that these events are abnormal, children might have difficulty calling to mind similar events when applying the similarity heuristic. As such, the similarity heuristic might underlie judgments that immoral actions (e.g., a girl lying to her mother about her school being closed) and violations of social conventions (wearing pajamas to school) are impossible. This proposal is purely speculative, but it could be tested by telling children about immoral events and asking if they know of those events or similar events having occurred. It might also be tested by telling children about violations of moral rules and social conventions, and seeing if this makes children more likely to affirm that similar events are possible.

At the opposite extreme, there might be no connection between the similarity heuristic and children's claims that moral and social violations are impossible. After all, the similarity heuristic may explain why young children deny that improbable events can happen, but it cannot explain all judgments of impossibility. As acknowledged above, children probably do not use the heuristic when denying the possibility of physically impossible events which violate their causal knowledge. Why then might children seem to conflate impossible and impermissible events? Children might have some ways of deciding that an event is impossible (e.g., drawing on causal knowledge, using the similarity heuristic), and other ways of deciding that an event is impermissible. But once they categorize an event as falling under one description, they might assume it also falls under the other.

Limitations and Future Directions

One potential concern with our task is that it likely introduced experimental demand. For example, having been told that one event was possible, children might have felt some pressure to then affirm that further events were possible. The developmental pattern we observed suggests

that younger children were more susceptible than older children to this experimental demand—children in our experiments became less likely with age to judge events possible, whereas previous studies have often found the opposite pattern (e.g., Lane et al., 2016; Shtulman & Carey, 2007; though for exceptions see Bowman-Smith et al., 2018 and Goulding & Friedman, in press). This might likewise help explain why we found only limited evidence that 4-year-olds (especially younger ones) use the similarity heuristic. These young children may have failed to negotiate a response that balanced the presence of these demands with their own intuitions, and therefore responded to the demands alone.

Importantly, however, these concerns about experimental demand do not suffice to explain away our findings. This is especially apparent from the findings of Experiment 2. Children exhibited greater agreement after hearing related than unrelated facts, and this effect emerged even when facts and events were presented separately (as demonstrated by the interaction between relation and item-block). These results follow directly from the similarity account and are difficult to explain by appealing to task demands alone. The results of Experiment 3 also speak against the influence of task demands, as children mostly denied the possibility of impossible events despite the same pressure to affirm presumably being present for both improbable and impossible items. And as noted above, it is unlikely that our older participants were as sensitive to the demand characteristics, as they were overall less likely than younger children to judge events possible across all manipulations. Regardless, it would be useful for future research to see if our findings replicate using a procedure that reduces demand. One experimenter might introduce the improbable facts, and later a different experimenter could ask the test questions. Removing experimental demand might help reveal whether younger 4-year-olds also use the similarity heuristic.

It is also worth noting that our work did not explore what makes two events similar enough that the possibility of one suggests the possibility of the other. Our fact and event pairings were designed to be thematically similar. For instance, we paired elephants and zebras 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). Future work should explore how children decide whether events are similar when inferring possibility, and how far this similarity heuristic extends.

Future work should also explore whether children older than 6 years and adults continue to use a similarity heuristic for inferring possibility. It might seem that adults should not use the similarity heuristic, perhaps because they have greater knowledge of the causal circumstances that would allow events to occur (Shtulman & Carey, 2007). However, it is likely that adults use it when they have limited knowledge about how or why an event can happen. For instance, adults judge it is possible to stay awake for 5 days, but not for 5 months (Shtulman, 2009). But it is unlikely that most adults know enough about the biological basis of sleep to understand why the less extreme event could happen, while the more extreme one could not. Instead, it could be that they have heard about people staying awake for several days (an outcome similar to 5 days) but have never heard of anyone staying awake for months. The similarity heuristic, then, may not just be for children. It may underlie possibility judgments in adults too.

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