Young children discriminate improbable from impossible events in fiction

Deena Skolnick Weisberg\textsuperscript{a,}\textsuperscript{*}, David M. Sobel\textsuperscript{b,1}

\textsuperscript{a} Center for Cognitive Science, Rutgers University; 152 Frelinghuysen Rd., Piscataway, NJ 08854, United States
\textsuperscript{b} Department of Cognitive, Linguistic, and Psychological Sciences, Brown University, Box 1821, Providence, RI 02912, United States

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ABSTRACT

Can young children discriminate impossible events, which cannot happen in reality, from improbable events, which are unfamiliar but could possibly happen in reality? When asked explicitly to categorize these types of events, 4-year-olds (N = 54) tended to report that improbable events were impossible, consistent with prior results (Shtulman & Carey, 2007). But when presented with stories made up of improbable events, children preferred to continue these stories with additional improbable events rather than with impossible events, demonstrating their sensitivity to the difference between the two types of events. Children were indifferent between continuing these stories with additional improbable events or with ordinary, possible events. Children’s differential performance on the story and categorization tasks suggests that they possess some knowledge of the distinction between improbable and impossible but find it difficult to express this knowledge without a supportive context.

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Alice laughed. “There’s no use trying,” she said: “one can’t believe impossible things.”
“I daresay you haven’t had much practice,” said the Queen.
- Lewis Carroll, Through the Looking Glass
1. Introduction

By the age of four, children have a well-developed sense of the physical and biological rules that govern reality and are sensitive to violations of these rules (Cook & Sobel, 2011; Johnson & Harris, 1994; Phelps & Woolley, 1994; Rosengren, Kalish, Hickling, & Gelman, 1994). For example, they know that objects cannot disappear from one place and reappear at another (Johnson & Harris, 1994) and that a machine cannot make a rock feel soft (Cook & Sobel, 2011). Children at this age can also generate appropriate explanations of why impossible events are such, often appealing to relevant domain-specific rules (Schult & Wellman, 1997; Sobel, 2004). Some have even argued that infants’ performance in many looking-time studies reveals a similar understanding of the difference between what is possible and what is impossible (Wellman & Liu, 2007).

Children’s developing knowledge might allow them to recognize violations of real world causal structure as impossible, but such knowledge potentially leads them to overgeneralize. They might struggle when making judgments about possible events that are unfamiliar, rare, or strange. Shtulman and Carey (2007) showed that preschool-aged children have difficulty categorizing such improbable events – events that could possibly happen, but that are strange or unlikely – as possible. They found that preschoolers judged both improbable and impossible events as impossible in the real world, while ordinary events were accurately judged as possible (see also Shtulman, 2009). These findings suggest that preschoolers see no distinction between events that are merely unlikely and events that violate some aspect of the world’s ontological structure. This is the main issue that we investigate here. Do young children genuinely fail to distinguish improbable events from impossible events?

If this is the case, it has some interesting implications for children’s cognitive development. For example, without the ability to distinguish improbable from impossible events, children may fail to consider unlikely but true causal relations and hence arrive at inaccurate theories about the structure of the world (Schulz, Bonawitz, & Griffiths, 2007). Similarly, children evaluate the information that they hear based on their analysis of the trustworthiness of the source (Jaswal & Malone, 2007; Koenig, Clément, & Harris, 2004; Woolley & Van Reet, 2006) and use their own and others’ causal knowledge as the basis for appraising others’ reliability (Sobel & Corriveau, 2010). In the absence of an ability to distinguish improbable from impossible statements, children may be presented with true (but improbable) information that they erroneously categorize as false. Children in this situation might not only fail to learn this piece of information, they might also arrive at an inaccurate conclusion regarding the trustworthiness of the source from which they hear it, potentially cutting off further learning opportunities. Both of these issues are important, particularly with respect to children’s ability to learn scientific concepts, which often involve unlikely and counterintuitive, yet true, causal mechanisms (Bloom & Weisberg, 2007).

When we look at children’s understanding of the fantasy/reality distinction, however, we find reasons to be skeptical of the conclusion that young children fail to discriminate improbable from impossible events. Just as children appreciate impossible events as such, they also recognize that the contents of stories are not real (Golomb & Galasso, 1995; Morison & Gardner, 1978; Samuels & Taylor, 1994) and that fictional characters can have different properties from real people (Boerger, 2011; Sharon & Woolley, 2004). Story content is not as important as the fact that the characters come from a fictional world—children recognize that Ross and Rachel on the television show Friends are just as fictional as Superman or Wonder Woman, even though the latter characters violate many more aspects of the real world (Woolley & Cox, 2007). In short, young children appear to have a relatively sophisticated understanding of fiction.

Why might preschoolers have a subtle understanding of fictional worlds but lack the capacity to distinguish impossible from improbable events? One possibility is that reasoning about fantasy and fictional worlds provides a general cognitive benefit. Indeed, couching counterfactual syllogisms that have false or unfamiliar premises in terms of a fictional context allows children to make more accurate logical inferences (Dias & Harris, 1988, 1990; see also Richards & Sanderson, 1999; Richert, Shawber, Hoffman, & Taylor, 2009). More specifically, children (at least in Western cultures) are often read stories and asked questions about the content of those stories (Gelman, Coley, Rosengren, Hartman, & Pappas, 1998; Rideout, Vandewater, & Wartella, 2003), while they are presumably less likely to be
asked directly whether something is possible. Questions about the content of fictional worlds are thus more familiar to young children than questions about possibilities. Given that young children reason better about events that are familiar (Berzonsky, 1971), they might be more sensitive to issues of possibility when reasoning about the content of a fictional world than when directly asked whether an event is possible.

In addition, thinking about fictional worlds implicitly involves activating the child’s concept of possibility. Consider that whenever children encounter a fictional world, they have to conceptualize the ontological commitments made by that world and how these commitments do and do not differ from reality. In order to understand what is happening in a story, children must create a holistic context for that story, in which they decide what violations of causal or deontic structure are licensed by that world. For example, regardless of the existence of transports and warp speed in Star Trek, the human beings on the show can’t fly, must breathe, and can’t see through walls. Adults are sensitive to the different kinds of fictional worlds that can be generated by stories (Weisberg & Goodstein, 2009), and given the ease with which children navigate fictional worlds in stories and pretend games, we would argue that they are as well. For all of these reasons, we predict that assessing children’s knowledge about improbability within the context of a fictional story will provide a more sensitive measure of this knowledge than simply asking them whether an impossible event is possible.

We thus presented 4-year-olds with two tasks. First, they heard stories that contained a set of improbable events. We define improbable events as those that could occur but are unlikely because they run counter to the typical functional or conventional structure of reality. In contrast, impossible events are those that cannot occur in reality because they violate some aspect of the world’s ontological structure. In one condition, we asked children to extend the improbable-event stories by choosing between a novel improbable event and a novel impossible event. In a second condition, we asked children to extend these stories by choosing between a novel improbable event and a novel ordinary event.

We predict that children should prefer to continue this story with an improbable event as opposed to an impossible one. Such behavior would demonstrate that they do possess some ability to distinguish between improbable and impossible events. We believe that children will do so because the improbable events violate the ontological structure of the real world (and presumably, of the fictional world created by the story events so far), while the improbable events do not. Previous work has shown that children have the capacity to recognize this fact: preschoolers understand that Batman thinks SpongeBob is fictional, but also that Batman has no problem seeing, touching, or talking to Robin (Skolnick & Bloom, 2006). These results, as well as those reviewed above, suggest that young children should be able to infer the structure of the fictional worlds these stories describe, because children appreciate that fictional worlds are distinct from one another and obey distinct sets of causal laws. However, we predict that children should choose randomly between the ordinary and improbable events as extensions for this same story, because both events could possibly happen in reality and hence in the story. Nothing in the improbable-event story has violated real-world ontological structure, suggesting that this fictional world is not fundamentally different from our own.

As a control, we included a third condition, in which children were read a story consisting entirely of ordinary events. They were asked to extend that story with either an ordinary event or an impossible event. In a study using a similar procedure, Weisberg, Sobel, Goodstein, and Bloom (submitted for publication) found that children extended ordinary-event stories with additional ordinary events, and we expect the same result.

In addition to engaging in this story-completion task, participants performed an explicit judgment task about the possible, improbable, and impossible pictures in our stimulus set. These ratings allow a direct comparison of performance when children are categorizing events explicitly, as opposed to when they are reasoning about the content of events within the context of a story. We expect to replicate Shtulman and Carey’s (2007) finding that children judge improbable events as impossible, but we also expect the same children to distinguish between these two types of events in our story-completion task.

The way in which children respond to these two tasks has implications for our understanding of young children’s developing ontological knowledge as well as for our understanding of how young
children conceptualize the reality/fantasy distinction. If children perform in the same way with the stories as with the ratings, it suggests that they lack an understanding of conceptual improbability and that their understanding of the world’s ontological structure may not be as sophisticated as previously thought. However, if children can discriminate between improbable and impossible events in the context of a fictional world, it suggests that they do possess some understanding of conceptual improbability as such, but require a supportive context to express this knowledge, as is the case with other developing skills. Further, it suggests that fictional contexts may assist children’s reasoning about other types of real-world causal structures and categories.

2. Methods

2.1. Participants

We chose our age range to match the 4-year-old samples studied by Shtulman and Carey (2007). The final sample contained 54 children (29 female), mean age = 54.81 months, range 41–66 months. All children were recruited from and tested at local preschools. All testing sessions were videotaped. Participants came from primarily middle-class backgrounds. An additional four children were recruited but not included in the final sample because they were unresponsive (n = 2), because they failed to complete both test trials (n = 1), or because they were too young for our target age range (n = 1, age 33 months).

Eighteen children were randomly assigned to each of three conditions: Improbable story with choice between Improbable and Impossible event as a continuation (Improbable–Improbable/Impossible), Improbable story with choice between Improbable and Ordinary continuation (Improbable–Improbable/Ordinary), or Ordinary story with choice between Ordinary and Impossible continuation (Ordinary–Ordinary/Impossible).

2.2. Materials

We constructed three sets of 10 pictures each. Each depicted a character engaging in an action or displaying a characteristic. In the Ordinary set, all of these actions and characteristics were highly realistic and familiar to children of this age (e.g., the character goes outside by walking through the door). In the Improbable set, all of these actions and characteristics were physically possible in reality, but unfamiliar or unusual given children’s experience (e.g., the character goes outside by walking through the window). In the Impossible set, all of these actions and characteristics were physically impossible in reality (e.g., the character goes outside by walking through the wall). The three sets were constructed as triads, so that the actions and characteristics depicted in the pictures matched each other as closely as possible across the three sets. There were two versions of these three sets of stimuli, one with a female main character (Luna) and one with a male main character (Moe). Children saw the pictures in which the main character’s gender matched their own.

For each child, the 10 pictures in his or her assigned set were arranged into two different stories. Each story consisted of four pictures in a pre-determined random order and a fifth picture that was used for the test question. Each of the 10 pictures in each set was used for the first test question for at least one participant per condition. For example, a child in the Improbable–Improbable/Impossible condition heard a story made up of a random set of four events from the Improbable set of pictures: “This is a story about a boy named Moe [or a girl named Luna]. First in the story, Moe/Luna sleeps on his/her roof. And look, whenever Moe/Luna is happy, s/he sneezes. Then, Moe/Luna eats vegetables for dessert. And then, Moe/Luna opens his/her closet and finds a real, live monkey.” At test, the child was asked to choose which of two pictures belongs in the story: “In this picture, Moe/Luna does cartwheels to school. And in this picture, Moe/Luna flies to school. Can you show me which of those two pictures belongs in this story?”

Because each child saw the pictures in a different, random order, there was no particular narrative to our stories. This was done deliberately, so as not to provide any clues as to which picture fit more naturally into the story; neither of the pictures presented at test could be seen as extending or completing the narrative.
2.3. Procedure

To begin, the experimenter explained that she had written some stories but needed the child's help because she could not figure out what should happen next in her stories. Children were asked if they could help the experimenter with her stories, and all children assented.

Children were then shown the first story, which consisted of four pictures from the Ordinary or Improbable set, depending on condition. Children assigned to the Improbable–Improbable/Ordinary condition were read a story that contained four events from the Improbable set and were then asked to continue it by choosing between a novel improbable event and its corresponding ordinary analog. Children assigned to the Improbable–Improbable/Impossible condition were read a story with four events from the Improbable set and were asked to continue it by choosing between a novel improbable event and its corresponding impossible analog. Children assigned to the Ordinary–Ordinary/Impossible condition were read a story with four ordinary events and were asked to continue it by choosing between a novel ordinary event and its impossible analog.

The story pictures were placed on the table in front of the child, one at a time, and the experimenter narrated the contents of each picture before moving it off to the side. By the end of the story, all four pictures were visible in a row on the table in front of the child. Then the experimenter brought out the two test pictures, telling the child that she could not decide which of these pictures should go in the story. The test pictures always included one picture from the same set as the child's story (the matching choice, i.e., the Improbable picture in the Improbable–Improbable/Ordinary and Improbable–Improbable/Impossible conditions, and the Ordinary picture in the Ordinary–Ordinary/Impossible condition) and one picture from a different set (the non-matching choice, i.e., the Ordinary picture in the Improbable–Improbable/Ordinary condition, and the Impossible picture in the Improbable–Improbable/Impossible and Ordinary–Ordinary/Impossible conditions). The two test pictures were taken from the same triad so that they were closely matched in content.

The two test pictures were shown to the child, one at a time, and their contents were narrated. During this narration, each picture was placed on the table below the four story pictures, with the left/right placement of the matching choice counterbalanced. After describing the two test pictures, the experimenter asked, “which one of these belongs in my story?” If children were hesitant to choose a picture, the experimenter reminded the child of the contents of each picture and repeated the test question. Following the child's choice, the experimenter provided positive feedback and asked the child to explain why s/he had chosen that picture to go into the story. These justifications did not reveal any statistically significant patterns and hence are not included in our reported analyses.

This procedure was repeated a second time, using the remaining five pictures in the child's assigned test set. Four of these pictures made up the second story and the fifth was used for the second test choice.

Following these two test trials, children completed a ratings task to check whether they could accurately categorize the pictures in the three sets as ordinary, improbable, and impossible. To avoid contamination with previously seen stimuli, this task involved the 10 pictures in the set that they had not previously seen: the Improbable set in the Ordinary–Ordinary/Impossible condition, the Impossible set in the Improbable–Improbable/Ordinary condition, and the Ordinary set in the Improbable–Improbable/Impossible condition. Children were shown each picture from the set in a random order and were asked whether the event depicted in the picture "could really happen, in real life." If children denied that the event could happen, they were shown the next picture. If children said that the event could happen, they were asked whether it was “normal” or “silly.”

3. Results

3.1. Story task

On each of the two test trials, children could choose either the matching picture, the one that came from the same set as the four pictures in the story, or the non-matching picture. Overall, then, children could choose the matching picture a total of zero, one, or two times (see Table 1). We counted the number of children who exhibited each of these three possible response patterns, and compared this
distribution to chance. For the purpose of these analyses, chance was defined as a 25% probability of choosing the match zero times or two times, and a 50% probability of choosing the match once.

Chi-Squared Goodness of Fit tests showed that, in the Ordinary–Ordinary/Impossible condition, children chose the matching (ordinary) picture significantly more often than what would be expected by chance, $\chi^2(2, N = 18) = 22.00, p < 0.01$. In the Improbable–Improbable/Ordinary condition, children’s choices did not differ from chance, $\chi^2(2, N = 18) = 2.78, ns$. In the Improbable–Improbable/Impossible condition, children again chose the matching (improbable) picture significantly more often than what would be expected by chance, $\chi^2(2, N = 18) = 6.33, p < 0.05$.

A comparison between the two conditions in which children heard the Improbable story reveals that children were significantly more likely to choose the matching (improbable) picture when the alternate picture depicted an improbable event than when it depicted an ordinary event, $\chi^2(2, N = 36) = 6.42, p < 0.05$, $\varphi = 0.42$. Children did not differ in their distribution of choosing the matching picture between the Improbable–Improbable/Impossible and the Ordinary–Ordinary/Impossible conditions, $\chi^2(2, N = 36) = 2.16, ns$. Children did differ in their distribution of choosing the matching picture between the Improbable–Improbable/Ordinary and the Ordinary–Ordinary/Impossible conditions $\chi^2(2, N = 36) = 14.12, p < 0.01$, $\varphi = 0.63$. These analyses suggest that preschoolers distinguish between possible and improbable events when extending a story, regardless of whether the possible events are ordinary or improbable.

3.2. Ratings task

Two children requested to end the procedure after the test trials, leaving 17 children who provided ratings for the Improbable and Impossible sets and 18 children who provided ratings for the Ordinary set. Children could respond to each picture they saw in one of three ways: (1) They could say that the event depicted could not happen in reality, which we coded as a response of “impossible” for that picture. (2) They could say that the event depicted could happen in reality, in which case we asked them to judge whether the event was normal or silly. If they said that it was normal, we coded this response as “ordinary.” (3) If they said that it was silly, we coded this response as “improbable.”

Table 2 shows the distribution of children’s ratings for each picture set. We looked at how often children rated the pictures in each set as impossible, compared to chance. Children rated on average 8.29 of the 10 impossible pictures as impossible, significantly greater than chance (50% or 5.00 of 10), $t(16) = 5.68, p < .01$. Children ranked on average 6.88 of the 10 improbable pictures as improbable, also significantly greater than chance, $t(16) = 2.75, p = .014$. Children rated on average only 1.06 of the 10 ordinary pictures as impossible, significantly below chance, $t(17) = -20.86, p < .01$.

We additionally looked at accuracy in rating their assigned set. Children rated 7.89 of the 10 ordinary pictures as ordinary, significantly greater than chance (25% or 2.5 of 10), $t(17) = 10.30, p < .01$, while they rated the 1.82 of the 10 improbable pictures as improbable, no different from chance levels.

### Table 2

<table>
<thead>
<tr>
<th>Condition</th>
<th>Rated as “Ordinary”</th>
<th>Rated as “Improbable”</th>
<th>Rated as “Impossible”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary set</td>
<td>7.89 (2.22)</td>
<td>1.06 (2.10)</td>
<td>1.06 (0.80)</td>
</tr>
<tr>
<td>Improbable set</td>
<td>1.29 (1.79)</td>
<td>1.82 (1.88)</td>
<td>6.88 (2.83)</td>
</tr>
<tr>
<td>Impossible set</td>
<td>0.71 (1.10)</td>
<td>1.00 (1.94)</td>
<td>8.29 (2.39)</td>
</tr>
</tbody>
</table>

Note: Standard deviations are shown in parentheses.
\( t(16) = 1.49, ns. \) Instead, children mostly rated the improbable pictures as impossible; there was no statistically significant difference between how often they rated the improbable pictures as impossible and how often they rated the impossible pictures as impossible, \( t(32) = 1.57, ns. \)

4. Discussion

We investigated whether 4-year-olds can distinguish improbable events from impossible ones and whether their ability to do so depends on how this question is posed. In our ratings task, 4-year-olds judged most of the improbable and impossible events as improbable and most of the ordinary events as possible, similar to Shtulman and Carey’s (2007) findings. Taken on its own, this finding suggests that children do not discriminate improbable events, which could possibly happen in reality, from impossible events, which could not.

However, when asked to extend stories made up of improbable events, they did discriminate between these two types of events. If children genuinely believe that improbable events are impossible, they would have demonstrated chance performance when asked to include either a novel improbable or a novel impossible event in an improbable-event story. But they did not; they saw only the improbable events as appropriately fitting into this story world. This response tendency is particularly striking when compared to children’s responses to the same stories when they were asked to continue these stories by choosing between another improbable event and an ordinary event. In this condition, children responded at chance, showing no strong preference for either improbable or ordinary events.

Finally, our control condition confirms that children’s imaginative tendencies are constrained when it comes to constructing stories. Children who saw a story in which only ordinary events occurred preferred to continue this story with a novel ordinary event, rather than with a novel impossible one.

We chose not to include a condition that presents children an impossible story and then asks them to choose between an improbable and improbable event. Although this would have provided an interesting extension to the current findings, this condition presented no clear predictions for performance. Both the improbable and the impossible event could possibly occur in a story that is made up entirely of impossible events; including impossible events in a story does not prevent possible or even improbable ones from also being present. This means that any choice children made in this condition would have potentially been correct. This proposed condition thus would not have given us any particular insight into children’s understanding of ontological structure. By contrast, the Improbable–Improbable/Impossible condition of our study did have a clear prediction: Only improbable events should occur in a story world that has previously presented no actual violations to the ontological commitments of the real world, so children should choose to continue these stories only with improbable, not impossible events. This prediction was supported by our data.

A possible objection to this conclusion is that children may have a general bias against impossible events, perhaps because they prefer stories that do not contain such events, for aesthetic reasons, or because they simply do not like choosing these events in general. Such a bias could explain why children chose improbable events rather impossible ones in the Improbable–Improbable/Impossible condition of our story task. But this explanation presupposes that they have a coherent category that contains impossible, but not improbable, events—precisely the issue that our study was designed to investigate. Children could only have a bias against impossible events, leading them to choose improbable events rather than impossible events, if they saw these events as belonging to different categories. The present study demonstrated that children indeed make this discrimination, at least in the context of a story task. The question of whether children prefer not to choose impossible events in general is orthogonal.

Why might children claim that improbable events are impossible when explicitly asked, yet categorize them differently within the context of a fictional world? This is the key finding of the present study, and it raises the question of which set of results provides a more representative picture of children’s knowledge. We favor the results of the story task, which showed that children are able to distinguish improbable from impossible events in at least some contexts. This conclusion is consistent with other evidence that young children demonstrate more mature reasoning in tasks that assess their abilities in more implicit ways. Most relevant to the current findings, Shtulman and Carey (2007, Experiment 4) found that even their 4-year-old participants were able to distinguish improbable from
impossible events when they were asked to make a forced-choice distinction among pairs of these types of events. In this case, unlike in the explicit categorization task, children were provided with a situation that imposed a lower level of demand and hence were able to more easily tap their developing knowledge. Similarly, when we asked children to extend fictional stories by choosing between two alternatives, we allowed children to access the content of their real-world knowledge without needing to directly consider each event’s ontological status. Thus, when shown a story with a set of improbable events, children recognized that a novel impossible event is less likely to occur in this story than a novel improbable event. On this view, explicit questioning might not be a sensitive enough measure to allow children to demonstrate the true depth of their knowledge.

A similar pattern is evident across a variety of developmental acquisitions, including numerical reasoning (Carey, 2009), naïve physics (Keen, 2003), and theory of mind (Apperly & Butterfill, 2009). For example, classic research on the false-belief task shows that children fail to produce the correct response to this task’s explicit test question until the age of four (Baron-Cohen, Leslie, & Frith, 1985; Wellman, Cross, & Watson, 2001; Wimmer & Perner, 1983). But studies that rely on more implicit measures, like looking time, anticipatory looking, and naturalistic interaction, show that toddlers (O’Neill, 1996; Southgate, Senju, & Csibra, 2007) and even infants (Baillargeon, Scott, & He, 2010; Onishi & Baillargeon, 2005) demonstrate expectations about others’ beliefs in certain circumstances. These results, and ours, conform to the general developmental pattern that children tend to display more advanced reasoning skills on tasks that tap these skills more implicitly—and, conversely, that children become more adept at applying these skills in a wider variety of contexts across development.

We close by noting that, in addition to demonstrating that young children can distinguish impossible from improbable events in certain contexts, the present results also suggest that children’s understanding of fictional stories is more mature than previously suspected. Although there are many cognitive processes that underlie children’s understanding of fictional stories, one of the most fundamental is the recognition that every fictional world has its own coherent internal structure; each fictional world obeys a set of rules that governs what can and cannot happen within the context of that world. Adults clearly understand this notion of internal coherence (Weisberg & Goodstein, 2009), and their imagined representations of stories are based on the extent to which those stories deviate from real-world laws. A future task is to describe the developmental trajectory of this explicit knowledge.

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