Original Articles

Children's imagination and belief: Prone to flights of fancy or grounded in reality? ☆

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ABSTRACT

Children ranging from 4 to 8 years ($n = 39$) reported whether they could imagine various improbable phenomena (e.g., a person making onion juice) as well as various impossible phenomena (e.g., a person turning an onion into a banana) and then described what they imagined. In their descriptions, children mentioned ordinary causes much more often than extraordinary causes. Descriptions of such ordinary causes were provided more often in relation to improbable (rather than impossible) phenomena. Following these imaginative efforts, children judged if each phenomenon could really happen. To check whether these reality judgments were affected by children's attempts to imagine, a control group ($n = 39$) made identical reality judgments but were not first prompted to imagine each phenomenon. Children across the age range judged that impossible phenomena cannot really happen but, with increasing age, judged that improbable phenomena can happen. This pattern emerged in both the imagination and control groups; thus simply prompting children to imagine did not alter their reality judgments. However, within the imagination group, judgments that phenomena can really happen were associated with children's claims to have successfully imagined the phenomena and with certain characteristics of their descriptions: imagining ordinary causes and imagining phenomena obtain. Results highlight close links between imagination and reality judgments in childhood. Contrary to the notion that young children have a rich imagination that readily defies reality, results indicate that their imagination is grounded in reality, as are their beliefs.

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1. Introduction

In everyday parlance, the imagination is often associated with flights of fancy in which unexpected, and even impossible, outcomes are entertained. According to popular wisdom, children easily and regularly represent improbable and indeed impossible outcomes in their imagination; consider the proliferation of fantastical phenomena in children's books, television shows, and movies. Yet research suggests that very young children transpose their understanding of everyday causal constraints to the make-believe world (Harris, 2000). Two-year-olds readily imagine ordinary outcomes – e.g., pretend tea pouring downward into a cup, or liquid wetting a surface that it is spilled upon. Moreover, young children often *prefer* stories with ordinary occurrences and ones that are purportedly factual, over those with extraordinary occurrences or that are purportedly make believe (Barnes, Bernstein, & Bloom, 2015; Sobel & Weisberg, 2014; Weisberg, Sobel, Goodstein, & Bloom, 2013). In the present study, we explore this potential tension between everyday assumptions about the richness of the child's imagination and empirical findings implying its close links to reality, by asking how far children's imagination is constrained by what they know about real-world causality.

In addition to asking about the possible constraints that children's causal knowledge imposes on their imagination, we also ask how the act of imagining a given phenomenon influences children's judgments about whether or not that phenomenon can

actually occur. Young children typically report that improbable and impossible phenomena cannot occur in real life. Indeed, they are even more skeptical than older children and adults, who often concede that improbable phenomena might occur (Shtulman, 2009; Shtulman & Carey, 2007). We ask if this developmental pattern is due, in part to changes in children's imagination, and if imagining improbable phenomena somehow 'loosens' children's belief that they cannot occur in real life.

In the sections below, we review in more detail evidence pertinent to: (i) the relation between children's causal knowledge and their imagination, and (ii) the relation between children's imagination and their judgments about what is real or possible.

1.1. The relation between children's causal knowledge and their imagination

In the context of fairytales, children in many Western cultures are regularly presented with outcomes that defy ordinary, causal regularities and constraints. They may learn about a prince who turns into a frog, animals that can talk, and magic potions that can make someone younger or invisible. The proliferation of such stories with violations of everyday causality reflects the popular wisdom that children are able to represent improbable and even impossible outcomes in their imagination.

Evidence consistent with this conclusion has emerged from the study of children's theory of mind. By approximately 4-years of age, children have a robust, explicit understanding of the relation between perceptual access and belief – e.g., they acknowledge that a person who has not seen inside a familiar container that holds unexpected contents (e.g., a crayon box that actually contains marbles) is likely to have a false belief about those contents (Wellman, Cross, & Watson, 2001). Despite children's insight into the causal constraints imposed on belief by restricted perceptual access, 4-year-olds can grasp that a being with X-ray vision is not subject to those constraints, and children begin to accurately predict what that being will know about the contents of closed containers, given his special capacities (e.g., Lane, Wellman, & Evans, 2010). Thus, older preschoolers can begin to imagine certain extraordinary outcomes that follow from someone possessing extraordinary (and otherwise impossible) powers.

Given children's ability to imagine some outcomes that would obtain as a result of certain extraordinary premises, it is feasible that children will succeed at imagining improbable phenomena and even impossible phenomena – at least when explicitly prompted to do so. Thus, pursuing the above example of the liquid being poured, children might successfully imagine tea spurting upward – like a geyser – even if such an outcome defies what they know about the normal, causal constraints that operate on a liquid tipped out of a container. We term this the *accommodation to fantasy hypothesis* – when prompted, young children can mentally represent unusual and extraordinary phenomena. To test this speculation, we asked 4–8-year-olds to imagine a range of phenomena – some were improbable but not impossible (defying everyday regularities) whereas some were impossible (defying physical or biological causal constraints). Children were then asked to report on whether they could imagine phenomena of each type and to describe what they had visualized. On the *accommodation to fantasy hypothesis*, children should generally report being able to imagine both improbable and impossible phenomena.

However, other work implies that young children's imagination might be grounded in reality rather than prone to flights of fancy. Harris and Kavanaugh (1993) demonstrated that 2-year-olds apply their everyday understanding of causality to interpret pretend actions. For example, children watched an adult pretend to squeeze toothpaste from a toothpaste tube onto one of two toy pigs. The adult then said, "Oh dear! Can you clean the pig who is

all dirty?" and handed children a tissue. Children appropriately wiped the pig that was (make-believe) dirty rather than the pig that remained clean. This finding suggests that children assumed that pretend toothpaste squeezed from a (closed) tube would end up on the tail of the pig contacted by the tube – and furthermore that a tissue could be used to remove it. Indeed, older 2-year-olds could put such pretend, causal sequences into words. Having seen a Teddy Bear puppet pick up a teapot and tilt it above a toy monkey, they described what had happened (e.g., "Teddy poured tea over the monkey") even though, objectively, they had seen nothing emerge from the teapot.

Research on children's explanations for ordinary phenomena and their counterfactual reasoning also illustrate children's reliance on everyday causality both to account for why things happened and to conjure up alternative possibilities. When 3- and 4-year-olds are asked to explain whether various impossible phenomena can occur—e.g., someone floating in air, never ageing, or walking through a fence—they typically report that those events cannot happen and their explanations appeal to ordinary causal principles that cannot be violated (Schult & Wellman, 1997; Sobel, 2004). Thus, they explain that a girl who wants to float cannot actually float because, "She's too heavy to float in the sky" (Schult & Wellman, 1997, p. 297). And when children are asked to generate ways for people to *produce* such events, they often generate ordinary solutions; for example they surmise that the girl who wants to float "needs some wings to do it" (Sobel, 2004, p. 43).

Extrapolating from these findings, we speculate that children not only rely on their everyday causal knowledge when imagining phenomena, but might even have difficulty in setting aside such knowledge when deploying their imagination. Children's imagination might move along only those pathways that have been well established by observed, everyday causality. These considerations lead to the *causal constraints* hypothesis—children will report being able to imagine improbable phenomena more often when they know of real-world ordinary causal mechanisms, but they will report being *unable* to imagine phenomena for which they know of no real-world ordinary causal mechanism. Indeed, the hypothesis predicts that children will be unable to imagine anything that defies their intuitions about biological, physical, or psychological causality. Thus, the *causal constraints* hypothesis predicts that children will more often say they can imagine improbable phenomena (for which ordinary causal mechanisms exist) as compared to impossible phenomena (for which such mechanisms typically do not exist). Compared to younger children, older children should have a richer store of causal mechanisms (based on first-hand experiences as well as others' testimony) and thus should more often report successfully imagining improbable phenomena.

Findings that are consistent with the causal constraints hypothesis come from research on children's story construction. When read realistic story introductions (e.g., a story about a boy who could ride a scooter and had a pet dog) or fantastical story introductions (e.g., a story about a boy who could fly and had a toy that could make him invisible), preschoolers preferred to continue *both* types of stories with ordinary events rather than fantastical events, whereas adults continued the stories based on the content of their introductions (Weisberg et al., 2013). This suggests that children's imagination proceeds along ordinary lines even when they are primed with fantastical contexts. However, children's story preferences do not necessarily reflect their imaginative capacities—children might prefer to hear and to create realistic stories even if they are capable of imagining more fantastical alternatives. In the current study, we examine children's imaginative capacities more directly.

In summary, we test the *accommodation to fantasy* and the *causal constraints* hypotheses by asking children to try to imagine improbable and impossible phenomena, to say whether they could

indeed imagine each phenomenon, and to describe what exactly they imagined for each phenomenon. The *accommodation to fantasy* hypothesis predicts that children will report being able to imagine both types of phenomena whereas the *causal constraints* hypothesis predicts that children will report being able to imagine improbable but not impossible phenomena.

1.2. The influence of the imagination on children's beliefs

So far, we have considered whether children's causal knowledge constrains their imagination. We now consider the extent to which engaging in an act of the imagination—more specifically, imagining an improbable or impossible phenomenon—might influence children's subsequent belief about the likelihood of that phenomenon really occurring. The available evidence is equivocal. On the one hand, there may be no relation between imagining a phenomenon and believing that the phenomenon can occur. After all, preschoolers can distinguish between what they imagine and what is real. For example, when asked to close their eyes and imagine an object (e.g., a balloon), 3-year-olds report that they cannot see the object with their eyes, cannot touch it with their hands, and that other people cannot see it (Estes, Wellman, & Woolley, 1989; Wellman & Estes, 1986). As well, 3-year-olds report that they can imagine entities that they acknowledge do not exist – e.g., a purple turtle (Woolley & Wellman, 1993). Thus, even preschoolers distinguish between what exists in their imagination and what exists in the real world.

On the other hand, in some circumstances, there might be a relation between what children imagine and their subsequent beliefs. In one study, young children were shown ordinary objects and were told that the objects were, in reality, different from what they appeared to be (e.g., they were told that a cookie was really a magnet). Children who could better imagine the objects' conflicting appearances and realities (gauged by their performance on appearance-reality tasks; e.g., Flavell, Flavell, & Green, 1983) demonstrated greater belief in the counter-perceptual claims (Lane, Harris, Gelman, & Wellman, 2014). Other research shows that when preschoolers are prompted to imagine an emotion-eliciting entity (e.g., a puppy or ice cream) inside a box that they had just witnessed to be empty, some children proceed to act as if those entities actually are in the box, and when subsequently interviewed do not completely discount that possibility (Harris, Brown, Marriott, Whittall, & Harmer, 1991; Johnson & Harris, 1994). Thus, the act of imagining that these emotion-eliciting entities were in the box might have increased some children's belief that they were actually present. Indeed, even adults' emotional reactions to imagined or pretend stimuli may affect their beliefs about and behaviors toward those stimuli (Rozin, Markwith, & Ross, 1990).

To examine the influence of the imagination on children's beliefs in the current study, children in the *imagination* condition (described earlier) were first asked to imagine improbable and impossible phenomena, reported whether they could do so, described what they had imagined, and then judged whether such phenomena could happen in real life. By contrast, children in a baseline condition were not asked to imagine the phenomena; they were asked only to judge whether the phenomena could happen in real life.

Given preschoolers' ability to distinguish between what they imagine and reality, we did not expect that merely attempting to imagine just anything would lead children to believe that it is real or possible. Rather, we expected at least two key, and interrelated, factors to moderate the impact of imagining phenomena on children's belief in their potential occurrence: (1) whether the phenomena can be achieved through ordinary causal mechanisms (i.e., whether they are improbable rather than impossible), and (2) the extent to which children can successfully imagine the phenomena. These two factors are interrelated

because, as described in the previous section, children may have more difficulty imagining impossible (vs. improbable) phenomena.

We anticipated that, as compared to children who were not asked to imagine the phenomena, children in the imagination condition would more often judge the improbable (i.e., more easily-imagined) phenomena as capable of happening in real life; we anticipated no group difference for belief in impossible phenomena – children in both groups and at all ages should rate them as unlikely to occur (Shtulman & Carey, 2007). Within the imagination group, we also anticipated that the *ease* with which phenomena are imagined will influence children's belief about the possibility of those phenomena: thus, we expected that (1) the phenomena children claimed to be unable to imagine would more often be later judged as unable to occur in real life; whereas (2) phenomena children imagined in greater detail – as indexed by their self-report – would more often be later judged as capable of occurring in real life.

Such a relation between children's imagination and their possibility judgments might help to account for an intriguing developmental pattern, mentioned earlier. Between the preschool years and middle childhood, children increasingly acknowledge that improbable phenomena – e.g., someone finding an alligator under his or her bed – can actually occur in real life (Shtulman, 2009; Shtulman & Carey, 2007). A plausible explanation for this developmental change, which we explore in the current study, is that older children are better *able* than younger children to imagine improbable phenomena. To test this hypothesis we evaluate age-related differences in children's descriptions of what they imagine and examine relations between such reported characteristics of children's imaginations and their subsequent possibility judgments. Alternatively, younger children might be less inclined to *spontaneously engage* in acts of the imagination and this might account for the developmental pattern found by Shtulman and colleagues. Indeed, prior work has demonstrated that *prompting* young children to imagine phenomena can lead young children to reason about those phenomena more like older children (Dias & Harris, 1990; Joh, Jaswal, & Keen, 2011). To test for this possibility we evaluate the effectiveness of our experimental manipulation—should age differences in deploying the imagination account for age differences in children's possibility judgments, then such age differences should diminish or disappear when children are prompted to imagine the phenomena.

2. Method

2.1. Participants

Participants included 78 children (44 boys) ranging in age from 4 to 8 years. Children were recruited during family visits to a science museum in the northeastern United States. An additional 5 children participated in the study but were excluded from analyses because they decided to end the interview session early or were notably distracted by other activities taking place in the museum. Participants were primarily Caucasian and from middle- to upper-middle-class socioeconomic backgrounds. Half of the children participated in an *imagination* condition (M_{age} = 6.34, SD = 1.20) and half participated in a *baseline* condition (M_{age} = 6.43, SD = 1.14).

2.2. Procedure

Each child was questioned about eight phenomena – four improbable and four impossible phenomena – presented in random order. Each of the eight items covered a different theme: running, talking, growing, apples, walking, onions, eggs, and dots

(see Appendix A). There were two interview versions. For approximately half of the children, the running, talking, growing, and apple items were improbable, whereas the walking, onion, egg, and dots items were impossible. The remaining half received a version in which the running, talking, growing, and apple items were impossible, and the walking, onion, egg, and dots items were improbable. The complete pool of 16 phenomena is presented in Appendix A. For each phenomenon, children were shown a picture to orient them (e.g., a prototypical jar of applesauce; see Appendix A for all 8 pictures) and were asked: "What's this?" Children's answers were either corrected or affirmed accordingly (e.g., "Right" or "No, that's applesauce"). Next, children were asked if they had ever *seen* the phenomenon (e.g., "Have you ever seen a person make blue applesauce?"). The picture was removed before moving to the next, focal questions.

Children in half of the sample (i.e., children in the *imagination condition*) were (i) asked to try to *imagine* the phenomenon (e.g., "Close your eyes, and imagine a person making blue applesauce."). The interviewer paused for several seconds and then (ii) asked if they could indeed imagine it ("Can you imagine that or not?"), and (iii) regardless of their answer to the latter question, asked children to describe what they imagined ("What do you see when you try to imagine that?"). Children in the other half of the sample (i.e., children in the *baseline condition*) were neither asked to imagine the phenomenon nor to describe what they were imagining. Next, participants in both conditions were asked the *belief* questions—their judgment of whether or not the phenomenon could happen in real life and their rating of their confidence in that judgment—e.g., "So, could a person make blue applesauce in real life, or not? Okay, you think that someone [could/could not] make blue applesauce in real life. Are you very, very sure or just a little sure?" This process was repeated for each of eight phenomena per child.

For each phenomenon, answers to the *belief* questions were scored such that 0 = very sure that the phenomenon could not happen, 1 = a little sure that the phenomenon could not happen, 2 = a little sure that the phenomenon could happen, and 3 = very sure that the phenomenon could happen. Thus, higher scores reflected greater belief that the phenomena could happen. A *belief-in-improbable* score was computed by averaging across the four improbable items, and a *belief-in-impossible* score was computed by averaging across the four impossible items.

2.2.1. Imagination coding

Children's answers were audio recorded (with parental permission) and transcribed. To categorize the descriptions of what children had imagined, provided by children in the *imagination* condition, the first and second authors devised a coding system, which categorized each response in terms of two focal qualities: (1) participants' mention of a *cause*, with three categories (no cause, ordinary cause, or extraordinary cause), and (2) participants' mention of an *outcome*, with four categories (no outcome, focal outcome obtained, focal outcome unattainable, or more ordinary outcome obtained). The coding system, including examples, is presented in Appendix B. Before coding, all open-ended responses were transferred to a separate data file that contained no additional information about participants. An initial, small batch of data was independently coded for practice by the first author and a research assistant who was unaware of the study's design, research questions, or hypotheses; coding discrepancies were noted and discussed. To establish inter-rater reliability, the two coders then independently coded 20% of the data (64 responses), for which they agreed on 100% of the Cause codes and 95% of the Outcome codes. Thus, the remaining 80% of the data were coded by the research assistant.

3. Results

We report our findings in two sections. First, to evaluate the *accommodation to fantasy* and *causal constraints* hypotheses, we report children's claims about whether they could imagine improbable and impossible phenomena, the characteristics of their imagination that they described, and relations between their claimed ability to imagine phenomena and those characteristics. Turning to our second question, we assess relations between children's imagination and their beliefs about whether improbable and impossible phenomena can really occur. Unless otherwise noted, the following analyses employ multi-level regression to account for the nesting of responses within children, and post hoc analyses are general linear hypothesis (GLH) tests.

3.1. Children's claims about their ability to imagine the improbable and the impossible

Recall that children in the *imagination* condition were asked whether they could imagine each phenomenon, and were then asked to describe what they had visualized. We first examine whether children were more likely to claim that they could imagine improbable rather than impossible phenomena and test whether this differentiation varied by age, using a multi-level logistic regression model with age as a continuous variable, type of phenomena (improbable = 1, impossible = 0), and the interaction between age and type of phenomena. This model significantly predicted the probability of a child saying that he or she could imagine a phenomenon, $\chi^2(3) = 14.07$, $p < 0.01$. As depicted in Fig. 1, there was a significant interaction between age and type of phenomenon, $B = 0.65$, $z = 2.38$, $p < 0.05$, 95% CI [0.11, 1.18]. Whereas there was a marginal age-graded decrease in the probability of children saying that they could imagine impossible phenomena, $B = -0.58$, $z = -1.87$, $p = 0.06$, 95% CI [−1.18, 0.03], there was no age-graded difference in their reports of imagining improbable phenomena. To further explore this interaction, we compared the two types of phenomena for children at 4-, 6-, and 8-years (see Fig. 2). At 4-years, there was no difference in the probability of children saying that they could imagine improbable as compared to impossible phenomena ($\chi^2(1) = 0.81$, *ns*) – they typically reported being able to imagine both. In contrast, at 6-years, children said that they were able to imagine improbable phenomena more often than impossible phenomena, ($\chi^2(1) = 3.90$, $p < 0.05$), and this difference was even greater at 8-years ($\chi^2(1) = 12.30$, $p < 0.001$).

In summary, all three age groups claimed that they could imagine the improbable phenomena but there was an age-graded decrease in claims that they could imagine the impossible phenomena.

3.2. Described characteristics of children's imagination

Regardless of whether children in the imagination condition had claimed that they could indeed imagine a particular phenomenon, they were subsequently asked to describe what they imagined. Table 1 presents the percentage of improbable and impossible phenomena for which children's descriptions fit into one of three categories with respect to cause and into one of four categories with respect to outcome. In the analyses presented below, we focus on children's use of the following five categories: (Causes) descriptions of either (i) *ordinary causes* or (ii) *extraordinary causes*, (Outcomes) descriptions in which either (i) the *focal phenomenon was unattainable*, (ii) the *focal phenomenon obtained*, or (iii) a *more ordinary phenomenon obtained*. We examine whether the percentage of children's descriptions falling into each of these categories varied by age and type of phenomena (improbable vs.
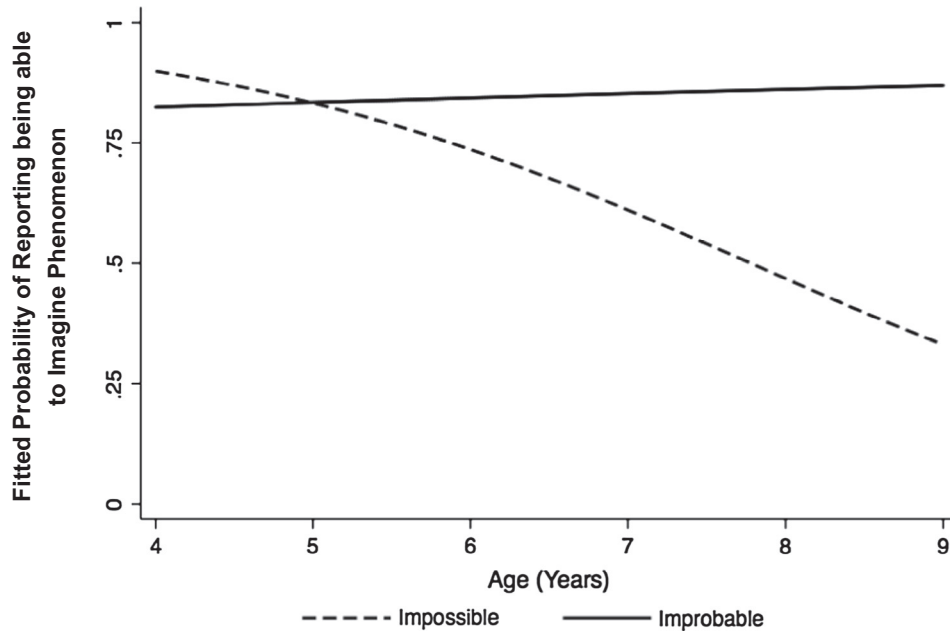
Fig. 1. Fitted probability of children reporting that they were able to imagine an item as a function of age for improbable phenomena (solid line) and impossible phenomena (dashed line).
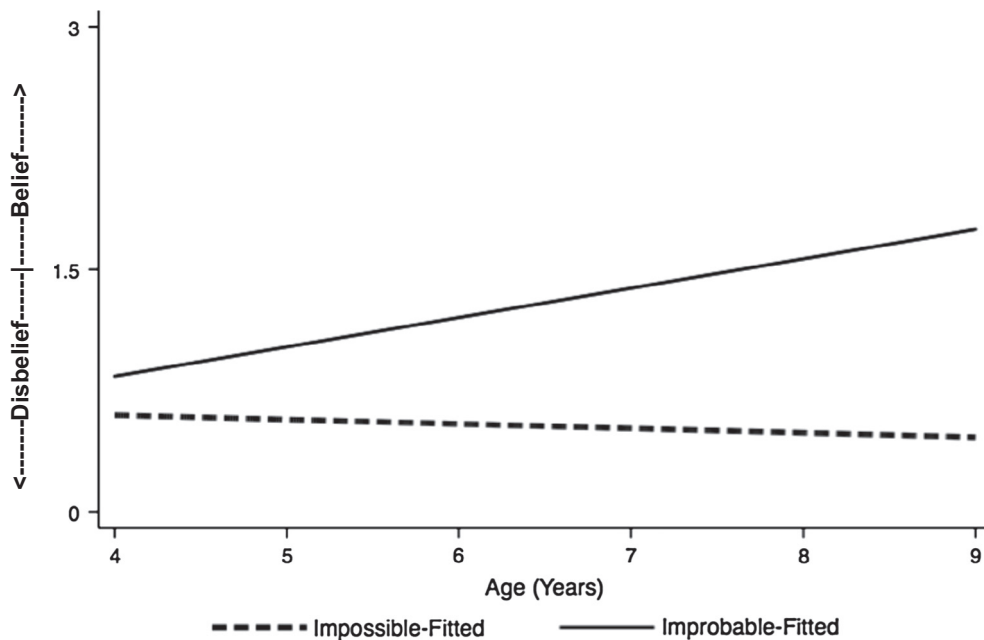

Fig. 2. Fitted belief as a function of age for improbable phenomena (solid line) and impossible phenomena (dashed line).

impossible phenomena). We fit multi-level logistic regression models to explore how children's use of each category is predicted by their age, the type of phenomenon, and the interaction between age and type of phenomenon. We report only statistically significant main effects and interactions (i.e., effects not mentioned are not statistically significant).

3.2.1. Imagining an ordinary cause

Overall, children described imagining ordinary causes for a modest proportion (16%) of the phenomena. Examples of such ordinary causal mechanisms include making onion juice by "squash[ing] an onion", and making blue applesauce by "putting blue food coloring and mixing it up into the applesauce." Our analyses revealed a marginally significant main effect of phenomena type ($B = 0.64$, $z = 1.84$, $p = 0.065$, 95% CI [−0.04, 1.33]), indicating that children described imagining ordinary causes more often for improbable than impossible phenomena.

3.2.2. Imagining an extraordinary cause

Children very rarely mentioned extraordinary causes – e.g., running for 10 hours with "magic boots", or going through a wall by "turning invisible" – they did so for just 5% of the phenomena. Their imagination of such causes did not significantly vary by age or type of phenomenon.

Table 1
Described characteristics of children's imagination of improbable and impossible phenomena.

	Improbable phenomena (%)	Impossible phenomena (%)
Cause		
No cause mentioned	77	81
Ordinary cause	19	12
Extraordinary cause	4	6
Outcome		
No outcome mentioned	44	49
Focal outcome obtained	33	28
Focal outcome unattainable	4	12
More ordinary outcome obtained	20	11

3.2.3. Comparing ordinary and extraordinary causes

Not surprisingly, a *t*-test confirmed that children mentioned ordinary causes ($M = 1.26$, $SD = 1.48$; out of a maximum score of 8.00) significantly more often than extraordinary causes ($M = 0.41$, $SD = 0.91$), $t(38) = 3.21$, $p < 0.01$.

3.2.4. Imagining that the focal outcome obtained

Children described imagining that the focal outcome obtained for a sizeable proportion (30%) of the phenomena. Such descriptions did not vary with age or phenomena type.

3.2.5. Describing that the focal outcome was unattainable

Overall, children rarely described that the focal outcome was unattainable—e.g., describing that they saw "a person trying to turn an onion into a banana but failing" or describing that they imagined "someone walking into a wall and banging their head" rather than walking *through* the wall—they provided these descriptions for just 8% of the phenomena. However, such descriptions increased with age, $B = 0.77$, $z = 2.34$, $p < 0.05$, 95% CI [0.13, 1.40] and were more frequent for impossible than improbable phenomena, $B = 1.43$, $z = 2.64$, $p < 0.01$, 95% CI [0.37, 2.49].

3.2.6. Imagining a more ordinary outcome

For a modest proportion of the phenomena (15%), children described imagining outcomes that were more ordinary than the prompted outcomes, e.g., someone running for "10 minutes" as opposed to 10 hours, or someone "walking around a brick wall" rather than through the wall. Children described these outcomes more often for improbable than for impossible phenomena, $B = 0.82$, $z = 2.33$, $p < 0.05$, 95% CI [0.13, 1.52].

In summary, children imagined ordinary causes for the phenomena more often than they imagined extraordinary causes. Children described imagining ordinary causes and more ordinary outcomes more often for improbable phenomena than impossible phenomena. In contrast, descriptions in which phenomena were *unattainable*, although generally rare, were more common for impossible phenomena than improbable phenomena. Taken together, children's descriptions indicate that they were more successful in imagining improbable as compared to impossible phenomena.

3.3. Relations between children's claims and subsequent descriptions

In what follows, we again concentrate on the five focal characteristics (i.e., *ordinary causes*, *extraordinary causes*, *phenomenon unattainable*, *phenomenon obtained*, *a more ordinary phenomenon obtained*), asking whether use of those characteristics varied depending on whether children had claimed that they could (or could not) imagine the phenomena in response to the initial, closed-ended questions. We do so using multi-level logistic

regression models. Age differences in children's imagination have been reported in prior sections, and preliminary analyses indicated that age did not statistically interact with any of the focal variables in the upcoming analyses and did not change our findings; thus to reduce redundancy in our reported findings, we do not enter age in the following analyses. Table 2 presents the percentage of responses falling into each of the coded categories, split by whether children claimed they could (vs. could not) imagine the phenomena.

Children described imagining ordinary causes 4 times as often for phenomena they claimed they could (vs. could not) imagine, $B = 1.60$, $z = 2.96$, $p < 0.01$, 95% CI [0.54, 2.66]; and reported imagining the focal outcome more than 4 times as often for phenomena they claimed they could (vs. could not) imagine, $B = 1.93$, $z = 4.37$, $p < 0.001$, 95% CI [1.07, 2.80]. In contrast, children said that the focal outcome could *not* obtain more than 6 times as often for phenomena they claimed they could *not* (vs. could) imagine, $B = 2.18$, $z = 3.84$, $p < 0.001$, 95% CI [1.07, 3.30].

Children's (rare) descriptions of extraordinary causes and their descriptions of imagining a more ordinary outcome did not vary with whether they claimed they could (vs. could not) imagine the phenomena.

In summary, after claiming that they could imagine phenomena, children often proceeded to describe ordinary causes that would support the phenomena obtaining and indeed to report that the focal outcome did obtain in their imagination. In contrast, after claiming that they could *not* imagine the phenomena, children more often went on to say that the phenomena could not or did not obtain in their imagination. Thus, children's initial claims about what they could or could not imagine were cogent in the sense that their subsequent descriptions were quite consistent with what they had initially claimed.

3.4. Interim discussion

Children across the age range of 4–8-years claimed that they could imagine improbable phenomena but there was an age-graded decrease in claims that they could imagine impossible phenomena, likely reflecting children's increasingly accurate (and less positive) assessment of their own capacities. Consistent with the *causal constraints* rather than the *accommodation to fantasy* hypothesis, children's descriptions seem to reflect an imagination anchored to reality. They described imagining ordinary causes more often than extraordinary causes. Indeed, children sometimes imagined outcomes that were more ordinary than those they had been asked to imagine. For improbable phenomena, children often described imagining ordinary causes and more ordinary outcomes obtaining whereas, for impossible phenomena, children often said that the phenomena were unattainable in their imagination.

Turning to the relation between children's initial claims about their imagination and their subsequent descriptions, when

Table 2
Described characteristics of children's imagination for phenomena that children claimed they could vs. could not imagine.

	Could imagine (%)	Could not imagine (%)
Cause		
No cause mentioned	74	92
Ordinary cause	20	5
Extraordinary cause	6	3
Outcome		
No outcome mentioned	42	56
Focal outcome obtained	40	9
Focal outcome unattainable	3	19
More ordinary outcome obtained	15	16

children claimed that they could imagine phenomena, they were more likely to subsequently describe ordinary causes that would support the phenomena obtaining and more often described that they had imagined the focal outcome obtain. In contrast, when children claimed they could *not* imagine phenomena, they were much more likely to subsequently describe that the phenomena could not or would not obtain in their imagination. Thus, children's initial claims of having imagined the phenomena seem to be closely tied to successfully imagining causes and outcomes.

In the next sections, we report on children's *beliefs* in the potential real-life occurrence of these phenomena, and we explore relations between imagination and belief in three ways: (1) by assessing whether children's beliefs were affected by their having been prompted to imagine the phenomena before stating their beliefs, (2) by examining relations between children's beliefs and their prior claims to have imagined the phenomena, and (3) by examining relations between beliefs and specific characteristics of children's imaginations.

3.5. Children's belief in the improbable and the impossible

Children in both the *imagination* and *baseline* conditions were asked how sure they were that the four improbable phenomena and the four impossible phenomena could happen in real life, with scores ranging from 0 (very sure the phenomena could not happen) to 3 (very sure the phenomena could happen). Children's average belief ratings for each phenomenon are presented in Table 3. Note that, for each of the eight phenomena pairs (e.g., walking), children reported greater belief in each improbable phenomenon compared to its impossible counterpart, and these differences were significant for all but one of the pairs. Thus, on the whole, children differentiated between impossible and improbable items across a variety of topics and domains. However, as seen in Table 3, there was variability in children's belief in the phenomena both within-item (as judged by the standard deviations), and between topics. Other studies have identified similar variability in children's evaluations of phenomena across topics (e.g., Shtulman & Carey, 2007) and such variability is particularly important in the current study as we explore how other factors co-vary with children's belief.

As a first step in examining how children's beliefs vary by both age and by type of phenomena, our regression model included age as a continuous variable, type of phenomena (improbable = 1, impossible = 0), and the interaction between age and type of phenomena. (Note that in this initial analysis we did not include condition as a factor). These predictors collectively explained a significant portion of the variance in children's belief, $\chi^2(3) = 103.38$, $p < 0.001$, $R^2_{within} = 0.16$, $R^2_{between} = 0.02$, and the interaction of Age × Type of Phenomena was significant, $B = 0.21$, $z = 3.13$, $p < 0.01$, 95% CI [0.08, 0.34]. Fig. 2 displays this interaction, with

children's belief plotted as a function of age for improbable phenomena (solid line) and impossible phenomena (dashed line). As is clear in that figure, there was a significant age-graded increase in children's belief in improbable phenomena, $B = 0.18$, $z = 2.77$, $p < 0.01$, 95% CI [0.05, 0.31], but no such increase in children's belief in impossible phenomena, $B = -0.03$, $z = -0.42$, *ns*, 95% CI [−0.16, 0.10].

To compare children's belief in improbable and impossible phenomena, we conducted 3 post hoc GLH tests at 4-, 6- and 8-years (the same ages targeted in prior research on children's belief in the improbable and impossible; e.g., Shtulman & Carey, 2007). At 4-years, there was no difference in belief in improbable and impossible phenomena ($\chi^2(1) = 1.84$, *ns*). In contrast, at 6- and 8-years, children's belief in improbable phenomena was greater than their belief in impossible phenomena ($\chi^2(1) = 65.52$, $p < 0.001$; $\chi^2(1) = 65.88$ $p < 0.001$, respectively). All three age groups, 4-, 6- and 8-year-olds, expressed significant disbelief in impossible phenomena (i.e., average belief below 1.50; $\chi^2(1) = 26.96$, $p < 0.001$; $\chi^2(1) = 143.76$ $p < 0.001$, $\chi^2(1) = 60.42$ $p < 0.001$, respectively). Four- and 6-years-olds also expressed significant disbelief in improbable phenomena, ($\chi^2(1) = 14.52$, $p < 0.001$; $\chi^2(1) = 13.96$ $p < 0.001$, respectively), but 8-year-olds expressed neither significant belief nor significant disbelief ($\chi^2(1) = 0.25$, *ns*).

Thus, we observed the same developmental pattern as Shtulman (2009) and Shtulman and Carey (2007), using slightly different phenomena. With age, children increasingly reported that improbable phenomena could happen in real life. In contrast, children across the age range reported that they were very sure that impossible phenomena could not happen in real life.

3.6. The influence of prompting children's imagination on belief

Next, we tested whether condition (i.e., having been asked vs. not asked to imagine the phenomena) influenced children's belief that those phenomena could really happen. We ran four additional regression models, building upon the model reported earlier. In these models, we sequentially added the main effect of condition (imagine = 1, control = 0), the interaction between condition and type of phenomena, the interaction between condition and age, and the three-way interaction between condition, type of phenomena, and age. In all models, the interaction of Age × Type of Phenomena remained the sole statistically significant term. Thus, having been asked to imagine the phenomena had no effect on children's subsequent reported belief; this was true for both improbable and impossible phenomena and was true across all ages.

As a more stringent test, we replicated our analyses limiting data for children in the *imagination* condition to just those phenomena that children claimed to be *able* to imagine when answering the initial, closed-ended questions, "Can you imagine that or not?" We still found no effect of being asked to imagine the phenomena on children's belief. Thus, prompting children's imagination appeared to have no influence on their subsequent beliefs even when children had claimed that they could imagine the phenomena in question.

3.7. Relations between children's claims about imagining phenomena and their beliefs

Next, we asked if individual differences among children in their claims of being able to imagine the phenomena were related to their belief in those phenomena. We regressed children's belief strength on whether children had claimed to be able to imagine the phenomena (yes = 1, no = 0), the type of phenomena (improbable = 1, impossible = 0), the interaction between these two

Table 3
Mean belief ratings for each phenomenon.

	Improbable		Impossible		*t*-tests
	M	*(SD)*	*M*	*(SD)*	
Run	1.69	(1.22)	1.06	(1.12)	$t(76) = 2.38^*$
Talk	1.20	(1.23)	0.82	(1.10)	$t(76) = 1.44$
Grow	1.05	(1.10)	0.28	(0.51)	$t(59.85) = 4.04^{***,a}$
Apples	1.24	(1.23)	0.57	(0.95)	$t(75.28) = 2.71^{**,a}$
Walk	1.03	(1.23)	0.24	(0.58)	$t(47.96) = 3.53^{***,a}$
Onion	1.25	(1.14)	0.48	(0.94)	$t(76) = 3.29^{**}$
Egg	1.15	(1.20)	0.57	(0.99)	$t(76) = 2.34^*$
Dots	1.56	(1.27)	0.36	(0.76)	$t(55.17) = 4.94^{***,a}$

[a] Corrected for unequal variances between groups.
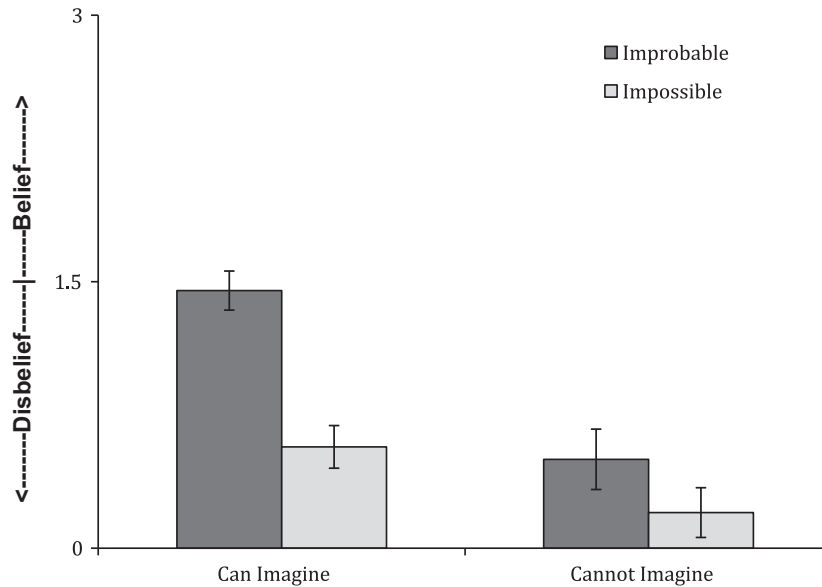[*] $p < 0.05$.
[**] $p < 0.01$.
[***] $p < 0.001$.

Fig. 3. Fitted belief for improbable (dark grey) and impossible (light grey) phenomena children reported they could vs. could not imagine. Error bars reflect ±1 Standard Error of the Mean.

variables, age (as a continuous variable), and the interaction between age and type of phenomena. These five predictors explained a significant proportion of the variance in children's beliefs, $\chi^2(5) = 88.98$, $p < 0.001$, $R^2_{within} = 0.26$, $R^2_{between} = 0.00$. Age and its interaction with type of phenomena were both non-significant ($B = 0.03$, $z = 0.30$, ns, 95% CI [-0.14, 0.19], $B = 0.09$, $z = 1.06$, ns, 95% CI [-0.08, 0.27]), whereas the interaction between the type of phenomena and children's claims about imagining the phenomena was significant, $B = 0.58$, $z = 2.48$, $p < 0.05$, 95% CI [0.12, 1.04]. Because age and its interaction were not significant predictors of belief, we ran a more parsimonious model that included being able to imagine the phenomena, type of phenomena, and their interaction. These three predictors continued to account for a significant proportion of the variance in children's beliefs, $\chi^2(3) = 86.45$, $p < 0.001$, $R^2_{within} = 0.26$, $R^2_{between} = 0.00$. Being able to imagine the phenomena predicted greater belief ($B = 0.37$, $z = 2.23$, $p < 0.05$, 95% CI [0.05, 0.70]), and being able to imagine the phenomena significantly interacted with the type of phenomena, $B = 0.58$, $z = 2.48$, $p < 0.05$, 95% CI [0.12, 1.04].

Fig. 3 displays the significant interaction of Type of Phenomena $\times$ Claims of being able to imagine the phenomena. Children reported greater belief in both improbable and impossible phenomena when they claimed to have imagined the phenomena, but this effect was much stronger for improbable phenomena ($B = 0.95$, $z = 5.13$, $p < 0.001$, 95% CI [0.59, 1.32]), than for impossible phenomena, $B = 0.37$, $z = 2.23$, $p < 0.05$, 95% CI [0.05, 0.70].

Because these are correlational data, another way to interpret the relation between imagination and belief is to consider belief as a proxy for children's prior knowledge and intuitions (insofar as beliefs about novel phenomena are highly influenced by and thus highly correlated with children's knowledge and intuitions about those phenomena; Chan & Tardif, 2013; Lane & Harris, 2015). Viewed this way, the relation might go from belief (serving as a proxy for prior knowledge and intuition) to imagination. Thus, we asked if children's reported belief in phenomena predicted their ability to imagine those phenomena. To examine this possibility, we regressed children's claims of being able to imagine phenomena on age (continuous), the type of phenomena (improbable = 1, impossible = 0), the interaction of age and type of phenomena, and belief. This model significantly predicted the probability of a child saying that they could imagine a phenomenon, $\chi^2(4)$

$= 27.73$, $p < 0.001$. As might be expected from these correlational data, belief significantly predicted children's reports of being able to imagine phenomena, $B = 0.91$, $z = 4.36$, $p < 0.001$, 95% CI [0.50, 1.32] (in addition to the significant interaction of age and type of phenomena, reported earlier; $B = 0.75$, $z = 2.41$, $p < 0.05$, 95% CI [0.14, 1.35]). Fig. 4 shows that children more often claimed that they could imagine a phenomenon when they had a stronger belief in its actual occurrence. As indicated by the parallel lines, the strength of this association between imagination and belief was robust – it did not vary with age or type of phenomenon.

In summary, children's claims about whether they could imagine a phenomenon were linked to the strength of their belief in that phenomenon. The first analysis showed that children expressed greater belief in phenomena, especially improbable phenomena, which they were able to imagine. The second analysis showed that the greater children's belief that a phenomenon could really occur, the more likely they were to have claimed that they could imagine it.

3.8. Relations between described characteristics of children's imagination and beliefs

We next examine relations between described characteristics of children's imagination and their stated beliefs. Table 4 presents the percentage of children's descriptions falling into the cause categories and outcome categories, split by their stated belief in those phenomena. In what follows, we examine whether the five focal characteristics of children's reports vary significantly by children's stated belief in those phenomena. Age differences in children's beliefs have been reported in prior sections, and preliminary analyses indicated that age did not statistically interact with any variables in the upcoming analyses; thus to reduce redundancy in our reported findings, we did not enter age in the following analyses.

The greater children's belief in phenomena, the more often they described imagining an *ordinary cause* ($B = 0.46$, $z = 2.95$, $p < 0.01$, 95% CI [0.15, 0.76]), and the more often they described having imagined the *focal outcome obtain* ($B = 0.30$, $z = 2.22$, $p < 0.05$, 95% CI [0.04, 0.57]). Conversely, the greater children's disbelief in phenomena, the more likely they were to have described that the focal outcome was *unattainable* in their imagination ($B = 0.94$, $z = 2.45$, $p < 0.01$, 95% CI [0.19, 1.69]).
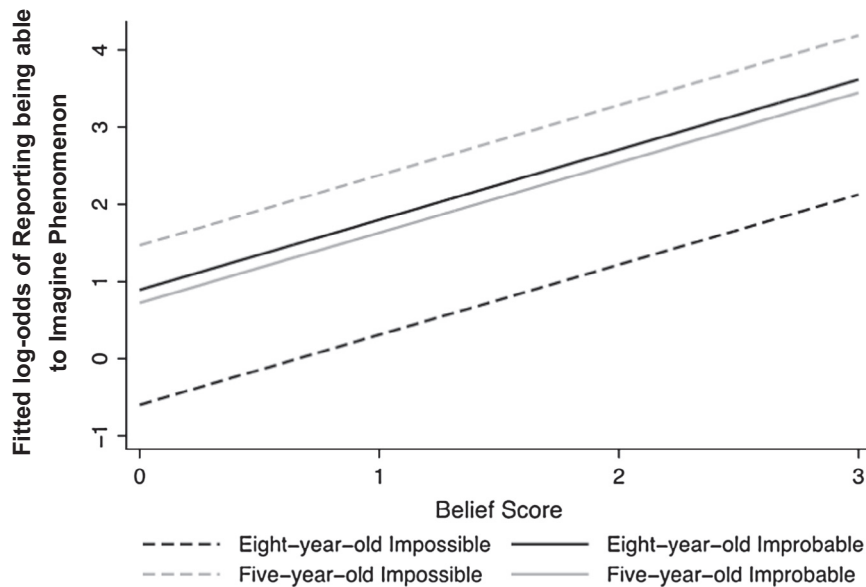
Fig. 4. Fitted log-odds of reporting being able to imagine phenomena as a function of stated belief for improbable phenomena (solid lines) and impossible phenomena (dashed lines) for an 8-year-old child (black lines) and a five-year-old child (grey lines).

Table 4
Described characteristics of children's imagination as a function of children's stated belief in the phenomena.

	Very Sure can't happen (%)	A little sure can't happen (%)	A little sure can happen (%)	Very sure can happen (%)
Cause				
No cause mentioned	84	76	70	73
Ordinary cause	10	16	30	27
Extraordinary cause	6	7	0	0
Outcome				
None mentioned	50	42	40	44
Focal outcome obtained	26	31	37	40
Focal outcome unattainable	10	9	3	0
More ordinary outcome obtained	14	18	20	16

As depicted in Table 4, the relation between children's imagination of extraordinary causes and their beliefs was non-linear; its step-like shape precluded our use of logistic regression. Thus, we combined the two "can happen" cells and the two "can't happen" cells and conducted a chi-square analysis, revealing a significant association between mentioning an extraordinary cause for a phenomenon and belief in that phenomenon, $\chi^2(1, n = 307) = 5.10$, $p < 0.05$, $V = 0.13$. For phenomena that children believed could *not* happen, a small portion (6.5%) were described in terms of an extraordinary cause; whereas none of the phenomena that children reported could happen were described in terms of such causes.

There was no relation between children's stated belief in the phenomena and their descriptions of having imagined a *more ordinary outcome*.

Thus, when children described imagining ordinary causes or imagining outcomes obtain, they often expressed the belief that the phenomena could indeed happen in real life, but when children said that the outcomes were unattainable in their imagination or when they mentioned extraordinary causes, they more often expressed the belief that the phenomena could not happen in real life.

4. General discussion

The current findings shed light on the qualities and development of children's imagination. As well, they highlight a close link

between children's imagination of phenomena and their stated beliefs about whether those phenomena can really occur. Children across the age range of 4–8 years claimed that they could imagine improbable phenomena but there was an age-graded decrease in children's claims that they could imagine impossible phenomena. Children described imagining ordinary causes for phenomena more frequently than they described imagining extraordinary causes, and children more often stated that phenomena could occur in real life when they claimed that they were able to imagine the phenomena. Finally, prompting children to imagine phenomena did not influence their beliefs at any age. These data suggest that the quality of children's imagination changes during early and middle childhood and such development is at least partly responsible for children's increasing willingness to concede that improbable phenomena can occur in real life.

4.1. Children's reports of imagining phenomena

Before delving further into the implications of these findings, it is important to first consider how children interpreted our "imagination" questions. Recall that children were given instructions such as: "Close your eyes, and imagine a person making blue applesauce. Can you imagine that or not?" Conceivably, children might have misinterpreted such instructions, especially the word 'imagine'. They may have thought that they were being invited to remember whether they had really seen such a phenomenon rather than to simply imagine it. If they found it difficult to

remember instances of those phenomena, their descriptions of what they imagined might simply reflect these prior experiences or lack of such experiences. However, children's descriptions of their imaginings strongly suggest that they were not confusing imagining with remembering. Their descriptions rarely, if ever, took the form of an episodic memory about a past event or of a denial that it was possible to remember such an event. Instead, their responses often referred to generic actors (e.g., "someone", "a person", "a girl") performing (or failing to perform) an action in the present, or they simply referred to the outcome.

Another possibility is that children interpreted questions about their imagination and questions about real life as one and the same. Thus, the question, "Can you imagine that or not?" was interpreted to mean, "Do you think it is likely" or "Do you think it is possible?" Note that, in everyday conversation, we sometimes do use 'imagine' in this way. An example would be when a person says: "I can't imagine her accepting that offer…", implying that he or she has judged the event to be highly improbable. However, it is unlikely that children interpreted the questions about their imagination in this way. First, young children can distinguish between phenomena that they are asked to "imagine" and phenomena that they have perceived in real life (Estes et al., 1989; Wellman & Estes, 1986; Woolley & Wellman, 1993). Second, if some children did misinterpret the question, it might be expected that the youngest children would do so most often. Yet the youngest children were both most likely to report that they *could* imagine the phenomena and to report that the phenomena could *not* happen in real life. Still, it is possible that children used what they could imagine to *guide* their judgments about what could happen in real life; we return to this possibility later.

Even if children across the age range appropriately interpreted the request as it was intended, other data nonetheless suggest some over-optimism among the youngest children about what they could imagine. In response to the initial closed-ended question about whether they could imagine a given phenomenon, the youngest children were equally likely to claim that they could imagine improbable and impossible phenomena. Older children were as likely as the youngest children to claim that they could imagine improbable phenomena, but they acknowledged that they could imagine impossible phenomena much less often. Importantly, younger children's over-reporting of their successful attempts at imagining cannot be credited to a general "Yes-bias", as children of this age were also the most likely to report that "No" the phenomena cannot occur in real life. The responses of the youngest children can be plausibly attributed to their general tendency to overestimate their abilities across a wide range of activities and tasks (Bjorklund, 1997). Older children might have more accurately estimated their imaginative capacities, as indicated by their claimed inability to imagine many impossible phenomena and by their subsequent reports of having imagined the phenomena *not* obtain (e.g., "Someone walking into a wall and banging their head" rather than going through the wall). A complementary account is that what constitutes successfully "imagining" something is different for younger and older children. For older children, the richness of what they imagine influences their judgments of whether they actually imagined a phenomenon, whereas for younger children the mere imaginative attempt might suffice for them to conclude that they imagined a phenomenon.

A final alternative interpretation of children's responses to the imagination questions is that they were reporting on their preferences rather than their abilities. However, the imagination questions were phrased specifically to elicit children's reports of their ability; they were asked, "Can you imagine that, or not?", rather than "Would you like to imagine that?" or "Would you like that to happen?" Empirically, if the youngest children were reporting on their preferences, then drawing upon research demonstrating

that 4-year-olds prefer the realistic vs. the fantastical in certain contexts (e.g., Sobel & Weisberg, 2014; Weisberg et al., 2013), we would expect them to report *not* imagining the improbable or impossible phenomena in the current study. Yet the youngest children in the current study apparently *over*-reported their ability to imagine phenomena (including phenomena that older children claimed to be unable to imagine), a finding that suggests that they were responding in terms of what they thought they were *capable* of imagining rather than what they preferred to think about.

4.2. Characteristics of children's imaginations

Turning now to the broader implications of the findings, it is often assumed, as discussed in the introduction, that children enjoy a rich imagination, which allows them to indulge in fantasies that violate ordinary causal constraints. Our data, by contrast, paint a different picture, consistent with recent evidence that children are not biased toward the fantastical; indeed, they might engage in and might prefer fantasy less so than adults (e.g., Barnes et al., 2015; Weisberg et al., 2013). Although the youngest children may have over-estimated their ability to imagine the impossible, children across the age range generally acknowledged that they could not imagine a phenomenon that they judged could not happen in reality. Moreover, the characteristics of the scenarios that children did imagine were relatively mundane. For example, children more often described ordinary causes that would yield the phenomena than extraordinary causes, consistent with prior findings on children's counterfactual reasoning (e.g., Sobel, 2004). Indeed, for a modest proportion of the improbable phenomena (19%), children described imagining more ordinary outcomes than the ones that they had been prompted to imagine. All of these findings are consistent with the *causal constraints* hypothesis and inconsistent with the *accommodation to fantasy* hypothesis – young children's imagination is not a vehicle in which they regularly enjoy extraordinary flights of fancy; instead, it is a vehicle that remains remarkably close to the contours of everyday reality.

At first blush, these results demonstrating children's fixation on the realistic and mundane may seem inconsistent with work on children's reasoning from counterfactual premises (e.g., Dias & Harris, 1990; Richards & Sanderson, 1999). In that work, preschoolers were asked to reason through syllogisms such as, "All snow is black. Tom touches some snow. Is it black?" Ordinarily, young children demonstrate an empirical or reality bias, e.g., they report that the snow is, in fact, not black. However, when children are instructed to "make a picture inside your head" following the first premise, and children describe what they imagined, they often go on to reason through the syllogism like older, formally-educated, children and adults, e.g., reporting that Tom touched black snow. However, the current study departs from that prior work in an important way. Following Shtulman (2009) and Shtulman and Carey (2007), children in the current study were not asked to reason about static phenomena, such as blue applesauce (an item nicely parallel to Dias and Harris's (1990) black snow). Instead, children were asked to imagine people pursuing improbable or impossible outcomes, e.g., someone *producing* blue applesauce. When children are asked to imagine such phenomena they are being invited to imagine the action, the sequence of steps through which blue applesauce is obtained. So, even if blue applesauce is an outcome that children can easily imagine, they have difficulty in imagining someone *producing* such an outcome. This distinction between the production process and the outcome is supported by our data—for phenomena that children reported that they could imagine, obtained outcomes were imagined for 40% of those phenomena, whereas processes or causal mechanisms through which the outcomes obtained were imagined for only 20% of those phenomena.

The current results might also initially seem inconsistent with findings from Joh et al. (2011), who examined the influence of imagination on children's judgments about physical motion. When asked about the trajectory of falling objects, 3-year-olds typically have a gravity bias—they tend to predict that objects, e.g., balls, will fall straight down from where they are dropped, even if those balls are dropped in (and thus their trajectories constrained by) a curved tube (Hood, 1995). However, when prompted to *imagine* a ball rolling down a curved tube, 3-year-olds accurately predict that the ball would land in a cup positioned directly beneath the tube's bottom rather than directly beneath the tube's top. This finding clearly demonstrates an effect of engaging in imagination on children's judgments. However, in contrast to the current study, Joh et al. (2011) specifically told children to imagine the causal mechanism (the ball rolling down the tube) that would yield the outcome (the ball landing directly beneath the tube's bottom) and the curved tube was right before their eyes the whole time. Thus, in Joh et al. (2011), children's imagination helped to pull them away from their cognitive bias and to focus instead on the data at hand, namely the way in which the ball's downward trajectory was constrained by the walls of the curved tube. In contrast, in the current study, children had to *generate*, via their imagination, the causal mechanisms through which the phenomena would obtain, and children rarely did so. Prompting young children to imagine phenomena may lead them to override certain intuitive biases about phenomena (e.g., an empirical bias or a gravity bias) when the range of possible solutions is small and well defined (e.g., when choosing if a ball will fall in one location or the other; or when determining whether hypothetical snow will be black or white). However, such prompting may prove ineffective when the range of possibilities is less determinate, as was the case when children were asked to imagine phenomena in the current study—there were numerous causal mechanisms by which children could have imagined the phenomena obtain, but these mechanisms were neither mentioned nor shown to children.

Based on these data, our general conclusion is that the causal relations found within young children's imagination tend to resemble the relations that are found in the real world. Additional research is needed to further test this conclusion. For example, when children are read stories that tell of unusual causal sequences and improbable or impossible outcomes, to what extent do children mentally represent those occurrences vs. passively observe them on the book's pages?

4.3. Relations between imagination and belief

We observed a close relationship between children's imagination and their stated beliefs. There are three plausible interpretations of this link. One interpretation is that children's imaginings guide their beliefs about what can actually happen. A second interpretation is that children's knowledge about causality guides their beliefs about what can really happen and also guides their imaginings. A third interpretation involves both directions of influence: children's knowledge about causality guides their imaginings but their imaginings can also guide their beliefs about what can actually happen. Below, we scrutinize each of these possibilities in turn.

The first interpretation—that children's imagination guides their beliefs about what can actually happen—implies that when asked if a given phenomenon can happen, children first engage their imagination. In some cases, they succeed in imagining the phenomenon and in other cases they fail. Then, they use the outcome of their imagination to decide what can and cannot happen. They judge phenomena that they can imagine to be possible in real life and they judge phenomena that they cannot imagine to be impossible. This interpretation would account for the relations that we find between characteristics of children's imaginations—their

tendencies to have imagined ordinary causes and to have imagined the phenomena obtain—and their subsequent belief in those phenomena. To take a concrete example, when asked if a person could walk through a brick wall, children try to imagine that outcome, fail to visualize how it could come about, and confidently conclude that such an outcome cannot really happen.

As noted in the introduction, this interpretation has some support from research on children's belief in others' counter-perceptual claims (Lane et al., 2014), and from research on children's belief in imagined entities (Harris et al., 1991; Johnson & Harris, 1994). Although not implausible, this interpretation faces two difficulties. First, it offers no explanation of *why* certain attempts at imagining phenomena succeed and others fail. The second weakness concerns the similarity between the baseline and imagination groups in their beliefs about what can really happen. Children in the imagination group were systematically invited to imagine phenomena before they went on to state their beliefs about whether those phenomena can actually happen. By contrast, children in the baseline group received no such invitation—they proceeded immediately to state their beliefs. Yet children in these two groups made very similar judgments about what can actually happen. If children were inclined to use their imagination as a heuristic for arriving at beliefs about what can actually happen, we might expect children who were systematically prompted to use their imagination to reach different, or at least more differentiated beliefs, about what can actually happen, as compared to children who received no such prompts.

Admittedly, one possible explanation for the lack of an effect of our manipulation is that when children were asked whether a given outcome can occur, they automatically deployed their imagination even when not prompted to do so. On this view, prompting children to use their imagination would have no impact on their subsequent beliefs because all children, whether prompted or not, spontaneously used their imagination to make judgments about whether an outcome can actually occur. In principle, this explanation might account for why we found no effect of prompting children to use their imagination. However, this interpretation does not explain why children sometimes reported being able to imagine the phenomena and sometimes not, why children's descriptions of what they imagined varied by age and by phenomena type, or why children's reports and descriptions of what they imagined should bear any relation to likelihood in the real world. Accordingly, we turn next to the second interpretation.

The second interpretation is that children's general knowledge and theories about the way the world actually works guide their beliefs about what can happen and also guide their spontaneous imaginings. Children of 4–8 years have a reservoir of knowledge about the way the world works; indeed, even young infants possess some of that knowledge, e.g., they understand that one solid object cannot pass through another (Spelke, Breinlinger, Macomber, & Jacobson, 1992). Thus, when asked whether a person can pass through a wall, children consult their knowledge and theories and state that it cannot really happen. We may further assume that children's knowledge and theories also constrain their imagination. Thus, when asked if they can imagine a person passing through a wall, they try to do so but fail because whatever they imagine is constrained by their knowledge that solid objects are not typically penetrable. Thus, their imagination is grounded in, and constrained by, their knowledge of reality.

Note that this interpretation is consistent with findings on young children's pretend play (Harris & Kavanaugh, 1993). When 2- and 3-year-olds watch a play partner 'pour' pretend tea from an empty teapot or 'shake' pretend talcum powder from an empty can, they work out the implications of their partner's pretend actions, guided by their understanding of ordinary causal constraints. They anticipate that the pretend tea or the pretend

powder will fall downward rather than rise upward or move horizontally. They also anticipate that the impact on a lower surface will vary depending on the pretend substance, e.g., the lower surface will be made wet by the tea but not by the powder. Thus, there is evidence that, even in early childhood, the outcomes that children imagine are guided by their naïve theories and knowledge of real-world causality.

There is, however, a plausible objection to the proposal that whenever children reported their beliefs about the actual likelihood of a phenomenon they simply consulted their naïve theories and stored knowledge. In the case of certain items, such naïve theories and stored knowledge do seem a feasible basis for making a judgment. For example, children are likely to have a wealth of stored knowledge and strong intuitions that people cannot pass through solid objects (indeed, they will have personal experience of bumping into, but not going through, solid objects). Hence, when they are asked to judge whether such an outcome is possible, they consult their knowledge and naïve theories and pronounce that such an outcome is impossible. For other items, however, children—especially younger children—are not likely to have much relevant stored knowledge. For example, they are unlikely to have rich knowledge about interacting with fire, and they are unlikely to have thought about whether or how a person can walk through fire.
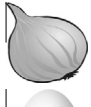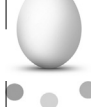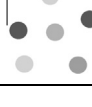
Granted this objection, we turn to the third interpretation, namely that although children's knowledge and theories often guide their imaginings, their imaginings may sometimes inform their stated beliefs about what can actually happen. Consider the following two-stage process. At the first stage, when asked whether an outcome is possible, children consult their general knowledge and theories. For some items, this stored knowledge supplies a definite answer and no recourse to the imagination is needed. For example, when asked if a person can walk through a wall, the child may know enough about object solidity to judge—without any further reflection—that such a phenomenon definitely cannot happen. Indeed, both preschoolers and adults do deny that such events can happen (Schult & Wellman, 1997; Shtulman, 2009; Weisberg & Sobel, 2012). For other items, however, no relevant stored knowledge may be available. For example, young children are unlikely to have much knowledge about whether or how a person could walk through fire. For some children, especially younger children, this *lack* of knowledge might be reason enough for them to conclude that the phenomenon is impossible; this proposal is similar to one put forward by Shtulman (2009) and Shtulman and Carey (2007). For other, typically older, children, it is feasible that these items are moved on to a second stage of processing; the imagination is engaged to further evaluate the plausibility of the outcome. Guided by their naïve theories and various items in stored knowledge (e.g., "fire is very hot", "very hot water hurts", "if you put your hand under hot water only briefly, it doesn't hurt as much", and "dad holds hot pans with a mitt") older children might use their imagination to envisage a process that would achieve an outcome that they previously had never thought about, e.g., someone walking through fire very quickly or walking through fire with a protective garment. Having succeeded in imagining that phenomenon, children might conclude that it could actually happen in real life. Younger children, having a less robust store of knowledge about phenomena within that domain, might be less able to conjure up the novel phenomena in their imagination even when they are prompted to do so (as were children in our *imagination* condition).

For now, this third interpretation seems the most plausible account for the various findings reported in the present study,

but further research will be needed to make a firm choice among the three interpretations. One particularly intriguing direction for future research—pertinent to the second and third interpretations—would be to examine how manipulating children's knowledge influences the quality of their imagination.

In summary, the current findings, along with other recent work, indicate that children's mental lives are different from the popular depiction. They are not imbued with fantastical acts and impossible transformations. Instead, we demonstrate that both children's imagination and their beliefs are closely tied to reality. Additionally, the current data join data from adults to reveal that links between imagination and belief emerge in childhood. Future research is needed to examine how reality biases are overcome in the course of development, and how the associations between imagination and belief function across the lifespan. Importantly, there are cases in which individuals may believe in the possibility or reality of phenomena even if they are unable to fully imagine those phenomena. Other factors, such as verbal or written testimony, might play a substantial role in such counter-intuitive beliefs (Harris, 2012). Thus, future work should address how the imageability of phenomena interacts with other factors, such as testimony about those phenomena, in influencing belief and disbelief across development.

Appendix A. Phenomena

	Improbable Version	Impossible Version
	A person run for 10 hours?	A person run for 10 days?
	A person talk without moving their lips?	A person speak two languages at the same time?
	A person grow a beard down to their toes?	A person grow from an adult back into a baby?
	A person make blue applesauce?	A person turn applesauce back into an apple?
	A person walk through a fire?	A person walk through a brick wall?
	A person make onion juice?	A person turn an onion into a banana?
	A person put a broken egg back together?	A person turn a scrambled egg back into a whole egg?
	A person paint polka dots on an airplane?	A person paint polka dots on clouds?

Appendix B. Coding for children's descriptions in response to the question, "What do you see when you try to imagine that?

Cause:

No cause mentioned beyond prompt or cause unrelated to expected outcome:

Run: "Someone running"

Talk: "I see a girl who's saying something without moving their lips"

Grow: "A really old, um, and he has a cane and a very long beard"; "Person w/ beard shrinking back into a baby"

Walk: "A person that walked through a brick wall"; "Someone walk around a brick wall"; "Person putting his foot up into the wall"

Onion: "Someone trying to cut a banana and try to go inside it and see if they can make into"

Egg: "Someone turning scrambled eggs into breakfast"

Paint: "An airplane and a person painting it on the airplane"

Ordinary causal mechanism related to prompted outcome:

Run: "A little boy putting foot up and hard up and stomping down"

Walk: "Fire fighter walking through a fire, trying to put it out"; "A person kicking a wall"

Onion: "Person that squashed an onion and it made juice"

Applesauce: "Putting blue food coloring and mixing it up into the applesauce"; "Blue apples being crushed"

Grow: "I see a guy growing his beard for a long, long time";

Paint: "Someone painting a picture of someone painting polka dots on clouds"; "The airplane is on the ground with its wheels out and a person painting polka dots on it"; "Person stepping on clouds, painting dots"

Egg: "I think I could do that. Like, an egg and you fit the pieces back together"

Talking: "Person saying words halfway in English, halfway in not English"

Extraordinary or magical causal mechanism:

Run: "A person who's running for 10 hours with magic boots"

Walk: "Someone just turning invisible for 1 second and going through the wall"

Onion: "Magician with an onion, he puts it in his top hat, waves his wand and takes out a banana"

Egg: "A magician doing it, like doing a magic trick to do that"

Outcome:

No outcome, starting point, irrelevant outcome, or attempt without clear outcome:

Run: "I saw this person running and keep running and eating and drinking while running" (*unclear outcome*)

Talk: "A human" (*no outcome*); "Someone like this..." [makes facial expression] (*unclear outcome*)

Grow: "I see a guy growing his beard for a long, long time" (*unclear outcome*)

Walk: "I can see a person trying to walk through a brick wall" (*unclear outcome*)

Egg: "Someone turning scrambled eggs into breakfast" (*irrelevant outcome*); "Two broken pieces" (*starting point*)

Onion: "I just see an onion" (*starting point*)

Unattainable:

"That's impossible"; "That's not even true"

Run: "Someone panting and not being able to make it"

Onion: "I can see a person trying to turn an onion into a banana but failing"

Egg: "Just someone with a scrambled egg...cause you can't turn a scrambled egg back into eggs"

Walk: "Someone walking into a wall and banging their head"

Prompted phenomena obtained (or achievement beyond the prompt):

Run: "A person that is running 10 hours and is super duper sweat"; "Someone running for 200 hours"

Talk: "A person smiling and talking behind their teeth"; "People closing their mouth, and they're talking"

Grow: "Person is really old and the beard is going all the way down to his toes and it's white"

Walk: "Someone just turning invisible for 1 second and going through the wall"

Onion: "Person turning onion into a banana"; "I see a really big white thing, and then it turns into a yellow thing"

Applesauce: "It's very blue and smushy"

More ordinary or partial phenomena obtained:

Run: "Someone running for 10 min"; "Someone running for 5 hours"

Talk: "She's talking without her lips moving...but you know some people can talk in their head!"

Grow: "Someone growing down to chin"; "Growing a very long beard"

Walk: "I see a person putting his foot up into the wall"; "Someone walk around a brick wall"

Egg: "Depends on the type of egg. It can be fragile, sometimes it works and sometimes it don't"

Applesauce: "Someone making yellow applesauce"

Appendix C. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.cognition.2016.03.022.

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