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The Development of Children's Ability to Use Evidence to Infer Reality Status

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Abstract

These studies investigate children's use of scientific reasoning to infer the reality status of novel entities. Four- to 8-year-olds heard about novel entities, and were asked to infer their reality status from three types of evidence: supporting evidence, irrelevant evidence, and no evidence. Experiment 1 revealed that children used supporting versus irrelevant and no evidence differentially. Experiment 2 demonstrated that children without initial reality status biases were better at evaluating evidence than were biased children. In conclusion, the ability to infer reality status from evidence develops incrementally between ages 4 and 6, and children perform better when their evaluation is free from bias.

Children learn much about the world through first hand experience. On a daily basis, they see new things that they have never encountered before and can acquire information about them through their interactions. However, children often are introduced to new things that they cannot experience directly. In these cases, they must rely on alternative sources to obtain information, such as television, books, and other people. Many of these new entities and events are real and are part of children's everyday world. For example, research by Au, Sidle and Rollins (1993) shows that young children believe in the existence of germs. How do children determine that germs are real, but that cooties are not? How do they know that dinosaurs are real but that dragons are not (Morison & Gardner, 1978)? Many theorists have argued that children are initially credulous and believe that everything they hear about or encounter is real (Gilbert, 1991; Dawkins, 1995). However, research has shown that children as young as 3 years of age can distinguish reality from a range of non-realities, including appearance (e.g., Flavell, Green, & Flavell, 1986; Woolley & Wellman, 1990), mental states (e.g., Estes, Wellman, & Woolley, 1989; Woolley & Wellman, 1993), and fantasy (e.g., Morison & Gardner, 1978, Sharon & Woolley, 2004). What researchers have not fully explored is how children are able to make these distinctions. What clues do children rely on to determine what is real and what is not?

Real versus Fantastical

Woolley and Van Reet (2006) have shown that children use the context in which a novel entity is presented to assign reality status. In this research, children heard descriptions of novel entities like 'surnits' and 'hercs'. Some children heard fantastical descriptions (e.g., "Dragons hide surnits in their caves"), some heard everyday descriptions (e.g., "Grandmothers find surnits in their gardens"), and some heard scientific descriptions (e.g., "Doctors use surnits to make medicine"). Woolley and Van Reet found that 4-, 5- and 6-

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year-olds were able to use context to assign reality status to novel entities. Five- and 6-year-olds were also able to verbalize their reasoning. For example, a 5-year-old might explain that a surnit is real because doctors use surnits and doctors are real. Woolley and Van Reet conclude that children develop the ability to assign reality status based on context during the preschool years.

Woolley, Boerger and Markman (2004) also examined how children assign reality status to novel entities. They introduced children to a novel fantastical entity, the Candy Witch, who visits children's homes on Halloween night to exchange candy for a new toy. In this research, parents of children in the experimental condition exchanged their children's candy for a toy on Halloween night to represent a visit from the Candy Witch. Children in the control condition were introduced to the Candy Witch at their school, but were not visited. Woolley et al. measured children's belief in the Candy Witch after Halloween and found an interaction between age and condition. Older preschool children (4 to 5 years) in the visit condition showed higher levels of belief than their counterparts in the control group, whereas the visit had no significant effect on young preschoolers' belief in the Candy Witch. Woolley et al. suggested that the interaction between age and condition might involve children's ability to analyze the evidence from the visit. Perhaps the older children were able to connect the evidence of the Candy Witch's visit to the Candy Witch's reality status, thereby increasing their belief in her.

Using Evidence to Infer Reality Status

The question of whether children can use evidence to infer the reality status of novel entities can be broken down into two parts: (1) Are children able to evaluate evidence to determine the identity of a novel entity? (2) Can they use this information to determine whether the novel entity is real or pretend? Here is one potential scenario concerning a commonly believed-in fantastical being, Santa Claus (Prentice & Gordon, 1987; Sharon & Woolley, 2004). First, children may begin with a hypothesis. Perhaps they believe that Santa Claus is real, but have no proof and/or have not considered the need for proof to support their hypothesis. Second, children may search for evidence to support or refute their hypothesis. There might be three types of indirect visual evidence children use: (1) supporting evidence, such as seeing presents under the tree, (2) irrelevant evidence, such as receiving a gift from one's grandmother on Christmas morning, and (3) no evidence, such as the absence of presents on Christmas morning. In addition to visual evidence, children may gather evidence about Santa Claus via testimony. Research by Baxter and Sabbagh (2005) suggests that children frequently gather testimonial evidence about Santa Claus. Third, based on the visual and testimonial evidence gathered, children must make an inference as to whether Santa Claus is real or pretend.

The last step is contingent on the previous steps; the inference process is dependent on children's ability to assess correctly the available evidence. If children receive presents on Christmas morning, they may come to the conclusion that Santa Claus is real. (Though note that in drawing this conclusion, children would be making a logic error. Presents under the tree certainly support the hypothesis that Santa Claus is real, but do not, by themselves, prove his existence.) However, what might children conclude about Santa Claus' reality status when they receive irrelevant evidence, such as a present from their grandmother, or no presents on Christmas morning? If children fail to detect the evidence or if they misunderstand the evidence, consequently, they may not make what is presumably the intended inference regarding the reality status of Santa Claus.

In addition to determining the reality status of fantasy figures, children use evidence to make a variety of inferences in everyday life. For example, imagine an innocent child who is being unfairly scolded for eating cookies before dinner. In order to avoid punishment, the innocent child needs to examine any available evidence to finger the correct culprit. If the child notices that a sibling’s shirt is littered with cookie crumbs, s/he might use that supporting evidence to redirect punishment to the guilty sibling. Anyone with siblings knows how important implicating evidence is in everyday life.

Before one can make an inference using evidence, detecting and correctly evaluating the evidence is a key first step. This ability plays an important role in the development of scientific reasoning. Research in scientific reasoning has investigated how inferences are made when receiving atypical evidence. Chinn and Brewer (1998) propose methods detailing how atypical evidence can potentially drive conceptual change: one might ignore, reject or express uncertainty about the evidence, reinterpret it to align with one’s current conceptual understanding, or use the evidence to effect a marginal or central conceptual change. Chinn and Malhotra (2002) examined how fourth to sixth graders dealt with evidence that contradicted their original belief. Specifically, they determined at which of the following cognitive steps children erred: (1) evidence observation, (2) interpretation, (3) generalization, or (4) retention. They found that children failed the first step, observation, which affected their ability to later interpret, generalize and retain the new ideas. They suggest that children erred at observation because their previous beliefs tainted their observations. This research demonstrates that older children can use evidence to make inferences, yet their inferential capabilities can be affected by previous conceptual biases.

What indications are there that younger children can use evidence to make inferences? With regard to visual evidence, children appear to consider a visual report to provide better evidence than an oral testimony. Zaitchik (1991) showed that 3-year-olds who hear testimony regarding an object’s true location pass the false-belief task more readily than children who see where an object really is. Children appear to find it easier to discount oral testimony than visual perception. Additionally, Woolley and Bruell (1996) found that when children learned about an object either through seeing, hearing, or inferring, they were best able to identify visual input as a source of their knowledge.

However, in the absence of visual input, children do consider testimony to be a good source of information. Specifically, there is evidence that children rely on testimony to learn new words. Koenig, Clément and Harris (2004) demonstrated that preschoolers are able to discriminate reliable from unreliable testifiers to learn words for novel objects. By age four, children are able to 1) determine whether an informant is giving correct word labels to familiar objects and 2) decide whether the informant is reliable, and then 3) to accept the reliable informant’s labels for novel objects, but not accept an unreliable testifier’s information. Jaswal (2004) found that children even consider an adult’s intention when choosing whether to accept an adult’s label for a novel entity or to rely on their own perceptual information. For example, when an adult labeled something with intention, such as “You’re not going to believe this, but that is actually a cat!”, children used the adult’s intention to determine that the label was veridical. Jaswal’s research indicates that children are able to evaluate critically the evidence they might use to label a novel entity; they can choose whether to label a novel item based on their own perceptual evidence, or to disregard their sensory input and label it based on testimonial evidence.

Sometimes children have to make a decision without information from their senses or testimony from others. In these cases, what other clues might children use? Inference provides a source of knowledge that can be used in the absence of explicit sensory or testimonial proof. Sodian and Wimmer (1987) demonstrated that 4-year-olds can use inference as a source of knowledge. First, they showed children a transparent box that contained only red balls. Next, children’s view was occluded while one of the objects (one of the red balls) was transferred into a brown paper bag. Afterwards, they asked children what object was in the bag. Most 4- and 6-year-olds knew there was a red ball in the bag even though they had not witnessed the transfer. However, when asked whether another person would know the contents of the bag in the same situation, 4-year-olds responded negatively, indicating that, whereas they can use inference as a source of knowledge, they are not fully aware of their ability. Thus, it appears that the use and understanding of inference as a source of knowledge may develop significantly between the ages of 4 and 6.

How might these abilities help children assign reality status to novel entities? Woolley et al. (2004) suggest that development occurs in children's ability to use evidence to infer the reality status of fantastical entities such as Santa Claus and the Tooth Fairy. There may be two components to this process. The first component involves children's ability to link evidence to an entity. For example, children need to be able to infer that cookie crumbs on a plate indicate that their sibling ate cookies for a snack. The second component involves understanding the relation between evidence and reality status. Evidence that supports the presence of an entity should lead children to conclude that the entity is real, whereas irrelevant evidence or the absence of evidence should not.

To validate our assumptions regarding how one might use evidence to determine reality status, we surveyed 55 adult undergraduate students. We introduced a set of novel animals and linked each one to a piece of physical evidence related to itself or its behavior. For example, we told participants about quetzals that have vibrantly colored red, green, and blue feathers. We then presented examples of: (1) supporting evidence (e.g., a vibrantly colored red, green, and blue feather), (2) irrelevant evidence (e.g., a jagged tooth), or (3) no evidence. Adults were asked two questions about the novel animal corresponding to the two components of this process. The first question asked adults to confirm whether or not they thought the novel animal left behind the evidence. The second question asked them to determine the novel animal's reality status (real, pretend, or indeterminate) based on the evidence.

On supporting trials (trials in which the evidence matched the description of the animal), 85% of the time adults said that they believed that the novel animal left the evidence, whereas they responded this way only 7% and 6% of the time when the evidence was irrelevant or nonexistent, respectively. When asked to determine the animal's reality status based on the evidence (the second component), on supporting trials adults inferred that the novel animal was real 88% of the time. However, when they received irrelevant evidence, they either said they could not determine the novel animal's reality status (56% of the time) or inferred that the novel animal was pretend (30% of the time). Similarly, in no-evidence trials, adults primarily either said they could not determine the novel animal's reality status (64% of the time) or said it was pretend (26% of the time). Thus, we confirmed that adults use evidence to determine the reality status of novel entities. They infer that the entity is real when they receive supporting evidence for its existence, but do not infer that it is real when the evidence is irrelevant or nonexistent. Given this adult pattern, we might ask when children develop the ability to use evidence to infer the reality status of novel entities.

To pilot this procedure on children, we recruited sixty children, ages 4 and 6 years. In this task, children were told that they should use clues that animals left behind in transportation boxes to determine whether the animals were real or pretend. On each trial, children were told about two novel animals and a behavior linked with each one. Children were given some information about each animal. For example, children were told that, "Takins eat twigs and always leave twigs behind wherever they go" but that "servals eat seeds…" Next children were asked to look inside each box to see if an animal left behind evidence. For example, children saw a twig in the box and then were asked the Identity Questions: "Do you think an animal was in this box, yes or no?" If they answered affirmatively, they were asked: "What animal do you think was in this box?" After naming the animal that they thought was in the box, children were asked the Reality Status Question for the novel animal. "What about takins, are they real or pretend?"

In this within-subjects design, each child completed two trials of three different evidence tasks: supporting evidence, irrelevant evidence, and no-evidence. In the supporting evidence tasks, after hearing the clues, children saw evidence supporting the existence of one of the two novel animals. For example, children saw twigs in the box to support the existence of the takin. In the irrelevant evidence tasks, children saw ambiguous evidence; evidence that was not associated with either of the two novel animals. For example, children saw a feather in the box. In the no-evidence tasks, the box was empty. After looking in the boxes, children were asked to answer the Identity Question and the Reality Status Question for each novel animal.

Results from the pilot study indicate that there was no significant age difference in the ability to answer the Identity Question, "What animal was in the box?" When children received supporting evidence to support the identity of the novel animal, they confirmed that the animal was in the box. When they received irrelevant or no evidence, they did not claim that the novel animal was in the box. Thus, it appears that both 4 and 6-year-olds are able to use evidence to determine whether an animal was present or not. After answering the Identity Question, children were asked whether they thought the novel animal was real or pretend. Results showed that, whereas 6-year-olds varied their judgments of reality status based on the evidence, four-year-olds did not. When 6-year-olds received supporting evidence, they said that the animal was real. However, when they received irrelevant or no evidence, their responses were distributed at chance. Four-year-olds said the animal was real regardless of the evidence.

The pilot data suggest that the ability to use evidence to judge reality status develops between the ages of 4 and 6. In order to accurately assign reality status in these tasks, children needed to be able to: (1) use the evidence to determine whether there was an animal in the box and if so, identify the animal, and then (2) evaluate the evidence to infer whether the animal was real or pretend. Whereas most 6-year-olds differentially used disparate types of evidence to make reality status judgments, 4-year-olds did not. Rather, they tended to judge most of the novel entities as real regardless of the type of evidence they received.

Although the pilot study suggested that the ability to use evidence to assign reality status develops between the ages of 4 and 6, it did not pinpoint the age when this ability develops. Additionally, whereas most of the 6-year-olds were able to use evidence to infer reality status, some were not. Experiment 1 attempts to provide more detailed information about the development of this ability by including children from a larger range of ages. Furthermore, when answering the Reality Status Question in the pilot study, children were not given the opportunity to say that they could not tell the reality status of the novel entity. The reason for this was that initial pilot testing showed that when given three choices "Real", "Pretend", or "Can't Tell", over 60% of children answered "Can't Tell" on every trial, even supporting ones. However, it seemed important to separate these choices into two questions to provide an opportunity for the children to say that they were uncertain, especially given that uncertainty might be expected on both the irrelevant and no-evidence tasks. Experiment 1 offered this option.

Experiment 1

Method

Participants—Twenty 4-year-olds (*M* = 4;4; range = 3;7 – 4;10; 6 girls and 14 boys), 22 five-year-olds (*M* = 5;5; range = 5;1 – 5;11; 9 girls and 13 boys), 19 six-year-olds (*M* = 6;8; range = 6;0 – 6;11; 11 girls and 8 boys), 19 seven-year-olds (*M* = 7;9; range = 7;1 – 7;11; 4 girls and 15 boys), and 18 eight-year-olds participated (*M* = 8;10; range = 8;9 – 8;11; 10 girls and 8 boys). Participants were mainly from middle- or upper-middle- class families. Seventy-eight percent of the children were Caucasian, 16% were Hispanic, 4% were Asian, and 2% were African American. In this and the following experiment, children were recruited from the participant database of the Children's Research Laboratory. Each child was seen individually for one 30-minute session, and received a small toy or t-shirt for participating.

Materials—The stimuli were as follows: six opaque plastic boxes (13-1/2″ × 8″ × 5-1/4″ h), and one pictured, dichotomous scale for the Reality Status Question. The Reality Status Scale was used to aid children in providing reality status judgments for the novel animals. The scale depicted a drawing of a cat to represent "real," and one of a ghost (or monster) representing "pretend". (Pre-testing indicated which entity the child believed was pretend. The entity that the child said was pretend was used to represent the pretend end of the scale in testing. When children answered that both a ghost and monster were pretend, the experimenter chose one at random to represent the pretend end.) The remaining materials were used as evidence in the boxes: bark, tree branches, twigs, rocks, pinecones, sand, dried corn kernels, bird feathers, rice, tree leaves, sunflower seeds, pecan shells, and sea shells. In order to make the evidence seem realistic, all of the evidence was real; none was fabricated. Nineteen novel animals, some of which are real and some of which are pretend, were used in the experiment: babbin, bracken, chibu, flina, floran, koref, langur, mahka, pikoy, pema, roker, ropangi, sanet, serow, takin, toki, tree-sloo, whistle-pig, woket. The novel animal names were chosen through pilot testing to identify animal names that were not perceived consistently as either real or pretend. The novel animals were randomly assigned to the six trials of supporting, irrelevant, or no-evidence. Sixteen orders of trials were created to counterbalance the novel animals and the evidence trials. Approximately one child from each age group was randomly assigned to each order.

Procedure—Children were asked to: (1) evaluate evidence left behind by a novel animal, and (2) infer the reality status of the animal. Before the experiment began, children practiced using the Reality Status Scale by classifying 4 familiar real and pretend entities. If children did not use both ends of the scale, they were given further practice with additional entities. After completing the practice questions, the experimenter told the children that s/he needed help to determine if various novel animals were real or pretend. The experimenter introduced the task by telling children about a scientist, Dr. Kim, whose job is to find new animals that no one has ever seen before. Children were told that when Dr. Kim found a new animal, she put it in a box to transport it back to her lab. Importantly, the animals left food or items from their habitat behind in the boxes. Children were shown a video of Dr. Kim working in her lab. The video depicted a female scientist dressed in a white lab coat, standing in front of terrariums, looking in transportation boxes, and taking notes. It was important to make sure that children understood the premise of the experiment. Previous research has shown that children as young as 3 know that doctors are experts in their domain (Lutz and Keil, 2002) and therefore the scientist in this study was always referred to as "Dr. Kim". During the introduction, the experimenter addressed any questions the children had about Dr. Kim to ensure that they understood the premise. After watching the video, children were told that Dr. Kim had index cards for all of the new, real animals she found,

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and she also had index cards for pretend animal names that she just made up for new animals she might find in the future. However, children were told that she got her cards mixed up, and could not remember which ones were the real animals she had found. Children were asked to help determine which represented the real animals by looking in the transportation boxes for clues that may have been left behind by the animals. Children were given no base rate information about the percentage of real versus pretend animals. Transportation boxes and the cards were labeled numerically to match the box to the animal's description.

After the introduction, children began with the first of six trials. In this within-subjects design, each child completed two trials of three different evidence tasks: supporting evidence, irrelevant evidence, and no-evidence. In the supporting evidence tasks, children saw evidence supporting the existence of the novel animal. For example, children saw twigs in the box to support the existence of the takin. In the irrelevant evidence tasks, children saw ambiguous evidence; evidence that was not associated with the novel animal. For example, children saw a feather in the box, which was not associated with the takin. In the no-evidence tasks, the box was empty. Children were asked to open the first transportation box and look inside to see if an animal left behind evidence. For example, children might see a twig or feather in the box. While the child was looking in the box, the experimenter read the novel animal's description to the child. For example, children heard: "Takins eat twigs and always leave twigs behind wherever they go." After looking in the box, children were asked to answer questions about the novel animal. First, children were asked the Identity Questions: "Do you think an animal was in this box, yes or no?" If they answered affirmatively, they were asked: "What animal do you think was in this box?" Next they were asked if they remembered what the description said the entity left behind, and if children did not remember, the experimenter reminded them. Next children were asked to answer the Determinate Question: "Is this a time when you can tell if takins are real or not; can you tell or can you not tell?" This question was added to give children an opportunity to indicate that they did not know the reality status of the novel animal without adding "don't know" as an optional answer to the Reality Status Question. Fay and Klahr (1996) successfully used a similar question to give 4- to 6-year-old children an opportunity to express uncertainty regarding whether a problem had a determinate solution. When children said that they could not tell the novel animal's reality status, the Reality Status Question was skipped and the trial was completed. However, when children said that they could tell whether the novel animal was real or pretend, children were asked the Reality Status Question for the novel animal ("Are takins real or pretend?").

Results and Discussion

Identity Question—The Identity Question was coded as confirming the identity of the novel animal (1) or disconfirming it (0) for each task. Answers were coded as confirming when children identified the novel animal; answers were scored as disconfirming when children identified any other animal or said that there was no animal in the box. Participants completed two trials (boxes) for each task resulting in scores from 0–2 confirming answers of the Identity Questions. As shown in Figure 1, 6-, 7-, and 8-year-olds confirmed the novel animal when they received supporting evidence, but disconfirmed it when they received irrelevant and no evidence. Four- and 5-year-olds did not successfully vary their answer to the Identity Question based on the evidence. A 5 (age) × 3 (task) Repeated Measures ANOVA revealed a main effect for evidence task (F (2, 182) = 70.28, $p < .001$, $\eta_p^2 = .44$), and a significant interaction between age and task (F (8, 182) = 3.22, $p < .01$, $\eta_p^2 = .12$). One-sample t-tests revealed that 6-, 7-, and 8-year-olds' scores were significantly different from chance when answering the Identity Question on all three tasks: (supporting tasks (M = 1.43, SD = .78, t (55) = 4.10, $p < .001$), irrelevant tasks (M = .30, SD = .57, t (55) = −9.15, p

$< .001$), and no-evidence tasks ($M = .14$, $SD = .40$, $t(55) = -15.98$, $p < .001$), indicating that they confirmed the identity of the novel animal when receiving supporting evidence, and disconfirmed it when receiving irrelevant and no-evidence. Note that for trichotomous data such as these, the normality assumption is violated. However, Monte Carlo techniques have demonstrated the robustness of ANOVA even when analyzing dichotomous data (D'Agostino, 1971;Gaito, 1980;Lunney, 1970).

Post-hoc analyses were conducted to determine how each age group performed on the Identity Question. They revealed significant main effects of task for 5-year-olds (F 2, 19) = 6.47, $p < .01$, $\eta_p^2 = .41$), 6-year-olds ($F(2, 17) = 14.51$, $p < .001$, $\eta_p^2 = .63$), 7-year-olds ($F(2, 16) = 16.52$, $p < .001$, $\eta_p^2 = .67$), and 8-year-olds ($F(2, 16) = 24.14$, $p < .001$, $\eta_p^2 = .75$), but not 4-year-olds ($F(2, 18) = 2.50$, ns.). Four-year-olds' scores were significantly different from chance on the irrelevant ($M = .55$, $SD = .83$, $t(19) = -2.44$, $p < .05$) and no-evidence tasks ($M = .40$, $SD = .68$, $t(19) = -3.94$, $p < .01$), but not on supporting tasks. Thus, 4-year-olds were able to successfully disconfirm the identity of the novel animal when receiving irrelevant and no-evidence, but had difficulty confirming its identity when receiving supporting evidence. Additionally, whereas 5-year-olds' scores demonstrate that they were able to distinguish supporting from non-supporting evidence, chance tests reveal that they did not successfully confirm the identity of the novel animal when receiving supporting evidence and successfully disconfirm it when receiving irrelevant evidence; 5-year-olds' scores did not differ from chance on any of the three tasks. Thus, whereas 6- through 8-year-olds used the evidence differentially to confirm or disconfirm the identity of the novel animal, 4- and 5-year-olds did not.

Reality Status Question—For adults, the reality status question had three possible answers: real, pretend, and can't tell. For children, we broke this question down into two questions: (1) the Determinate Question followed by (2) the Reality Status Question. In analysis, these two questions were consolidated to reflect real, pretend, and can't tell answers. 'Real' answers were coded as 1 and 'pretend' answers were coded as 0. Can't tell responses on the Determinate Question were coded as .5 on the Reality Status Question. As reviewed in the Introduction, we consider the ability to use evidence to assign reality status a two-step procedure; first children must decide whether the evidence is associated with the novel entity; second, based on their first answer, they must decide whether the animal is real or pretend, or if they can't tell. In supporting tasks, children should confirm the identity of the novel entity in step 1, and then based on this confirmation, they should decide that the animal is real. However, in irrelevant and no-evidence tasks, because the evidence does not lead to a confirmation of the novel entity's identity, they should not claim that the animal is real. Therefore, the second step (deciding the animal's reality status) is contingent on the first step (identifying the novel entity as the animal in the box).

The Reality Status Question analysis was conditional on appropriate answers to the Identity Question. If children did not answer this question appropriately, it would be difficult to interpret their response to the Reality Status Question. To test this prediction, we first compared children who answered the Identity Question appropriately on both trials of each task (the "successful group") to children who did not answer both Identity Questions appropriately (the "unsuccessful group"). Because children had a 50% chance of answering the Identity Question appropriately on each trial, we conservatively limited our "successful group" assignments to children who answered the Identity Question appropriately on both trials for each evidence task.

As shown in Figure 2, children in the "successful group" answered the Reality Status Question differentially by evidence task. They said the animal was real when they received supporting evidence, and said that the animal was pretend or they could not determine the animal's reality status when they received irrelevant or no evidence. However, children in the "unsuccessful group" failed to assign reality status differentially to the novel entities based on the evidence. In the supporting task, children who answered the Identity Question correctly on both supporting trials had a mean reality status score of 1.62 (*SD* = .57), whereas children who missed at least one Identity Question had a mean reality status score of 1.08 (*SD* = .62, F (1,79) = 15.65, $p < .001$, $\eta_p^2 = .17$); children who successfully answered the Identity Question were more likely to infer that the supported animal was real. On the irrelevant task, successful children answered the Reality Status Question differently (*M* = .70, *SD* = .85) than children who missed at least one Identity Question (*M* = 1.57, *SD* = .59, F (1, 58) = 18.33, $p < .001$, $\eta_p^2 = .24$). Children in the unsuccessful group were more likely to claim that the novel animal was real even in the absence of evidence supporting its existence. On the no-evidence trials, the same pattern was evident. Successful children had a mean reality status score of .67 (*SD* = .77), whereas children who missed at least one Identity Question had a mean reality status score of 1.29 (*SD* = .77, F (1, 54) = 7.82, $p < .01$, $\eta_p^2 = .13$).

Additionally, when comparing performance across age groups, including only successful children, in supporting tasks no age differences were found (F (4, 46) = 1.05, ns.). Overall, these results indicate that being able to use evidence to determine a novel animal's reality status first requires one to correctly identity the evidence and then determine whether the novel animal is associated with the evidence.

The data from this task demonstrate that children's ability to use physical evidence to make reality status judgments about novel entities develops significantly between the ages of 4 and 6. However, regardless of age, children who appropriately answered the Identity Question were also more successful at answering the Reality Status Question, affirming the two-step cognitive process required to use evidence to determine a novel entity's reality status. When children appropriately identified which (if any) animal was in the box based on the evidence (step 1), they were better able to determine the animal's reality status or to understand that it could not be determined (step 2). The results of the Identity Question and the Reality Status Question together demonstrate that the Identity Question is developmentally determined, but the Reality Status Question may not be. With age children appear to improve at linking evidence with the identity of an animal. Once they have mastered this, judgments about its reality status seem to come for free.

During the interviews, experimenters noticed that some children would state confidently that all of the novel animals were real (or all were pretend) regardless of the evidence. Sixteen percent of the children in Experiment 1 answered the Reality Status Question the same way on all trials (7% gave all pretend answers, 9% gave all real answers). Sometimes children explained why they thought the animals were real, "I think I saw it at the zoo", or why they thought they were pretend, "I've never heard of it so it must be pretend." It seemed that these children had a hypothesis about the novel animals from the onset. Thus, the purpose of Experiment 2 was to determine two things: (1) Do children form hypotheses about a novel entity's reality status before gathering evidence to make an informed inference? (2) If children do have a hypothesis, does it interfere with their ability to evaluate the evidence to infer the novel animal's reality status?

Experiment 2

Method

Participants—Twenty 4-year-olds (*M* = 4;7; range = 4;0 – 4;11; 10 girls and 10 boys) and fifteen 6-year-olds (*M* = 6;7; range = 6;1 – 6;11; 8 girls and 7 boys) participated. Participants were mainly from middle- or upper-middle-class families. Seventy-three

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percent of the children were Caucasian, 11 % were Hispanic, 11% were African American, and 5% were Asian.

Materials—The stimuli used in this experiment were the same as in Experiment 1 with the following additions. Two picture books, one of real animals and one of pretend creatures, were used to ascertain children's initial hypothesis about the novel entity's reality status. Each book contained 17 pages with a picture of each animal or creature, its name, and a short description of it. The book covers had pictures of real animals or pretend creatures to help children who could not read identify the books.

Procedure—The procedure was the same as in Experiment 1, but with a few changes. The introduction to the experiment was changed slightly, and a measure of children's initial hypothesis regarding the novel animal's reality status was added. To introduce the experiment, children were told that a scientist, Dr. Kim, had index cards for all of the new, real animals she found, and she also had index cards for pretend animals she had seen on TV, in movies and storybooks. However, children were told that she got her cards mixed up, and could not remember which ones were the real animals she had found. Children were asked to help determine which cards represented the real animals she found and which represented the pretend animals, by looking in the books and in the transportation boxes for clues that may have been left behind by the animals. As in Experiment 1, cards and transportation boxes were numerically labeled to link them to each other. At the beginning of each trial, the experimenter picked up the first card and read the animal's name to the child. Then the experimenter said "Let's see if we can find the takin in the books. Remember, this is the real animal book, and this is the pretend animal book. Which book should we look in first?" The experimenter helped children who could not read look for the animal in the book by reading aloud the names of the animals on each page and making comments such as "This furry animal is called a quokka. It's not the takin." Children's first book choice was used as an indicator of their hypothesis about the novel animal's reality status. The verbal and positioning order of the books was counterbalanced and the novel test animals were not represented in either book. Before the test trials, a practice session was added to orient children to the picture books. In the practice session, children were asked to indicate in which book they would find familiar, real animals and in which book they would find familiar, pretend creatures. This pretest ensured that children knew the content of the books differentially.

In addition to the six test trials, there were four dummy trials in which children found the animals in the books. The 10 trials were randomized within 16 orders, with the constraint that dummy trials were not consecutive. These four dummy trials, two with real animals and two with pretend creatures, were added to encourage the children to keep looking in the books throughout the entire experimental session. After children looked in the first book for the novel animal, if they did not find it, they were encouraged to look in the second book where they either found the dummy animal or realized that the novel animal was not in either book. In the six test trials, after looking in the books and not finding the novel animal in either book, the experimenter read the children a clue about the animal from the back of the numbered index card: "It says here that takins eat twigs and always leave twigs behind wherever they go." After children heard the clue about the novel animal, they looked in the numerically corresponding box provided by the experimenter. The remaining questions in each trial were the same as in Experiment 1. Children first answered the Identity Questions ("Do you think one of Dr. Kim's animals was in the box?" If yes, "What animal was in the box?"). Next they were asked if they remembered what the entity left behind, and if children did not remember, the experimenter told them. Then children answered the Determinate Question ("Is this a time when you can tell if takins are real or not, can you tell or can you not tell?"), followed by the Reality Status Question ("Are takins real or pretend?") if they answered the Determinate Question affirmatively. As in Experiment 1, children were given two trials for each of the three tasks: supporting evidence, irrelevant evidence, and no-evidence. The evidence tasks and novel animals were counterbalanced among 16 orders. Approximately two children, one child from each age group, were randomly assigned to each order.

Results and Discussion

Identity Question—The Identity Question was coded in the same manner as Experiment 1. Across age groups, children gave more affirmative answers when eceiving supporting evidence (*M* =1.67, *SD* = .64) than when receiving irrelevant evidence (*M* =.73, *SD* = .85) or no evidence (*M* =.66, *SD* = .83); resulting in a significant ain effect of task, F (2, 32) = 25.68, $p < .001$, $\eta_p^2 = .62$), and a significant task by age interaction, F (2, 32) = 5.01, $p < .05$, $\eta_p^2 = .24$). Post-hoc analyses were conducted to determine how each age group performed on the Identity Question. They revealed ignificant main effects of task for 4-year-olds (F (2,18) = 3.81, $p < .05$, $\eta_p^2 = .30$) and 6-year-olds (F (2,13) = 33.53, $p < .001$, $\eta_p^2 = .84$). However, as shown in Figure 3, whereas 6-year-olds successfully confirmed the novel animal when receiving supporting vidence (*M* = 1.93, *SD* = .26, t (14) = 14.00, $p < .001$), and disconfirmed it when receiving irrelevant (*M* = .60, *SD* = .83, t (14) = −1.87, $p = .08$) and no evidence (*M* = .46, *SD* = .74, t (14) = −2.78, $p < .05$), 4-year-olds' responses to the Identity Question were only different from chance levels for supporting evidence (*M* = 1.40, *SD* = .75, t (19) = 2.37, $p < .05$). Their responses were distributed at chance levels when receiving irrelevant (*M* = .85, *SD* = .88, t (19) = −.77, ns) and no evidence (*M* = .85, *SD* = .88, t (19) = −.77, ns), indicating that 4-year-olds were unsure of whether or not to disconfirm the animal's identity when receiving non-supporting evidence.

Reality Status Question—Answers to the Reality Status Question were coded in the same way that they were in Experiment 1. As shown in Figure 4, children who answered the Identity Question appropriately on both trials (the "successful group") correctly varied their answers to the Reality Status Question based on the evidence. They said the animal was real when they received supporting evidence, and said that they could not determine the animal's reality status when they received irrelevant or no evidence. However, children who did not answer both Identity Questions appropriately (the "unsuccessful group") failed to assign the correct reality status to the novel entities based on the evidence. As shown in Figure 4, on supporting trials, the successful group had a mean reality status score of 1.60 (*SD* = .58), with responses to the Reality Status Question differing from chance, t (24) = 5.20, $p < .001$. However, their Reality Status Question scores were distributed at chance when receiving irrelevant evidence (*M* = 1.25, *SD* = .69) or no evidence (*M* = .79, *SD* = .85), indicating that the reality status of the novel animal could not be determined based on the non-supporting evidence. In contrast, the unsuccessful group did not vary their answers to the Reality Status Question when receiving supporting evidence (*M* = 1.20, *SD* = .79), irrelevant evidence (*M* = 1.29, *SD* = .77), and no evidence (*M* = 1.13, *SD* = .89).

Hypothesis Question—Children's initial hypotheses were assessed by noting the first book in which they looked for the novel animal. Choice of the real animal book was coded as 1, and choice of the pretend book was coded as 0. To compare children with differing biases, children were divided into three groups. In six trials, children with one or fewer "real" hypotheses were categorized as having a pretend bias (n = 11). Children who had 2–4 "real" hypotheses were labeled as having no bias (n = 16), and children with five or more "real" hypotheses were categorized as having a real bias (n = 8). As shown in Table 1, some children demonstrated biases in their hypotheses, whereas others did not. Four-year-olds displayed more of a pretend bias, whereas 6-year-olds displayed more of a reality bias. Chi-

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Square Test of Independence revealed a significant difference in the age groups' biases, $\chi^2(2)=6.12$, $p < .05$, $\Phi_c=.42$.

To determine whether children who had a real/pretend bias differed in their ability to answer the Identity Question (step 1) from children who did not, we conducted a 3 (bias: pretend, real, none) × 3 (task) Repeated Measures ANOVA on children's answers to the Identity Question. This analysis revealed that children's original reality status hypothesis did not influence their ability to use evidence to identify which animal was in the box.

The primary question of interest was whether children who had a real/pretend bias differed in answering the Reality Status Question (step 2) from children without a bias. Repeated Measures ANOVA revealed a marginally significant interaction between hypothesis bias and evidence type, F (2, 66) = 3.01, $p < .06$, $\eta_p^2 = .08$.

As seen in Table 2, pretend-biased children's answers to the Reality Status Question on all 3 tasks were distributed at chance even when receiving evidence that supported the reality of the novel animal. Real-biased children answered that the novel animal was real in supporting tasks, as expected; however, they also answered that the novel animal was real in irrelevant evidence tasks. Thus, it appears that when evidence contradicted their hypothesis, their original hypothesis interfered with their ability to observe and use the evidence appropriately. Only children with no bias used the evidence differentially to answer the Reality Status Question. When receiving supporting evidence, children without bias used the evidence to answer that the novel animal was real, when receiving irrelevant evidence, their answers to the Reality Status Question were distributed at chance, and when receiving no evidence, they said the animal was pretend.

Experiment 2 replicated the findings of Experiment 1, demonstrating that, in this task, between the ages of 4 and 6 children improve in their ability to use evidence to infer the identity – and thus the reality status – of a novel entity. Additionally, Experiment 2 revealed that many children had initial hypotheses about the reality status of novel entities; some thought that the entity was real, whereas others assumed that it was pretend. A third group of children had no reality status bias.

One might argue that children's book choice did not reflect a conscious hypothesis about reality status, but rather a preference or interest in fantasy over reality, or vice versa. Regardless of whether children's biases were conscious hypotheses or simple preferences, they did affect how children used evidence to determine reality status. Children who were unbiased used supporting evidence to substantiate the existence of a novel entity, and expressed doubt or uncertainty about a novel entity's reality when receiving irrelevant or no evidence. Biased children, on the other hand, allowed their initial hypotheses to interfere with their reality status inferences. It is interesting to note that sometimes the biased children's reality status judgments did not seem to reflect their bias. One might assume that children with a pretend bias would always claim that the animal was pretend, for example. However, children with pretend biases' responses to the Reality Status Question were at chance regardless of the type of evidence they received. Chinn and Malhotra (2002) found similar results in which children with prior expectations failed to observe the evidence correctly. They proposed that having a bias disrupts children's information processing at observation, which in turn affects later stages of processing such as inference, and may eventually lead to random responding.

General Discussion

Results of the present studies shed new light on how young children make the distinction between reality and fantasy. Previous studies have shown that children use a variety of sources to determine whether a novel entity is real or pretend. For example, they are able to use first-hand visual cues (Wellman & Estes, 1986; Woolley & Bruell, 1996), testimony from others (Baxter & Sabbagh, 2005), and contextual cues (Woolley & Van Reet, 2006) to ascertain reality status. The present research extends findings on children's fantasy-reality differentiation by providing information on when and how children use evidence to infer reality status.

Our research demonstrates that the ability to assign reality status based on the use of evidence develops significantly between the ages of 4 and 6. In the pilot study, where children heard about two animals, 4-year-olds were able to identify the presence or absence of the novel entity, but were not able to use this information to assign reality status. In Experiments 1 and 2, where children only received information about one animal, 4-year-olds showed some ability to identify the novel animal but were not consistent in their use of evidence. Five-year-olds were able to distinguish supporting and non-supporting evidence, but their answers were not consistently different from chance. Six-year-olds consistently, across the pilot and two experiments, demonstrated an understanding of the implications of the different types of evidence for their decisions about reality status. They understood that supporting evidence should be used to confirm the identity of a novel entity to conclude that it is real, whereas in the absence of such evidence, an entity's reality status is doubtful or uncertain.

Our findings join other recent findings in beginning to address empirically the much-debated question of young children's credulity (Dawkins, 1995; Woolley, 1997). Shtulman and Carey (2007), for example, found that 4-year-olds denied the possibility of events that were merely improbable. By age 6, children were more willing to admit that unusual events could possibly happen in real life. They suggest that young children deny the possibility of events for which they cannot imagine how they would occur. In our first experiment, 4-year-olds were more likely to reject the existence of entities in the no evidence and irrelevant evidence tasks than they were to confirm the existence of the entities in the supporting task. In Experiment 2, 4-year-olds were more likely than 6-year-olds to have a pretend bias. These findings together suggest that, rather than starting off credulous and becoming more skeptical with age, as some have argued (Dawkins, 1995; Gilbert, 1991), the starting state may be more one of incredulity.

Our results also revealed that, independent of age, children who consistently used evidence to identify (or not identify) the entity were better able to answer the Reality Status Question. This finding lends support to our proposal that the ability to use evidence to determine reality status is a two-step cognitive process. One must first evaluate the evidence to determine the novel entity's identity, and then use that knowledge to determine its reality status. It also indicates that what appear to be developmental changes in children's ability to distinguish fantasy from reality may sometimes reflect the development of underlying, more general abilities. In this case, that ability, linking evidence to something's identity is one with important implications beyond fantasy/reality concerns.

One of these important implications concerns children's scientific thinking. Research by Fay and Klahr (1996), and Klahr and Chen (2003) has shown that by the age of 5, children are able to say when a problem has an indeterminate solution. In other words, they are able to determine when they lack enough information to make a definite conclusion. In Experiment 1, we found that, whereas 5-year-olds showed some ability to do this, only the older children, 6- through 8-year-olds, were able to consistently evaluate their own knowledge state and to know when they lacked evidence to make a decision about reality status. By age 6, children understood that whereas supporting evidence gave them a solid basis for making a decision about reality status, irrelevant evidence, or a lack of evidence, did not. The findings together show a possible progression in children's understanding of indeterminacy. Although children appear to have a basic understanding by age 5 that they can use in decisions about physical object properties, the ability to use this knowledge in more abstract situations, such as assigning reality status, continues to develop with age. In our task, children needed to understand that neither irrelevant evidence nor a lack of evidence was sufficient to judge whether something existed or not. This seems an impressive ability for a 6-year-old, and one that should have far-reaching implications.

In Experiment 2, we found that children who had an initial hypothesis about the reality status of the novel entity tended to disregard the available evidence in making a decision about reality status. Children who initially believed that the novel animal was real still claimed that the animal was real even when presented with irrelevant evidence. Children who initially believed that the novel animal was pretend did not judge the novel animal as real even when presented with evidence supporting the animal's existence. Only children who had no initial hypothesis were able to critically evaluate the evidence and to infer logically whether the novel animal was real or pretend.

This finding that children tend to neglect relevant evidence when it is inconsistent with their own hypotheses is consistent with research on older children's scientific reasoning (e.g., Kuhn, Amsel, & O'Loughlin, 1988). But there is less work with younger children of the age tested here. Ruffman, Perner, Olson, and Doherty (1993) showed that, by age 5, children are aware of the basic distinction between hypothesis and evidence. The children in their studies understood that tampered evidence would lead someone to have a different belief (hypothesis) about something than their own. Koerber, Sodian, Thoermer, and Nett (2005) show that young children often have trouble using evidence when it conflicts with their prior beliefs. They found that 5- and 6-year-olds more often correctly predicted another person's belief when they lacked prior beliefs about a domain than when the evidence contradicted their beliefs. Similarly, in our study, the children without initial biases were much more successful at using evidence to come to accurate conclusions about reality status.

One possible explanation for why children may have difficulty integrating the new evidence with their original hypothesis concerns the role of higher order executive functions such as inhibitory control. Inhibitory control allows one to prevent or stop a prepotent, automated response and instead initiate an alternative response. Previous research has shown that inhibitory control develops significantly between the ages of 3½-to 6-years of age (Gerstadt, Hong & Diamond, 1994), and has been shown to affect performance on other cognitive tasks such as those assessing theory of mind (Carlson & Moses, 2001). Our task required skills in two executive functions, working memory and inhibitory control; children had to keep track of both the clue presented by the experimenter and the evidence found in the box, and then inhibit their initial hypothesis in order to determine the animal's reality status. Children with no reality status bias did not have an initial hypothesis to inhibit, and thus the task may have been easier for them. Further research on children's use of evidence should include inhibitory control tasks to assess this possibility.

In their everyday lives, many children believe in fantastical figures such as the Tooth Fairy and Santa Claus (Prentice, Manosevitz & Hubbs, 1978; Morison & Gardner, 1978; Clark, 1995; Sharon & Woolley, 2004). As both children and adults did in the present research, children often interpret supporting evidence (e.g., presents, money) as conclusive evidence for the existence of these entities. In doing so, however, children are making a logic error; although such evidence is supportive of or consistent with the existence of these entities, it should not be taken as proof. In the present studies, neither children nor adults judged the entity as real 100% of the time when receiving supporting evidence, indicating that, at least on some level, they were aware of this error in logic. Yet the fact that they came to this conclusion as often as they did suggests potential limitations in the logical abilities of both children and adults.

Children also often receive evidence that does not support the reality of these fantastical figures. For example, children may wake up to find their mother putting money under their pillow or putting gifts from Santa under the tree. The current research suggests that children under the age of six may be less likely to integrate this information into their existing belief systems. However, as children develop, perhaps as their inhibitory control processes develop, they may become better able to inhibit their initial hypothesis that the fantastical figure is real, and thus better evaluate the evidence to determine the fantasy figure's reality status. This may help explain the sharp decline in beliefs in fantasy figures between the ages of 6 and 8.

We conclude that the ability to infer a novel entity's reality status based on evidence develops significantly between the ages of 4 and 6. Thus, it appears that children are able to use inferences based on evidence evaluation, as well as their own sensory perception, testimony from others, and contextual cues to determine the reality status of novel entities. Additionally, children's initial hypotheses may play a strong role in their ability to use evidence to make accurate reality status decisions. One question this research raises is whether reasoning about the reality status of unseen entities is more difficult than other types of scientific reasoning; future studies should explore this possibility. Future research should also assess whether indeed certain executive functions are at the root of this process or whether other factors, such as metacognitive knowledge, play a role. Answers to such questions will have far-reaching implications not just for our knowledge about children's fantasy-reality differentiation but also for our understanding of their ability to reason scientifically.

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References

Au TK, Sidle A, Rollins K. Developing an intuitive understanding of conservation and contamination: Invisible particles as a plausible mechanism. Developmental Psychology. 1993; 29:286–299.

Baxter, JM.; Sabbagh, MA. Examining young children's changing theories about Santa Claus through parent-child conversations. Poster session presented at the biannual meeting of the Society of Child Development; San Diego, CA. 2005 October.

Carlson SA, Moses LJ. Individual differences in inhibitory control and children's Theory of Mind. Child Development. 2001; 72:1032–1053. [PubMed: 11480933]

Chinn CA, Brewer WF. An empirical test of a taxonomy of responses to anomalous data in science. Journal of Research in Science Teaching. 1998; 35:623–654.

Chinn CA, Malhotra BA. Children's responses to anomalous scientific data: How is conceptual change impeded? Journal of Educational Psychology. 2002; 94:327–343.

Clark, CD. Flights of fancy, leaps of faith: Children's myths in contemporary America. Chicago: University of Chicago Press; 1995.

D'Agostino RB. A second look at analysis of variance on dichotomous data. Journal of Educational Measurement. 1971; 8:327–333.

Dawkins R. Putting away childish things. Skeptical Inquirer. 1995 January/February.

Estes, D.; Wellman, HM.; Woolley, J. Children's understanding of mental phenomena. In: Reese, H., editor. Advances in Child Development and Behavior. N.Y: Academic Press; 1989. p. 41-86.

Fay AL, Klahr D. Knowing and guessing and guessing about knowing: Preschoolers' understanding of indeterminacy. Child Development. 1996; 67:689–716. [PubMed: 8625734]

Flavell JH, Green FL, Flavell ER. Development of knowledge about the appearance-reality distinction. Monographs of the Society for Research in Child Development. 1986; 51:1–68.

Gaito J. Measurement scales and statistics: resurgence of an old misconception. Psychological Bulletin. 1980; 87:564–567.

Gerstadt CL, Hong YJ, Diamond A. The relationship between cognition and action: performance of children 3 ½ - 7 years old on a Stroop-like day-night test. Cognition. 1994; 53:129–153. [PubMed: 7805351]

Gilbert DT. How mental systems believe. American Psychologist. 1991; 46:107–119.

Jaswal V. Don't believe everything you hear: Preschoolers' sensitivity to speaker intent in category induction. Child Development. 2004; 75:1871–1885. [PubMed: 15566385]

Klahr D, Chen Z. Overcoming the positive-capture strategy in young children: Learning about indeterminacy. Child Development. 2003; 74:1275–1296. [PubMed: 14552398]

Koenig MA, Clément F, Harris PL. Trust in testimony: Children's use of true and false statements. Psychological Science. 2004; 15:694–698. [PubMed: 15447641]

Kuhn, D.; Amsel, E.; O'Loughlin, M. The development of scientific thinking skills. Orlando, FL: Academic Press; 1988.

Koerber S, Sodian B, Thoermer C, Nett U. Scientific reasoning in young children: Prescholers' ability to evaluate covariation evidence. Swiss Journal of Psychology. 2005; 64:141–152.

Lunney GH. Using analysis of variance with a dichotomous dependent variable: An empirical study. Journal of Educational Measurement. 1970; 7:263–269.

Lutz DL, Keil FC. Early understanding of the division of cognitive labor. Child Development. 2002; 73:1073–1084. [PubMed: 12146734]

Morison P, Gardner H. Dragons and dinosaurs: The child's capacity to differentiate fantasy from reality. Child Development. 1978; 49:642–648.

Prentice N, Gordon D. Santa Claus & the Tooth Fairy for the Jewish child and parent. Journal of Genetic Psychology. 1987; 148:139–151.

Prentice NM, Manosevitz M, Hubbs L. Imaginary figures of early childhood: Santa Claus, Easter bunny, and the tooth fairy. American Journal of Orthopsychiatry. 1978; 48:618–628. [PubMed: 707613]

Ruffman T, Perner J, Olson DR, Doherty M. Reflecting on scientific thinking: Children's understanding of the hypothesis-evidence relation. Child Development. 1993; 64:1617–1636. [PubMed: 8112110]

Sharon T, Woolley JD. Do monsters dream? Young children's understanding of the fantasy/reality distinction. British Journal of Developmental Psychology. 2004; 22:293–310.

Shtulman A, Carey S. Improbable or impossible? How children reason about the possibility of extraordinary events. Child Development. 2007; 78:1015–1032. [PubMed: 17517019]

Sodian B, Wimmer H. Children's understanding of inference as a source of knowledge. Child Development. 1987; 58:424–433.

Wellman HM, Estes D. Early understanding of mental entities: A reexamination of childhood realism. Child Development. 1986; 57:910–923. [PubMed: 3757609]

Woolley JD. Thinking about fantasy: Are children fundamentally different thinkers and believers from adults? Child Development. 1997; 68:991–1011. [PubMed: 9418217]

Woolley JD, Boerger EA, Markman AB. A visit from the Candy Witch: factors influencing young children's belief in a novel fantastical entity. Developmental Science. 2004; 7:456–468. [PubMed: 15484594]

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Woolley JD, Bruell MJ. Young children's awareness of the origins of their mental representations. Developmental Psychology. 1996; 32:335–346.

Woolley JD, Van Reet J. Effects of context on judgments concerning the reality status of novel entities. Child Development. 2006; 77:1778–1793. [PubMed: 17107460]

Woolley JD, Wellman HM. Young children's understanding of realities, nonrealities, and appearances. Child Development. 1990; 61:946–961. [PubMed: 2209198]

Woolley JD, Wellman HM. Origin and truth: Young children's understanding of imaginary mental representations. Child Development. 1993; 64:1–17. [PubMed: 8436024]

Zaitchik D. Is only seeing really believing? Sources of the true belief in the false belief task. Cognitive Development. 1991; 6:91–103.

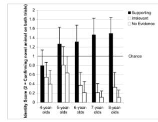

Figure 1.
Mean Identity Question scores for each age group by evidence task (Error bars are 95% confidence intervals.)

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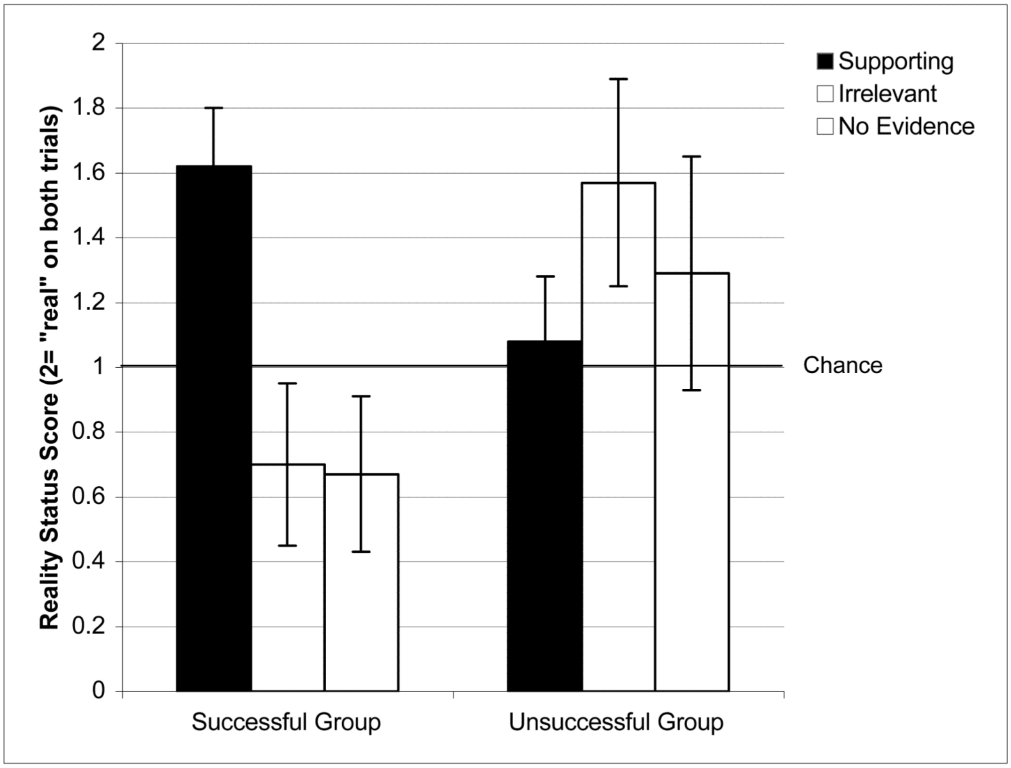

Figure 2.
Mean Reality Status Question scores for each evidence task comparing children who were successful vs. unsuccessful at appropriately answering the Identity Question (Error bars are 95% confidence intervals.)

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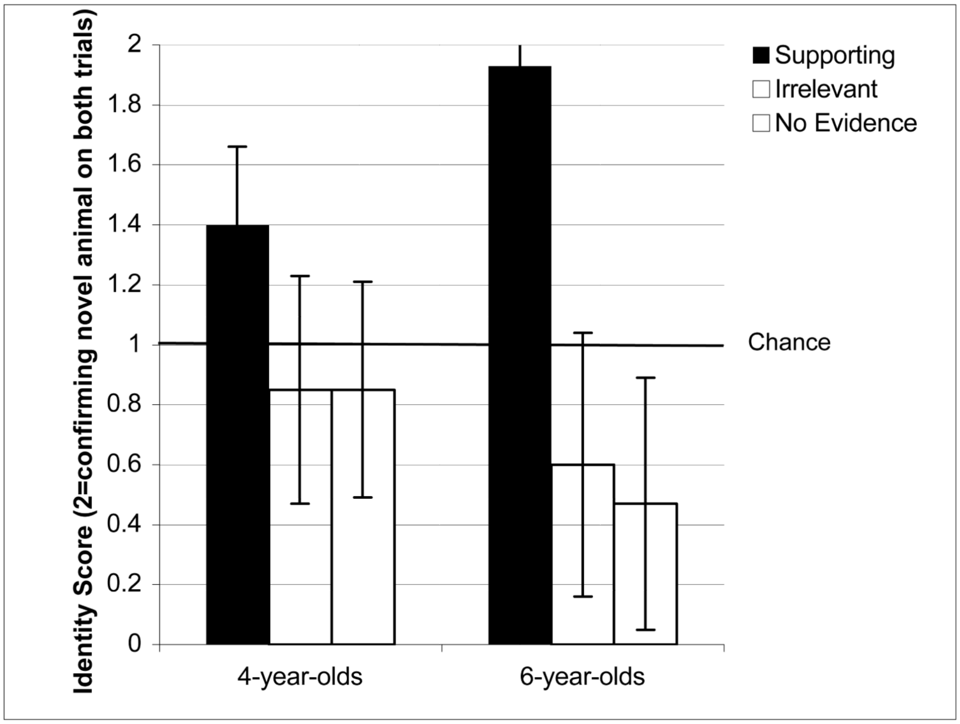

Figure 3.
Mean Identity Question scores for each age group by evidence task (Error bars are 95% confidence intervals.)

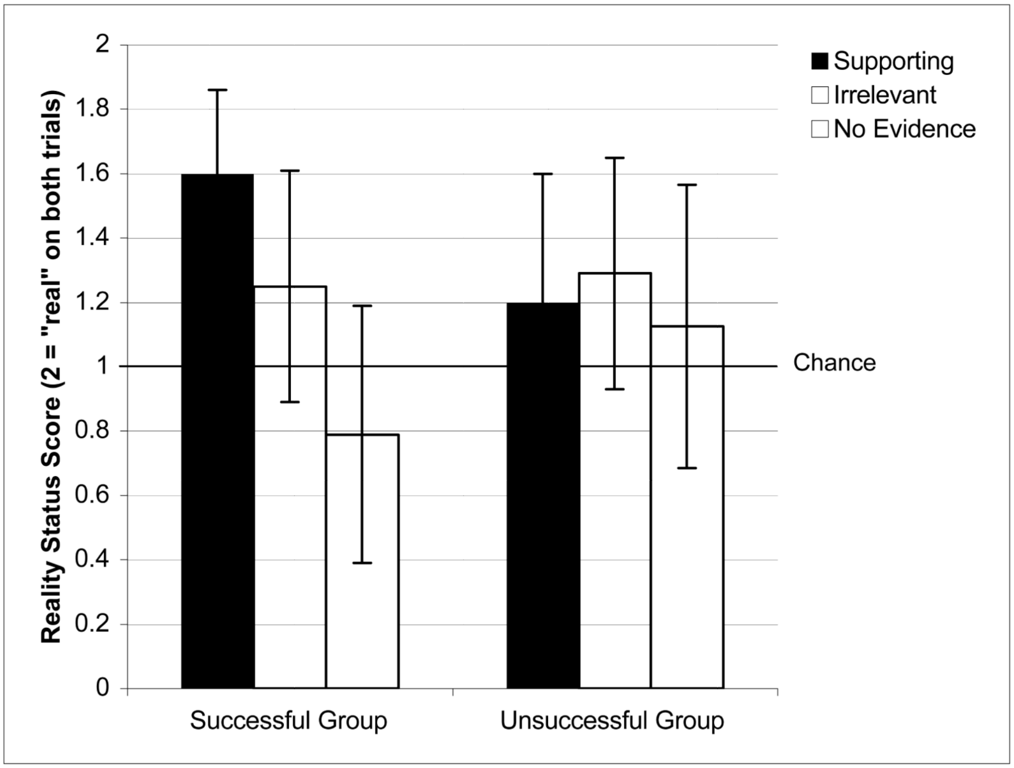

Figure 4.
Mean Reality Status Question scores for each evidence task comparing children who were successful vs. unsuccessful at appropriately answering the Identity Question (Error bars are 95% confidence intervals.)

Table 1

Distribution of children's hypothesis biases in six trials by age.

	4-year-olds	**6-year-olds**
Pretend Bias	9 (45%)	2 (13%)
No Bias	9 (45%)	7 (47%)
Real Bias	2 (10%)	6 (40%)

In six trials, children with one or fewer “real” hypotheses were categorized as having a pretend bias. Children who had 2–4 “real” hypotheses were labeled as having no bias, and children with five or more “real” hypotheses were categorized as having a real bias.

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Table 2

Children's mean reality status question answers for each evidence task grouped by bias type

	Supporting Evidence	Irrelevant Evidence	No Evidence
Real bias	1.75*	1.50*	1.25
No bias	1.44*	1.28	.56*
Pretend bias	1.36	1.09	1.27

*Mean is significantly different from chance ($p < .05$)