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Only Familiar Information is a "Curse": Children's Ability to Predict What Their Peers Know

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The ability to make inferences about what one's peers know is critical for social interaction and communication. Three experiments (n = 309) examined the curse of knowledge, the tendency to be biased by one's knowledge when reasoning about others' knowledge, in children's estimates of their peers' knowledge. Four- to 7-year-olds were taught the answers to factual questions and estimated how many peers would know the answers. When children learned familiar answers, they showed a curse of knowledge in their peer estimates. But, when children learned unfamiliar answers to the same questions, they did not show a curse of knowledge. These data shed light on the mechanisms underlying perspective taking, supporting a fluency misattribution account of the curse of knowledge.

The capacity to infer and reason about other people's perspectives is essential for social well-being and efficient communication. There are vast individual differences in this capacity, whereby more accurate perspective taking is associated with many positive outcomes (e.g., fewer relationship problems, higher academic achievement, more prosocial behaviour; Caputi, Lecce, Pagnin, & Banerjee, 2012; Fink, Begeer, Peterson, Slaughter, & de Rosnay, 2015; Lecce, Caputi, Pagnin, & Banerjee, 2017; Smith & Rose, 2011; for reviews see: Haddock, Lau, Ghrear, & Birch, 2017). An important component of reasoning about other perspectives is the ability to make inferences about what others know. For example, to effectively communicate with others one must routinely infer what others already know to gauge what information needs elaboration.

The ability to make inferences about the knowledge of others is, however, susceptible to bias (i.e., a systematic distortion in thinking; Haselton, Nettle, & Murray, 2015). When individuals know a piece of information they tend to overestimate the likelihood that others will also know this information, compared to individuals who do not know (see Ghrear, Birch, & Bernstein, 2016). For example, a child who knows the hiding location of his candy may overestimate how likely his siblings are to know the hiding location as well. This bias, coined "the curse of knowledge" (e.g., Camerer, Loewenstein, & Weber, 1989), refers to the tendency to be biased by one's current knowledge (or belief) when reasoning about a less informed perspective. Different manifestations of this bias have received various names in the literature, including: "hindsight bias" (Bernstein, Aßfalg, Kumar, & Ackerman, 2016), "creeping determinism" (see Fischhoff, 1975), the "knew-it-all-along effect" (e.g., Wood, 1978), "adult egocentrism" (e.g., Royzman, Cassidy, & Baron, 2003), "reality bias" (e.g., Mitchell & Taylor, 1999), "outcome bias" (Baron & Hershey, 1988), and "curse of belief" (Ichikawa & Steup, 2013). In each case, the bias described is consistent with the tendency to be influenced by one's current knowledge when reasoning about a more naïve perspective, so hereafter we use the overarching term, the "curse of knowledge," or sometimes simply "the bias."

A wealth of cognitive and social psychological research has investigated the pervasive nature of the curse of knowledge and its effects on social cognition and memory. The curse of knowledge is robust and widespread. It persists after explicitly warning participants about it and giving cash incentives to avoid it (Camerer et al., 1989; Pohl & Hell, 1996). It occurs across a variety of paradigms and information types (Blank, Fischer, & Erdfelder, 2003; Bryant & Brockway, 1997; Tykocinski, Pick, & Kedmi, 2002), across cultures (Heine & Lehman, 1996; Pohl, Bender, & Lachmann, 2002), and has been documented in many applied settings,

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including business, education and politics, as well as in academic writing and legal, political, and medical decision-making (e.g., Harley, 2007; Pinker, 2014). We begin by briefly reviewing the literature on the bias in adults and children, distinguishing between three different manifestations: (a) its effect on one's ability to recall his or her earlier, more naïve, knowledge state in hindsight, (b) its effect on the ability to infer another individual's knowledge state, and (c) its effect on one's ability to estimate how widely known information is among others. This third manifestation is of particular interest in the current experiments.

Three Manifestations of the Curse of Knowledge

Manifestation 1: The Curse of Knowledge in Recalling One's Earlier Perspective

To investigate the first manifestation (also known as, "hindsight bias" or "the knew-it-all-along" effect) among adults, researchers typically use the "memory design" where they ask participants to answer a set of questions (Pohl, 2007). Later, participants learn the correct answers and must recall their original answers. Participants' recollections of their original answers tend to be biased toward the newly learned answers. For example, Fischhoff and Beyth (1975) asked participants to predict the likelihood of a set of possible outcomes of Nixon's future visit to the USSR (e.g., a joint space program between United States and the USSR). Upon learning the outcomes of Nixon's visit, participants were asked to recall their earlier predictions of the likelihood of the different outcomes. Participants' recollections were biased toward their newfound knowledge of the outcome. Specifically, participants were more likely to erroneously recall having predicted the actual outcome. In that study, and many others like it (e.g., Hoffrage, Hertwig, & Gigerenzer, 2000), participants' current knowledge biased their recollections of what they had previously thought (see Blank, Musch, & Pohl, 2007; Pohl, 2007).

Similarly, Taylor, Esbensen, and Bennett (1994) found that when young children learned new information (e.g., the color chartreuse) they claimed they knew it all along. They were unable to differentiate between knowledge that they learned a long time ago (e.g., the color red), and knowledge that they learned that day (see also Sutherland, Cimpian, Leslie, & Gelman, 2015). Importantly, young children are not just attempting to "look smart," they think that others would know this information too. In fact, young children sometimes claim that peers, adults, and even babies will share their knowledge (Taylor, Cartwright, & Bowden, 1991).

Manifestation 2: The Curse of Knowledge in Judging What Another Individual Knows

To examine the second manifestation among adults, researchers typically use the "hypothetical design" where they present participants with answers to a set of questions and then ask how another individual, who had not learned the answer, would respond (Pohl, 2007). For example, Fischhoff (1975) provided participants with descriptions of an historical event involving the war between the British and the Gurkha. Some participants did not learn the war's outcome, whereas others learned that "The British and the Gurkha reached a military stalemate." Subsequently, participants considered several possible outcomes, including the actual outcome. For each of these outcomes, participants estimated how likely it would be for a naïve peer to predict that outcome. Compared to participants who did not learn the outcome, participants who knew the outcome estimated that a naïve peer would be more likely to predict that outcome of the war. In this study, and many others like it, participants' current knowledge biases their ability to infer what someone else would think (for reviews see: Hoffrage & Pohl, 2003).

In a developmental demonstration of this manifestation, Birch and Bloom (2003) investigated children's ability to infer another's knowledge of the contents of different containers when the children were informed of the containers' contents versus when they were uninformed. Three- to 5-year-old children saw sets of containers, each containing "a special thing inside." Children learned that Percy, a puppet, had seen what was inside one set, but not the other. On half the trials, children saw what was inside both sets of containers; on remaining trials, children did not see what was inside either set, resulting in a 2×2 cross between Percy's knowledge (or ignorance) and the child's knowledge (or ignorance). When children knew the containers' contents, they overestimated Percy's knowledge compared to when they did not know the containers' contents. That is, knowledge of the containers' contents led to overestimations about what Percy knew. The magnitude of the bias decreased significantly between 3 and 5 years of age. These age-related changes lend support to claims that the curse of knowledge may contribute to young children's difficulty with false belief reasoning—the so-called "litmus" test of children's "theory of mind," or their ability to reason about mental states (e.g., Birch, 2005; Birch & Bloom, 2003; Bernstein, Atance, Loftus, & Meltzoff, 2004; Royzman et al., 2003).

Similarly, in a visual perspective taking measure used in the current study, Bernstein, Atance, Meltzoff, and Loftus (2007) found that knowledgeable children and adults were more likely to overestimate another individual's knowledge. In this procedure, referred to as the Visual Hindsight Bias measure (VHB measure; developed by Harley, Carlsen, & Loftus, 2004; see Figure S1), 3- to 5-year-old children and adults saw degraded images of common objects that gradually clarified on a computer. In a baseline condition, participants identified an image as it clarified. In a hindsight condition, participants first saw a clear version of the image, and then estimated when another individual, a puppet named Ernie, would identify the image as it clarified. The researchers found that after seeing the clear images of the objects, participants overestimated how early, in the course of clarification, Ernie would be able to identify the degraded images. In a follow-up study examining participants from 3 to 95 years of age, Bernstein, Erdfelder, Meltzoff, Peria, and Loftus (2011) found that the curse of knowledge follows a U-shaped trajectory across the life span, with young children and aging adults exhibiting a greater curse of knowledge than older children and younger adults (for related research see, Bernstein et al., 2007; Lagattuta, Sayfan, & Harvey, 2014).

Manifestation 3: The Curse of Knowledge in Judging How Widely Known Information is Among One's Peers

To investigate the third manifestation of the curse of knowledge, adult participants are presented with questions and asked to estimate how many of their peers will know the answers to each of the questions (e.g., Birch, Brosseau-Liard, Haddock, & Ghrear, 2017). Importantly, the participants are taught some of the answers but not others. Participants who knew the answer to a question estimated that more peers would also know the answer to the question, compared to participants who did not know the answer to the same question. Critically, participants who did not know the answer were more accurate in estimating how widely known the information is among their peers, compared to the participants who knew the answer; hence, the "curse" of knowledge (see also Heine & Lehman, 1996; Nickerson, Baddeley, & Freeman, 1987; Pohl et al., 2002).

There is research confirming that children can make a variety of inferences about a group's knowledge; for instance, children can infer that adults tend to know more than children (e.g., Cluver, Heyman, & Carver, 2013; Fitneva, 2010; Rakoczy, Hamann, Warneken, & Tomasello, 2010). Nonetheless, there is little work examining the important role of the curse of knowledge in children's inferences about a group's knowledge. To our knowledge, there is only one study (to date) that specifically examined how the curse of knowledge affects children's inferences about their peers' knowledge. In that study, 40 children from a nomadic pastoralist culture in Northern Kenya were taught the answers to some factual questions and not others. Males, but not females, overestimated how many of their peers would know the answers to the questions they were taught compared to those they were not taught. No statistical differences emerged with age, though the study was limited in its ability to make clear developmental conclusions given that the participants' ages were estimated, since the Western calendar is not used to track birth dates in their culture (Ghrear, Chudek, Fung, Mathew, & Birch, 2019). In our Experiment 1, we expand upon that work to provide the first assessment of the role of the curse of knowledge in North American children's judgments of their peers' knowledge and how it changes with development.

Rationale, Design, and Hypotheses for Experiment 1

In our social world, there are several situations where one must make inferences about how widespread knowledge will be among a group of people. These situations include, for instance: the coordination and communication that occurs in team sports and group projects, or when public speaking, reporting the news, writing, and teaching. In Experiment 1, we investigated the magnitude of the curse of knowledge in children's estimates of their peers knowledge. To do this, 4- to 7-year-old participants were presented with eight factual questions and were asked how many children "about your age" would know the answers (referred to hereafter as the peer estimates, or PE, task). For half of the questions, the "Knowledgeable trials," they were told the answers before they made their PE using a 5-option visual scale indicating how widely known information is among their peers (Figure 1A). For the other questions, the "Ignorant trials," they were not told the answers before making PE. We counterbalanced

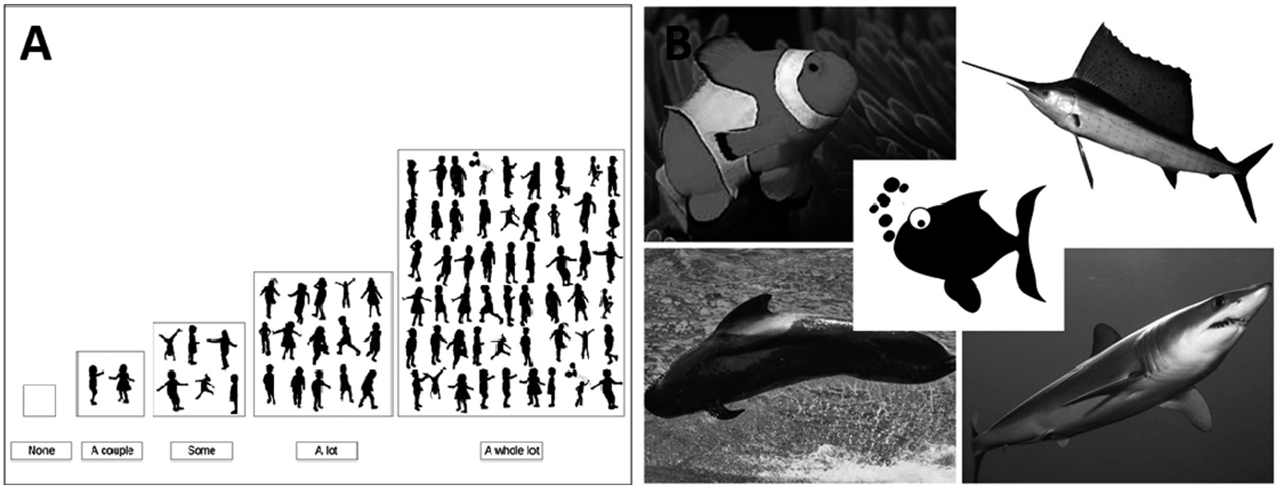

Figure 1. (Panel A) The peer estimates task's 5-option visual scale. Children used this scale to indicate their estimates of how many peers would know the answers to each question. (Panel B) Sample picture with four possible options for the questions. After testing, we assessed children's knowledge about the questions presented in the Test Phase. Children were asked each question and presented with four possible answers.

which set of questions served as Ignorant trials across children (see Table 1). Subsequently, participants were administered the VHB measure, a measure of the second manifestation of the bias developed by Harley et al. (2004; discussed above), to gauge the nature of the relation between the different manifestations.

We formed three predictions based on previous research. First, we hypothesized that children would be cursed by their knowledge when judging how widespread their knowledge is among their peers, given the aforementioned literature showing that children exhibit the other two manifestations of the bias (e.g., Birch & Bloom, 2003; Bernstein et al., 2007; Lagattuta et al., 2014; Royzman et al., 2003; Sutherland & Cimpian, 2015; Wood, 1978). Specifically, we predicted that children would make bigger PE in the Knowledgeable trials (when they were told the answers) compared to the Ignorant trials (when they were not told the answers). Second, given the literature suggesting that younger children tend to be more cursed by their knowledge than older children and adults (Bernstein et al., 2007; Birch & Bloom, 2003), we hypothesized that older children would be less likely to overestimate how widely known information is among their peers when they know the information compared to when they do not. Lastly, given research on adults suggesting that the ability to infer the knowledge of an individual and a group are related (Christensen-Szalanski & Willham, 1991), we predicted that the magnitude of children's bias in the PE task would be correlated with the magnitude of their bias in the VHB measure, after controlling for any age-related changes. However, we suspected that the effect size of the relation would be small, given (a) the differences in reasoning about a specific individual versus a more abstract group of children "about your age," and (b) the different methods employed by the two measures (e.g., conceptual vs. perceptual).

Experiment 1

Method

Participants

We recruited 125 children from a multicultural city in North America between January and June 2016. We recruited this sample through multiple strategies, including contacting families through the university's recruitment database, approaching parents in a children's museum, and contacting parents through school recruitment, where teachers sent students home with consent forms. Predominately, we recruited children who belonged to middle or upper-middle class families. We aimed for a sample of children who were functional in English, and who spoke English at least 50% of their daily lives. We only tested children who were eager to participate. Children were tested individually in our laboratory, at a museum, or at local schools.

Table 1
Mean Peer Estimates (PE) for Each Question Across Knowledge and Ignorant Trials in Experiments 1 and 2

		Experiment 1				Experiment 2			
	Factual question	Answers	Magnitude of bias	Mean PE in knowledgeable trials	Mean PE in ignorant trials	Familiar answers	Magnitude of bias	Mean PE in knowledge trials	Mean PE in ignorant trials
Set A	How many children will know which kind of insect, or bug, is the smallest?	Fairyfly	−.67 ($p < .001$)	1.39	2.06	Ladybug (57.4%)	.59 ($p < .001$)	2.39	1.80
	How many children will know which kind of bear is the largest?	Polar bear	.12 ($p > .60$)	2.41	2.29	Polar bear (44.7%)	.46 ($p = .004$)	2.76	2.3
	How many children will know which kind of dog cannot swim?	The basset hound	−.04 ($p > .85$)	1.98	2.02	Poodle (27.7%)	.73 ($p < .001$)	2.37	1.64
	How many children will know which animal is the best jumper?	Flea	−.52 ($p = .005$)	2.27	2.79	Rabbit (40.4%)	.36 ($p = .006$)	3.22	2.86
	Set A average		**−.29** ($p = .015$)	**2.00** ($SD = .79$)	**2.29** ($SD = .85$)		**.54** ($p < .001$)	**2.69** ($SD = .53$)	**2.15** ($SD = .64$)
Set B	How many children will know which kind of bird can fly the highest?	Ruppell's vulture	−.60 ($p = .002$)	1.81	2.41	Eagle (65.3%)	.82 ($p < .001$)	2.78	1.96
	How many children will know which part of the human body is called a nape?	The back of the neck	.16 ($p > .35$)	1.33	1.16	Top of the head (42.9%)	−.03 ($p > .85$)	1.54	1.57
	How many children will know which animal is the fastest in the sea?	Sailfish	−.05 ($p > .75$)	2.15	2.20	The Mako shark (46.9%)	.07 ($p > .70$)	2.20	2.13
	How many children will know which animal has the best hearing?	The greater wax moth	−.51 ($p = .004$)	1.73	2.24	Bat (49%)	.50 ($p = .012$)	2.46	1.96

Table 1
Continued

Factual question	Answers	Experiment 1: Magnitude of bias	Experiment 1: Mean PE in knowledgeable trials	Experiment 1: Mean PE in ignorant trials	Experiment 2: Familiar answers	Experiment 2: Magnitude of bias	Experiment 2: Mean PE in knowledge trials	Experiment 2: Mean PE in ignorant trials
Set B average		**−.25** (p = .049)	**1.75** (SD = .90)	**2.00** (SD = .72)		**.34** (p = .009)	**2.25** (SD = .88)	**1.91** (SD = .84)

Note. For the Magnitude of Bias columns, we reported the mean difference in peer estimates for Knowledgeable and Ignorant trials, and we ran one-sample *t*-tests to examine whether the differences were significantly different than zero (i.e., no bias). We reported the *p*-values in brackets. In Experiment 2, we taught children fake but familiar answers in the Knowledgeable Trials. These answers were most commonly selected as being correct in Experiment 1 (see Procedure). In brackets, under the familiar answers, we indicated the percentage of children who selected those answers as being correct when they were not taught the answers to those questions in Experiment 1.

For the PE task, we analyzed the data of 101 children (66% male). Of the children who were excluded from analyses, five of them were excluded because they were distracted, were unable to follow instructions, or did not understand English. Nineteen children were excluded because they failed the exclusion criteria (discussed in Experiment 1, Procedure), suggesting that they did not understand the task. According to G*Power post hoc analyses, given our sample size, we had 0.77 power of detecting a small to medium effect of the magnitude of bias, if it existed. Children who were included in our analyses were 4–7 years old (M = 6 years 0 months; range = 4 years 0 months–7 years 11 months); including twenty-four 4-year-olds (M = 4,5; range = 4,0–4,11), twenty-five 5-year-olds (M = 5,5; range = 5,0–5,11), twenty-five 6-year-olds (M = 6,6; range = 6,0–6,10), and twenty-seven 7-year-olds (M = 7,4; range = 7,0–7,11). Fifty-two per cent were Caucasian, 13% were East or Southeast Asian, 8% were South Asian, and 22% were of mixed background. Parents did not disclose the ethnicity for the remaining 5%.

From the 125 children recruited, 117 children completed the VHB measure. From this sample, 99 children's data were included in our analyses of the VHB measure. As for the children's data that were excluded, seven were excluded because they were distracted, five did not understand the task or did not follow instructions (e.g., peeked behind the screens), three did not complete sufficient trials, one participant did not speak English, and two were excluded because of experimenter error. According to G*Power post hoc analyses, given our sample size, we had over 0.90 power of detecting a medium effect size of the hindsight bias, if it existed. Children who were included in analyses were 4- to 7-years-old (M = 5 years 11 months; range = 4 years 0 month–7 years 11 months; 61% male); including twenty-seven 4-year-olds (M = 4,6; range = 4,0–4,11), twenty-five 5-year-olds (M = 5,5; range = 5,0–5,11), twenty-two 6-year-olds (M = 6,5; range = 6,0–6,11), and twenty-five 7-year-olds (M = 7,4; range = 7,0–7,11). Fifty-four percent of the participants were Caucasian, 13% were East and Southeast Asian, 8% were South Asian, and 21% were of mixed background.

Material

For the PE Task, we used a 5-point visual scale that represents a progressively larger number of peers: *none*, *a couple*, *some*, *a lot*, and *a whole lot*. For example, the first point is "none" and the box does not have any child silhouettes, the second point is “a couple” and the box contains two child silhouettes, the third point is “some” and the box contains six child silhouettes, and so on (Figure 1A).

For the VHB measure, we used materials akin to those used in the VHB measure in Bernstein et al. (2007). The procedure involved four objects that measured up to 5 in. long: a bird, a school bus, a tree, and a horse. The materials included a box measuring 13 × 15 in. with one open side and a three-ringed binder placed on top of the box. The binder held 10 clear plastic sheets speckled with black dots. These sheets hung in front of the open side of the box, to occlude the participant’s view of what was inside. Each sheet had a unique pattern of black dots that cover 5% of each sheet, such that each sheet was transparent but blurry. Behind the 10th sheet it was extremely difficult to identify the object inside the box, however, as the experimenter flipped through the sheets the view of the object became clearer (Figure 2).

Procedure

Warm-up phase. For each study session, the experimenter introduced herself, and asked the child some questions about his or her hobbies, to get the child comfortable answering questions. The experimenter then showed the participant the scale and discussed the different amounts of children associated with each point on the scale (Figure 1A). Then, the experimenter explained that she will ask some questions about how many of the child’s peers will know different things. The child was asked to indicate their answers by pointing to one of the points on the scale.

Demonstration phase. Subsequently, the experimenter administered three demonstration trials where she showed the child how to make a PE. Through these trials, the experimenter showed the participant how to make a PE for an easy question, a difficult question, and a question that is medium in difficulty. To demonstrate an easy question, the experimenter asked, “A cow says moo. How many children your age will know that?” then the experimenter went on to say that a whole lot of children will know the answer to that question and she pointed to “a whole lot” on the 5-point scale. To demonstrate a difficult question, the experimenter showed children a picture of an odd object and said “This is a holophonor. How many children your age will know that?” Then the experimenter went on to say that no children would know the answer to this question and pointed to “none” on the 5-point scale. Lastly, to demonstrate a medium in difficulty question, the experimenter asked, “a giraffe is the tallest animal. How many children your age will know that?” then she went on to say that some children will know the answer to this question and she pointed to “some.”

PE test phase. For the experimental trials, the experimenter asked the child to make PE about how many children would know different factual questions. Each question was presented with a corresponding picture (e.g., a question about fish was presented with a silhouette of a fish). The questions were divided into two sets; Sets A and B. All participants were presented with both sets of questions: half of the participants were taught the answers to Set A, and not Set B, whereas the other half were taught the answers to Set B, and not Set A. Thus, answers for half of the questions were

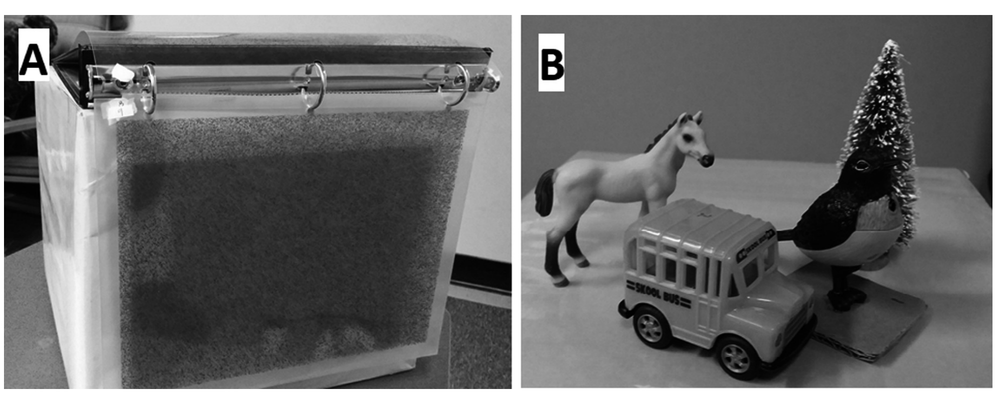

Figure 2. Material for Visual Hindsight Bias (VHB) measure. We used this material to conduct the VHB measure (Bernstein et al., 2011). We used the binder and the box in Panel A to hide each toy (see Panel B). In the Baseline condition, we hid each toy in the box and covered it up with the 10 plastic sheets making it difficult to see what was inside the box. Then we removed one sheet at a time and asked children what was inside the box. In the Hindsight condition, we repeated the same procedure, however, children were asked to estimate when Ernie, a puppet, could see inside the box.

taught to children prior to making their PE (e.g., "A Ruppell's vulture can fly the highest. How many children will know which kind of bird can fly the highest?"), and the other half of the questions were not taught (e.g., "How many children will know which kind of bear is the largest?"). Half of the participants were presented with Set A first, whereas the other half were presented with Set B first. To ensure that children had no prior knowledge about the questions before the experimental session, we selected unfamiliar (or unique) factual trivia-like questions (Table 1).

The child was then asked two posttest questions to further confirm that they understood the 5-point scale: "How many children like to be happy?" and "How many children like to be sad?" If the child indicated that *less* than "some" of their peers like to be happy, or that *more* than "some" of their peers like to be sad, then we inferred that the child did not understand the task and we excluded their data. Lastly, the experimenter asked the child the factual questions with four possible response options (Figure 1B), to confirm that children did not know the answers to the questions they were not taught.

VHB measure. Following the PE Task most children agreed to participate in the VHB measure. In a Baseline condition, the experimenter hid a toy inside a box, behind the 10 speckled sheets, such that it was impossible for the child to see the hidden toy. The experimenter then removed one sheet at a time, so that the toy became progressively clearer, and the child was asked what he or she thought the toy was, before each sheet was removed. When the child identified the toy, the experimenter noted how many of the 10 sheets had been removed. The experimenter completed this procedure four times with four different toys. In the Hindsight condition that followed directly (i.e., with no delay), the experimenter introduced Ernie, the puppet, and explained that Ernie is just as smart as the participant, but he had never played this game before. The experimenter told the child that they will be playing the same game with Ernie. The experimenter then hid each toy, and once again, removed each sheet. During this round, the child was asked to indicate when Ernie could identify the toy behind the sheets. When the child indicated that Ernie identified the toy, the experimenter asked the child "What will Ernie say is inside the box?" If the child indicated the appropriate toy, the experimenter noted the number of sheets removed. Then, the experimenter asked the child *how* Ernie knew what was inside the box. This question confirmed that the child believed that Ernie could identify the toy because he could currently see it, as opposed to the child thinking that Ernie has seen the toy before (only one child's data was excluded for that reason).

Results

PE Task: Did Children Show the Curse of Knowledge?

Before we began our main analyses, we confirmed that participants did not know the answers to the questions that they were not taught. Here chance for each question is 25% because the question was presented as a four-option forced choice task. To compare children's total score on the four Ignorant trials, we ran a one-sample t-test comparing their mean score against one (i.e., chance for four questions). Children's mean score was 0.73 which was significantly below chance, $t(98) = -3.67$, $p < .001$, confirming that children were unlikely to know the answers to the questions that were not taught, even when given the opportunity to guess the correct answer from four possible answers.

To examine the effect of knowledge on PE, we created a magnitude of bias score for each child by subtracting each child's PE in the knowledgeable trials by the average PE in the Ignorant (baseline) trials for each factual question. Given that children estimated that some factual questions were more difficult than others (e.g., Table 1, for a summary of the baseline estimates of peer's knowledge by question), we used these difference scores to account for differences in question difficulty. That is, for each factual question (e.g., How many children will know which bird can fly the highest?), we subtracted each child's PE when they were taught the answer to the question (e.g., Ruppell's vulture can fly the highest) by the average PE when children did not learn the answer to the question (see Blank, Nestler, von Collani, & Fischer, 2008, for similar analyses). We then examined whether the average magnitude of bias across factual questions was significantly different from zero. A one-sample t-test showed that the average magnitude of bias was significantly different than zero, $t(100) = -2.68$, $p = .009$, $d = .27$. Contrary to our prediction, however, children made lower PE when they learned the answers to the factual questions, compared to when they did not learn the answers (average magnitude of bias = -0.24). Note, we confirmed that children were attentive to the information we taught them, as they recalled the answers significantly above chance (Table S1).

PE Task: Did the Magnitude of the Bias Decrease With Age?

We conducted a multiple linear regression investigating the effect of age (in months) on the average magnitude of bias, as well as the effect of set order (i.e., whether children were presented with Set A or B first), Set taught (i.e., whether children were taught the answers to Set A or Set B) and sex. Using the enter method, we found that age, set order, set taught, and sex, explained a significant amount of the variance, $F(3, 97) = 7.49$, $p < .001$, with an adjusted R^2 of .16. Age was a significant predictor of the magnitude of bias ($\beta = -.42$, $p < .001$), whereas set order ($\beta = -.13$, $p > .15$), set taught ($\beta = -.02$, $p > .80$), and sex ($\beta = .03$, $p > .70$) were not significant predictors. That is, older children were more likely to make lower PE upon learning the answers to factual questions, compared to younger children (see Figure 3, for an illustration of the magnitude of bias by age in years).

VHB Measure: Did Children Show the Bias? If So, Did It Decrease With Age?

For our main analyses here, we conducted multilevel regression using the lme4 package (Bates, Mächler, Bolker, & Walker, 2015) in the R environment (R Core Development Team, 2016), and we probed interactions and calculated regions of significance with the online calculator (Preacher, Curran, & Bauer, 2006). Maximum likelihood was used for estimation. To examine whether children showed the curse of knowledge in the VHB measure, we entered the number of sheets removed to uncover the identity of the toy as a continuous dependent variable nested within participants (i.e., 0–10). Condition, centered age (in months), and their interaction were entered as predictors. As expected (Table 2), we found a main effect of the curse of knowledge, $p < .001$; that is, children removed more sheets, in the Baseline condition, when they were identifying the toys *themselves*, compared to Hindsight condition, when they removed sheets to estimate when *Ernie* can identify the toys. We also found a significant interaction between age and condition, $p < .01$. Probing the interaction suggested that the number of sheets removed in the Hindsight condition was significantly lower than in the Baseline condition across all ages and the difference was larger for younger than older participants (Figure S2). That is, as observed in previous studies (e.g., Bernstein et al., 2011), younger children showed a bigger curse of knowledge in the VHB measure than older children.

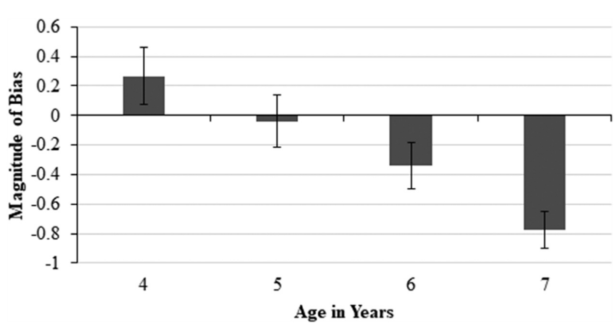

Figure 3. The magnitude of bias by age in Experiment 1 in peer estimates (PE) task. To calculate the magnitude of bias, we subtracted children's PE in each Knowledgeable trial by the average PE for the Ignorant trial and averaged across these difference scores. As illustrated, the magnitude of bias decreases with age, such that older children tended to make lower PE in the Knowledgeable trials versus the Ignorant trials. Error bars represent standard error.

Did Performance on the PE Task Correlate With Performance on the VHB Measure?

To create a magnitude of bias score for the VHB measure, we took the average of the differences between the number of sheets children removed in the Baseline condition and the Hindsight condition to identify each object. We found a significant bivariate correlation between magnitude of bias in the PE task and the VHB measure, $r(81) = .34$, $p = .002$. Indeed, the association between the magnitude of the bias in the PE task and VHB measure is significant, even after controlling for age, $r(78) = .27$, $p = .014$. Children who showed a bigger magnitude of bias in the PE task (i.e., the children who were cursed by their knowledge in the PE task) were likely to also show a bigger curse of knowledge in the VHB measure.

Discussion

In contradiction to our first prediction, we found that on average 4- to 7-year-old children were more likely to make lower PE when they learned the answers to the factual questions, and this tendency to make lower estimates upon learning the answers increased with age. Also, we found that children's performance on the VHB measure was related to their performance on the PE task, such that children who showed a bigger magnitude of bias in the

Table 2
Experiment 1 Multilevel Regression Analyses Visual Hindsight Bias Measure

Predictor	Intercept only	Intercept + condition	Intercept + Condition × Age
Fixed			
Intercept	7.44 (.12)***	7.44 (.12)***	7.44 (.12)***
Condition (recognition = −.5, hindsight = .5)		−1.17 (.12)***	−1.17 (.12)***
Age in months (centered)			−0.005 (.009)
Condition × Age			0.03 (.009)**
Random			
Variance of participant-level error	1.10	1.15	1.15
Variance of response-level error	3.32	2.93	2.90
Deviance	3,326.3	3,239.6	3,231.0
Akaike information criterion	3,332.3	3,247.6	3,243.0
Bayesian information criterion	3,346.3	3,266.3	3,271.0

Note. Standard errors are in parentheses.
$^{**}p < .01$. $^{***}p < .001$.

VHB measure tended to show a bigger magnitude of bias in the PE task (i.e., greater PE when they knew the factual questions vs. when they did not). This suggests that the two manifestations of the curse of knowledge are related, even though they were assessed using two very different designs: one focused on conceptual information (animal facts) and the other focused on perceptual information (visual recognition of objects), thereby eliminating any concern that shared method variance could account for this relation.

Why did we find a reversal of the typical curse of knowledge in the PE task, such that children (on average) made lower, not higher, PE when they knew the answers? We suspect that children showed this pattern of responses for theoretically interesting reasons—namely because the answers to those questions were especially unfamiliar, and therefore lacked a sense of fluency (i.e., ease in processing). When designing Experiment 1, we intentionally selected factual questions (e.g., "What animal has the best hearing?" Answer: "The Greater Wax Moth") that children were very unlikely to know, to ensure that children did not know the answers for the set of factual questions in the Ignorant trials (i.e., so we could experimentally manipulate knowing vs. not knowing).

Even though we predicted that children would show the curse of knowledge in their PE, this contradictory finding fits with research in adults demonstrating the unique circumstances that circumvent the typically observed curse of knowledge. Although the curse of knowledge appears to be the prevalent outcome of acquiring new information, some research with adult participants has found that the bias can be diminished, prevented, or even reversed under certain circumstances, such as when information is surprising or implausible (e.g., Birch & Bloom, 2007; Mazursky & Ofir, 1990; Ofir & Mazursky, 1997; Pohl et al., 2002; Sanna & Schwarz, 2003; Wasserman, Lempert, & Hastie, 1991; Yopchick & Kim, 2012).

Much debate exists over the specific cognitive mechanism that mediates the bias (e.g., Bernstein, Kumar, Masson, & Levitin, 2018; Pezzo, 2003, Pohl, 1998; Pohl, Bayen, Arnold, Auer, & Martin, 2018; Wasserman et al., 1991). We believe that the instances that do *not* result in the curse of knowledge are as theoretically informative (if not more informative) than instances that result in the curse of knowledge. As such, we capitalized on this unique opportunity afforded by the unexpected results to investigate the factors that mediate the curse of knowledge. In Experiments 2 and 3, we examined the factors that do, versus do not, contribute to the curse of knowledge. Before outlining the rationale and hypotheses for Experiments 2 and 3, we first review key literature discussing the mechanisms underlying the curse of knowledge.

Mechanisms Underlying the Curse of Knowledge

According to an inhibitory control account, the curse of knowledge can be overcome by suppressing, or inhibiting, one's privileged knowledge when reasoning about a naïve perspective (e.g., Bayen, Pohl, Erdfelder, & Auer, 2007). For example, if you know the location of the Trevi Fountain, you must inhibit that information (Rome, Italy) to make accurate inferences about others' knowledge. Conversely, an inability to adequately inhibit your knowledge contributes to the bias. Inhibitory control, as a cognitive skill, develops across childhood and deteriorates with older age (e.g., Groß & Bayen, 2015), consistent with the age-related changes associated with the curse of knowledge where young children and aging adults are more affected by the bias (e.g., Bernstein et al., 2011).

Researchers have also proposed fluency misattribution as a mechanism that contributes to the curse of knowledge. Researchers suggest that when information feels fluent (i.e., easy to process, easy to recall, or easy to integrate with our existing knowledge structures), we tend to think that this information is obvious to others (Bernstein et al., 2018; Birch et al., 2017; Harley et al., 2004). In other words, we misattribute the subjective ease associated with a piece of information to its objective ease, or foreseeability, to others. According to a fluency misattribution account, the curse of knowledge is not due to a failure to inhibit the *content* of one's knowledge, but rather a tendency to misinterpret the ease (fluency) with which the information is processed, or comes to mind. For example, if one knows that the Trevi Fountain is in Rome, one must be able to fully discount the ease with which this information comes to mind to make accurate inferences about others' knowledge of this fact.

Fluency *misattribution* results in errors in a variety of judgments in perceptual, conceptual, and social reasoning, but it stems from an otherwise useful heuristic, namely fluency *attribution* (see Whittlesea, 1993, for a review). Information that has been processed before (due to prior exposure) is processed more fluently (Jacoby & Whitehouse, 1989; Whittlesea, 1993). As such, it serves an important memory function by signaling that we have previously encountered the information. That is, when participants process information fluently, they attribute those feelings of fluency to prior exposure (e.g., Jacoby & Dallas, 1981). Fluency *mis*attribution occurs when the subjective feeling of fluency is attributed to something *other* than prior exposure. For instance, individuals may misattribute the feeling of fluency to an inaccurate source, such as how objectively easy the information is, or how widely known it is.

Harley et al. (2004) were the first to examine the effect of fluency misattribution on the curse of knowledge, by using a VHB design. In one condition (baseline), participants watched degraded images of celebrity faces gradually clarify. For each image, participants indicated when they could identify the celebrity. Subsequently, in the hindsight condition, participants were asked to watch a similar series of degraded images, but they were instructed to estimate when a naïve peer would identify the celebrities. For each trial, in the hindsight condition, participants saw a clear image of the celebrity (visual knowledge), and then the degraded images. Importantly, in this condition, participants saw the degraded images of celebrities that they themselves identified in the baseline condition (Familiar celebrities), as well as degraded image of celebrities that they had not identified before (New celebrities). Participants knew the identities of both the Familiar and New celebrities, but they had previous experience identifying the Familiar celebrities, and as such would have processed that information more fluently. Participants' knowledge of the celebrities' identity led to overestimations of how early, in the course of clarification, the naïve peer would identify the celebrities. Importantly, participants were more likely to show the bias for the Familiar celebrities compared to the New celebrities. The latter finding suggests that familiarity with processing the images evoked a feeling of fluency that strengthened the effect of the bias. That is, fluency misattribution contributed to the curse of knowledge over and above the effect of simply possessing knowledge (see also Birch et al., 2017).

Importantly, the fluency misattribution account is quite different from the inhibitory control account of the curse of knowledge. The key difference here is that the fluency misattribution account suggests that there are specific characteristics of knowledge (e.g., familiarity, prior exposure) that contribute to, or minimize (e.g., unfamiliarity) the curse of knowledge. Fluency misattribution emphasizes the role of fluently *processing* the information, whereas the inhibitory control account emphasizes the role of *possessing* knowledge. That is, according to the fluency misattribution account, certain types of knowledge (i.e., information that is easy to process) will lead to larger bias in our judgments, whereas according to the inhibitory control account, as it currently stands, any knowledge can lead to the bias.

Rationale, Design, and Hypotheses for Experiment 2

We hypothesized that children made lower PE upon learning the answers to the factual questions in Experiment 1, because the answers to the questions were unfamiliar, not just unknown, and therefore they did not *feel* fluent to children. For example, children may have never heard of "the Greater Wax Moth" before. This unfamiliarity likely led to a dysfluency in the processing of the information, which negated the fluency misattribution process. Indeed, this is the opposite of the curse of knowledge effect that these same children showed in the VHB measure, where the items were made fluent via repeated exposure over the 10 trials. We suspected that if the answers in the PE tasks contained more familiar information (e.g., the "bat" has the best hearing), children would show a typical curse of knowledge. To test this hypothesis, in Experiment 2, we presented children with the *same questions* as in Experiment 1, except we taught children fake, but *familiar* (and therefore more fluent), answers. We hypothesized that unlike in Experiment 1, children would show a typical curse of knowledge and think that questions they were taught were more widely known among their peers, than questions they were not taught. Moreover, we predicted that familiar answers in Experiment 2 would lead to a greater curse of knowledge, than the unfamiliar answers in Experiment 1. Our other predictions for Experiment 2 were the same as Experiment 1: We predicted that age would moderate the effect of the curse of knowledge on PE (i.e., older children will show a smaller curse of knowledge compared to younger children) and that children's performance in the PE task would correlate modestly with their performance on the VHB measure, even after controlling for age effects.

Experiment 2

Method

Participants

We recruited 176 children from a multicultural city in North America between November 2016 and November 2017. We used the same recruitment strategies as Experiment 1 (see Participants), and we aimed for a similar sample of children (e.g., functional in English, eager to participate). Again, children belonged to middle or upper-middle class families, and they were tested individually in our laboratory, at a museum, or at local schools.

For the PE task, we analyzed the data of 104 children (46% male). Of the children who were excluded from analyses, 11 were excluded because they did not follow instructions, or did not complete sufficient trials. Forty-one participants were excluded because they failed the exclusion criteria (discussed in Experiment 1 Procedure) suggesting that they did not understand the task. Lastly, 20 participants' data were excluded because they knew the true answer to at least one of the questions that they were taught. Recall, we replaced the true (unfamiliar) answers with fake (familiar) answers, so children who knew the true answers may question the researcher's validity as an informant, and therefore our experimental manipulation could have been compromised. Note that our findings were consistent even if we did not exclude these children's data. We decided to exclude their data, because they did not meet our preset exclusion criteria.

According to G*Power post hoc analyses, given our sample size, we had over 0.9 power of detecting a medium effect of the magnitude of bias, if it existed. Children who were included in our analyses were 4–7 years old (M = 5 years 11 months; range = 4 years 0 months–7 years 11 months): twenty-five 4-year-olds (M = 4,5; range = 4,0–4,9), twenty-nine 5-year-olds (M = 5,5; range = 5,0–5,11), twenty-four 6-year-olds (M = 6,5; range = 6,0–6,11), and twenty-six 7-year-olds (M = 7,7; range = 7, 0–7,11). Forty per cent of the participants were Caucasian, 29% were East or Southeast Asian, 4% were South Asian, and 19% were of mixed background. As for the remaining 8%, parents did not disclose their ethnic background.

From the 176 children recruited, 105 children participated in the VHB measure. From this sample, 93 children's data were included in our analyses of the VHB measure. Of the children who were excluded from analyses, five decided not to continue, four were very distracted, three did not follow instructions or did not understand the task (e.g., a child thought that Ernie knew which toys were hidden because he overheard the researcher). According to G*Power post hoc analyses, given our sample size, we had over 0.90 power of detecting a medium effect size of the hindsight bias, if it existed. The children included in our analyses were 4- to 7-year-olds (M = 5 years 10 months; range = 4 years 1 month–7 years 11 months; 47% male). Thirty-two 4-year-olds (M = 4,5; range = 4,1–4,11), seventeen 5-year-olds (M = 5,5; range = 5,1–5,11), twenty-one 6-year-olds (M = 6,6; range = 6,0–6,11), and twenty-three 7-year-olds (M = 7,6; range = 7,1–7,11). Forty-seven per cent of the participants were Caucasian, 25% were East or Southeast Asian, 5% were South Asian, and 18% were of mixed background.

Material and Procedure

Experiment 2 used the same material and followed the same procedure as Experiment 1. Except, we replaced the accurate, but unfamiliar, answers to the questions with fake, but familiar, answers. Specifically, in Experiment 2, we used the most commonly selected guesses from Experiment 1, Ignorant trials, when children were asked the factual questions and presented with four possible answers (Figure 1b). For example, we told participants that the "lady bug" instead of the "fairyfly" is the smallest insect (see Table 1). We made parents aware that children would be given fake, but familiar, answers to some of the factual questions during the informed consent, and at the end of testing, we told children the accurate answers to the factual questions.

Results

PE Task: Did Children Show the Curse of Knowledge?

Like Experiment 1, we confirmed that children were unlikely to have prior knowledge of the factual questions by examining their answers to the questions in the Ignorant trials, $t(103) = -5.36$, $p < .001$. Then, we computed the magnitude of bias scores for each child. We found that children showed a significant curse of knowledge effect, such that the magnitude of the bias ($M = 0.44$) was significantly bigger than zero, $t(103) = 6.24$, $p < .001$, $d = .61$. Children made bigger PE when they were taught the answers to the factual questions, compared to when they were not taught—the classic curse of knowledge.

PE Task: Did the Magnitude of Bias Decrease With Age?

Again, we conducted a multiple linear regression investigating the effect of age on the magnitude of the bias, as well as the effect of set order, set taught, and sex. We found that these variables did not explain a significant amount of the variance in the magnitude of the bias, $F(4, 98) = 1.18$, $p = .32$, with an adjusted R^2 of .01. Age was marginally predictive of the magnitude of bias ($\beta = -.16$, $p = .12$), such that older children showed a smaller magnitude of bias compared to younger children (see Figure 4).

VHB Measure: Did children Show the Bias? If So, Did It Decrease With Age?

We used the same analyses plan as Experiment 1, condition, centered age, and their interaction were entered as predictors. As shown in Table 3, we found a main effect of the curse of knowledge, $p < .001$. We also found a significant interaction between age and condition, $p < .05$. Probing the interaction suggested that the number of sheets removed in the hindsight condition was significantly lower than in the Baseline condition across all ages and the difference was larger for younger than older participants: Younger children showed a bigger curse of knowledge effect than older children (Figure S3).

Did Performance on the PE Task Correlate With Performance on the VHB Measure?

We did not find a significant bivariate correlation between the magnitude of bias in the PE task and VHB measure, $r(62) = .16$, $p = .21$. Indeed, the correlation was not significant, when we controlled for age, $r(59) = .12$, $p = .37$. That is, children's performance on the PE task appeared to be unrelated to their performance on the VHB measure.

Does the Magnitude of the Curse of Knowledge Differ Across Experiment 1 and 2?

To directly compare the effects of being taught familiar versus unfamiliar answers to the questions, we conducted a multiple linear regression investigating the effect of experiment (1, 2), as well as age on the magnitude of bias. We found a significant regression equation, $F(2, 201) = 30.21$, $p < .001$, with an adjusted R^2 of .22. Both experiment ($\beta = .39$, $p < .001$) and age ($\beta = -.27$, $p < .001$) were significant predictors of the curse of knowledge. When children were taught familiar answers to the factual questions, they made bigger PE for the Knowledgeable trials compared to the Ignorant trials. And

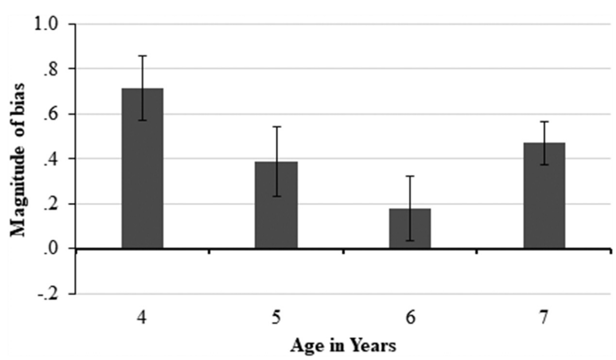

Figure 4. The magnitude of bias by age in Experiment 2 in peer estimates (PE) task. Overall, children showed a magnitude of bias that is significantly bigger than zero, demonstrating the typical curse of knowledge effect. Children made higher PE when they learned the familiar answers to the factual questions, compared to when they did not learn the answers. Error bars reflect standard error.

Table 3
Experiment 2 Multilevel Regression Analyses Visual Hindsight Bias Measure

Predictor	Intercept only	Intercept + condition	Intercept + Condition × Age
Fixed			
Intercept	7.33 (.13)***	7.33 (.13)***	7.33 (.13)***
Condition (recognition = −.5, hindsight = .5)		−1.60 (.13)***	−1.60 (.13)***
Age in months (centered)			−0.010 (.008)
Condition × Age			0.02 (.009)*
Random			
Variance of participant-level error	1.04	1.12	1.12
Variance of response-level error	3.94	3.21	3.18
Deviance	3,219.4	3,086.9	3,080.1
Akaike information criterion	3,225.4	3,094.9	3,092.1
Bayesian information criterion	3,239.2	3,113.3	3,119.8

Note. Standard errors are in parentheses.
*$p < .05$. ***$p < .001$.

overall, younger children showed a bigger curse of knowledge compared to older children.

Discussion

In Experiment 2, when children were taught familiar answers to the same factual questions as in Experiment 1, children made higher PE for the questions that were taught versus the questions that were not taught, as hypothesized. That is, upon hearing answers that contained familiar items, children estimated that the questions that they were taught would be more widely known compared to the questions that they were not taught. There was only modest support for our second prediction; the magnitude of the curse of knowledge in the PE task decreased marginally with age in Experiment 2, but significantly when combining Experiments 1 and 2, suggesting that the age-related decline previously observed in the other two manifestations of the curse of knowledge is also present in children's judgments of how prevalent knowledge is among one's peers, but may not be as robust. This time, when we taught children familiar answers in the PE task, we did not find a significant correlation between the magnitude of the bias in the PE task and the VHB measure. We discuss the implications of not finding a correlation between the two tasks in the General Discussion.

Importantly, we found an interaction between Experiment 1 and 2 on PE, such that children showed a curse of knowledge in Experiment 2 but not in Experiment 1; children showed a reversal of the bias in Experiment 1. That is, children who were presented with unfamiliar answers to the questions made lower PE compared to baseline (Ignorant) estimates; whereas children who were presented with familiar answers to those same questions made bigger PE compared to the baseline estimates.

One limitation of the cross-experimental comparisions is that children were not randomly assigned to the two experiments. Experiment 1 data collection was completed before we started data collection for Experiment 2. To address this limitation, we conducted Experiment 3, where children were randomly assigned to one of three conditions; an Unfamiliar condition, a Familiar condition, or an Ignorant condition. In all three conditions, we presented children with the same six factual questions. In the Ignorant condition, we did not teach children answers to the factual questions, before asking them to make PE (e.g., "How many children will know which kind of insect can fly the highest?"). In the Familiar condition, we taught children familiar answers to the factual questions (e.g., "the butterfly can fly the highest") before asking them to make PE. In the Unfamiliar condition, we taught children unfamiliar answers to the factual questions (e.g., "the stonefly can fly the highest") before asking them to make PE.

In this experiment, we used a different set of questions from those used in Experiments 1 and 2, to confirm that the curse of knowledge is not specific to the factual questions we used in Experiment 1 and 2. This time, we directly examined the effect of familiarity on the curse of knowledge. We selected 11 pairs of familiar and unfamiliar animals, and we conducted a pretest to confirm that one of the animals was more familiar to children than the other.

In the pretest, we asked twelve 5- to 8-year-old children (67% male) which of two similar animals they heard of before. For example, we asked children which type of eagle they heard of before, a bald eagle or a harpy eagle. We selected six pairs of animals for Experiment 3 that at least 11 (out of 12) children chose the "familiar" animal.

Lastly, we selected six factual questions that fit with either the familiar or unfamiliar animal. For example, we presented children with the question "which type of insect, or bug, can fly the highest?", because both the butterfly and the stonefly can fly the highest relative to other flying insects. See Table 4, for an overview of the six factual questions and their corresponding familiar and unfamiliar animals. For this experiment, we tested one prediction; that children would only show the curse of knowledge when they were taught familiar information. We predicted that children would not show the curse of knowledge in the unfamiliar condition, and might even show a full reversal of the bias, as in Experiment 1.

Experiment 3

Method

Participants

We recruited 149 children from a multicultural city in North American between May and December 2019. We used the same recruitment strategies as Experiment 1, and we aimed for similar sample characteristics. Predominately, children belonged to middle or upper-middle class families. One hundred and thirty-eight children (46% male) were included in our analyses. Of the children who were excluded from analyses, five children were distracted, four children were atypically developing (e.g., diagnosed Autism Spectrum Disorder), and two did not understand the task (e.g., provided their own answers to factual questions when they were asked for PE). Children were tested individually at a university laboratory, children's museum, and local schools. The participants were 6–7 years old (M = 6 years 11 months; range = 6 years 0 months–7 years 11 months). The sample consisted of seventy-one 6-year-olds (M = 6,7; range = 6,0–6,11), and sixty-six 7-year-olds (M = 7,5; range = 7,0–7,11). Thirty-seven percent were Caucasian, 29% were East and Southeast Asian, 5% were South Asian, 4% Middle Eastern, 1% aboriginal, 1% Latin American, and 13% were of mixed background (e.g., half east Asian, half Caucasian). As for the remaining 10% of children, parents did not indicate ethnicity.

Material and Procedure

Each child watched a series of PowerPoint slides with an experimenter who guided them through the study. Like Experiment 1 and 2, the session began with a demonstration of how to use the 5-point scale (see Experiment 1, Procedure). Then, the Powerpoint slides presented the experimental trials. Each child was presented with factual questions and asked to make a PE on the 5-point scale (see Table 4, for questions and answers). In the Ignorant condition, children were not presented with answers to the factual questions. In the Familiar condition, children were presented with familiar answers, and in the Unfamiliar condition, children were presented with unfamiliar answers. At the end of each condition, children were asked the answers to the factual questions and provided with three possible answers. Again, we counterbalanced the order of the factual questions by splitting the six questions into Set A and B, and we presented half of the children with Set A first, and the other half with Set B first.

Results

Did Children Show the Curse of Knowledge in the Familiar and Unfamiliar Conditions?

As in Experiments 1 and 2, we computed the magnitude of bias scores for the Familiar and the Unfamiliar conditions. As predicted, we found a curse of knowledge effect in the Familiar condition, where the magnitude of the bias was significantly higher than zero, $t(45) = 2.60$, $p = .012$, $d = .38$: Children gave higher PE when they were taught familiar answers to the questions; they were cursed by their knowledge (Figure 5). A multiple linear regression investigating the effect of set order and sex on the magnitude of bias in the Familiar condition, found that these variables did not explain a significant amount of variance ($p > .80$).

Importantly, we also found that the bias was not significantly different than zero in the Unfamiliar condition ($p > .50$): Children did not give higher PE when they were taught unfamiliar answers to the questions; they were not cursed by their knowledge. Interestingly, they also did not give lower PE when children were taught the unfamiliar answers, as they did in Experiment 1. See Supporting Information (Table S2), for analyses confirming that children learned the new information in the experimental trials. Also, see Supporting Information, for additional analyses examining the effect of familiarity on the magnitude of bias, as well as item analyses (Figure S4).

Table 4
Mean Magnitude of Bias for Familiar and Unfamiliar Conditions in Experiment 3

	Familiar condition (n = 46; M_{age} = 7 years; 41% male)		Unfamiliar condition (n = 46; M_{age} = 7 years; 41% male)		
Factual questions	Answers	Magnitude of bias	Answers	Magnitude of bias	Ignorant condition (n = 45; M_{age} = 7 years; 53% male)
How many children will know which kind of bear can run the fastest?	Grizzly M = 1.98	.13 (p = .40)	Pizzly M = 1.91	.07 (p = .69)	M = 1.84
How many children will know which kind of bee is the least likely to sting?	Bumblebee M = 2.28	.06 (p > .70)	Solitary bee M = 1.98	−.24 (p = .18)	M = 2.22
How many children will know which kind of insect is the heaviest?	Beetle M = 1.76	.36 (p = .043)	Weta M = 1.63	.23 (p = .17)	M = 1.40
How many children will know which kind of insect can fly the highest?	Butterfly M = 2.37	.28 (p = .097)	Stonefly M = 2.04	−.05 (p > .80)	M = 2.09
How many children will know which kind of bird is the smartest?	Crow M = 2.24	.36 (p = .039)	Jackdaw M = 1.72	−.15 (p = .40)	M = 1.87
How many children will know which kind of fish changes colors?	Goldfish M = 1.43	.08 (p > .75)	Goby fish M = 1.91	.56 (p = .01)	M = 1.36
Average	2.01 (SD = .55)	.21 (p = .012)	1.87 (SD = .69)	.07 (p = .51)	1.80 (SD = .65)

Note. In the Magnitude of Bias columns, we reported the mean difference between Ignorant and Familiar Conditions and Ignorant and Unfamiliar Conditions. We reported the alphas in brackets, showing whether the magnitude was significantly different than zero (i.e., no bias). For each factual question, we reported the mean peer estimate across conditions. In the last row, we reported the overall means for the Ignorant, Familiar, and Unfamiliar conditions.

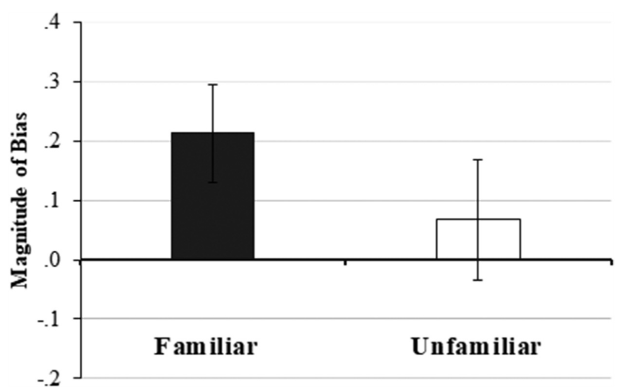

Figure 5. The magnitude of bias across Familiar and Unfamiliar conditions in peer estimates task, Experiment 3. Children showed a magnitude of bias that is significantly bigger than zero in the Familiar condition, but not the Unfamiliar condition. Error bars reflect standard error.

Discussion

Children only showed a curse of knowledge effect when they were taught familiar information. That is, they made bigger PE when they were taught familiar information, compared to when they were not taught the answers to the factual questions. In contrast, children did not show a significant difference in their PE when they were taught unfamiliar information, compared to when they were not taught the answers. Accordingly, we can conclude that the familiarity of the information is a key contributor to the curse of knowledge.

General Discussion

In the current research, we examined whether the curse of knowledge affects children's estimates of how widely known information is among their peers. Across three experiments, we presented children with factual questions, and we taught them the answers to half of those questions. In Experiment 1, we presented children with unfamiliar answers to half of the questions, and we found that children made *lower* PE when they were taught the answers, compared to when they were not taught the answers. In comparison, in Experiment 2, we presented children with familiar (but fake) answers to half of the same factual questions, and they made *higher* PE when they were taught the answers, compared to when they were not taught the answers (i.e., they showed the curse of knowledge effect). In Experiment 3, we directly compared children's PE when taught familiar answers, and children's PE when taught unfamiliar answers, with baseline estimates, where children were not taught any answers to the factual questions. Again, we found that children showed the curse of knowledge effect only when taught familiar answers. They did not show the curse of knowledge when taught unfamiliar information.

These experiments provide support for the fluency misattribution account of the curse of knowledge, and provide the first evidence for this in children's ability to reason about what others know. The fluency misattribution account suggests that the curse of knowledge occurs when we misattribute the fluency (ease, or familiarity) associated with information. Instead of correctly attributing the ease to our familiarity with the information, we misattribute that ease as it being indicative of how apparent that information is to others (or how widely known it is among others). In other words, when considering other individuals' perspectives, we tend to use the fluency of the information (the ease in processing) as a cue for how obvious or widespread the answer is (e.g., Birch et al., 2017; Harley et al., 2004). When children found the information familiar and easy to process, they tended to misattribute their subjective ease in processing the information as indicative of its *objective* ease. We examined the role of fluency misattribution in children's judgments of how widely known information is (Manifestation 3). We suspect that fluency misattribution will affect children's curse of knowledge similarly whether one is considering a previously held perspective (Manifestation 1) or is considering another individual's perspective (Manifestation 2), however, future research is needed to address that question empirically.

The current research suggests that the inhibitory control account—on its own—does not fully explain the curse of knowledge. The inhibitory control account suggests that the bias occurs because of a difficulty inhibiting the knowledge one possesses when reasoning about naïve perspectives. Our findings reveal that the curse of knowledge does not occur every time one possesses information, but rather the bias is contingent on the familiarity of the information. The inhibitory control account has not addressed how the characteristics of knowledge (e.g., familiarity, clarity) can influence the occurrence of the bias, whereas the fluency misattribution account has. According to a fluency misattribution account, the unfamiliar nature of the answers in Experiment 1 and Experiment 3 (Unfamiliar Condition) disrupts the fluency in processing the information, negating fluency misattribution, and eliminating the typically observed curse of knowledge effect. On the other hand, when the information is familiar, it is fluently processed, and fluency misattribution occurs (children misattribute their *subjective* ease of processing as stemming from the *objective* ease of the information). Still, it is worth considering whether inhibitory control might works in tandem with fluency misattribution to contribute to (or alleviate) the curse of knowledge, potentially accounting for the age-related decline sometimes observed in this bias. It may be the case that once fluency misattribution leads to the curse of knowledge, inhibitory control can be evoked to minimize the bias. Future work could examine how both mechanisms might contribute to the curse of knowledge (e.g., Birch et al., 2017). A wealth of research has demonstrated the important role that inhibitory control, and executive function more broadly, play in children's social cognition (e.g., Bühler, Bachmann, Goyert, Heinzel-Gutenbrunner, & Kamp-Becker, 2011; Carlson & Moses, 2001; Carlson, Moses, & Breton, 2002). Instead of contradicting the important role that inhibitory control plays in children's social cognition, the current work highlights the important, yet previously unacknowledged, role of fluency misattribution in children's social cognition (see Geurten, Lloyd, & Willems, 2017, for evidence of fluency *attribution* in childhood).

Researchers have also put forth 'sense making' as a mechanism that leads to the curse of knowledge. When individuals can make sense of certain information (e.g., it fits with their knowledge structure), they are more likely to overestimate the apparentness of this information (e.g., Pezzo, 2003; see also, Bernstein et al., 2018, suggesting that fluency misattribution is a better account for the bias). On the other hand, if information is surprising, implausible, or does not make sense, researchers tend to find either no bias (e.g., Birch & Bloom, 2007) or even a reversal of the bias (e.g., Yopchick & Kim, 2012). We believe the sense making account is consistent with, or subsumed under, a fluency misattribution account. That is, when individuals can make sense of new information, they process the information more fluently, and that fluency can be misattributed. In contrast, when the information is surprising or does not make sense, individuals may experience a dysfluency in processing, that negates fluency misattribution and cues them to realize the difficulty of the information at hand and eliminates the bias.

Why did children show a significant reversal of the bias in Experiment 1, but not in Experiment 3? We suspect that the answers in Experiment 1 felt more disfluent than the answers in Experiment 3. It is possible that the answers in Experiment 1 felt more unfamiliar than the answers in Experiment 3, or that answers in Experiment 1 seemed more implausible (or surprising) than answers in Experiment 3. For example, children in Experiment 1 may have been genuinely surprised to learn that a moth, and not the bat, has the best hearing. Or, that a flea, and not a rabbit, is the best jumper. On the other hand, it is possible that children in Experiment 3 had no inclinations about the answers. For example, it is possible that children had no expectations for which bug is the heaviest. Indeed, adults show a complete reversal of the bias when they find information surprising (e.g., Yopchick & Kim, 2012). Although Experiment 3 did not reveal a full reversal of the bias, the primary hypothesis that familiar answers will lead to a curse of knowledge, whereas unfamiliar answers will not, was supported.

Interestingly, the finding that children do not show the curse of knowledge when reasoning about unfamiliar information suggests that children are less vulnerable to the bias than earlier work might have implied. Indeed, 4- to 7-year-old children were fairly competent at making judgments about the prevalence of a piece of knowledge. We found that when they were exposed to unfamiliar answers, they realized the obscuirty of the questions and logically lowered their PE. These findings are especially intriguing because the literature on the curse of knowledge, so far, had suggested that young children are routinely biased by their own knowledge. Instead, children demonstrated critical thinking skills when considering what their peers know and were surprisingly adept at using the unfamiliarity of the information as a cue to guide their PE.

We also investigated the relation between the second and third manifestations of the curse of knowledge. Specifically, we examined whether children's tendency to be biased by their knowledge is similar when judging the pervasiveness of knowledge and when judging the knowledge of a specific individual. We found some evidence that these manifestations of the curse of knowledge are related. Particularly, in Experiment 1, we found that children who tended to show a bigger magnitude of bias in their PE, also showed a bigger magnitude of bias when judging Ernie's ability to see an object. It is important to note, however, that we did not show this finding in Experiment 2, suggesting there may not be as much overlap between these manifestions in childhood as initially hypothesized. We acknowledge, however, that our findings rest on correlational analyses of two very different methodologies; the VHB measure examines children's reasoning about knowledge acquired perceptually (visual recognition), whereas the PE task examines their reasoning about conceptual knowledge. As such, we are cautious in making any strong claims about the similarities or differences of these two manifestations in this research. Although research with adults suggests that the ability to make inferences about the knowledge of an individual and the prevalence of knowledge in a group are related (Christensen-Szalanski & Willham, 1991), there is reason to believe that these abilities have different implications in the real world and may follow different developmental trajectories. Often when one is making inferences about a specific individual's mental state, he or she has some knowledge about characteristics of the person that can guide inferences about what he or she knows (e.g., their age, profession, interests), as well as contextual information that can guide inferences (e.g., whether the individual was present when a given event unfolded). In comparison, making inferences about how widespread information is among a group of people involves more abstract reasoning. Reasoning about the likelihood that Jane knows X is quite different from reasoning about the proportion of one's peer group who will likely know X, given that a group, by its nature, is composed of multiple individuals whose characteristics and contextual experiences can vary in many ways.

Limitations and Future Directions

Although the current work demonstrated the first evidence of a reverse bias in childhood, it is unclear why we found a full reversal of the bias in Experiment 1, but not in Experiment 3. Recall, we presented children with unfamiliar information in both Experiments 1 and 3. As discussed earlier, it is possible that in Experiment 1, we provided more surpirisng or more unfamiliar information than Experiment 3. We suggest that unfamiliarity and surprise may work together to create disfluency and suspect that the magnitude of the disfluency verus fluency will affect the magnitude of the bias and the extent of its reversal. Future research could compare the separate effects of unfamiliarity and surprise on the reduction or reversal of the bias, for example, by presenting children with factual questions that have surprising answers (e.g., the loudest animal is a shrimp) and factual questions that have unfamiliar sounding answers (e.g., the fear of the dark is called Achluophobia).

Also, the current work does not fully address the question of whether Manifestations 2 and 3 of the curse of knowledge are correlated in childhood. That is, are children similarly biased by their own knowledge when infering another individual's knowledge versus their peer group's knowledge? As mentioned above, we used somewhat different methods to examine the relation between the two manifestations, and accordingly we are unable to draw definitive conclusions about the relation between the manifestations. Future work is needed to elucidate this relation. For example, one way to address this question is by presenting children with factual information and asking them how many of their peers would know the answer, and then asking them whether a specific individual would be the answer.

Another potential limitation of the current work is that we did not directly measure fluency across experimental designs. A similar limitation exists in many experiments on fluency misattribution (e.g., Bernstein et al., 2018; Harley et al., 2004), whereby instead of measuring fluency directly, the work relies on the well-documented observation that more familiar information is processed more fluently than less familiar information (e.g., Whittlesea, 1993). Nonetheless, future work could attempt to measure more directly the extent to which fluency is experienced by children and its relation to the magnitude of the curse of knowledge.

Finally, the current research puts forth a new way of examining the curse of knowledge on social judgments. The PE task measures individual, and age-related, differences in children's judgments of how widely known information is. This assessment can be used with a variety of factual questions for future research investigating the relations between individual differences in the curse of knowledge and various aspects of children's social functioning, such as their ability to communicate with others or the extent of their peer relationship problems. This line of research will allow for a better understanding of the curse of knowledge, and how it affects different aspects of children's social perspective taking, as well as their cognitive development.

Summary

We found evidence that the curse of knowledge plays a role in children's ability to reason about how widely known information is among their peers. Critically, we found that children do not become cursed by their knowledge every time they learn new information, the bias is contingent on the familiarity of the information they learn. These findings provide the first evidence of fluency misattribution in children's ability to reason about what others know. We hope to encourage research examining the previously neglected role of fluency misattribution in children's social cognition. There is a wealth of research showing the effect of fluency misattribution on social and cognitive judgments in adulthood (e.g., Unkelbach & Greifeneder, 2013), however, this line of research is sparse in childhood. Given the important role that the bias plays in on our communication and social reasoning, research aimed at better understanding the mechanisms that contribute to the curse of knowledge and the ways to minimize it will be especially fruitful.

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website:

Appendix S1. Supplementary material