A REVERSE CURSE OF KNOWLEDGE IN CHILDHOOD

by

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Abstract

Communicating effectively involves reasoning about what others know. Yet ample research shows that our ability to reason about what others' know is sometimes compromised by the 'curse of knowledge': a tendency to be biased by one's current knowledge when reasoning about a more naïve perspective. To date no research has examined this bias in children's estimates of how widely known information is among their peers. My thesis fills that gap. One hundred and twenty 4 to 7-year-olds were presented with eight factual questions and asked to judge how common that knowledge is among their peers. Children were taught the answers to only half of the questions. I predicted that: 1. Children would estimate that more of their peers would know the answers to the facts they were taught versus not taught, 2. The bias would decrease with age, and 3. The magnitude of children's bias in their peer judgements would correlate with the magnitude of their bias in judging another individual's visual perspective. Contrary to my predictions, children estimated that less of their peers would know the answers to the taught versus not taught questions. Children's 'reverse curse of knowledge' did not vary by age and did not correlate with their judgement of another individual's visual perspective. Nonetheless, these results shed light on the nature of the mechanisms underlying the curse of knowledge and make important contributions to our understanding of how children reason about what others know.

Preface

The study included in this thesis contains original, unpublished work by the author, Siba Ghrear. The research was conducted in Dr. Susan Birch's laboratory at the UBC, Department of Psychology. I, Siba Ghrear, was responsible for the research design, data collection, data analyses, and the writing. It should also be noted that my supervisor, Dr. Birch, was heavily involved in the research design, as well as the data analyses and writing process.

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Acknowledgements

I would like to begin by expressing my deepest gratitude for my supervisor, Dr. Susan Birch. Sue has not only given me the opportunity to contribute to research, but she has been a truly kind and astute mentor. I cannot say enough to show my appreciation for her unwavering support. I would also like to thank my committee members, Dr. Charlotte Johnston and Dr. Darko Odic. Their helpful advice taught me to think more critically about the present research and its contribution to the literature. I would also like to thank the research assistants at the Kidlab, truly this research would not have been possible without their hard work. Lastly, a special thanks to Klint Fung. His passion for research has never failed to inspire me.

Dedications

I dedicate my thesis to my *family*, especially my *parents* who have done everything in their power to secure a bright future for my siblings and I.

1. Introduction

The capacity to infer and reason about other people's perspectives is fundamental for social wellbeing and efficient communication. There are vast individual differences in this capacity among people, and more accurate perspective taking is associated with many positive outcomes (e.g., fewer relationship problems, higher academic achievement, more prosocial behaviour; Lalonde & Chandler, 1995; Caputi, Lecce, Pagnin, & Banerjee, 2011; Smith & Rose, 2011; for reviews see: Chandler & Birch, 2010; Repacholi & Slaughter, 2004). An important component of reasoning about other perspectives is the ability to make accurate inferences about what other people know. For example, to effectively communicate with others one must routinely make inferences about what others already know in order to gauge what information needs explanation or elaboration, and what information does not.

However, the ability to make inferences about the knowledge of others is susceptible to error or bias. In particular, 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. For example, a child who knows the hiding location of his candy bar may overestimate how likely his siblings are to know the hiding location as well. This bias is known as 'the curse of knowledge' (e.g., Camerer, Lowenstein, & Weber, 1989), and it refers to the difficulty ignoring one's current knowledge when reasoning about a less informed perspective. The curse of knowledge leads to an overestimation of what others know, that in turn, interferes with the ability to make accurate inferences about other people's perspectives and their resulting actions. Accordingly, the child, from my earlier example, may panic anytime his sister is close to the hiding location because he mistakenly thinks she knows where the candy bar is, and may try to steal it. In other words, the curse of knowledge interferes with the ability to distinguish between privileged knowledge (i.e., information that you know) and common knowledge (i.e., information that is shared by many)[1]. It is no surprise, then, that the curse of knowledge affects our ability to understand one another and communicate effectively. For instance, when I am discussing psychology research with my mother, and I do not discriminate a jargon word (e.g., control group) as privileged knowledge, then I may fail to explain the meaning of the term and compromise my ability to communicate my thoughts.

The curse of knowledge has been studied extensively across various disciplines and contexts. This bias has received a number of names in the literature, including: 'hindsight bias' (Bernstein, Aßfalg, Kumar, & Ackerman, 2015), 'creeping determinism' (see Fischhoff, 1975), the 'knew-it-all-along effect' (e.g., Wood, 1978), 'adult egocentrism' (e.g., Royzman, Cassidy, & Baron, 2003), and 'reality bias' (e.g. Mitchell & Taylor, 1999). Despite the many names, each of these terms ultimately refers to the tendency to be biased by one's current knowledge when reasoning about a more naïve perspective. This effect occurs when one is reasoning in hindsight about one's earlier less-informed perspective, or when one is reasoning about the perspectives of less knowledgeable individuals (e.g., Birch & Bloom, 2003). For simplicity, I will refer to the bias as the curse of knowledge throughout, but will distinguish between three different manifestations of the bias.

In the current research literature, three manifestations of the curse of knowledge have been examined. First, researchers have examined how the curse of knowledge affects the ability to recall one's own knowledge state before learning a particular fact. This first manifestation of the bias has been investigated among adults and children (e.g., Bernstein, Atance, Loftus, &

[1] Note that I have distinguished between privileged information and common knowledge here to highlight two ends of a continuum. Of course how widely known a particular piece of information is, will depend on the nature of the information, as well as the target group (e.g., some information will be widely known among one group of people, e.g., psychologists, but would not be considered common knowledge among the general public).

Meltzoff, 2004; Fischhoff & Beyth, 1975). Second, researchers have examined how the curse of knowledge affects the ability to reason about another individual's perspective (see Birch & Bernstein, 2007). Again, this manifestation has been investigated among adults and children (e.g., Bernstein, Atance, Meltzoff, & Loftus, 2007; Fischhoff, 1975; Taylor, Esbensen, & Bennett, 1994). Third, researchers have examined the influence of the bias on judgements of how widely known certain information is among others (e.g., one's peers). This manifestation of the curse of knowledge, however, has only been investigated in adults (e.g., Fussell & Krauss, 1991). My thesis aims to address this gap. Specifically, I will examine how the curse of knowledge affects children's judgements of *how widely known information is among their peers*.

As an overview, I begin this paper by offering a review of the literature on the curse of knowledge in adults, where it was first reported. I then review the literature examining the curse of knowledge in children. Next, I briefly discuss some of the mechanisms that have been put forth to explain the curse of knowledge. I then close the introduction section by providing an overview of the methods I used in my present study and the rationale for these methods. This study will test three hypotheses, namely: <u>Hypothesis #1</u>: Children will show a curse of knowledge bias in judging how common knowledge is among their peers. <u>Hypothesis #2</u>: Younger children will exhibit a greater curse of knowledge bias than older children. <u>Hypothesis #3</u>: The magnitude of the curse of knowledge bias in children's judgements of how widely known information is, among their peers, will be correlated with the magnitude of the bias on children's judgements about what a specific individual knows in a visual perspective-taking task.

1.1. Literature Review

1.1.1. The Curse of Knowledge in Adults

Our brains are geared towards acquiring knowledge, rather than ignoring it. Although we sometimes unintentionally forget information, it is difficult to *intentionally* ‘unknow’ something (see Golding, Long, & MacLeod, 1994). 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 (see Lilienfeld, Amirati, & Landfield, 2009; Roese & Vohs, 2012). The curse of knowledge is robust and widespread. It persists after explicitly warning participants about it, and giving out cash incentives to avoid it (Camerer et al., 1989; Pohl & Hell, 1996). It also 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 including business, education and politics, as well as in academic writing and legal, governmental, and medical decision-making to name a few (e.g., Harley, 2007; Pinker, 2014). Below, I discuss each of the three manifestation in turn and provide an example of an experiment for each.

1.1.1.1. The curse of knowledge in recalling one’s earlier perspective

To investigate this manifestation (sometimes referred to as ‘hindsight bias’ or ‘the knew-it-all-along effect), researchers first ask participants to answer a set of questions. Later, participants learn the correct answers to the questions, and must recall their original answers. Participants’ recollections of their original answers tend to be biased toward the newly learned (correct) 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., ‘The USA and the USSR will agree to a joint space program'). Upon learning the outcomes of Nixon's visit, which involved several agreements with the USSR leader, including a joint space flight, participants had to recall their earlier responses on the likelihood of the different outcomes. Participants' newfound knowledge of the actual outcomes of Nixon's visit biased their recollections of their prior estimates towards the actual outcomes of the event. Specifically, participants were more likely to erroneously recall having predicted the actual outcome. In these curse of knowledge studies, and many others like them, participants' current knowledge biases their recollections of what they previously thought (for reviews see Ghrear, Birch & Bernstein, 2016; Hawkins & Hastie, 1990).

1.1.1.2. The curse of knowledge in judging what another individual knows

To examine this manifestation of the bias, researchers present participants with answers to a set of questions and the participants are then asked how another individual, who had not learned the answer, would respond. For example, Fischhoff (1975) provided participants with descriptions of a 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 had to consider several possible outcomes, including the actual outcome. For each of these outcome, participants estimated how likely it would be for a naïve peer to predict the outcome. Compared to participants who did not learn the true outcome, participants who learned the outcome estimated that a naïve peer would be more likely to predict the true outcome of the war. In these curse of knowledge studies, and many others like them, participants' current knowledge biases their ability to predict what someone else would think (for reviews see: Ghrear, Birch & Bernstein, 2016; Hawkins & Hastie, 1990).

1.1.1.3. The curse of knowledge in judging how widely known information is among one's peers

For this manifestation of the bias, researchers present participants with questions and ask them to estimate how many of their peers will know the answers to each of the questions (Birch, Brosseau-Liard, Haddock & Ghrear, under review; Fussell & Krauss, 1991; Fussell & Krauss, 1992; Nickerson, Baddeley & Freeman, 1987). Importantly, the participants knew some of the answers and not others. Findings suggest that participants' estimates were biased in the direction of their own knowledge. That is, participants estimated that questions that *they knew* were more widely known among their peers, compared to questions that they did not know. For example, participants who were able to identify a picture of the United Nations Building judged that more of their peers could also identify the building, compared to participants who were not able to identify the building (Fussell & Krauss, 1991). In contrast, participants' estimates of what others knew were more accurate when *they did not know* the answer.

1.1.2. The Curse of Knowledge in Children

Relative to the wealth of adult work, few studies in the developmental literature have examined the curse of knowledge bias. Taylor et al. (1994) found that when preschoolers 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). Interestingly, young children are not just attempting to 'look smart,' they seem to 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).

Interestingly, the curse of knowledge is more likely to occur when reasoning about generic information (e.g., A baby can't taste salt until it is four months old), compared to individual-specific information (e.g., A baby wasn't able to taste salt until it was four years old; Sutherland et al., 2015). In a series of studies, researchers presented four to seven-year-old children with generic and individual-specific facts. After each fact, children were asked if they had known the information before. The researchers found that children were more likely to say that they had known generic facts all along compared to individual-specific facts. These findings suggest the curse of knowledge stems from a sophisticated knowledge updating system that privileges generic information over individual-specific information.

Importantly, the curse of knowledge affects younger children more than older children and adults (Birch & Bloom, 2003; Mitchell & Taylor, 1999). To show this, 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 five-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 x 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 three to five years of age.

In an additional demonstration of the curse of knowledge, Lagattuta, Sayfan, and Harvey (2014) tested four- to seven-year-old children's and adults' ability to estimate a naïve individual's interpretation of partially-occluded pictures. The pictures were covered by an occluder that revealed only a small, often uninformative, portion of the picture. Some participants saw the pictures before they were occluded, and others only saw the pictures after they were partially occluded. Participants who saw the pictures before the occlusion, and thus knew the pictures' identity, overestimated the likelihood that a naïve individual would correctly guess the pictures' identity (see also Chandler & Helm, 1984, Mossler, Marvin, & Greenberg, 1976; Taylor, 1988). Moreover, children were more likely to be biased by their knowledge compared to adults (see also Epley, Morewedge, & Keysar, 2004; Lagattuta, Sayfan, Blattman, 2010).

Similarly, in a visual perspective taking measure Bernstein et al. (2007) found that knowledgeable children and adults were more likely to overestimate another individual's knowledge. In this procedure (the Visual Hindsight Bias Measure, see Figure 1 and Harley, Carlsen, & Loftus, 2004), three- to five-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 three to ninety-five years of age, Bernstein, Erdfelder, Meltzoff, Peria, and Loftus (2011) found that the curse of knowledge follows a U-shaped trajectory across the lifespan, with young children and aging adults exhibiting a greater curse of knowledge bias than older children and younger adults (see also, Bernstein et al., 2007).

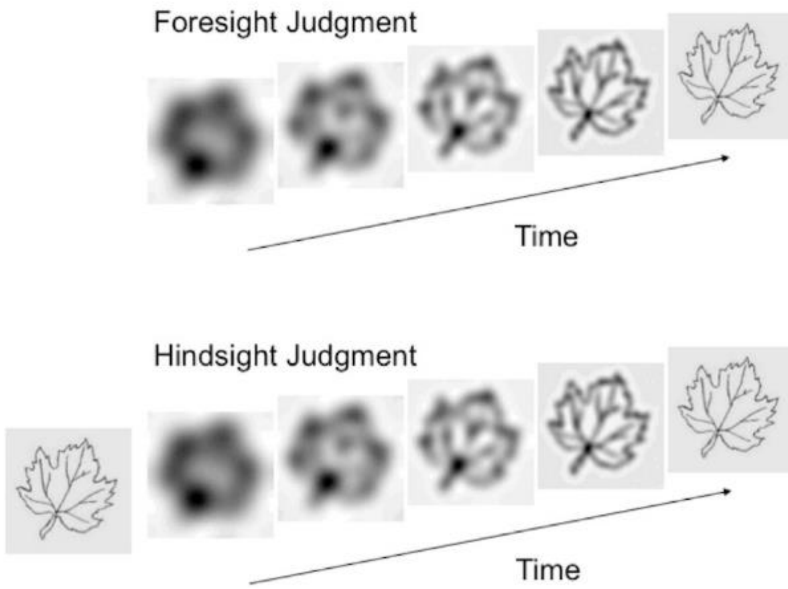

Figure 1. Stimuli from the Visual Hindsight Bias measure. In the baseline condition, participants try to identify the object as it clarifies on a computer screen. In the hindsight condition, participants see the object in advance of estimating when a naïve, same-age peer will identify the object. From "Hindsight Bias from 3 to 95 years of age" by Bernstein et al., 2011, *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 37, p. 383. Copyright 2011 by the American Psychological Association.

1.1.3. Mechanisms Underlying the Curse of Knowledge

Although the curse of knowledge interferes with our ability to make accurate inferences about other perspectives, this bias is nonetheless believed to be a by-product of an adaptive learning system (Hoffrage, Hertwig, & Gigerenzer, 2000; Henriksen & Kaplan, 2003). That is, the curse of knowledge is a result of the updating that occurs to our knowledge structures when we acquire new information. This updating typically occurs so efficiently that it becomes difficult to disengage from new information, even when we aim to reason about a naïve perspective. Although this automatic updating process interferes with our perspective taking ability, it serves an adaptive function of keeping track of our new state of affairs, and focusing our cognitive resources towards new knowledge, which is critical for functioning in a changing environment (Hoffrage et al., 2000).

Indeed, the adaptive learning framework helps to explain the pervasiveness of the curse of knowledge across cultures and across contexts. However, it is important to point out that this framework does not provide an adequate developmental explanation of the curse of knowledge. Research suggests that young children and aging adults are more prone to the bias than older children and adults (For a review, see Birch & Bernstein, 2007). These findings cannot be explained by an adaptive learning framework (in an of itself), because young children and aging adults are not better 'learners' than older children and adults. One way to reconcile this discrepancy is by considering the development of other cognitive abilities that may facilitate more accurate perspective taking. The curse of knowledge may be a by-product of an efficient updating system, however there are a separate set of cognitive skills that help one to overcome the bias.

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., see 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 curse of knowledge bias. Interestingly, inhibitory control, as a cognitive skill, develops across childhood and deteriorates with older age (e.g., Groß & Bayen, 2015b). This developmental trajectory is consistent with the age-related changes associated with the curse of knowledge where young children and aging adults are more affected by the bias.

Researchers have also proposed fluency misattribution as a mechanism that contributes to the curse of knowledge. Researchers suggest that when information is fluent (or easy to process), we tend to think that this information is obvious to others (Harley et al., 2004; Birch et al., under review). In other words, we misattribute the ease with which a piece of information comes to mind as indicative of how apparent this information really is. According to a fluency misattribution account, the bias is not due to a failure to inhibit the content knowledge that leads to a curse of knowledge, but rather a tendency to misinterpret the ease with which the information comes to mind (or the feelings of fluency associated with the information). For example, if one knows that the Trevi Fountain is located in Rome, one must be able to discount the ease with which this information comes to mind to make accurate inferences about others' knowledge. As you may imagine, it is difficult to tease apart whether the curse of knowledge is difficult to overcome because of a failure to inhibit the content of one's knowledge or because of a tendency to misattribute the ease with which that information comes to mind.

Interestingly, Harley et al. (2004) designed a study that examined the effect of fluency misattribution over and above content knowledge using a visual hindsight bias measure. In the baseline condition, participants watched a series of degraded images of celebrity faces gradually clarify (see Figure 2, for a visual illustration of the degraded images). For each image, participants were asked to indicate when they could identify the celebrity. Subsequently, in the hindsight condition, participants were asked to watch a similar series of degraded images, however, 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 series of 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). Critically, participants knew the identities of both the Familiar and New celebrities, however they had previous experience identifying the Familiar celebrities. Participants showed a curse of knowledge in their judgements of when the naïve peer would know the identity of the celebrities. That is, participants' knowledge of the celebrities' identity led to overestimations of how early, in the course of clarification, the naïve peer would identify the celebrities. Critically, the participants were more likely to show a curse of knowledge for the Familiar celebrities compared to the New celebrities. The latter findings suggest that previous processing of the images evoked a feeling of fluency that strengthened the effect of the curse of knowledge. That is, fluency misattribution contributes to the curse of knowledge over and above content knowledge.

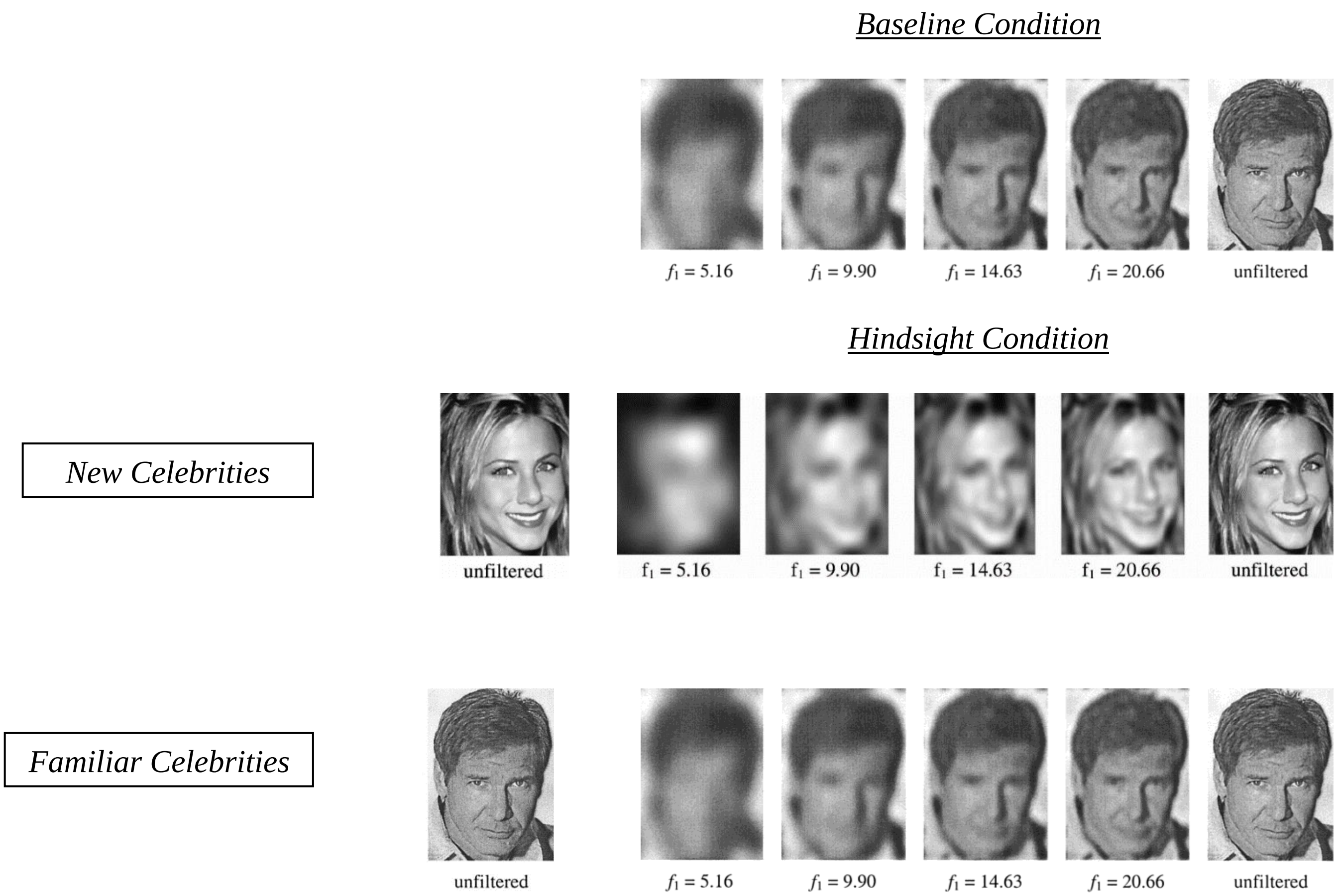

Figure 2. Stimuli from the study by Harley et al. (2004). In the baseline condition, participants were instructed to identify celebrities as the images clarified, and in the hindsight condition, participants were instructed to estimate when a naïve peer can identify the images. In the hindsight condition, there were Familiar Celebrities who were identified in the baseline condition, and new celebrities who were not identified before. The top and bottom images are from "The "Saw-It-All-Along" Effect: Demonstrations of Visual Hindsight Bias" by Harley et al., 2004, *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 30, p. 962. Copyright 2004 by the American Psychological Association. The middle images are from "Fluency Misattribution and visual Hindsight bias" by Bernstein & Harley (2007), *MEMORY*, 15, p. 551. Copyright 2007 by Psychology Press.

Similarly, my research with adults has also shown that repeated exposure to factual questions (e.g., “Who invented the TV?”), without any content knowledge (i.e., without being given the answers to the questions), can also lead to overestimates of what others know (Birch et al., under review). That is, when participants are more familiar with the factual questions, the ease of processing these questions can lead to overestimations of how apparent they are. Taken together, the latter two studies show how the ease of processing information can contribute to the curse of knowledge separate from the need to inhibit content knowledge. I believe that examining the curse of knowledge across development can help elucidate how inhibitory control and fluency misattribution contribute to the curse of knowledge.

1.2. Rationale for The Current Study

The curse of knowledge has been studied extensively among adults, with more limited research on children (see Bayen, et al., 2007). Research with adults has shown that the curse of knowledge can manifest itself in many ways. It can bias adults’ memories of earlier events, it can influence their judgements of how easily a peer will be able to solve a task or recognize an object, and it can bias their judgments of how widely known information is among their peers. In contrast, only the first two manifestations have been documented in the developmental literature. I intend to fill that gap.

My study contributes to the literature in several ways. For one thing, examining how the bias affects children’s judgements of the commonality of knowledge will shed light on children’s ability to consider the perspective of a group of people, rather than an individual. To my knowledge, this will be the first test of children’s ability to reason about the knowledge of a group of people. In our social world, there are several situations where one must make inferences about the perspectives, or knowledge, of a group of people. These situations range from teaching a class, reporting the news, to writing an article. Although the adult literature suggests that the ability to make inferences about the knowledge of an individual and the knowledge of a group are related (Christensen-Szalanski & Willham, 1991), there is reason to believe that these abilities have different implications in the real world. Often times, when one is making knowledge inferences about one individual's mental state, he/she has access to cues that help guide these inferences; such as characteristics about the person (e.g., age, occupation), as well as feedback from the person (e.g., facial reactions, body language). For example, if one is communicating with a six-year-old boy, it would be safe to assume that the boy does not yet understand what stem cell research entails. Also, when communicating with the boy, one could gauge which information the boy understands by examining his facial expressions (e.g., does he look confused?). On the other hand, when one is making inferences about what a group of people are likely to know, it entails reasoning about the broader characteristics of the group and the overall prevalence of knowledge within a group.

Additionally, my thesis contributes to the literature by examining the effect of the bias on inferences about *conceptual* knowledge. As discussed above, there is an already well-established measure of the curse of knowledge, the Visual Hindsight Bias Measure, that specifically examines the influence of the bias on perceptual knowledge (Bernstein et al., 2007). Indeed, the bulk of the earlier work with children has focused on knowledge acquired by looking (e.g., Bernstein et al, 2004; Birch & Bloom, 2003; Lagattuta et al., 2014). The curse of knowledge for visual knowledge may be somewhat different than the curse of knowledge for conceptual knowledge. For one thing, the ability to update visual knowledge may be more automatic (or unconscious) than the ability to update conceptual knowledge. Henceforth, it may be the case that it is more difficult to put aside visual, versus conceptual, knowledge when considering a naïve perspective.

All in all, there are several important implications for studying the curse of knowledge in children. Research will benefit from a better understanding of the specific ways the curse of knowledge manifests itself in children and how this bias changes across development. It will also be important for future work examining the relationships between individual differences in the curse of knowledge bias and individual differences in the various aspects of social functioning that have been linked to perspective taking abilities. To this end, there is a clear need for developmental studies that investigate the role of the curse of knowledge in judging how common knowledge is among their peers; in particular, studies that examine the effects of the bias across development and that also capture individual differences. The current study aims to address this need and pave the way for future research exploring the specific mechanisms underlying the curse of knowledge bias, and the ways it might be reduced to improve social perspective taking and communication.

For my study, I designed a task (referred to as the Peer Estimates Task) that examined four-to seven-year-olds' estimates of how many of their peers (none, a couple, some, a lot, or a whole lot) know the answers to different factual questions. In this task, participants were presented with the answers for half of the factual questions before they made their peer estimates (estimates of how many of their peers would know the answer), while the other half of the factual questions remained unknown. Subsequently, participants were administered the Visual Hindsight Bias Measure development by Bernstein et al. (2007).

Based on previous research on the curse of knowledge, I formed three hypotheses to test. Specifically, given the research suggesting that knowledge of a fact can bias our social judgements (e.g., Ghrear et al., 2016), I predict Hypothesis #1: Children will show a curse of knowledge bias in judging how common knowledge is among their peers. Based on research showing age-related changes in the bias (e.g., Birch & Bloom, 2003; Bernstein et al.; 2011), I put forth Hypothesis #2: Younger children will show a greater curse of knowledge bias than older children. Lastly, based on the adult literature suggesting that the ability to make inferences about the knowledge of an individual and the knowledge of a group are related (Christensen-Szalanski & Willham, 1991), I predict Hypothesis #3: Children's performance on the Peer Estimates Task, will correlate with their performance on the Visual Hindsight Bias measure, controlling for any age-related changes. That is, children who are affected by the curse of knowledge when estimating how widely known a fact is among peers (Peer Estimates Task), will also be affected by the curse of knowledge when determining when another individual will be able to identify an object that they have already identified (Visual Hindsight Bias measure). Given the different methodology of the two measures, however I suspect that the effect size of the correlation will be medium to small.

2. Method

2.1. Participants

One hundred and twenty participants were recruited from Greater Vancouver through the University of British Columbia's Early Development Research Group, Science World, and local daycares and schools. A total of twenty-four participants' data were excluded from the analyses. Five participants' data were excluded from analyses due to a failure to complete the task, or due to an inability to follow the study's instructions. Nineteen participants were excluded because they failed the exclusion criteria (discussed below) suggesting that did not understand the task. Accordingly, ninety-six participants' data were used for the analyses. The participants' ages were four to seven years old (Mean = 5 years, 11 months; Minimum = 4 years, 0 months; Maximum = 7 years, 11 months). Sixty-seven percent of the participants were males. The current sample consisted of twenty-four four year olds (Mean = 4, 5; Minimum = 4,0; Maximum = 4,11), twenty-four five year olds (Mean = 5,5; Minimum = 5,0; Maximum = 5,11), twenty-four six year olds (Mean = 6,5; Minimum = 6,0; Maximum = 6,10), and twenty-six seven year olds (Mean = 7,4; Minimum = 7,0; Maximum = 7,11). Fifty-one percent of the participants were of Caucasian background, thirteen percent were of east Asian background, eight percent were of south Asian background, and twenty-three percent were of mixed background (e.g., half east Asian and half Caucasian).

Only a subsample of the ninety-six participants continued the study session and completed the Visual Hindsight Bias Measure. Specifically, eighty-nine participants continued to the Visual Hindsight Bias Measure. Twelve of those participants, however, did not complete sufficient trials, terminated the study session, or did not understand the task or follow instructions (discussed below). Those participants' data were thus excluded from the analyses involving the Visual Hindsight Bias Measure. Accordingly, the present sample included seventy-seven participants (Mean = 6 years, 0 months; Minimum = 4 years, 1 month; Maximum = 7 years, 11 months). Sixteen four year olds (Mean = 4, 6; Minimum = 4,1; Maximum = 4,11), twenty-two five year olds (Mean = 5, 6; Minimum = 5,0; Maximum = 5,11), eighteen six year olds (Mean = 6, 5; Minimum = 6,0; Maximum = 6,10), and twenty-one seven year olds (Mean = 7, 4; Minimum = 7,0; Maximum = 7,11). Sixty-eight percent of the participants are males. Fifty-five percent of the participants were of Caucasian background, twelve percent were of east Asian background, nine percent were of south Asian background, and twenty-two percent were of mixed background (e.g., half east Asian and half Caucasian).

2.2. Material

For the Peer Estimates Task, I used a five-point scale with boxes that demonstrate the numerical values for each point. For example, the first point is ‘none’ and the box associated with the point does not have any child silhouettes, the second point is ‘a couple’ and the box associated with that point contains two child silhouettes, the third point is ‘some’ and the box associated with that point contains six child silhouettes, and so on. Each box is progressively bigger than the last and contains more individuals (refer to Appendix C, for a visual illustration of the five-point scale).

For the Visual Hindsight Bias Measure, I used materials akin to those used in the Visual Hindsight Bias Measure developed by Bernstein et al. (2007). The procedure involved four objects that measure up to five inches long: a bird, a school bus, a tree, and a horse. The materials also included a box measuring 13 by 15 inches with one open side and a three ringedbinder placed on top of the box. The binder held ten clear plastic sheets that are speckled with black dots. These plastic sheets hung in front of the open side of the box, to occlude the participant's view of what is inside. Each plastic sheet had a unique pattern of black dots that cover 5% of each sheet, such that each plastic sheet is transparent but blurry. Behind the tenth 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 progressively clearer (refer to Appendix E for a picture of the apparatus).

2.3. Procedure

Warm-up Phase: Each child was tested individually. 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 (for the introductory script, please refer to Appendix A). The experimenter then showed the participant the scale and discussed the different amounts of children associated with each point on the scale (refer to Appendix C, to see the five-point scale). 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.

Practice Phase: After the introduction, the experimenter administered three demonstration trials where she showed the child how to make a peer estimate (refer to Appendix A, for the introductory script used by the experimenter). For example, 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 five-point scale. Through the three demonstration trials, the experimenter showed the participant how to make a peer estimate for an easy question, a difficult question, and a question that is medium in difficulty.

Peer Estimates Task Test Phase: Subsequently, the experimenter administered the experimental trials. The participants were asked to make peer estimates about how many children would know different factual questions. Each factual question was presented with a corresponding picture (e.g., a question about fish was presented with a silhouette of a fish). The factual questions were divided into two sets; Set A and Set B. All participants were presented with both sets of factual questions, however half of the participants were taught the answers to Set A, and not Set B. Whereas the other half of the participants were taught the answers to Set B, and not Set A. Thus, answers for half of the factual questions were taught to children prior to making their peer estimate (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 factual questions were not taught (e.g., "How many children will know which kind of insect, or bug, is the smallest?"). Half of the participants were presented with Set A first followed by Set B, whereas the other half were presented with Set B first. To ensure that children had no prior knowledge about the factual questions before the study session, I selected difficult (or unique) factual questions (see Appendix B, for the factual questions used). I confirmed children's lack of a priori knowledge of the facts by asking them the answer to each factual question at the end of the experimental trials. Specifically, children were asked the factual question and presented with four possible answers (e.g., "Which animal is the fastest in the sea? Is it the clownfish, the sailfish, the pilot whale, or the mako shark?"; See Appendix F, for a picture of the four possible answers). I expected that children would be at chance (25%) when answering the factual questions that were not taught.

Subsequent to the experimental trials, the participants were asked two post-test questions to confirm that they understood how to use the five-point scale: ‘How many children like to be happy?’ and ‘how many children like to be sad?”. If a participant provided peer estimates to these questions that were counterintuitive, I inferred that the participant did not understand the task and I excluded his or her data. Specifically, if a participant indicated that *less* than ‘a lot’ of peers like to be happy, or that *more* than ‘some’ peers like to be sad, then I excluded their data.

<u>Visual Hindsight Bias Measure:</u> Following the Peer Estimates Task children participated in the Visual Hindsight Bias measure. In a baseline condition, the experimenter hid a toy inside a box, behind ten plastic sheets speckled with black dots, such that it was impossible for the child to see the hidden toy behind the sheets. The experimenter then removed one sheet at a time, so that the view of the toy became progressively clearer, and the child was asked what he or she thought the toy was, before each sheet is removed. When the child identified the toy, the experimenter noted how many of the ten numbered sheets had been removed. The experimenter completed this procedure four times with four different toys. In the experimental (or hindsight) condition, 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, however, the child was asked to indicate when Ernie could tell what toy was 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. The latter question served to confirm that the participant believed that Ernie could identify the object because he could currently see it (as opposed to him knowing because children did not believe the experimenter when she said that Ernie did not see what we hid; See Appendix D, for the script). This question also allowed me to exclude data where the child thought that Ernie knew what was inside the box because he had seen these toys before. I excluded one child's data for this reason.

3. Results

In the current study, there are three main questions: 1. Does knowledge affect children's peer estimates? That is, are children's peer estimates larger when they know the answers to the questions (Knowledgeable trials) versus when they do not know the answers to the questions (Ignorant trials)? 2. Will this difference in children's peer estimates decrease with age? Specifically, are children's judgments of how widely known information is among their peers less likely to be affected by the curse of knowledge bias as they grow older? 3. Is children's performance on the Peer Estimates task related to their performance on the Visual Hindsight Bias Measure, above and beyond any effects of age? In the following sections, I outline the analytic strategy that I used, as well as the results for each research question. Unless otherwise specified, I reported non-directional (two-tailed) tests using $p < .05$.

3.1. Preliminary Analyses

First, to ensure that my participants did not know the answers to the not taught questions (i.e., the Ignorant Trials) I compared children's performance on the four Ignorant trials to chance. Here, chance for each factual 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, I ran a one-sample t-test comparing their mean scores against one (that is, chance for the four factual questions). The results indicate that children's scores on the not taught questions were significantly below chance, t (93) = -3.75, p < .001 (see Appendix H, for the most common answers to each not taught question). Suggesting that children were unlikely to know the answers to the factual questions that were not taught.

3.2. Question 1: Does knowledge affect children's peer estimates?

My dependent variable was the peer estimates that were measured through the five-point scale (0 = none, 1 = a couple, 2 = some, 3 = a lot, 4 = a whole lot). To begin the analyses, I took the mean for each child's peer estimates in the Knowledgeable trials, as well as the Ignorant trials. To test whether there were any effects of order or gender, I conducted a mixed 2 x 2 x 2 x 2 ANOVA with taught set (Set A, Set B), set order (Set A presented first, Set B presented first), and gender (Male, Female) as between-subjects variables and trial type (Knowledgeable or Ignorant) as within-subjects. There were no main effects of taught set, taught order, or gender, all *p*s >.10. There was a significant main effect of trial type, revealing that overall children's peer estimates when they were taught the answers (M = 1.88, SD = .84) were lower than when they were not taught (M = 2.13, SD = .79), F (1, 88) 8.74, p = .004, η^2 = .09, in direct contradiction to my prediction (see Appendix G, for a breakdown of the peer estimates for each question in the Knowledgeable and Ignorant trials; see Figure 3, for the mean peer estimates in the Knowledgeable and Ignorant trials).

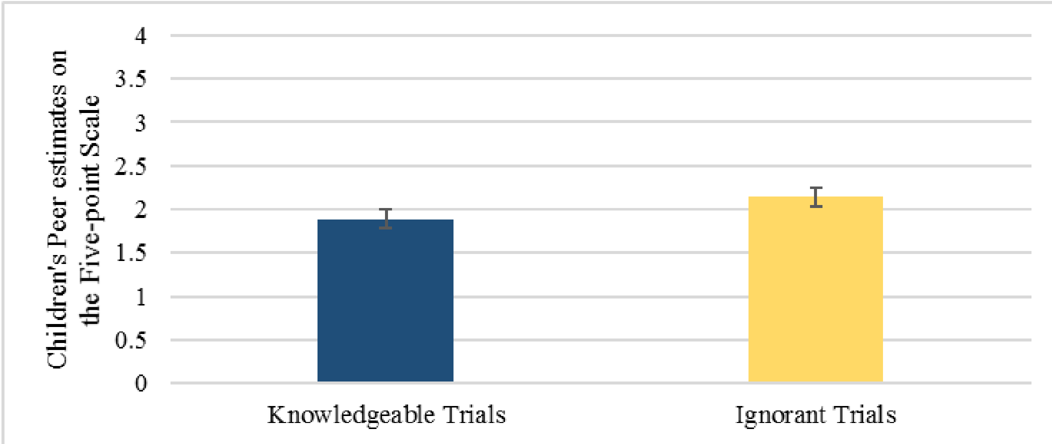

Figure 3. The mean peer estimates in the Knowledgeable Trials and the Ignorant Trials. Error bars represent the standard errors of the means.

However, there was a significant interaction between trial type and taught set, F (1, 88) = 5.591, p = .020, η^2 = .060. To analyze this interaction, I examined the simple main effects of trial type on peer estimates at each level of taught set. Note, I ran all simple main effects analyses with a Bonferroni correction. There was no significant simple main effect of trial type on peer estimates when Set A was taught, F (1, 94) .00, p = 1.00 (see Figure 4, for an illustration of the interaction). That is, the mean peer estimate in Knowledgeable trials (M = 2.01, SD = .79) was equal to the mean peer estimate in Ignorant trials (M = 2.01, SD = .73). On the other hand, there was a significant simple main effect of trial type on peer estimates when Set B was taught, F (1, 94) 19.77, p < .001, such that, the mean peer estimate in Knowledgeable trials (M = 1.78, SD = .88) was smaller than the mean peer estimate in the Ignorant trials (M = 2.28, SD = .84). Therefore, the taught set variable was included in subsequent analyses.

Furthermore, there were two marginally significant three-way interactions from the mixed 2 x 2 x 2 x 2 ANOVA: A three-way interaction between trial type, gender, and taught set, F (1, 88) = 2.98, p = .088, η^2 = .03, and a three-way interaction between trial type, taught set, and set order, F (1, 88) = 3.65, p = .059, η^2 = .04. I examined these interactions further by conducting simple main effects analyses. First, I examined the simple main effects in the interaction between trial type, gender, and taught set. There were no significant simple main effects of trial type on peer estimates when Set A is taught among males and females, ps > .55. There was a significant simple main effect of trial type on peer estimates when Set B was taught among males, F (1, 92) = 21.29, p < .001. Among females, on the other hand, there was no simple main effect of trial type on peer estimates when Set B is taught, F (1, 92) = 1.86, p = .18.[2] Second, I conducted simple main effects analysis to examine the interaction between trial type, taught set, and set order. There were no significant simple main effects when Set A was taught in cases where Set A was presented first, and in cases where Set B was presented first, ps > .51. There was a significant simple main effect of trial type on peer estimates when Set B was taught and presented first, F (1, 92) = 20.3, p < .001. Lastly, there was no significant simple main effect of trial type on peer estimates when Set B was taught and Set A was presented first, F (1, 92) = 3.47, p = .065. These results were not anticipated and may have come about by chance.

[2] Note there was only thirty-two females in my sample, compared to sixty-four males, therefore the latter non-significant result may be a result of low power.

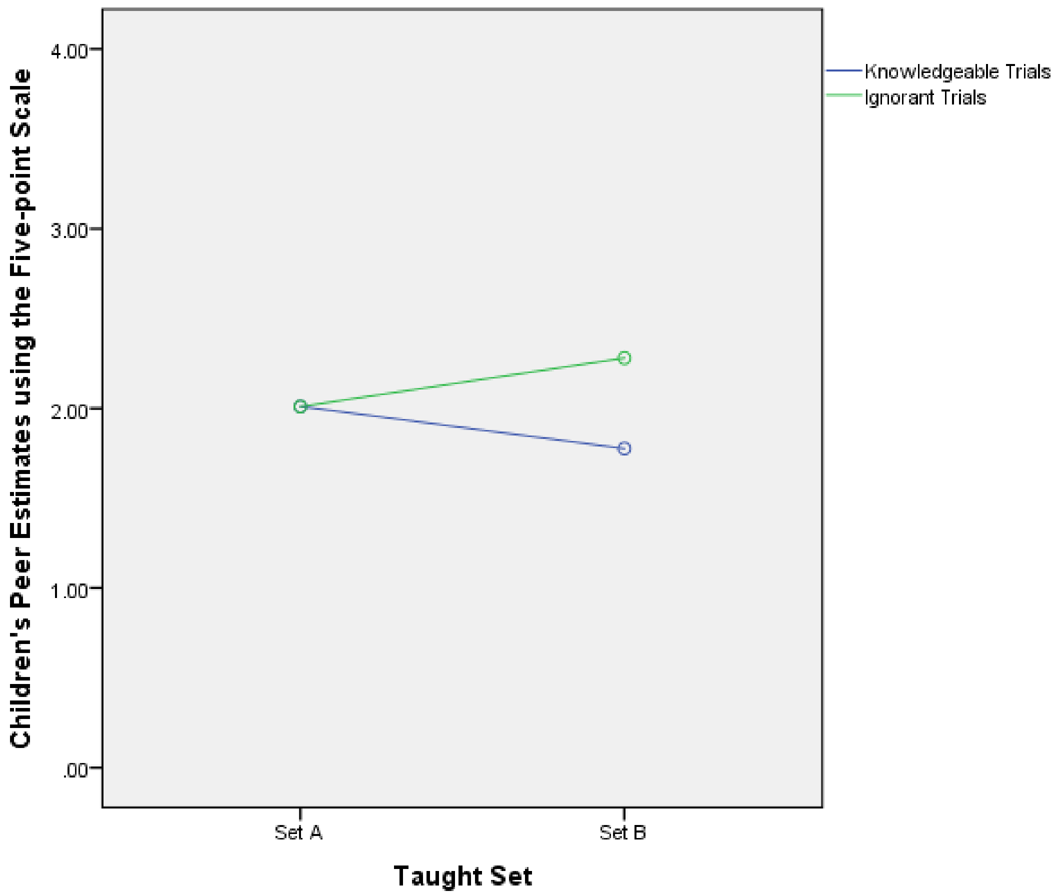

Figure 4. The mean peer estimates for Knowledgeable and Ignorant trials when Set A is taught and when Set B is taught.

3.3. Question 2: Will the curse of knowledge bias decrease with age?

To examine the effects of age I conducted a mixed 2 x 2 x 4 ANOVA with taught set (Set A, Set B) and age (4, 5, 6, 7), as the between-subjects variables, and trial type (Knowledgeable or Ignorant) as the within-subjects variable. Again, there was a main effect of trial type, F (1, 88) = 9.73, p = .002, η^2 = .10, such that peer estimates in Knowledgeable trials (M = 1.89, SD = .84) were lower than peer estimates in Ignorant trials (M = 2.15, SD = .79), and an interaction between trial type and taught set, F (1, 88) = 9.73, p = .002, η^2 = .10. There was also a significant main effect of age, F (3, 88) = 8.33, p < .001, η^2 = .22., such that older participant made lower (more accurate) peer estimates on average than younger participants. However, contrary to my prediction, there was no significant interaction between trial type and age, F (1, 88) = .46, p = .71, η^2 = .02 (see Figure 5, for a visual illustration of the effect of trial type on peer estimates across age). That is, the effect of trial type on peer estimates did not change across age.

To further examine the relationship between the curse of knowledge and age, I conducted a bivariate correlation between age (in months) and the magnitude of the curse of knowledge. That is, I computed the difference between each individual's average peer estimate in the Knowledgeable trials and his or her average peer estimate in the Ignorant trials. Age and the magnitude of the curse of knowledge were not significantly correlated, r (96) = -.05, p = .62.

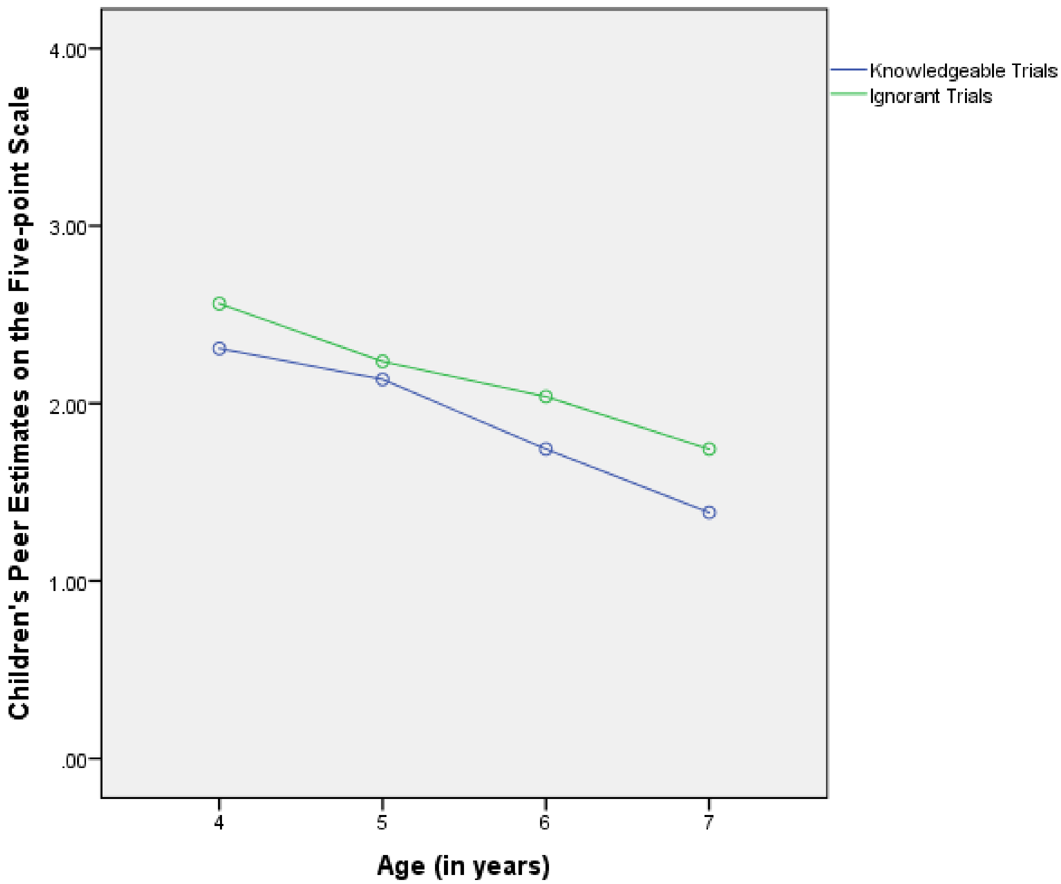

Figure 5. The mean peer estimates across Knowledgeable and Ignorant Trials for each age group.

3.4. Question 3: Is children's performance on the Peer Estimates task related to their performance on the Visual Hindsight Bias measure?

3.4.1. Preliminary Analyses

First, I would like to remind the reader that only a subsample of participants completed the Visual Hindsight Bias measure. Specifically, I was able to use seventy-seven participants' data on this measure. Before I examined whether children's performance on the Peer Estimates task and the Visual Hindsight Bias measure were related I first examined whether I replicated the findings of previous work using the Visual Hindsight Bias measure. To do this, I conducted a mixed ANOVA with condition (baseline, hindsight) as the within subject factor, and age (four, five, six, seven) as the between subject factor, using the number of sheets removed as the dependent measure. That is, the number of sheets removed in the baseline condition where participants identified toys, and the number of sheets in the hindsight condition where participants have already seen the toys and estimated Ernie's knowledge of the objects' identities. As expected, there was a significant effect of condition on the number of sheets removed, F (1, 73) = 44.27, p < .001, η^2 = .38 such that more sheets were removed during the baseline condition (M = 7.97, SD = 1.10), compared to the hindsight condition (M = 6.73, SD = 1.91). There was no main effect of age on the number of sheets removed, F (3, 73) = 1.53, p = .21, η^2 = .06. That is, age did not affect the number of sheets removed across the baseline and hindsight conditions. Lastly, there was no significant condition by age interaction on the number of sheets removed, F (3, 73) = .99, p = .40, η^2 = .04. That is, the difference between the number of sheets removed across conditions was not affected by age; all children predicted that Ernie would be able to identify the toys earlier than they themselves could (i.e., the classic visual hindsight or curse of knowledge effect). See Figure 6 for an illustration of the number of sheets removed in each condition across ages.

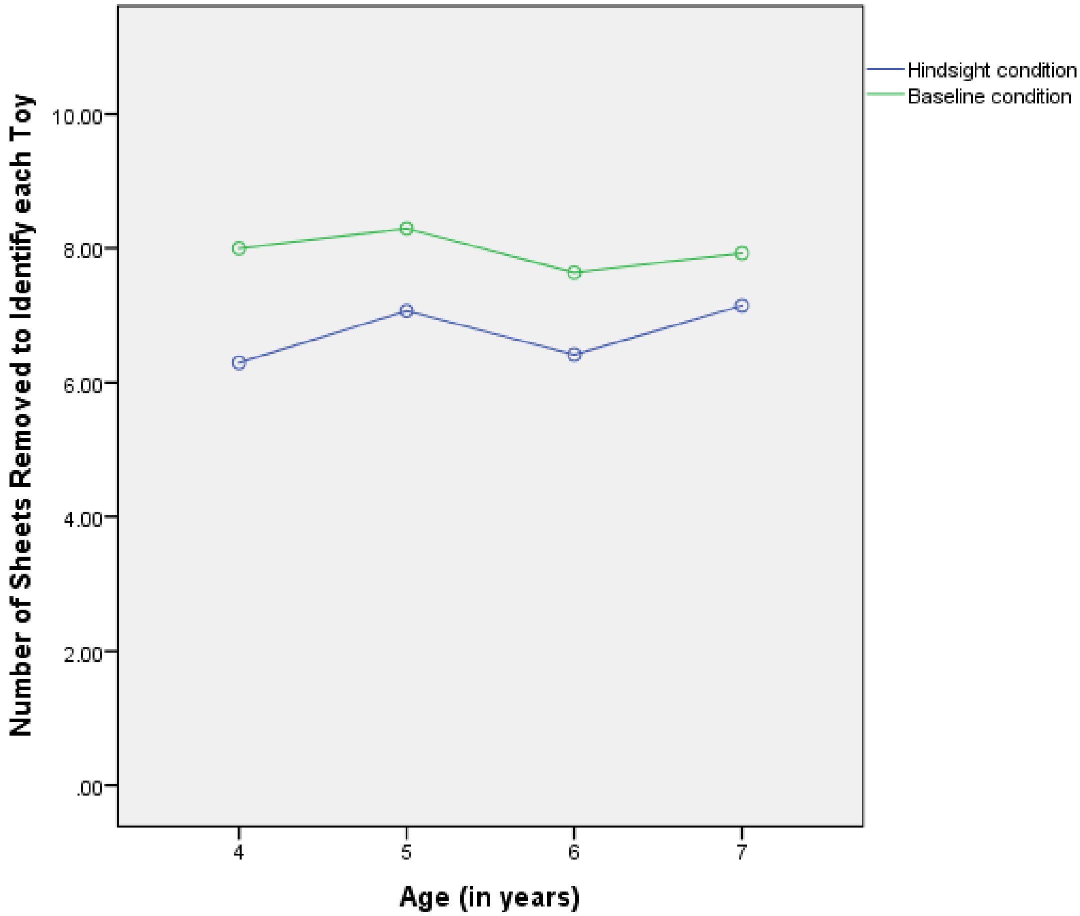

Figure 6. Mean number of sheets removed to view the hidden objects in the baseline and hindsight conditions across age groups.

However, given my *a priori* hypothesis based on earlier work revealing that the visual hindsight bias declines with age (Bernstein et al., 2011), I further examined the relationship between age and the magnitude of the curse of knowledge by running a bivariate correlation between age in months and the magnitude of the bias on the Visual Hindsight Bias measure. To arrive at the magnitude of the curse of knowledge, I subtracted the mean number of sheets in the baseline condition by the mean number of sheets in the hindsight condition. The relationship between age in months and the magnitude of the bias was significant, r (77) = -.21, p = .036, *directional*. That is, the magnitude of the curse of knowledge in the Visual Hindsight Bias measure decreased as age increased (see Figure 7, for a visual illustration of this relationship). In other words, children of all ages showed the predicted hindsight effect, but the magnitude of this effect decreased as a function of age. Next, I tested whether the magnitude of the curse of knowledge in the visual task varied as a function of gender. An independent t-test comparing this magnitude between males and females was non-significant, $p > .35$.

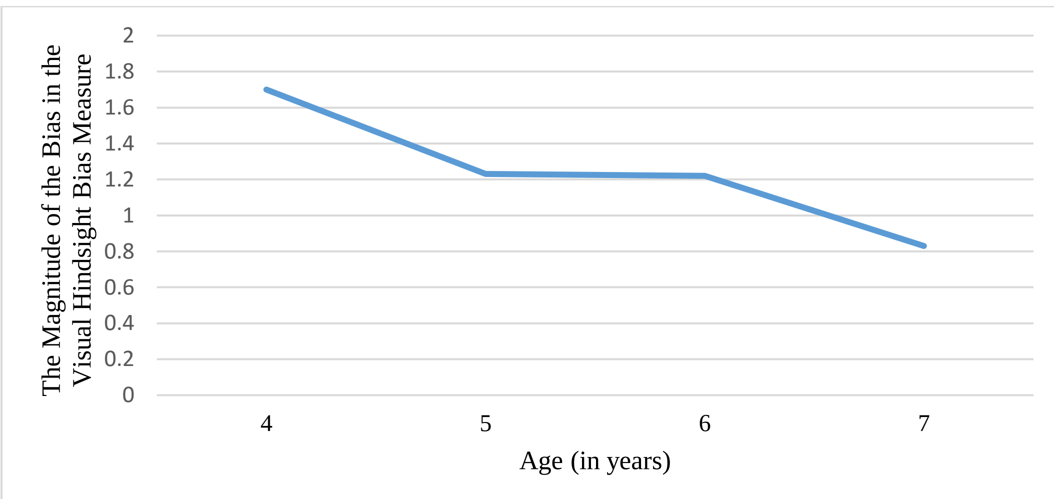

Figure 7. The magnitude of the curse of knowledge bias in the Visual Hindsight Bias measure across age.

3.4.2. Main Analyses

Finally, to examine Question 3, I conducted a partial correlation between the magnitude of the curse of knowledge in the Peer Estimates Task and the magnitude of the curse of knowledge in the Visual Hindsight Bias Measure, while controlling for age in months. The correlation between the magnitude of the curse of knowledge in the Peer Estimates Task and the Visual Hindsight Bias Measure was not significant, $r(74) = .08$, $p = .49$, revealing that children's performance across the two tasks was unrelated.

4. General Discussion

The current study aimed to examine whether the curse of knowledge influences children's estimates of how common knowledge is among their peers. Specifically, children were asked to estimate how many of their peers will know the answers to eight different factual questions. Half of the factual questions were taught, while the other half were not. Based on the wealth of aforementioned research on the curse of knowledge, I expected that when children were taught the answers to factual questions they would estimate that more of their peers would know the answers to those questions than when they were not taught the answers. I also expected that younger children would be more 'cursed' by their knowledge than older children. Lastly, I expected that children who showed the curse of knowledge bias in their estimates of how widely known conceptual knowledge would be among their peers would also show a curse of knowledge in their judgements about when another individual would be able to identify an obscured object.

In stark contrast to my first hypothesis, the present results show that teaching four- to seven-year-old children answers to the factual questions used in my design led to *lower* peer estimates, compared to not teaching them the answers. That is, children estimated that less of their peers will know the answers to taught factual questions, as opposed to not taught questions. The present results demonstrate a *reverse* of the curse of knowledge whereby children estimate that less of their peers will know the answers to the factual questions when they themselves know the answers.

Although I did not foresee this outcome, it likely has theoretical significance as it fits with a large body of work with adults highlighting the circumstances under which one does not find the curse of knowledge or finds a reverse bias. One possibility is that the reverse bias observed in my data occurred because the factual questions I selected for the Peer Estimates Task were too difficult or unusual. As described above, I selected difficult factual questions for this task to decrease the chances of any prior knowledge of the questions. Specifically, I wanted to ensure that children did not know the answers to the questions that were not taught. The factual questions had unique, or unfamiliar, answers (e.g., '*The Greater Wax Moth has the best hearing*. How many children will know which animal has the best hearing?'; see Appendix G, for a list of the factual questions). Accordingly, I believe that when children heard the answers to the questions they realized just how difficult the questions were, and in turn, estimated that few children would know the information. On the other hand, when children were not presented with answers to the factual questions (e.g., How many children will know which animal has the best hearing?'), they were less aware of how difficult the questions really were. Interestingly, the reverse bias only occurred when Set B of the factual questions was taught. I did not anticipate this outcome. However, it does seem like Set B has more questions that involve unfamiliar answers than Set A (see Appendix H for a comparison of Set A and Set B questions). This is consistent with the idea that children show a reverse curse of knowledge when they are presented with unfamiliar answers. Specifically, Set B had more unfamiliar answers than Set A, and children were more likely to show the reverse bias when Set B was taught.

Furthermore, the current results did not support my second hypothesis that younger children would show a greater curse of knowledge bias than older children. Indeed, children across all ages tended to show lower peer estimates when they were taught the answers compared to when they were not taught the answers (see Figure 4 for a visual illustration of the peer estimates for taught and not taught trials, across ages). In other words, this reverse curse of knowledge did not change with age.

Lastly, the current findings do not support my third hypothesis that children's performance on the Peer Estimates Task would correlate with their performance on a published measure of the curse of knowledge (the Visual Hindsight Bias Measure), controlling for any age-related changes. That is, children's performance on the Peer Estimates Task was not correlated with their performance on the Visual Hindsight Bias Measure. Importantly, the present study contributes to the growing body of literature on the curse of knowledge in children by replicating previous findings using the Visual Hindsight Bias measure (e.g., Bernstein et al., 2007; Bernstein et al., 2011). In fact, the results suggest that visual knowledge has a large effect on children's judgement about the perceptual perspective of another individual (η^2 = .38), suggesting that visual knowledge is especially powerful in biasing our judgements. I suspect that the relationship between performance on the Visual Hindsight Bias Measure and performance on the Peer Estimates task was not detected because the Peer Estimates task did not show a curse of knowledge, but rather a reverse. It is also possible that, as discussed above, the curse of knowledge bias for *conceptual* information is not related to the curse of knowledge for *perceptual* information. That is, these two types of the curse of knowledge may operate somewhat differently. For instance, reasoning about the conceptual knowledge of others may be a conscious process, whereas considering the visual knowledge of another may be a more automatic, or unconscious process. In other words, it is possible that the same curse of knowledge tendency may stem from different knowledge updating systems (e.g., conceptual updating and visual updating), and the nature of these updating systems may lead to differences in the curse of knowledge tendencies (e.g., visual curse of knowledge is more).

Although the hypotheses of the current study were contradicted, the present findings are nonetheless informative. After all, children's performance was not at chance; they were significantly lowering their peer estimates when they knew the answers compared to when they did not, and this pattern was consistent across all of the age groups. This is not the first study to report a reverse of the curse of knowledge. Yopchick and Kim (2012) found that adults show a reverse of the curse of knowledge when outcome information is surprising and unexplainable. Specifically, the researchers presented participants with stories that had two possible outcomes, and a 'causal factor' (the author's term) that supported one of the outcomes. For example, participants were presented with a scenario about a battle between the Hutus and the Tutsis, and were told that the Hutus have superior discipline in battle. Participants showed the curse of knowledge when estimating a peer's ability to predict the outcome, when this outcome was supported by a causal factor (e.g., the Hutus won the battle). However, participants showed a reverse curse of knowledge when they received the outcome that was inconsistent with a causal factor (e.g., the Hutus lost the battle). Furthermore, the researchers found that the curse of knowledge did not occur at all when there was no causal factor to support the outcome information. These findings suggest that one must be able to reconcile the outcome information for the curse of knowledge to occur (i.e., it needs to make sense). Indeed, a number of other researchers have shown that if the information is surprising, or hard to explain, the reverse of the curse of knowledge occurs (see also, Ofir & Mazursky, 1997; Ofir & Mazursky, 1990; Pohl, Bender & Lachmann, 2002).

I believe that the present findings show a reverse curse of knowledge because children found the answers to be surprising or difficult. To assess the viability of this argument for my findings in particular, I examined children's answers to the factual questions that were not taught and found that the majority of children seemed to expect specific *alternative* answers for most of the factual questions (see Appendix H for the alternative answers that children expected). For example, when asked ‘which kind of bird can fly the highest?’, most children thought it was an eagle but the correct answer was a ‘Ruppell’s vulture’. Accordingly, the majority of children may have been surprised to learn that the Ruppell’s vulture can fly the highest. This suggests that the information we presented for the factual questions were both surprising and unfamiliar. Indeed, it would be hard to imagine that one would be surprised by a piece of information, and yet think of it as *common knowledge.*

In fact, I argue that the body of work showing no bias (or even a reverse bias) for surprising or difficult information helps elucidate the mechanisms that underlie the curse of knowledge. As you may recall, fluency misattribution is a mechanism that contributes to the curse of knowledge (see, Harley, Carlsen, & Loftus, 2004; Birch et al., under review). Specifically, when a piece of information seems fluent, the ease with which the information comes to mind is misattributed to its overall apparentness (e.g., Roese & Vohs, 2012). A body of research has reported fluency misattribution’s influence on a range of judgements, including judgements about the clarity of images, fame of individuals, and difficulty of tasks (Harley, Carlsen & Loftus, 2004; Jacoby, Kelley, Brown & Jasechko, 1989; Song & Schwarz, 2008). Specifically, in all of these judgements, the fluency with which information is processed or comes to mind invokes a sense of ease that can be mistaken for objective transparency.

My findings on the effect of knowledge on peer estimates suggest that the curse of knowledge does not occur (or even reverses) when fluency misattribution is not possible. Specifically, judgements about common knowledge is not affected by the curse of knowledge when information does not *feel* fluent. Consistently, Werth and Strack (2003) demonstrated that the curse of knowledge can be attenuated by decreasing the perceptual fluency of written information. That is, participants were presented with factual questions and answers, and asked to determine whether they could have predicted the answer, if they had not seen it. The perceptual fluency was manipulated by either presenting the factual questions and answers in easy to read colours against the background screen, or difficult to read colours. The researchers found that participants estimated that they would be more likely to predict the answers of the factual questions that were presented in easy to read colours compared to those presented in difficult to read colours.

Furthermore, in earlier work my colleagues and I (Birch et al., under review) demonstrated that adults show a curse of knowledge for factual questions that were shown repeatedly (and thus fluently processed), but not known. That is, fluency misattribution can contribute to the curse of knowledge even in the absence of content knowledge. In one study, for example, participants were presented with three lists of factual questions (e.g., “What was the first organ successfully transplanted from a cadaver to a live person?”) and were given the answers to each to memorize (Known questions). The participants were then presented with a second list of factual questions that were not taught (Familiar questions). Subsequently, participants were exposed to both the Known and the Familiar questions (but not the answers) three additional times. One week later, participants were presented with the same factual questions (Known and Familiar), as well as a new list of factual questions (New questions). After each question, participants were asked to estimate the percentage of their peers who would know the answer to the question. We found that adults made higher peer estimates for factual questions that had been taught (Known), compared to factual questions that were not presented before (New questions); a classic curse of knowledge effect. We also found that adults made higher peer estimates for factual questions that were repeatedly presented a week earlier without the answers (Familiar), compared to factual questions that were not presented before (New); a fluency misattribution effect. These findings suggest that the fluency associated with an item is sufficient in biasing adults' judgements about how common knowledge is among their peers.

Similarly, preliminary findings from a current study being conducted in our laboratory suggest that fluency misattribution also affects children's judgements of the commonality of knowledge (Haddock; Unpublished master's thesis). In the study, four- to seven-year-old children were read four stories about different groups of animals. For each story, there was one group of animals that was recited frequently throughout (Fluent; e.g., a group of bears), while another group of animals was only mentioned once (Non-Fluent; e.g., a group of badgers). That is, one group of animals was made more familiar than the other via repetition. After each story, children were asked to predict whether their peers will know the name of the Fluent group of animals or the Non-Fluent group of animals (e.g., "Will more kids know what a group of bears is called or what a group of badgers is called?"). Not surprisingly, children judged that their peers will know the name of the Fluent group of animals versus the Not Fluent group of animals. That is, the frequency of exposure to a group of animals influenced children's judgements of how widely known that information would be among their peers. On the flip side, my current results show the effect of dysfluent information on estimates of common knowledge. That is, the factual information presented in the current study was unfamiliar, and seemingly surprising, to children. I argue that this created a lack of fluency that led to a reverse curse of knowledge, where children made lower peer estimates when they were taught information versus not taught.

It is interesting to note that the current results do not lend support to the inhibitory control account of the curse of knowledge. As you may recall, the inhibitory control account suggests that the curse of knowledge occurs because of the difficulty associated with inhibiting content knowledge. In reference to a previous example, if one knows that the Trevi fountain is located in Rome, he or she may find it difficult to suppress this content knowledge and make accurate inferences about what others know. In the current study, however, children *were* presented with content knowledge and did not show a curse of knowledge in their judgements. According to a strict inhibitory control account, children should have shown the curse of knowledge when taught content information, even if that information was dysfluent.

Having said that, I would like to acknowledge that inhibitory control may be working in tandem with fluency misattribution to contribute to the curse of knowledge. That is, the influence of inhibitory control may be triggered when information is fluent. For example, I have known that Paris is the capital of France for quite a long time and the information comes to mind quickly and easily. If one asked me how many of my peers would know that information, I may easily picture Paris and the Eiffel tower and conclude that many of my peers must know this information. In other words, this content knowledge is so fluent to me that it became particularly difficult to suppress (i.e., I'm cursed not just because I know it but because I have encountered it frequently). Interestingly, Birch et al. (under review) found that factual questions that are both fluent and taught invoke a stronger curse of knowledge than factual questions that are fluent but not taught, suggesting that both content knowledge and fluency contribute to the curse of knowledge.

It is worth noting that there may be other mechanisms that contribute to the curse of knowledge bias or influence our judgments of what others know. For example, it is easy to imagine how self-simulation, or a 'like me' framework, can contribute to the bias. Self-simulation is a theoretical approach explaining the ability to reason about other perspectives

(Gordon, 1996). Specifically, self-simulation suggests that when attempting to reason about the perspective of others, we tend to ‘simulate’ how we would react in similar situations, and draw mental state inferences accordingly (e.g., Ball, Besozzi, Ball, Anderson & Geye, 2013). In some ways, self-simulation can explain why we think that others share our knowledge. That is, when attempting to take on another perspective, we simulate ‘our selves’ in the same context as another individual, therefore we simulate our own beliefs, knowledge, and feelings, into that context as well. For instance, when considering whether other people know the answer to a question, we simulate our own perspective, and if we know the answer we become biased by our knowledge. However, self-simulation does not adequately explain the curse of knowledge, in that it does not explain why we do not ‘share’ our ignorance with others. As you may recall, Birch and Bloom (2003) examined children’s ability to attribute knowledge to a puppet, Percy. Consistent with the self-simulation approach, the researchers found that when children were knowledgeable about the contents of a container, they were more likely to think that Percy would know the contents of the container as well. However, when children did not know the contents, they did not think that Percy would also not know the contents. That is, there was no ‘curse of ignorance’. Children did not simply project their own mental state onto Percy. In fact, when children were ignorant of the containers’ contents, they were more accurate in estimating what Percy did or did not know.

Although it is important to dissect the effect of each mechanism behind the curse of knowledge, it is also critical to consider how these mechanisms are working together outside of the lab setting. I would argue that self-simulation, inhibitory control, and fluency misattribution all contribute to the curse of knowledge bias, and interact with each other as well as other factors in the environment to strengthen or dampen the effect of the bias. For example, when we consider the perspective of another individual, the characteristics of this individual may either trigger or limit the process of self-simulation. That is, a large body of research suggests that when we consider the perspective of another individual, we use our own perspective as a starting point, and we adjust this perspective based on other information we have available (e.g., information we have about the individual or group); this process is referred to as ‘anchoring and adjustment’ (e.g., Pohl & Hell, 1996; Tversky & Kahneman, 1974). It is quite possible that when we consider the perspective of someone who seems more ‘like us’, we are more likely to attribute our own thoughts, beliefs, and knowledge to this individual. For example, if I am considering whether another individual knows that Paris is the capital of France, the characteristics of this individual may affect my judgement. That is, if the individual is ‘more like me’, a university student who was raised in Canada, I would be more likely to attribute my knowledge to her. However, if the individual is a six-year-old boy who was raised in Afghanistan, I may be less likely to assume that he knows what I know. More so, one may even argue that shared similarity with another individual, gives us a reason not to suppress our own knowledge and to use the fluency of the information as a guide for our knowledge attributions.

4.1. Limitations and Future Directions

The most glaring limitation of my thesis research is that I had intended to examine the effect of the curse of knowledge on judgements of the commonality of knowledge, but instead my results show a reverse of the bias. Specifically, I selected factual questions that were too unfamiliar to trigger the curse of knowledge. This is a critical point for future research examining the curse of knowledge. Specifically, participants must be able to fluently process new information to show a curse of knowledge. That is, information must seem familiar or intuitive.

In a future study, I will test my interpretation that the current results are due to the dysfluency of the items I chose by using familiar answers for the taught factual questions. Specifically, I intend to use the same procedures but using the most ‘common answers’ that children selected in the current study (e.g., the smallest bug is a lady bug). That is, I will use fake answers that are familiar to children between the ages of four to seven years. I suspect that when children learn answers that sound familiar they will show a curse of knowledge in their peer estimates. Specifically, they will make higher peer estimates for factual questions that were taught versus not taught, supporting my claim that the current results are due to the surprising or unfamiliar nature of the answers to the questions rather than a lack of a curse of knowledge in children’s judgments of how widely known information is among their peers.

Another limitation of the current study is that it is hard to parse whether children showed a reverse bias because the information was unfamiliar, or because it was surprising. As discussed above, children had alternative expectations for what the answers for the factual questions should be. For example, children expected that the animal with the best hearing was a bat rather than a Greater Wax moth. It is possible that children showed a reverse curse of knowledge because they really thought that a ‘bat’ was the right answer. But, it is also possible that the unfamiliarity associated with the term ‘greater wax moth’ reversed the effect of the bias. One way future research can parse the effects of unfamiliarity and surprise is by comparing the reverse curse of knowledge across factual questions that have counterintuitive 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).

Lastly, in the current study, children estimated that more of their peers would know the answers to factual questions in Set A versus factual questions in Set B (See Appendix G, for the mean peer estimates of each factual question). This outcome was not anticipated. Indeed, I thought that factual questions in Set A and Set B would be equally difficult. For future studies examining children's assessments of factual information, I would recommend that the researchers pre-test the factual questions to determine whether they are equally difficult in a separate sample of children of the same ages.

4.2. Implications

The current study sheds light on how knowledge about a fact can influence children's estimates of the commonality of conceptual information. As far as I know, this is the first study to demonstrate a reverse curse of knowledge among children. These findings suggest that the curse of knowledge is a phenomenon that is contingent on the ease with which new information is processed. That is, the curse of knowledge does not occur any time new information is introduced. The information must be easily processed to induce the bias.

Remarkably, children were more competent in judging the commonality of conceptual knowledge, than I had anticipated. That is, children were less vulnerable to the curse of knowledge than earlier work suggested. When children were exposed to the difficult factual information, they realized the difficulty of the questions at hand and logically lowered their peer estimates. In other words, four to seven-year-old children were sensitive to the difficulty of the questions and did not arbitrarily attribute new knowledge to their peers. This speaks to children's already sophisticated perspective taking abilities. I believe these findings are especially interesting because the literature on the curse of knowledge among children, so far, suggests that children are particularly vulnerable to the bias. Conversely, the current findings suggest that children are not as vulnerable to the curse of knowledge as we had originally thought. Indeed, children demonstrated critical thinking skills when considering what their peers would know, and were surprisingly adept at judging difficulty. These findings reframe our understanding of children's critical thinking skills and ability to make accurate knowledge inferences.

Furthermore, to my knowledge, this is the first study to demonstrate that four to seven year olds can reason about the knowledge of their peers as a group. That is, children were able to use a scale to indicate their judgements about the knowledge of their age group. Reasoning about such an abstract concept is quite impressive. Specifically, no one has met all of their peers, yet children were seemingly able to imagine their peers as a group and judge how prevalent information is among 'kids their age'. In designing the task, I had included exclusion criteria for the five-point scale, to identify children that did not seem to understand the scale. Interestingly, only nineteen out of 120 children, were excluded because they did not seem to understand the scale.

Taken together, the present study is the first to examine how knowledge about a particular fact can influence children's judgements about the commonality of that knowledge among peers. The findings shed light on the factors that contribute to, and even reverse, the curse of knowledge. For example, the curse of knowledge reverses when information is dysfluent and surprising. Furthermore, the current study puts forth a new way of examining the continuity of the effect of knowledge on social judgements. The five-point scale measures individual, and age-related, differences in children's judgements on the commonality of knowledge. By providing this assessment, the current study laid the groundwork for future research investigating the relationships between individual differences in the curse of knowledge and various aspects of children's social functioning, such as the extent of their peer relationship problems. It also helps pave the way for future research examining the specific mechanisms that contribute to the curse of knowledge bias (and its reverse). This line of research will allow for a better understanding of the curse of knowledge bias, and how it affects different aspects of our day-to-day social encounters.

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Appendices

Appendix A: Experimenter Introductory Script for Peer Estimates Task

Researcher:___________ Participant ID: _________ Baby ID: ____________ Daycare ID: ____________	Age: yrs:______mm:______ DOE: dd:____ mm: ___yrs:______ DOB: dd:____mm: ___yrs:_______ Ethnicity: ☐ White ☐ East Asian ☐ South Asian (e.g., Indian) ☐ African ☐ Other	Experiment Place: ☐ SW ☐ Daycare ☐ Lab Gender: ☐ Male ☐ Female	Video Recording? ☐ OK ☐ No recording Parent Questionnaire? ☐ Yes ☐ No ☐ Video release?

[Warm child up by asking about age, pets, hobbies, etc.]

Training:
Would you like to play a game with me? Let me show you how to play. See this board, there's no children in here, there's a couple of children here, there's some here, a lot here, and there's a whole lot of children here!

I am going to ask you some questions and you can show me how many children your age will know the right answer by pointing to one of these!

Let me show you how to play.
(for each question flip to the related descriptive picture)

Question	**Comment**
A cow says moo. How many children your age will know that?	That's a really easy one. I think that a whole lot of children your age will know that one, so you'd point here! (point to the fifth group of kids)
Let's try another one. **This is a holophonor. How many children your age will know that?**	That's a really hard one. I just learned it myself. So no children your age will know that one. So you'd point here. (point to the 1st group of kids)
A giraffe is the tallest animal. How many children your age will know that?	That's not really hard or easy. Some children will know that one, so you'd point here (point to the 3rd group of kids)

Appendix B: Experimental Script for Peer Estimates Task (version one)

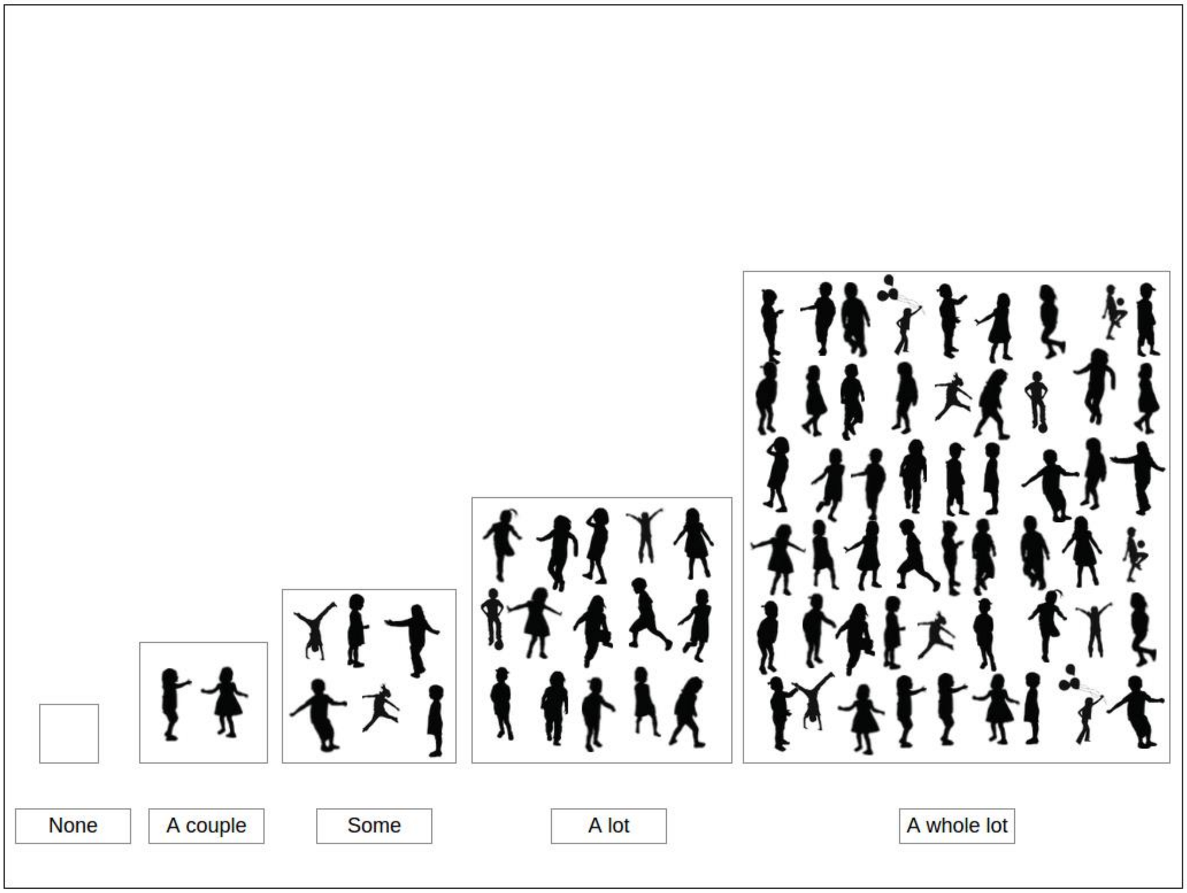
Let's try some other questions!
Remember, you can point to **any** of these when I ask you how many children will know the answer; there's no children here, there's a couple here, there's some here, a lot here, and there's a whole lot of children here!

(For the next set of questions, set up the descriptive picture for each question)

Question	Number of children (circle one)	Guesses?
A1. **How many children will know which kind of insect, or bug, is the smallest?**	None Couple Some A lot A whole lot	
A2. **How many children will know which kind of bear is the largest?**	None Couple Some A lot A whole lot	
A3. **How many children will know which kind of dog cannot swim?**	None Couple Some A lot A whole lot	
A4. **How many children will know which animal is the best jumper?**	None Couple Some A lot A whole lot	
B1. ***A Ruppell's vulture can fly the highest.*** **How many children will know which kind of bird can fly the highest?**	None Couple Some A lot A whole lot	
B2. ***The back of the neck is called a nape.*** **How many children will know which part of the human body is called a nape?**	None Couple Some A lot A whole lot	
B3. ***The sailfish is the fastest sea animal.*** **How many children will know which animal is the fastest in the sea?**	None Couple Some A lot A whole lot	
B4. ***The greater wax moth has the best hearing.*** **How many children will know which animal has the best hearing?**	None Couple Some A lot A whole lot	
	Post-Questions	
How many children like to be happy?	None Couple Some A lot A whole lot	
And, how many children like to be sad?	None Couple Some A lot A whole lot	

Now, I want to ask you about the questions we talked about earlier!	
Question	Child Response
A1. **Which kind of insect, or bug, is the smallest? Is it a fairyfly, a leaf beetle, a lady bug, or a seed bug?** (point to each animal)	☐ Correct answer (Fairyfly) ☐ Wrong answer: ________ ☐ No response/ don't know
A2. **Which kind of bear is the largest? Is it a grizzly bear, polar bear, black bear, or panda bear?** (point to each animal)	☐ Correct answer (polar bear) ☐ Wrong answer: ________ ☐ No response/ don't know
A3. **Which kind of dog cannot swim? Is it a pug, a brussels griffon, a poodle, or a basset hound?** (point to each animal)	☐ Correct answer (basset hound) ☐ Wrong answer: ________ ☐ No response/ don't know
A4. **Which animal is the best jumper? Is it a flea, a goat, a grasshopper, or a rabbit?** (point to each animal)	☐ Correct answer (flea) ☐ Wrong answer: ________ ☐ No response/ don't know
B1. **Do you remember which kind of bird can fly the highest? Is it a peregrine falcon, a malleefowl, a ruppell's vulture, or an eagle?** (point to each animal)	☐ Correct answer (ruppell's vulture) ☐ Wrong answer: ________ ☐ No response/ don't know
B2. **Do you remember which part of the body is called the nape? Is it the bottom of the feet, the back of the knees, the back of the neck, or the top of the head?** (point to each animal)	☐ Correct answer (back of the neck) ☐ Wrong answer: ________ ☐ No response/ don't know
B3. **Do you remember which animal is the fastest in the sea? Is it the clownfish, the sailfish, the pilot whale, or the mako Shark?** (point to each animal)	☐ Correct answer (sailfish) ☐ Wrong answer: ________ ☐ No response/ don't know
B4. **Do you remember which animal has the best hearing? Is it the elephant, the bat, the three-toed sloth, or the greater wax moth?** (point to each animal)	☐ Correct answer (the greater wax moth) ☐ Wrong answer: ________ ☐ No response/ don't know

Appendix C: Five-point scale for Peer Estimates Task



Appendix D: Visual Hindsight Bias Task Script

Researcher : **Now we're going to play the hide-it game. I'm going to hide a toy right here (point to the pencil holder) and then cover it up so it's really hard to see what's inside. I'll flip through these sheets and you tell me when you have a guess of what it might be!**

[Hide the toys in the following order: object 1, object 2, etc.]

Researcher: **Can you see what's inside the box?** [As you flip through the sheets, follow this order of questions] … **Can you see what's inside the box now?** [flip the sheet] **How about now?** [flip the sheet] **Now?** [flip the sheet] **Can you see what's inside the box?** [flip the sheet] … [repeat the questions until there's no more sheets for that round].

[If child says he/ she could see, ask the following]

Researcher: **What is it?** [If child *does not identify* the object correctly, record the guess on the corresponding box. If child *identifies* the object, put a check in the corresponding box. For both situations, <u>continue to flip through all the sheets before ending the round for that object.</u> Then continue to the next object round.]

<u>Recognition Trial</u>

	Object 1	Object 2	Object 3	Object 4
Sheet 1				
Sheet 2				
Sheet 3				
Sheet 4				
Sheet 5				
Sheet 6				
Sheet 7				
Sheet 8				
Sheet 9				
Sheet 10				

Researcher: **Now, we're going to play the hide-it game again. We'll see all those toys you saw earlier, but this time we're going to play the game with Ernie, here** [Introduce Ernie]. **Ernie is just as smart as you, but he hasn't played this game before. Let's begin! We're going to put Ernie under the table here, so he can't see what we hide in the box! And, he can't hear us!** [Put Ernie away]

Researcher: **First, we're going to hide this toy** [show child toy] **here, and then we'll get Ernie and see when he will know what's hiding inside the box.**

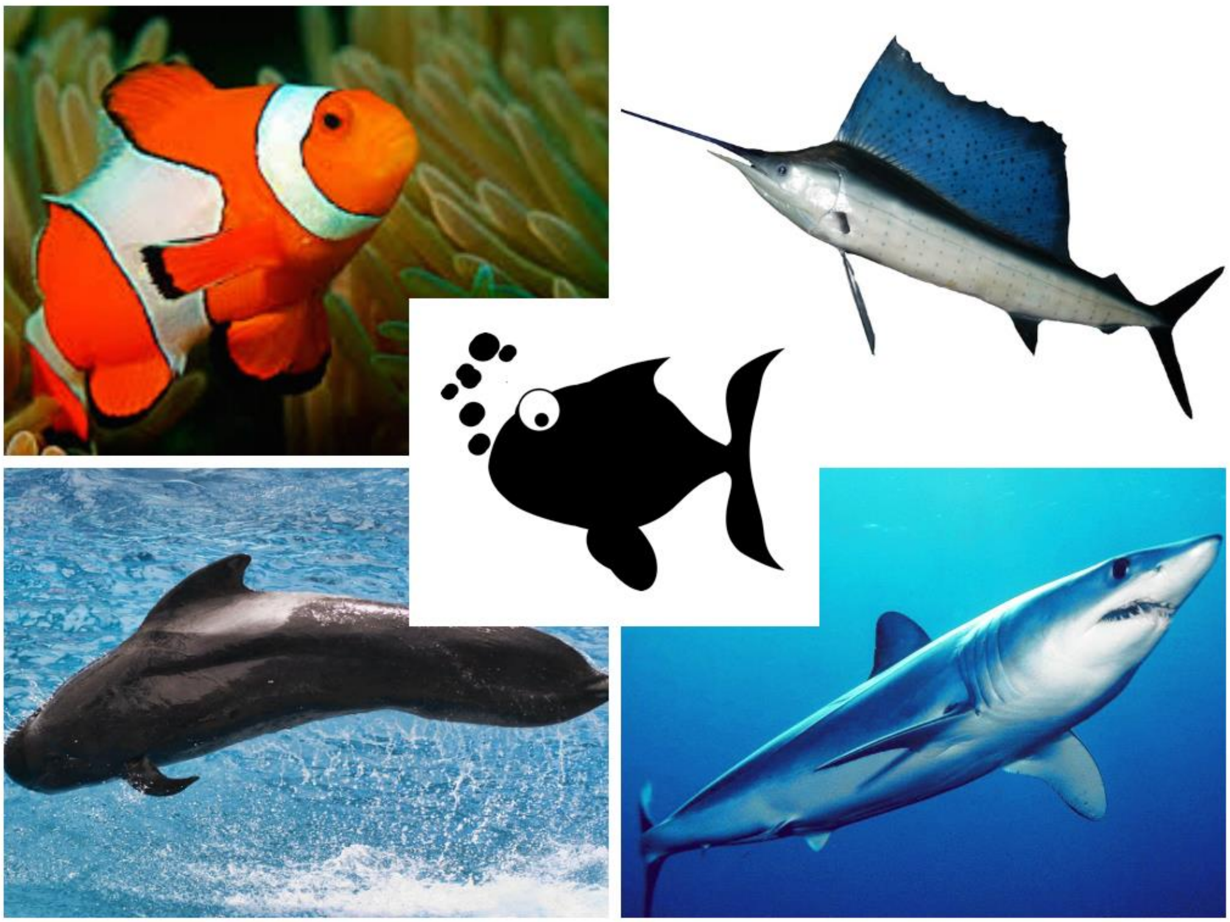
Researcher: **Can Ernie see what we put inside the box?** [As you flip through the sheets, follow this pattern of questions] … **Can Ernie see what we put inside the box now?** [flip the sheet] **how about now?** [flip the sheet] **Now?** [flip the sheet] **Can Ernie see what we put inside the box?** [flip the sheet] … [When child says that Ernie can see what's inside the box, ask the following] **What will Ernie say is inside the box?** [If child does not identify the object, record the 'guess' on corresponding box. If child identifies the object hidden in box, put a check in the corresponding box. Then ask the following question.] **How does Ernie know that it is a [NAME of OBJECT]?** [Continue with the next object]

Hindsight Trial

	Object 1	Object 2	Object 3	Object 4
Sheet 1				
Sheet 2				
Sheet 3				
Sheet 4				
Sheet 5				
Sheet 6				
Sheet 7				
Sheet 8				
Sheet 9				
Sheet 10				
How did Ernie know ?				

Appendix E: Visual Hindsight Bias Measure Box

Appendix F: Factual Question with four possible answers



Appendix G: Breakdown of Mean Peer Estimates for each Factual Question

	Answer	Factual Question	Mean peer estimate	Mean peer estimate in Knowledge Trials	Mean peer estimate in Ignorant Trials	Mean Difference (Known – Ignorant)
Set A	The smallest insect or bug is a fairyfly.	How many children will know which kind of insect, or bug, is the smallest?	1.73	1.38	2.08	-0.7
	The largest bear is a polar bear.	How many children will know which kind of bear is the largest?	2.33	2.40	2.27	.13
	The basset hound cannot swim.	How many children will know which kind of dog cannot swim?	2.02	2.00	2.04	-.04
	A flea is the best jumper in the world.	How many children will know which animal is the best jumper?	2.53	2.29	2.77	-.48
		Average	**2.15**	**2.02**	**2.29**	**-.27**
Set B	A Ruppell's vulture can fly the highest.	How many children will know which kind of bird can fly the highest?	2.14	1.85	2.42	-.57
	The back of the neck is called a nape.	How many children will know which part of the human body is called a nape?	1.28	1.40	1.17	.23
	The sailfish is the fastest sea animal.	How many children will know which animal is the fastest in the sea?	2.18	2.15	2.21	-.06
	The greater wax moth has the best hearing.	How many children will know which animal has the best hearing?	1.98	1.71	2.25	-.54
		Average	**1.90**	**1.78**	**2.01**	**-.23**

Appendix H: The Most Common Answers for the Factual Questions

	Factual Question	Correct Answer	Most Common Answer	Percentage of Children choosing the common Answer
Set A	Which kind of insect, or bug, is the smallest?	Fairyfly	Lady Bug	57.4%
	Which kind of bear is the largest?	Polar Bear	Polar Bear	44.7%
	Which kind of dog cannot swim?	Basset Hound	Poodle	27.7%
	Which animal is the best jumper?	Flea	Rabbit	40.4%
Set B	Which kind of bird can fly the highest?	A Ruppell's vulture	Eagle	65.3%
	Which part of the body is called the nape?	Back of the neck	Top of head	42.9%
	Which animal is fastest in the sea?	Sailfish	Mako Shark	46.9%
	Which animal has the best hearing?	The Great Wax Moth	Bat	49.0%