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Understanding children's and adults' limitations in mental state reasoning

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Young children exhibit several deficits in reasoning about their own and other people's mental states. We propose that these deficits, along with more subtle limitations in adults' social-cognitive reasoning, are all manifestations of the same cognitive bias. This is the 'curse of knowledge' – a tendency to be biased by one's own knowledge when attempting to appreciate a more naïve or uninformed perspective. We suggest the developmental differences in mental state reasoning exist because the strength of this bias diminishes with age, not because of a conceptual change in how young children understand mental states. By pointing out the common denominator in children's and adults' limitations in mental state reasoning we hope to provide a unified framework for understanding the nature and development of social cognition.

Preschool children can be remarkably bad at reasoning about mental states. They are often poor judges of what information other people are likely to know, and are notoriously bad at recalling when they themselves acquired new information. For example, once four- and five-year-olds are taught a new fact (e.g. that tigers' stripes go up and down) they assume that other children know this fact, and insist that they themselves had always known this fact [1]. Young children also have problems with perspective-taking, doing poorly, for instance, at tasks requiring them to figure out how a particular scene will look from another person's viewpoint [2]. Piaget described this perspective-taking problem as 'egocentrism', suggesting that young children are unable to appreciate that other people's perspectives can differ from their own [3].

Finally, young children have serious difficulties in reasoning about false beliefs. In the standard demonstration of this, children are presented with a story (see Figure 1a) in which one character, Sally, puts an object (e.g. a ball) in one location (Location A) and goes outside. While Sally is outside Ann moves the ball to Location B. Children are then asked: *When Sally comes back wanting her ball*, *where will she look for it*? Children younger than four tend to say that she will look for it in Location B, failing to appreciate that Sally should believe (falsely) that it is in Location A where she left it [4,5].

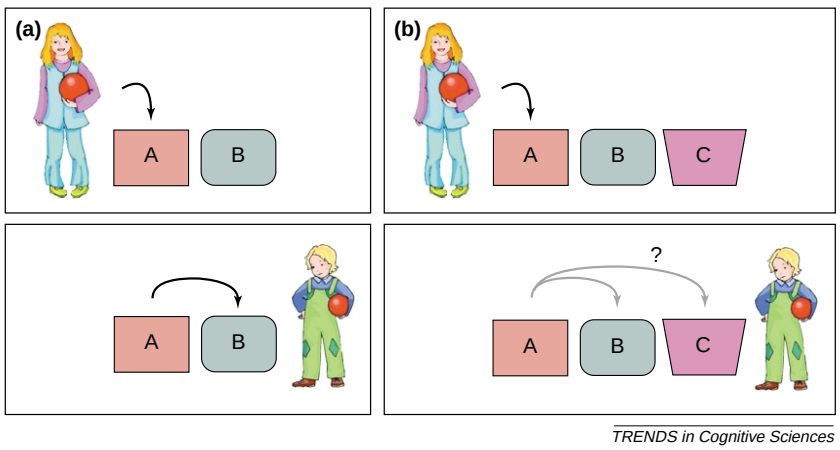

Figure 1. **(a)** A representation of the 'Sally-Ann' false-belief task used to assess children's understanding that other people can hold false beliefs – beliefs that contradict reality. In these tasks, children are told that Sally places an object (e.g. her ball) in one location (A) and then goes outside. While Sally is away, Ann moves her ball to a different location (B). The question posed to children is: *When Sally returns and wants to find her ball, where will she look for it*? Children younger than age four typically say she will look in location B, failing to attribute a false belief to Sally. **(b)** A representation of a false-belief task that would remove or diminish the curse of knowledge. We propose this is a better test of children's abilities to reason about false beliefs because it diminishes the specificity of their outcome knowledge – knowledge that has been shown to pose a greater source of difficulty for younger children [23]. This task is the same as the standard task outlined in (a), except that an additional location would be added, meaning that the child participant remained ignorant of the exact outcome of the false-belief event. Here, while Sally is away, Ann moves her ball to a different location, either B or C, and the child does not know which one. As in the standard task, to succeed, the child must attribute a false belief to Sally (that she will believe it is in location A) and know this to be false.

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A different paradigm shows that this confusion also applies when assessing one's own beliefs. In the classic 'unexpected contents' task [6], children are shown a candy box and asked what is inside. When they answer 'candy', the box is opened to reveal pencils. The box is then closed and the children are asked what they originally thought was in the box and what someone else, who was absent when the real contents were revealed, will think is in the box. Children younger than four answer both questions incorrectly, stating that they themselves initially thought there were pencils inside and that someone else would think there were pencils inside. They fail to recall their own earlier false belief and they fail to appreciate that someone else, who was absent when the real contents were revealed, will hold a false belief.

Why do children experience these problems with reasoning about mental states? Children's difficulties are often taken as reflecting a qualitative and conceptual difference in the way that they understand the mind. For instance, young children are sometimes said to lack a concept of belief or a concept of mental representation more generally [3,7–11]. We offer a different theory (see [12,13] for related accounts). We propose that these difficulties stem from a more exaggerated version of the same cognitive bias that has been found in adults. This is the 'curse of knowledge' [14] – a tendency to be biased by one's own knowledge when attempting to appreciate a more naïve or uninformed perspective. For example, adults who know the solution to a problem tend to overestimate how easy it is for someone else to solve [15]. Similarly, people who know a company's earnings [14], the outcome of an event [16], or whether or not a statement is sarcastic [17], tend to overestimate the knowledge of others (see also [18,19]). These and similar findings have been given a wealth of other names including 'creeping determinism' or 'hindsight' bias [16], the 'knew-it-all-along' effect [20], 'the curse of expertise' [21], 'adult egocentrism' [15,22], 'reality bias' [12] and 'epistemic egocentrism' [13]. We believe they are all manifestations of, and can most accurately be described by, the curse of knowledge (see also Box 1).

Box 1. How does the curse of knowledge relate to other biases in social cognition?

One phenomenon that appears closely related to the curse of knowledge is the 'spotlight effect': a tendency for people to overestimate the extent their appearance and actions are noticed by others [38]. For example, in one study, participants were asked to don a T-shirt depicting an image of someone famous and then were led into a room where other participants were completing a questionnaire. After leaving the room, the participants tended to overestimate how many people in the room noticed who was on the T-shirt. It seems plausible that the curse of knowledge is driving this effect. The T-shirt-wearing participants found it difficult to put aside their own knowledge of what they were wearing to appreciate the naïve observer's point of view.

A related phenomenon is the 'illusion of transparency' – the belief that one's internal states are more discernable to others than they really are [39]. In one study, subjects stood in front of a group, were handed a card containing a question, and were required to answer by either telling the truth or telling a lie. The job of the rest of the group was to be astute lie detectors. The results revealed that when participants lied they tended to overestimate the detectability of their lies [39]. In a second study, subjects were 'yoked' to partners who were provided with the same information as the subjects answering the question. The yoked subjects did not overestimate the transparency of their partner's lies as much as the liars themselves, even though they were just as knowledgeable of the veracity of the statements as the liars [39].

The difference between the liars and the yoked participants shows that knowledge *per se* is not enough to account for the illusion of transparency. It could be that knowledge is an even stronger 'curse' when it is from a first-person perspective. The subjective experience of actually producing the lie might make the knowledge more salient, and thus, more difficult to appreciate a naïve perspective. In addition, the yoked partners simultaneously have the vantage point of seeing the liar lie and experiencing the lie's perceptibility from an observer's perspective. Perhaps this information allowed the yoked observers to be more accurate in their assessment of what the other observers would know.

The curse of knowledge also seems to share a fundamental commonality with the 'false consensus effect'. This is a tendency for people to assume that their beliefs, values or attitudes are more common and more normative than they really are [40]. Similarly, the curse of knowledge is a tendency for people to assume that their knowledge is more common than it really is. It is an interesting question whether the same development trajectory and knowledge/ignorance asymmetry exists for the false consensus effect.

Over-estimating what others know and what we ourselves once knew

Do children suffer from the curse of knowledge? In one study to explore this, three-, four-, and five-year-olds were presented with two sets of toys: one described as being familiar to the experimenter's puppet friend, Percy, and one described as being unfamiliar to Percy. The children were told that each toy had an object inside and were asked to judge whether Percy would know what was inside. The key manipulation was that sometimes the children were shown the toys' contents, and sometimes they were not. When the children themselves knew the toys' contents, they tended to overestimate what Percy knew – they were 'cursed' by this knowledge. Importantly, this tendency significantly declined from age three to age five [23] (see also [1,24]).

We suggest that the curse of knowledge is an important factor in explaining children's difficulties in false-belief reasoning, perspective-taking, and knowledge assessment more generally. Indeed, there are some interesting parallels between 'curse of knowledge' studies with adults and the knowledge-assessment and false-belief tasks given to children. For instance, Fischhoff provided adults with descriptions of events and told them that these descriptions were also presented to other students [16]. Some participants were told the outcome of the event, others were not. Participants in both conditions were asked to estimate what 'outcome-naïve' students would predict as the likelihood of the different outcomes. The participants who had been told the outcome overestimated naïve students' predictions of that particular outcome. In other words, they responded as if ignorant others shared their knowledge of the right answer – much like children in the 'Sally-Ann' false-belief task.

Consider also a task in which adults were asked on the eve of former President Nixon's trips to China and the USSR to estimate the probability of various possible

outcomes of the visit [25]. Two weeks to six months later, the same participants were asked to remember their original predictions. Participants remembered giving higher probabilities than they originally had to the events that they now knew had actually transpired. These biased recollections resemble young children's claims that they had known newly acquired facts all along [1] as well as their failures to recall their own earlier false belief about the candy box's contents [6]. Thus, our knowledge not only interferes with the ability to appreciate what a naïve *other* will know, it also interferes with our recollections of what we *ourselves* knew or thought in a previously more naïve state.

Difficulties in false-belief reasoning

Standard false-belief tasks are cursed. In these tasks, the children always know the outcome – either that Sally's ball has been moved to the box or that the candy has been replaced with pencils. Even adults, who undoubtedly have the ability to reason about false beliefs, still experience difficulty on such tasks when they know the outcome of the event. In a four-box version of the 'Sally-Ann' task, participants reported the probability that the protagonist would look in each of four possible locations after her violin was moved in her absence. When adults knew the exact outcome of the displacement event (i.e. the violin was moved to the 'red container'), they were biased by this knowledge, in comparison with adults who heard the same story but did not know which of the boxes held her object (i.e. the violin was moved to 'another container'). The 'cursed' participants were more likely than 'un-cursed' participants to predict that the protagonist would look to the location where the object actually was, and consequently were less likely to attribute a false belief to the protagonist (S. Birch and P. Bloom, unpublished). Because adults have difficulty reasoning about false beliefs under conditions in which they have outcome knowledge, this suggests that children's more extreme limitations do not necessarily reflect a conceptual deficit.

It is of course possible that the curse of knowledge is not the only factor contributing to children's difficulties with false-belief tasks. There are other reasons why children might fail at such tasks, including, among other things, problems they have coping with multiple conflicting representations and with overriding an assumption that agents will act in a rational manner ([26,27], and O. Koos, G. Gergely, G. Csibra and S. Biro, unpublished). And it is possible that, in addition to the curse of knowledge, children also suffer from a conceptual deficit [7–11]. But at the very least, the curse of knowledge makes these tasks unnecessarily difficult, particularly for younger children who are more likely to fall prey to it. Thus, we suggest that these tasks are unfair assessments of young children's true competencies in false-belief reasoning.

Difficulties in perspective-taking

Preschool children are often said to be 'egocentric' – they view the world entirely from their own point of view. One prominent area of research on egocentrism has focused on children's communication. For example, in the classic experiment demonstrating egocentric speech [28], two children are seated across from each other with a screen placed so they cannot see one another. One child is designated the speaker, the other the listener. The speaker's job is to communicate to the listener what objects he or she is selecting so the listener can choose the same objects. Most four-and five-year-old children in the role of speaker provide too little information for the listener to be able to choose the correct object. They fail to appreciate that the other person cannot know which object they are referring to. These egocentric tendencies decrease with age [28].

We propose that this limitation is also a manifestation of the curse of knowledge. Children have difficulty appreciating the listener's more naïve perspective not because they are unable to appreciate that others can have different perspectives, but because they have a hard time putting aside their own knowledge. Indeed, adults, who are undoubtedly able to appreciate that others can have different perspectives, demonstrate similar tendencies. In a study by Keysar and his colleagues [22], a person playing the role of 'director' in a communication game instructed a participant to move certain objects around in a grid. Before receiving instructions from the director, participants hid an object in a bag, such as a roll of tape. The participant knew what was in the bag, but the director did not (and the participant was aware that the director did not.) When the director said something such as '*Move the tape*', there were two candidate 'tapes' among the array of objects: a videotape that was visible to both the participant and director, and the secret roll of tape in the bag. The correct response here would be to move the videotape – the director could not be talking about the object hidden in the bag because he did not know about it. Nonetheless, the adults often moved the bag containing the tape. They behaved 'egocentrically', interpreting what was said in terms of their own knowledge, not the knowledge of the speaker.

Much of what has been previously labeled egocentrism in both adults and in children could perhaps be defined more accurately as the curse of knowledge. The primary distinction between egocentrism and the curse of knowledge is one of scope. Unlike egocentrism – which is typically defined as an inability to appreciate *any* perspective other than one's own – the curse of knowledge is asymmetric. It is a difficulty appreciating a perspective that is more ignorant than one's own, but not a difficulty appreciating a perspective that is more knowledgeable. That is, when people are knowledgeable they *over* estimate what someone else knows, but when they are ignorant they do not *under* estimate what someone else knows [1,23] (see Figure 2). (See also Box 2 for a discussion of how a curse of knowledge account might explain why children exhibit competencies in mental-state reasoning in some circumstances and limitations in others.)

What is the nature and origin of the curse of knowledge?

When assessing the knowledge of another person, an adaptive and useful heuristic is to default to one's own knowledge [29,30], whether it is through a 'simulation' process involving imagining oneself as the other person (e.g. [31]) or through a more direct projection of one's own knowledge [30]. If you are asked to predict whether someone will know the capital of France, for instance, the

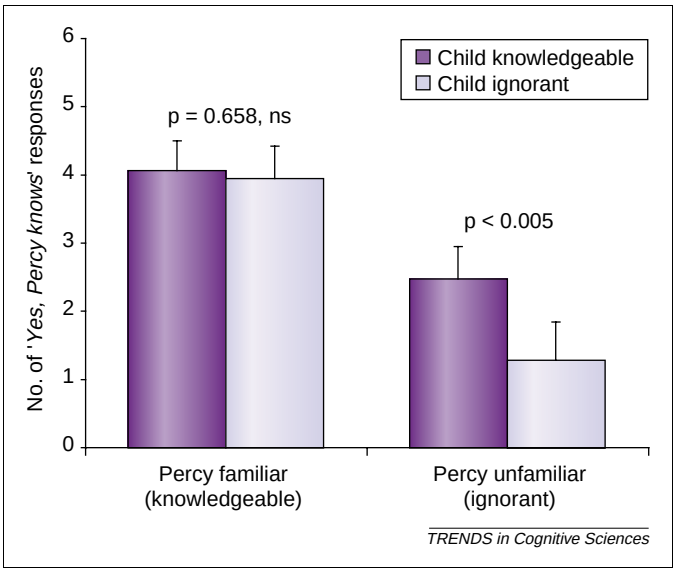

Figure 2. We think '*Others know what we know*' but we don't think '*Others don't know what we don't know*'. This figure presents data from three- and four-year-olds' knowledge assessments in a study by Birch and Bloom [23]. In a knowledge-assessment task, children were asked to judge whether a puppet, Percy, would know what was inside toys with which he was either familiar (i.e. '*he had played with the toys before*') or unfamiliar (i.e. '*he had never ever seen the toys before*'). The data demonstrate the asymmetry in knowledge assessment. When the children were themselves knowledgeable of the contents of the toys, they *over* estimated Percy's knowledge of the contents. However, when the children were ignorant of the contents, they did not *under* estimate Percy's knowledge.

best, and often only, way to do so is to appeal to one's own knowledge state. But when another person's capacities or experiences are relevantly different from our own, we need to alter this default – this is essential to appreciate that someone knows more than oneself and to attribute ignorance and false belief. Nickerson [29,30] proposes this alteration is a case of anchoring and adjustment [32]: people anchor to their own knowledge, and then, realizing its inaccuracy, they adjust. And, as is typical in other instances of anchoring and adjustment [32,33], the adjustment tends to be insufficient. This is a promising model, but there remains the puzzle of the asymmetry in knowledge assessment: that people tend to overestimate what others know when they are more knowledgeable, but do not underestimate what others know when they are more ignorant. Why would adjusting *up* from one's anchor to a more knowledgeable state lead to more accurate assessments than adjusting *down*?

One possible mechanism that might explain this asymmetry, and result in the curse of knowledge, is cognitive inhibition. When attributing mental states to others, it might be harder to inhibit one's knowledge than to inhibit one's ignorance. Differences in the nature of knowledgeable versus ignorant states might explain the asymmetry. Knowledge invariably involves a more substantive mental representation than ignorance. If a person knows the capital of France, then judging that someone else is ignorant requires inhibiting the answer and associated thoughts and mental representations that come to mind (e.g the name 'Paris' and perhaps even a mental image such as the Eiffel Tower). But if the person making the judgment is ignorant, there is not a specific answer and associated mental representations to inhibit. Similarly, a subject in a false-belief task, who knows precisely where the object is, faces a different (and more difficult) inhibitory task than someone who does not or whose knowledge is less specific.

Importantly, age-related changes in inhibitory mechanisms (e.g. [34]) have been found across the preschool years and might explain why younger children are more likely to be vulnerable to the curse of knowledge than older children and adults. Indeed, inhibition has been found to play an important role in false-belief reasoning [35–37]. Increased inhibitory control would allow children to rescind their own knowledge more successfully when trying to appreciate a more naïve perspective.

Conclusions

We propose that the curse of knowledge account provides a unified framework for conceptualizing mental state

Box 2. Why are children sometimes successful at reasoning about knowledge?

Children are sometimes surprisingly good at reasoning about the knowledge and ignorance of others [41–46]. For example, if a two-year-old's mother is absent when an attractive toy is placed onto a high shelf, the child will gesture towards the toy when she returns more so than if she was present when the toy was hidden, suggesting the child knows the mother is ignorant of the toy's location [42]. Furthermore, when task demands are minimized, two- and three-year-olds seem to be capable of deception [44,45]. To deceive, the child must appreciate, at least tacitly, that another person can hold a false belief.

The curse of knowledge account offers two explanations of why children experience limitations in reasoning about mental states in some conditions and demonstrate considerable competencies in others. First, the curse of knowledge is a partial bias rather than a pure bias. Adults who know the earnings of a company, for instance, will show a bias *towards* the answer that they know when assessing the knowledge of an ignorant person; they do not assume that other people will guess the exact right answer [14]. Similarly, preschool children were more likely to over-attribute knowledge to an ignorant individual concerning a toy's contents when they were knowledgeable of the contents, compared with when they were ignorant – but even when they were knowledgeable, they still took into account the other individual's experience when making this judgment [23]. Given the partial nature of this bias, one would be more likely to find successes in mental state reasoning when continuous measures are used, such as eye-gaze or amount of gesturing (e.g. [42,46]), rather than the less sensitive categorical measures.

Second, the asymmetry in knowledge assessment predicts that children should find mental state reasoning easier when they are ignorant of the information being assessed. For example, Pratt and Bryant [43] demonstrated that three-year-olds understand that a person who has looked in a box knows what is inside and someone who hasn't looked does not know. In this task, the children themselves did not know what was inside the box. Children might therefore succeed on these tasks, but fail on parallel tasks in which they are knowledgeable.

Standard false-belief tests involve both of these factors – they use categorical measures and they 'curse' the child with specific knowledge of outcome. When studies use more continuous measures, they find enhanced performance in young children's false-belief reasoning (e.g. [46]). In addition, one can restructure the false-belief task by having the participant be ignorant of the exact outcome of the false-belief event. Such a task would involve having more than two locations so that when Ann moves the object in Sally's absence the child is told it is moved to a different location, but does not know which one (see Figure 1b in main text).

Box 3. Questions for future research

- What is the complete developmental trajectory of the 'curse of knowledge' bias? Are elderly individuals, who experience diminished inhibitory control, particularly prone to suffer from the curse of knowledge?
- Do other related biases in social cognition follow a similar developmental trajectory?
- What is the relationship between the curse of knowledge and children's difficulties with source monitoring and counterfactual reasoning?
- How do our assumptions of how similar someone else is to us, for example in age, gender or ethnicity, affect our assessments of whether that person will share our knowledge?
- What are the specific implications of the curse of knowledge account for theories of moral development?
- How can we best explain individual differences in the extent to which people suffer from the curse of knowledge? Will these simply follow from differences in memory and processing abilities, or will there be more subtle relationships with temperament, personality and empathy?

reasoning throughout development. We suggest that younger children's heightened susceptibility to the curse of knowledge explains their tendencies to overestimate what others know, their proclivity to claim they 'knew it all along', their perspective-taking limitations, and their difficulties in reasoning about false beliefs. Similarly, we propose that several adult biases in social cognition (see, for example, [15–22,24,25]) also stem from this single underlying source.

Research from adult social cognition has demonstrated how the curse of knowledge can manifest itself in several different domains. This is a particularly rich area for study across development (see also Box 3) because the implications of the curse of knowledge are exceedingly pervasive. Biased assumptions about what others know lead in turn to erroneous expectations about how someone will behave or feel, and can thereby permeate our moral judgments, our assessments of other's behavior, our feelings and attitudes towards others, and virtually all social interaction.

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