Knowledge before belief: Response-times indicate evaluations of knowledge prior to belief

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Abstract

In a series of studies, we investigate the relationship between evaluations of knowledge and belief in human adult theory of mind, and provide evidence that evaluations of knowledge do not dependent on belief. Study 1 finds that people can accurately evaluate others' knowledge before they can accurately evaluate their beliefs. Study 2 demonstrates that this pattern cannot be not explained by pragmatic differences. Study 3 illustrates that pattern occurs cross-linguistically and unlikely to be accounted for by differences in word frequency. Study 4 provides evidence that this difference in response times generalizes to the larger class of factive and non-factive attitudes (to which knowledge and belief respectively belong). Together, these studies demonstrate that in determining what others know, human adults do not first determine what they believe, and more generally lend support a view on which knowledge representations are a basic way in which we make sense of others' minds.

Keywords: knowledge; belief; theory of mind; factive attitudes; non-factive attitudes; false belief; knowledge first

Introduction

Ordinarily, we say that a person 'knows' something only if she both believes it, and it is true. For instance, we would say that Jane knows that it is raining only if she both believes that it is raining, and it turns out that it actually is raining. Given that knowledge ordinarily entails belief[1], an obvious hypothesis is that people make use of this principle when evaluating whether a person knows something by first evaluating whether they believe it. At the same time though, there is evidence to support the opposing hypothesis that evaluations of knowledge do not depend on prior evaluations of belief. In particular, the capacity for knowledge representation appears to have evolved first and to emerge earlier than belief in human development. This paper asks which of these two hypotheses is correct by comparing the speed with which human adults are able to correctly evaluate knowledge and belief ascriptions.

Two opposing views of belief and knowledge

Previous research on theory of mind provides support for two conflicting ways of understanding the relationship between knowledge and belief. One view suggests that belief is more basic than knowledge, and that knowledge may depend on belief; the other suggests that knowledge is as or more basic than belief. We review the evidence for these views below.

[1]This view, while dominant (see, e.g., Gettier, 1963; Lehrer, 1968; Williamson, 2002), has not gone unchallenged (see, e.g., Radford, 1966; Myers-Schulz & Schwitzgebel, 2013).

View 1: Belief is basic Within theory of mind research, a pervasive assumption is that the capacity to represent others' *beliefs* is among the most basic ways in which we understand others' minds (Dennett, 1987). We can, of course, also represent more complicated mental states (e.g., what others *hope for*, or *suppose*), but representing these attitudes will require some additional processing beyond that required to simply represent what others believe. Consistent with this picture, empirical research has provided evidence that the capacity to represent others' beliefs emerges extremely early in human development (Onishi & Baillargeon, 2005; Kovács, Téglás, & Endress, 2010). And very recently, a new study that employs an anticipatory looking paradigm has provided the first piece of evidence that even non-human primates may have some way of representing others' beliefs (Krupenye, Kano, Hirata, Call, & Tomasello, 2016). Taken together, this research suggests that the ability to represent beliefs may be the among the most basic components of theory of mind.

In comparison, representations of others knowledge (like representations of what others hope for) are typically taken to be more complex and require additional processing beyond a mere representation of belief. An important question, on this view, is how representations of knowledge go beyond belief. One natural place to turn is the research within philosophy that has sought to capture the conditions under which one can accurately be said to 'know' a proposition. According to this work, knowledge that p can be understood as an instance of (1) having some belief that p, (2) p being true, (3) being justified in having the belief that p, and (4) satisfying some number of additional criteria (see Ichikawa and Steup (2016) for a helpful overview of the kinds of criteria that have been proposed).

On this general picture of the relationship between knowledge and belief, it would be natural to think that human adults would be able to correctly evaluate others' beliefs before they were able to correctly evaluate others' knowledge. After all, beliefs should be comparatively simple, and are among the most basic ways of representing others' minds.

View 2: Knowledge is basic At the same time, there may also be some reason to think that representations of knowledge are the more basic way in which we understand others' minds. One set of evidence supporting this basic picture comes from work that have specifically investigated representations of what others 'know'. For example, work on linguis-

tic development has shown that children begin productively using the term 'know' before 'believe' or 'think' (Bretherton & Beeghly, 1982). Moreover, studies show that most children robustly succeed in evaluating others' knowledge states before they succeed in evaluating their belief states (Mar, Tackett, & Moore, 2010; Tahiroglu et al., 2014).

More generally, one of the central differences between knowledge and belief is that representations of knowledge are *factive*, meaning that one cannot represent others as *knowing* something false (while one can represent others as *believing* something false).[2] Within theory of mind research, there is an enormous amount of work suggesting that factive attitude representations (e.g., seeing, hearing, being aware) may be simpler or more basic that non-factive representations. This is true for example, in developmental work, where there is clear evidence for the representation of others' factive mental states substantially before there is any evidence for non-factive mental state representations (i.e., 6 months vs. 8-12 months) (Luo & Johnson, 2009; Vouloumanos, Martin, & Onishi, 2014). Additionally, within non-human primate research, there is overwhelming evidence that a range of non-human primates can represent factive attitudes (Santos, Nissen, & Ferrugia, 2006; Melis, Call, & Tomasello, 2006), and even some convincing evidence that they fail to represent beliefs (Martin & Santos, 2014, 2016).

As a whole, this research paints a picture on which representations of knowledge, rather than belief, may be the more basic way in which we make sense of others minds, and representations of belief may turn out to be more complicated than representations of knowledge. In line with this perspective, a growing movement within philosophy, often referred to as 'knowledge first' epistemology, has rejected the idea that knowledge is more complex than belief, and has instead argued that belief ought to be analyzed in terms of knowledge, which is the more basic notion (Williamson, 2002; Nagel, 2013).

This opposing picture of the relationship between knowledge and belief makes it natural to think that human adults may be able to correctly evaluate others' knowledge before they were able to correctly evaluate others' beliefs.

The present studies

A series of four experiments provide an empirical answer to the question of whether human adults are faster in correctly evaluating others' knowledge or beliefs. Experiments 1a-b demonstrate that knowledge evaluations are faster than belief evaluations. Experiment 2 provides evidence that the difference in the response times cannot be fully accounted for by differences in pragmatics. Experiment 3 then shows that this same pattern occurs cross-linguistically and unlikely to be accounted for by differences in the word frequency of the mental state verbs. Finally, Experiment 4 demonstrates that this difference in response times generalizes to the larger class of factive and non-factive attitudes, to which knowledge and belief respectively belong. Together, these experiments suggest that in determining what others know, human adults do not first determine what they believe, and more generally provides evidence for a view on which knowledge is a basic way in which we understand others' minds.

[2]Within linguistics, the distinction between factive and non-factive attitudes is roughly that factive attitude ascription, e.g., $\ulcorner S$ knows that $p\urcorner$, presuppose that the complement p, while non-factive attitude ascriptions, e.g., $\ulcorner S$ believes that $p\urcorner$, do not presuppose p (Kiparsky & Kiparsky, 1970).

Experiment 1a-b

Methods

Participants. In Experiment 1a, 200 participants (M_{age} = 32.76, SD_{age} = 12.67; 108 females) were recruited through a psychology based website (`http://www.moralsensetest.com/`. Experiment 1b was an exact replication involving 501 new participants recruited through Amazon Mechanical Turk.

Stimuli and procedure. Participants began by completing a demographic questionnaire, and two practice trials in which they were familiarized with the task they would be completing. Participants then completed twenty-four trials which involved reading a short vignette involving an agent and then deciding whether a sentence about the story was true or false. Participants were instructed to indicate their responses as quickly as possible by pressing one of two keys on their keyboard. On twelve of these trials, participants were presented with sentences that did not mention the agent's mental states. These were included to prevent participants from anticipating the sentences they would be evaluating. In the remaining twelve trials, participants read a vignette that described the agent as either having a true belief about some proposition p (as in **True Belief**), simply being ignorant of p (as in **Ignorance**), or believing some proposition q that was both false and inconsistent with p (as in **Different Belief**).

True Belief: Mira looks at the night sky with her telescope. She owns the most accurate books on the locations of the different planets throughout the year. Mira reads in her astronomy books that she can see Neptune through her telescope, and she waits until it's dark enough outside. She points her telescope towards the coordinates that her books specify for Neptune, and sees a bright dot in the middle of the sky. That bright dot is Neptune. She is excited that she found the planet she was looking for so easily.

Ignorance: Mira likes looking at the night sky with her telescope. She owns the most accurate books on the locations of the different planets throughout the year. It is night and Mira decides not to read her astronomy books and instead just look through telescope. Ignoring her book, she sets up her telescope and points it towards a group of dots that catch her attention. She looks into the telescope and she sees a bright dot in the middle of

the sky. That bright dot is actually Neptune.

Different Belief: Mira likes looking at the night sky with her telescope. She owns the most accurate books on the locations of the different planets throughout the year. It is night and Mira reads in her astronomy books that she can see Mercury through her telescope. Misreading her book, she sets up her telescope and points it towards the coordinates that her books specify for Neptune, which also happens to be in the sky. She looks into the telescope and she sees a bright dot in the middle of the sky. That bright dot is actually Neptune.

On each of the twelve test trials, participants were asked to evaluate the truth or falsity of a sentence about about knowledge, as in (1), or belief, as in (2).

(1) Mira knows she is looking at Neptune.

(2) Mira thinks she is looking at Neptune.[3]

Analysis approach

In all studies, response times for trials on which participants correctly assessed the truth of the knowledge and belief statements were analyzed with linear mixed effects models using the lme4 package in R (Bates, Maechler, Bolker, Walker, et al., 2014), with both participants and scenario included as random factors. Participants were excluded from the analysis if they answered less than 60% of the questions correctly or if their mean response time was less than 1000ms or greater than 4000ms. We additionally excluded all trials on which the response was given in less than 1000ms or longer than 4500ms.

Experiment 1a Results

The overall analysis of participants response times revealed no main effect of Belief Type, $\chi^2(2) = 1.445$, $p = .486$, and no Belief Type * Ascription interaction, $\chi^(2) = 1.615$, $p = .446$. However, there was a significant main effect of Ascription Type, $\chi^2(1) = 22.382$, $p < .001$, such that participants were faster to correctly assess the truth of statements about whether the agent knows something ($M = 2814.45$, $SD = 935.82$) than statements about whether the agent thinks something ($M = 2991.30$, $SD = 986.34$).

Experiment 1b Results

The overall analysis of participants response times revealed no main effect of Belief Type, $\chi^2(2) = 1.716$, $p = .424$, but did reveal a main effect of Ascription Type, $\chi^2(1) = 27.687$, $p < .001$, such that participants were faster to correctly assess the truth of statements about whether the agent knows something ($M = 2485.92$, $SD = 655.13$) than statements about whether the agent thinks something ($M = 2545.73$, $SD = 660.12$). Additionally, there was a significant Belief Type * Ascription Type interaction, $\chi^(2) = 23.85$, $p < .001$. Given that this interaction was not observed in Experiment 1a, we combined the data to ask whether it was maintained within the entire data set.

[3]We used 'thinks' instead of'believes' in these studies to better equate for word frequency and length.

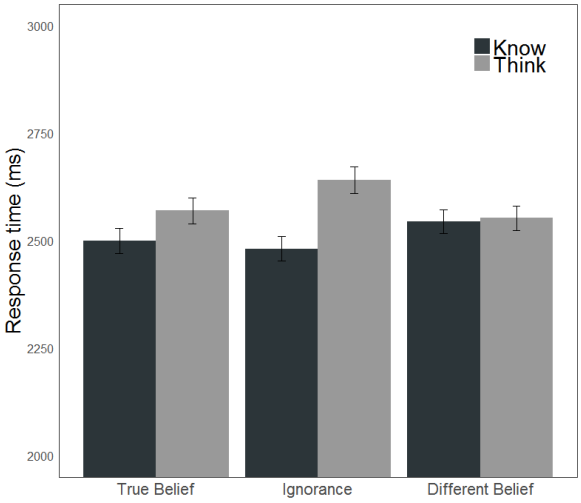

Figure 1: Mean response time for correct evaluations of knowledge ascriptions (dark bars) and belief ascriptions (light bars) as a function of Belief Condition for each of the three Belief Conditions. Error bars depict +/- 1 SEM.

Combined Analysis

This analysis continued to reveal no main effect of Belief Type, $\chi^2(2) = 2.215$, $p = .330$, but did reveal a main effect of Ascription Type, $\chi^2(1) = 48.418$, $p < .001$, such that participants were overall faster to correctly assess the truth of statements about whether the agent knows something ($M = 2508.20$, $SD = 653.03$) than statements about whether the agent thinks something ($M = 2587.25$, $SD = 661.14$). Moreover, there was a significant Belief Type * Ascription Type interaction, $\chi^(2) = 12.352$, $p = .002$. Planned pairwise comparisons revealed that participants response times only differed in the True Belief, $t(450) = 2.525$, $p = .012$, $d = 0.121$, and No Belief, $t(436) = 5.331$, $p < .001$, $d = 0.270$ conditions, but not in in the Different Belief condition, $t(442) = 1.959$, $p > .05$, $d = 0.097$ (see Figure 1).

Experiment 2

The results from the previous studies provide a clear demonstration that participants are able to correctly evaluate knowledge ascriptions before belief ascriptions. One concern with this initial study is that involves cases in which belief ascriptions may suffer from an odd Gricean pragmatic implicature. Specifically, there is reason to think that there is something pragmatically odd about belief ascriptions like (2) in cases where the agent seems to actually know the relevant propo-

sition (as in **True Belief**)[4] While pragmatic theories do not predict a difference in knowledge and belief ascriptions when the agent is ignorant or has a false belief, we also decided to collected felicity judgments for these cases. Accordingly, we collected judgments of the felicity of each of the belief and knowledge ascriptions in each of the three belief conditions for all twelve of the scenarios used in the previous experiments. Collecting all of these judgments should allow us to ask both whether we find the predicted pragmatic difference in cases of true belief and whether the response time effect in the other two cases can also be accounted for by differences in felicity.

Methods

Participants. 537 participants ($M_{age} = 33.97$, $SD_{age} = 10.95$; 250 females) were recruited through Amazon Mechanical Turk.

Stimuli and procedure Participants were recruited in two groups and were instructed that they would read short stories and then be asked to judge whether a statement about the story 'sounded weird' or 'sounded normal' (in addition to indicating whether the statement was true or false).[5] Each participant completed a training session in which the felicity-judgment-task was thoroughly explained. In addition, they completed four practice trials using statements that were clearly felicitous or clearly infelicitous, and were given feedback on their responses. Participants then completed twelve trials on which they judged the felicity of a belief or knowledge ascription.

Results

Felicity judgments for trials on which participants correctly assessed the truth of the knowledge and belief statements were analyzed as in the previous studies. This analysis revealed a main effect of Belief Type, $\chi^(2) = 25.588$, $p < .001$, a main effect Ascription Type, $\chi^(2) = 42.238$, $p < .001$, and a significant interaction effect, $\chi^(2) = 28.257$, $p < .001$. As predicted by pragmatic theories, planned comparisons revealed a large difference in felicity judgments in the True Belief condition, $t(247) = 7.20$, $p < .001$, $d = 0.629$. While not predicted, we also observed a small but significant difference in the No Belief condition, $t(228) = 3.29$, $p = .001$, $d = 0.209$. We did not observe a significant difference in the Different Belief condition, $t(231) = -1.23$, $p = .219$, $d = 0.080$.

Next, we asked whether, as suggested by pragmatic theories, differences in the felicity of the knowledge and belief ascriptions could account for the difference in response times observed in the True Belief scenarios e.g., . To ask this statistically, we computed the mean felicity rating for each of the 24 different knowledge/belief ascriptions in the true belief scenarios. We then compared two linear mixed-effects models. The first included both whether the ascription was about knowledge or belief and the mean felicity judgment for that ascription (in addition to the random effects). The second included only judgments of felicity but had an identical random effects structure. We found that the two models did not differ in how well they fit the data, $\chi^(2) = 0.9423$, $p = .332$, suggesting that felicity judgments tracked the difference between knowledge and belief ascriptions and could have accounted for the resulting difference in response times.

We then asked whether felicity judgments could also account for the difference in response times in the Ignorance and Different Belief scenarios, where it is not predicted to matter. While not initially predicted, we did observe a difference in the felicity of these statements. Accordingly, we performed a similar analysis by comparing two models that differed in whether the included Ascription Type as a fixed factor, we found that the model that included Ascription Type provided a significantly better fit, $\chi^(2) = 18.359$, $p < .001$, providing evidence that any differences in the felicity of the ascriptions could not account for the effect whereby participants were faster to evaluate knowledge ascriptions. Using the same procedure, we also asked whether we continued to observe a Belief Type * Ascription Type interaction effect that could not be accounted for by differences in felicity, and found that this was the case, $\chi^(2) = 8.446$, $p = .004$.

Experiment 3

Experiments 1-2 demonstrate that people are able to evaluate what others know before they are able to evaluate what they believe, and that this difference cannot be fully accounted for by pragmatic differences in the mental state ascriptions.

However, a general limitation of these studies is that they were conducted in English, and thus it is possible that the observed differences arise from some idiosyncratic feature of the English words 'think' and 'know' rather than reflecting the underlying cognition involved in representing agents as knowing or believing some proposition. Accordingly, a critical question to ask is whether the pattern we observed in Experiment 1 occurs cross-linguistically.

To answer this question, we conducted a similar experiment in French using 'savoir' instead of 'know', and 'penser' instead of 'think'. French is a particularly strong test case because, unlike English, the French word for think occurs more frequently than the word for know[6], and thus faster evaluations of knowledge ascriptions in French could not be explained by the term for knowledge being more frequent.

Methods

Participants 150 participants ($M_{age} = 37.70$, $SD_{age} = 12.16$; 83 females) were recruited and paid through Foule Factory (`https://www.foulefactory.com/`).

[4]This kind of pragmatic effect would be predicted on a number of different theories (e.g., Heim, 1991; Hirschberg, 1985).

[5]In the second of these two groups, participants were additionally asked to rate the felicity of negated knowledge and belief ascriptions. These ratings are not discussed due to a lack of direct relevance and space constraints.

[6]In English, 'know that' is ≈ 1.52 times more frequent than 'think that', while in French, 'penser que' is ≈ 1.49 times more frequent than 'savoir que'.

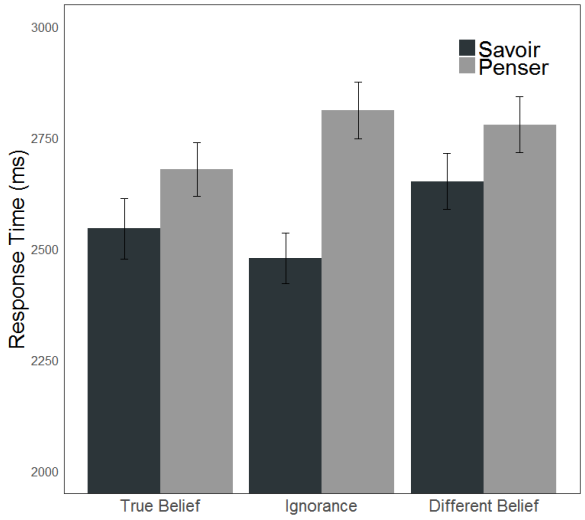

Figure 2: Mean response time for correct evaluations of knowledge ascriptions (dark bars) and belief ascriptions (light bars) as a function of Belief Condition for each of the three Belief Conditions. Error bars depict +/- 1 SEM.

Stimuli and procedure

The methods and procedures in this experiment were identical to that of Experiment 1a-b, except that the study was translated into French, and the English names were replaced with more typical French names. Thus, for example, instead of evaluating the truth of falsity of (1) or (2), participants evaluated the truth or falsity of (3) or (4).

(3) Nora sait qu'elle regarde Neptune.

(4) Nora pense qu'elle regarde Neptune.

Results

As in Experiment 1, data were excluded at the participant- and trial-level, and then analyzed using linear mixed-effects models. This revealed a marginal effect of Belief Type, $\chi^2(2) = 5.513$, $p = .064$ and a highly significant main effect Ascription, $\chi^2(1) = 25.351$, $p < .001$, such that participants were faster to correctly assess the truth of statements about what the agent knows ($M = 2565.27$, $SD = 722.63$) than statements about what the agent thinks ($M = 2729.57$, $SD = 719.52$). Additionally, there was a significant Belief Type * Ascription Type interaction, $\chi^(2) = 6.587$, $p = .037$ (see Figure 2).

Experiment 4

The previous experiments present cross-linguistic evidence that human adults are able to evaluate the truth of knowledge ascriptions prior to equivalent belief ascriptions. They also provide evidence against explaining this difference in terms of word frequencies or pragmatics, and instead suggest that the difference may reflect some aspect of underlying theory of mind processing.

If this is correct, a critical question is which aspect of knowledge and belief representation results in the observed difference in response times. As discussed in the introduction, one essential difference between knowledge and belief is that knowledge is factive while belief is not. To ask if this difference is responsible for the observed difference in response times between knowledge and belief, we asked whether the difference persisted in a larger group of factive and non-factive attitudes.

Methods

Participants 250 participants ($M_{age} = 33.432$, $SD_{age} = 9.32$; 126 females) were recruited and paid through Amazon Mechanical Turk.

Stimuli and procedure

The methods and procedures in this experiment were similar to the preceding studies except that the term 'know' was replaced by a set of factive attitude verbs (realize', 'is aware', 'understand', 'recognize'), and the term 'think' was replaced by a set of non-factive attitude verbs ('believe', 'guess', 'assume', 'imagine'). Thus, for example, instead of evaluating the truth of falsity of (1) or (2), participants evaluated the truth or falsity of (5) or (6), respectively. Critically, these factive and non-factive terms were chosen such that the non-factive terms were both shorter in length and more frequent in use than the factive terms.

(5) **Factive:** Mira recognizes that she is looking at Neptune.

(6) **Non-factive:** Mira believes that she is looking at Neptune.

Results

As in the previous experiments, data were excluded at the participant- and trial-level, and then analyzed using linear mixed-effects models. This revealed no main effect of Belief Type, $\chi^2(2) = 4.014$, $p = .134$ and no Belief Type * Ascription Type interaction, $\chi^(2) = 0.955$, $p = .620$. We did, however, observe a highly significant main effect of Ascription Type, $\chi^2(1) = 11.127$, $p < .001$, such that participants were faster to correctly assess the truth of acscriptions involving factive attitudes ($M = 2362.83$, $SD = 610.68$) than ascriptions involving non-factive attitudes ($M = 2433.10$, $SD = 640.03$) (see Figure 3).

General Discussion

In the four studies we just presented, we investigated the relationship between evaluations of knowledge and belief in human adult theory of mind, and found evidence that evaluations of knowledge do not dependent on prior evaluations of belief. To recap, Study 1 found that people can accurately evaluate others' knowledge before they can accurately evaluate their beliefs. Study 2 demonstrated that this pattern cannot be not explained by pragmatic differences. Study 3 illustrated

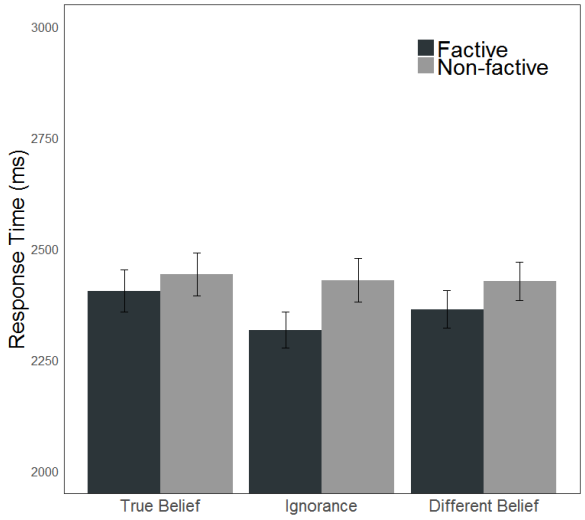

Figure 3: Mean response time for correct evaluations of factive attitude ascriptions (dark bars) and non-factive ascriptions (light bars) as a function of Belief Condition for each of the three Belief Conditions. Error bars depict +/- 1 SEM.

that pattern occurs cross-linguistically and unlikely to be accounted for by differences in word frequency. And, finally, Study 4 provided evidence that this difference in response times generalized to the larger class of factive and non-factive attitudes. Together, these studies demonstrate that in determining what others know, human adults do not first determine what they believe, and lend support the view according to which knowledge representations are a basic way in which we understand others' minds.

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