Preschoolers represent others' false beliefs about emotionsAlexis S. Smith-Flores¹ & Lisa Feigenson²¹Department of Psychology, University of California – San Diego

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The data that support the findings of this study are available on request from the corresponding author.

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Conflict of Interest

The authors declare no conflicts of interest.

Ethics Approval Statement

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Abstract

The ability to track and explicitly report another's beliefs about the world, even when those beliefs conflict with reality, is a milestone that children typically attain between the ages of 3 and 5 years. The majority of work investigating the development of false belief representation has probed children's ability to track beliefs about tangible entities, such as an object's location. However, false beliefs are not content specific; they can be about anything that can be represented, including entities that are not directly observable, like others' emotions. Across two experiments, we tested 3- to 5-year-old children's ability to track someone else's false beliefs about an object's location, versus about an agent's emotional state ($N=160$). Our findings reveal parallel developmental progression across the two content types. Our findings suggest that young children likely represent false beliefs about any content that they themselves can represent—an ability that emerges over the preschool years.

Keywords: false beliefs, emotion, theory of mind

Preschoolers represent false beliefs about emotions

From early in life, we make sense of the world around us by thinking about what other people see, want, believe, and hope for. This ability to attribute mental states to others has often been referred to as having a Theory of Mind (ToM), and is crucial for navigating social interactions, interpreting others' behavior, and cooperating towards common goals. A critical aspect of ToM is the understanding that what others believe (and what one believes oneself) does not necessarily reflect the true state of the world—that is, beliefs can be false. Recognizing that people sometimes act based on false beliefs is seen as a milestone in representing the mind as distinct from the world (Atance & O'Neill, 2004).

Much of what we know of children's false belief understanding has come from classic tasks using either an unexpected location or an unexpected contents paradigm. In the unexpected location paradigm, children hear about a character who puts an object in one location and then leaves (e.g., Sally puts her marble in a basket). Then another character moves the object to a new location (e.g., Anne moves the marble to a box). Finally the first character returns, at which point children are asked where she will look for her object (Baron-Cohen et al., 1985; Wimmer & Perner, 1983). Typically, 5-year-old children and some 4-year-old children answer correctly, saying that Sally will search in the basket, where she last saw the marble. In contrast, 3-year-olds answer that Sally will look in the box, where the marble really is. Subsequent studies that modified the Sally-Anne task to reduce verbal processing and eliminate the need for children to make explicit predictions have found success in younger children (Rubio-Fernández & Geurts, 2013; Setoh et al., 2016; Surian & Leslie, 1999), including in infants as young as 15 months using a looking-time measure (Onishi & Baillargeon, 2005; Scott et al., 2010). In the unexpected contents paradigm, children see a container that they predict will contain one type of item, and

then are shown that it actually contains something else (e.g., children predict that a box will contain Smarties candies, but then see it contains pencils). When asked what another person will think is in the Smarties box, 4- and 5-year-old children usually answer candies, whereas 3-year-olds answer pencils (Perner, Leekam, & Wimmer, 1987). As with the unexpected location task, younger children can succeed at the unexpected contents task when the task does not require an explicit prediction (Buttelmann, Over, Carpenter, & Tomasello, 2014).

While the above two paradigms, and the modifications that followed them, have been enormously productive in revealing how children think about beliefs, they are limited in the range of belief contents that they probe. This is because nearly all extant studies probing children's false beliefs center on *objects*, with stories or events that involve someone's false belief about either an object's location or its identity. Yet, beliefs can be about anything that can be represented — beliefs about objects occupy only a small area in this large space. Indeed, reasoning about others' beliefs about aspects of the world that are harder to directly observe—like beliefs about what people are feeling—may be especially important to social development. For example, recognizing the possibility of false beliefs about emotions allows children to act brave when they actually feel scared, or to feign surprise despite knowing what was about to happen.

Surprisingly, very little of the ample ToM literature has focused on whether children can represent false beliefs about non-object contents like emotions, despite the fact that children are sensitive to emotions starting in infancy and can use emotions to guide their behaviors (Sorce et al. 1985; see Walden & Ogan, 1988 for a review). Comparing children's ability to represent false beliefs about objects versus emotions is especially interesting because any lag between the two may help to reveal the processing required for false belief representation. On the one hand,

representing false beliefs about objects might be easier, and/or appear earlier in development, because objects are ubiquitous in children's environments. The sheer number of object interactions children experience, and the fact that objects are often directly perceptually accessible, may support early reasoning about object beliefs (e.g., a child might see for herself that a bottle is under the chair, and at the same time see her parent searching for the bottle on the table, offering an opportunity to represent the parent as having a false belief about the bottle's location). Alternatively, representing false beliefs about objects might be harder than representing false beliefs about emotions, precisely because objects are directly perceivable whereas emotions are invisible to perception. Representing another's false belief about an object's location or identity might be challenging because of the need to override the direct perceptual evidence (e.g., the bottle can easily be seen to be under the chair), such that, counterintuitively, representing false beliefs about non-visible entities like emotions is actually easier.

Some research has examined children's understanding of the emotional consequences of having a false belief—that is, whether children understand that emotions are tied to the experiencer's beliefs rather than to reality (Bradmetz & Schneider, 1999, 2004; Ronfard & Harris, 2014). And other work has asked when children can use someone's emotions to infer what they know or desire (Wu et al., 2018; Wu & Schulz, 2018). However, the question of whether children can represent false beliefs whose contents are emotions, and how this compares to false beliefs about objects, has only been addressed in a few studies. Gross & Harris (1988) found that 6-year-old children who heard about a character who felt sad but tried to hide their feelings knew that others would not perceive the character as sad; in contrast, 4-year-olds struggled to understand this discrepancy. However, children's ability to represent false beliefs

about contents other than emotions was not probed. Davis (2001) compared 3- and 4-year-olds' ability to represent someone's false beliefs about object identity (they were shown that a crayon box actually contained candles, and then were asked what someone else would think was in the box), versus about emotions (they were shown a doll with one emotional expression, heard that the doll really felt the opposite, and then were asked how someone else would think the doll felt). Children performed similarly in the object and emotion versions of the task. However, this result is difficult to interpret, as children were at chance across both conditions (except for the 3-year-olds, who were below chance in the object false belief condition). Finally, Parker, MacDonald, & Miller (2007) tested older children's ability to represent false beliefs about physical facts (including object locations) and about people's emotional states, and found no significant difference across the two domains. But because this study tested older, 5- to 8-year-old children, past the age at which major developmental shifts in explicit false beliefs tasks are typically seen (Wellman, Cross, & Watson, 2001), it is still unclear whether there is any developmental lag in representing false beliefs about objects versus emotions.

Therefore, in the present study we targeted children ranging in age from 3- to 5-years, in order to capture the shift from failing to passing the traditional explicit false belief task (Wellman et al., 2001). Our aims were two-fold: we wanted to know whether these younger, preschool aged children could represent false beliefs about emotions, and we wanted to compare this to their ability to represent false beliefs about objects. In Experiment 1, children were presented with two modified Sally-Anne stories using computer animated stimuli—one story involved a false belief about an object's location, and the other involved a false belief about a character's emotional state. We found that, when children were asked about the story characters' beliefs, they exhibited the typical pattern of performance—systematic failure at 3 years,

intermediate performance at 4 years, and success at 5 years—across both the object and the emotion domains. In Experiment 2 we replicated these effects using a more traditional puppet version of the Sally-Anne task, and with tighter experimental controls.

Experiment 1

Method

Participants

Eighty preschool-aged children participated: 20 3-year-olds ($M_{\text{age}} = 3.41$ years; $SD = 0.25$; 12 girls), 20 4- to 4.5-year-olds ($M_{\text{age}} = 4.28$; $SD = 0.14$; 8 girls), 20 4.5- to 5-year-olds ($M_{\text{age}} = 4.72$; $SD = 0.16$; 7 girls), and 20 5-year-olds ($M_{\text{age}} = 5.53$; $SD = 0.32$; 8 girls)¹. We tested both younger and older 4-year-olds because previous research suggests that many children start to pass explicit false belief tasks between ages 4 and 5 (Baron-Cohen et al., 1985; Wimmer & Perner, 1983); therefore this broader sample of 4-year-olds afforded us the opportunity to better identify age-related changes in performance. A post-hoc power analysis using G*Power (Faul et al., 2007) assuming a large effect size (.80) confirmed that these samples conferred adequate power to compare the performance of children in each age group ($N = 20$) on each type of false belief question to chance using a two-tailed binomial test (at the .05 alpha level). The parents of 64 children identified them as White, seven as Black, and nine as Asian. Seven additional children were tested but their data were excluded due to failure to pass the comprehension checks (see below). All children received a small gift (e.g. shirt, book, toy, or \$5 Amazon gift card) to thank them for their participation.

¹ Twenty-seven children of these children were tested online using Google Hangouts as a result of COVID-19 related campus closures.

Design and Procedure

Children were presented with two animated stories on a laptop computer: an Object False Belief story and an Emotion False Belief story, with story order counterbalanced across children. Each story lasted approximately two minutes (Figure 1). Children first were familiarized to the story characters. The experimenter pointed at each character as they appeared onscreen, introducing them by name (e.g., “That’s Paul, and that’s Sam.”). Children were then asked to point to each character (“Can you point to Paul? Can you point to Sam?”)². If children pointed incorrectly, the story was replayed and they were reintroduced to the characters.

In the Object False Belief story, which was modeled on previous stories involving false beliefs about the location of a hidden object (Wimmer & Perner, 1983; Baron-Cohen, Leslie, & Frith, 1985), children heard about two friends, Paul and Sam, who went to the park together. Paul brought his backpack with a baseball inside it so that he and Sam could play catch. The experimenter showed children the baseball field and explained that Paul and Sam were going to play in the middle of field because there was a big mud puddle on one side, and the friends did not want to get dirty. Children then saw Paul and Sam throwing and catching the ball several times. When they finished, Sam watched Paul put the baseball in his backpack, and then Paul and Sam said good-bye and Sam went home (and children watched as Sam disappeared off-screen). Next, as Paul turned to go home, the baseball fell out of his backpack. Paul saw the baseball roll into the mud puddle and disappear from view. At this point, the experimenter asked two comprehension check questions to ensure that children had understood the basic events in the story. To confirm that children understood that Sam did not see the ball fall out of the

² Children who were tested online could not point to demonstrate their understanding, so instead were asked which character was wearing a particular color shirt (“Who is wearing the red shirt, Paul or Sam? Who is wearing the blue shirt, Paul or Sam?”).

Figure 1*Schematic of Experiment 1***Object False Belief Story**

1. Paul and Sam play catch on the baseball field.

2. Paul puts his ball in his backpack, Sam sees him do that.

3. They say good-bye and Sam leaves.

4. As Paul moves to go home, his ball falls out of his backpack and rolls into the mud.

5. Perception Check
"Did Sam see that happen?"

6. True Belief Check
"Where does Paul think the ball is, right now? In the mud or in the backpack?"

7. False Belief Question
"Where does Sam think the ball is, right now? In the mud or in the backpack?"

Emotion False Belief Story

1. Sally and Anne get ice cream from the ice cream truck

2. Sally and Anne are so happy to have their ice cream.

3. They say good-bye and Anne leaves.

4. As Sally moves to go home, she drops her ice cream in the grass.

5. Perception Check
"Did Anne see that happen?"

6. True Belief Check
"How do you think Sally feels right now? Happy or Sad?"

7. False Belief Question
"How does Anne think Sally feels right now? Happy or Sad?"

backpack and roll into the mud, the experimenter asked, “Did Sam see that happen?” (Perception Check). If children answered the Perception Check question incorrectly, they were reminded that that Sam had gone home and then were re-asked the question (“Remember, Sam went home. Did he see the ball roll into the mud?”). If children did not answer correctly after three attempts they were excluded from further analysis. To confirm that children understood that Paul, who saw the ball roll into the mud, had a true belief about the ball’s location, the experimenter asked, “Where does Paul think the ball is right now: in the mud or in the backpack?” (True Belief Check). To illustrate the options, an image of the mud puddle and an image of the backpack appeared and children were asked to point or verbally indicate their answer (e.g., “mud” or “backpack”). In the final portion of the story, children saw Sam open the door and enter his house. The experimenter said, “Remember, Sam went home. Where does Sam *think* the ball is right now? In the mud or in the backpack?” (Object False Belief Question). Children were asked to point to either the image of the mud puddle or the backpack, or to give a verbal answer.

The Emotion False Belief story was designed to match the Object False Belief story in length, complexity, and overall structure. Children heard about two characters, Sally and Anne, who went to the park to get ice cream from an ice cream truck. Children saw Sally and Anne approach the ice cream truck and receive ice cream cones, and were told that Sally and Anne were very happy to have their ice cream cones. Both characters were seen to be smiling so that it was clear they felt happy. Then Anne had to go home (and children watched as she disappeared off-screen). As Sally started to head home too, she dropped her ice cream. At this point Sally’s facial expression was hidden so that children had to infer how she felt. The experimenter then asked two comprehension check questions. To confirm that children understood that Anne did not see the ice cream fall into the grass, the experimenter asked, “Did Anne see that happen?”

(Perception Check). If children answered incorrectly, they were reminded that Anne had gone home and then were re-asked the question (“Remember, Anne went home. Did she see the ice cream fall into the grass?”). If children did not answer correctly after three attempts they were excluded from further analysis. To confirm that children understood how Sally actually felt after losing her ice cream, the experimenter asked, “How do you think Sally feels right now: happy or sad?” (Emotion Check). To illustrate the options, an image of Sally smiling and an image of Sally frowning appeared and children were asked to point or verbally answer (e.g., “happy” or “sad”). In the final portion of the story, children saw a smiling Anne open her door and enter her house. The experimenter said, “Remember, Anne went home. How does Anne *think* Sally feels right now: happy or sad?” (Emotion False Belief Question). Children were asked to point to either the image of Sally smiling or frowning or give a verbal answer.

False belief responses were scored as 1 if they correctly reflected the character’s false belief, and 0 if they were incorrect—that is, if they reflected the true state of the world as described in the story. Responses were coded from video by the experimenter and an additional coder; agreement was 100%. If children did not answer a question right away, the experimenter waited five seconds and repeated the question. No children gave an answer other than one of the two prompted responses, or declined to answer.

Results

We used Generalized Estimating Equations (GEE) to analyze children’s responses to the critical False Belief questions because our data consisted of repeated binary responses. The model included age in years as a continuous variable, Story Type (Object or Emotion), and Story Order (Object or Emotion story first). The analysis revealed a significant main effect of age, $\beta = 1.75$, $SE = .59$, $\chi^2 [1, N = 160] = 8.77$, $p < .01$, 95% CI [0.59, 2.92], with older children

performing better overall. Critically there was no effect of Story Type, $\beta = 0.67$, $SE = 2.11$, $\chi^2 [1, N = 160] = 0.10$, $p = .75$, $[-3.45, 4.80]$ —children performed similarly when asked to reason about a person's false belief regarding an object's location, and when asked to reason about a person's false belief about how someone else was feeling. There was no effect of Story Order, $\beta = -1.41$, $SE = 4.08$, $\chi^2 [1, N = 160] = 0.12$, $p = .73$, $[-9.42, 6.59]$, no interaction between Age and Story Order, $\beta = 0.26$, $SE = 0.90$, $\chi^2 [1, N = 160] = .08$, $p = .77$, $[-1.50, 2.02]$, and no interaction between Age and Story Type, $\beta = -0.27$, $SE = 0.46$, $\chi^2 [1, N = 160] = 0.34$, $p = .56$, $[-1.17, 0.63]$.

Given the significant effect of age, we also analyzed children's performance with age treated categorically, as in many previous studies (Figure 2). A two-tailed binomial test revealed that on the Object False Belief question, 3- and 4-year-old children performed significantly below chance, answering in accord with reality rather than with the character's false belief (3-year-olds: 4/20 correct, $p = .01$; 95% CI $[0.06, 0.44]$; 4-year-olds: 4/20 correct, $p = .01$, $[0.06, 0.44]$). The 4.5-year-old children performed at chance (12/20 correct, $p = .50$, $[0.36, 0.81]$), and 5-year-old children performed significantly better than chance (15/20 correct, $p = .04$, $[0.51, 0.91]$). Notably, this pattern replicates previous tasks probing children's reasoning about false beliefs concerning object location (Dalke, 1995; Wimmer & Perner, 1983). On the Emotion False Belief question, 3- and 4-year-old children performed significantly below chance (3-year-olds: 3/20 correct, $p < .01$, $[0.03, 0.38]$; 4-year-olds: 5/20 correct, $p = .04$, $[0.09, 0.49]$), whereas the 4.5- and 5-year-olds performed significantly better than chance (4.5-year-olds: 15/20 correct, $p = .04$, $[0.51, 0.91]$; 5-year-olds: 16/20 correct, $p = .01$, $[0.56, 0.94]$).

Figure 2*Children's performance on the false belief questions in Experiment 1*

Note. Dotted line indicates chance. Error bars reflect *SEM*. * $p < .05$, ** $p < .01$.

Experiment 2

Consistent with previous research on children's ToM (e.g., Liu et al., 2008; Wellman, 2014; Wellman et al., 2001), Experiment 1 found that children's ability to reason about other's false beliefs improves with age, with children younger than 4 years systematically being misled by the true state of the world, children between 4 and 5 performing at chance, and children 5 years and older successfully reasoning about others' beliefs. Our results extend this work, showing that children's false belief reasoning develops similarly regardless of whether children are reasoning about others' beliefs about object locations, or about beliefs about other people's emotions.

However, there is at least one alternative interpretation of the older children's success in our Emotion False belief condition. In the final image of the Emotion story, the character whose belief children were asked about was seen to be smiling (Figure 2). This leaves open the possibility that children used this evidence to answer the question, rather than representing Anne's belief about Sally's mental state (i.e., children could have reasoned that Anne is clearly smiling so Sally is probably smiling too). Therefore, in Experiment 2 we aimed to replicate the findings of Experiment 1 using a design that eliminated all perceptual cues to the characters' emotional states. Instead of animated stories, Experiment 2 used a live task with puppets (which had no visible facial expressions). The act-out nature of this method more closely mirrored the original Sally-Anne task (Baron-Cohen, Leslie, Frith, 1985). An additional feature of Experiment 2 was the tighter match in structure across the Object and Emotion stories. Children heard two stories (one about two characters who baked cookies and one about two characters who made a paper airplane)—for half the children the cookie story involved a false belief about an object's location and the paper airplane story involved a false belief about someone's emotion, and for half the children this pairing was reversed.

Method

Participants

Eighty preschool-aged children participated: 20 3-year-olds ($M_{\text{age}} = 3.51$ years; $SD = 0.32$; 10 girls), 20 4- to 4.5-year-olds ($M_{\text{age}} = 4.23$; $SD = 0.13$; 7 girls), 20 4.5- to 5-year-olds ($M_{\text{age}} = 4.73$; $SD = 0.15$; 12 girls), and 20 5-year-olds ($M_{\text{age}} = 5.44$ years; $SD = 0.28$; 10 girls)³. The parents of 64 children identified them as White, six as Black, and ten as Asian. Five

³ Seventeen children were tested online using Google Hangouts as a result of COVID related campus closure.

additional children were tested but their data were excluded from analysis due to failure to pass the comprehension checks (2) or because of experimenter error (3).

Design and Procedure

As in Experiment 1, children were tested on an Object False Belief story and an Emotion False Belief story, with order counterbalanced across participants. Stories were acted out live using animal puppets and object props⁴(Figure 3). The puppets were Elephant, Tiger, Giraffe, and Monkey; which two participated in the Object False Belief story and which two participated in the Emotion False Belief story was counterbalanced across participants. The pronouns used for the puppets were gender-matched to each child.

Children sat at a small table across from the experimenter. In the Cookie False Belief story, the experimenter introduced children to two puppets (e.g., Elephant and Tiger), and told them that Elephant and Tiger decided to make some cookies because they love cookies. When their cookies were done baking, children saw Elephant put his cookie (a plastic toy cookie) into the cookie jar (a plastic container on the table), whereas Tiger took his cookie home—at this point children saw Tiger leave with his cookie and disappear under the table. Next the experimenter explained that while Tiger was gone, Elephant got hungry so he took his cookie out of the cookie jar so he could eat it. But as Elephant started to eat his cookie, he accidentally dropped it. Elephant picked up his fallen cookie and put it in the trashcan (a different container depending on condition: “Did Tiger see that happen?” (Perception Check) and either “Where does Elephant think the cookie is right now? In the cookie jar or in the trashcan?” (True Belief Check), or “How does Elephant feel right now? Happy or sad?” (Emotion Check). As in

⁴ Children who were tested online watched a video of the puppet show, and then were asked questions live by the experimenter.

Figure 3*Schematic of Experiment 2*

Object False Belief Story	Emotion False Belief Story
<p>1. Elephant and Tiger make cookies.</p>	<p>1. Monkey makes Giraffe a paper airplane.</p>
<p>2. Elephant puts Elephant's cookie in the cookie jar.</p>	<p>2. Giraffe puts his/her new paper airplane in the toy box.</p>
<p>3. Tiger goes home with Tiger's cookie.</p>	<p>3. Monkey goes home.</p>
<p>4. Elephant takes his/her cookie out of the cookie jar, but drops it on the floor!</p>	<p>4. Giraffe takes the paper airplane out of the toybox to play with it, but it crashes and breaks!</p>
<p>5. Elephant puts his/her cookie in the trashcan.</p>	<p>5. Giraffe puts the broken paper airplane in the recycling bin.</p>
<p>6. Perception & True Belief Check "Did Tiger see that happen?...Where does Elephant think their cookie is, right now? In the cookie jar or in the trash can?"</p>	<p>6. Perception & True Belief Check "Did Monkey see that happen?...How does Giraffe feel right now? Happy or sad?"</p>
<p>7. False Belief Question "Where does Tiger think Elephant's cookie is, right now? In the cookie jar or in the trash can?"</p>	<p>7. False Belief Question "How does Monkey think Giraffe feels right now? Happy or sad?"</p>

Experiment 1, if children failed the Perception Check they were reminded that that Tiger went home and were re-asked the question (up to three times). Finally, children saw Tiger return to the scene and were asked the critical question: either “Where does Tiger *think* Elephant’s cookie is right now? In the cookie jar or in the trash can?” (Object False Belief question) or “How does Tiger *think* Elephant feels right now? Happy or sad?” (Emotion False Belief question).

In the Paper Airplane False Belief story, the experimenter introduced children to two puppets (e.g., Giraffe and Monkey), and told them that Giraffe and Monkey were playing together and that Monkey made Giraffe a paper airplane because Giraffe loves paper airplanes. Children saw Giraffe put his airplane (a small pre-folded paper airplane) into his toybox (a plastic container on the table), because he wanted to play with it later. After observing this, Monkey had to go home—at this point children saw Monkey disappear under the table. Next the experimenter explained that while Monkey was gone, Giraffe wanted to play with his airplane, so he took it out of the toybox. But as he was playing with it, the airplane went too fast and crashed. Giraffe picked up his crushed airplane and put it in the recycling bin (a different container on the table). At this point the experimenter asked two comprehension check questions depending on condition: “Did Monkey see that happen?” (Perception Check) and either “Where does Giraffe think the airplane is right now? In the toybox or in the recycling bin?” (True Belief Check) or “How does Giraffe feel right now? Happy or sad?” (Emotion Check). Finally, children saw Monkey return and were asked the critical question: either “Where does Monkey *think* Giraffe’s airplane is right now? In the toybox or in the recycling bin?” (Object False Belief question) or “How does Tiger *think* Elephant feels right now? Happy or Sad?” (Emotion False Belief question). If children were asked about an object’s location in the first story, then they were asked about one of the puppet’s emotions in the second story.

Results

As in Experiment 1, we used GEE to examine children's responses to the critical False Belief questions. The model included age as a continuous variable, False Belief Question Type (Object or Emotion), and False Belief Question Order (Object or Emotion first). This analysis revealed a significant main effect of age, $\beta = 1.47$, $SE = 0.58$, $\chi^2 [1, N = 160] = 6.40$, $p = .01$, 95% CI [0.33, 2.61], with older children performing better overall. Critically, there was no effect of False Belief Question Type, $\beta = 1.93$, $SE = 1.71$, $\chi^2 [1, N = 160] = 1.58$, $p = .21$, [-5.52, 1.21]—as in Experiment 1, children performed similarly when asked to reason about a person's false belief regarding an object's location versus a false belief about how someone was feeling. There was no effect of False Belief Question Order, $\beta = 1.93$, $SE = 3.39$, $\chi^2 [1, N = 160] = 0.32$, $p = .57$, [-4.72, 8.57], no interaction between Age and False Belief Question Order, $\beta = -0.49$, $SE = 0.74$, $\chi^2 [1, N = 160] = 0.44$, $p = .51$, [-1.95, 0.97], and no interaction between Age and False Belief Question Type, $\beta = 0.57$, $SE = 0.39$, $\chi^2 [1, N = 160] = 2.18$, $p = .14$, [-0.19, 1.33].

As in Experiment 1, we also analyzed children's performance binned by age (Figure 4). A two-tailed binomial test revealed that on the Object False Belief question, 3-year-old children performed significantly below chance (3-year-olds: 5/20 correct, $p = .04$, 95% CI [0.09, 0.49], 4-year-old children performed at chance (4-year-olds: 7/20 correct, $p = .26$, [0.15, 0.59]), and 4.5- and 5-year-old children performed significantly better than chance (4.5-year-olds: 16/20 correct, $p = .01$, [0.56, 0.94]; 5-year-olds: 17/20 correct, $p = .003$, [0.62, 0.97]). A similar pattern was observed for the Emotion False Belief question. Three-year-old children performed significantly below chance (5/15 correct, $p = .04$, [0.09, 0.49]), 4- and 4.5-year-old children performed at chance (4-year-olds: 6/20 correct, $p = .12$, [0.12, 0.54]; 4.5-year-olds: 13/20 correct, $p = .26$, [0.41, 0.85]), and 5-year-old children performed better than chance (15/20 correct, $p = .04$, [0.52,

0.91]). These results replicate the key findings from Experiment 1: children's ability to represent false beliefs increased between the ages of 3 and 5 years, and children's ability to reason about another person's false beliefs about someone's emotions mirrored the ability to represent false beliefs about an object's location.

Experiments 1 and 2 revealed comparable performance when children were asked to reason about a person's false beliefs regarding objects and regarding someone's emotional state. Combining across the two experiments offers additional power for detecting any difference in children's false belief reasoning across the two domains. We used GEE to compare false belief performance across Experiments 1 and 2, including Experiment (Experiment 1 vs. Experiment 2), Age (as a continuous variable), False Belief Question Type (Object or Emotion), and False Belief Question Order (Object or Emotion story first). The GEE revealed no main effect of Experiment, $\beta = -1.41$, $SE = 3.82$, $\chi^2 [1, N = 320] = 0.14$, $p = .71$, 95% CI [-8.90, 6.07] – children performed similarly across the computer-based and live versions of our false belief task. The model showed a main effect of Age $\beta = 1.48$, $SE = 0.59$, $\chi^2 [1, N = 320] = 6.31$, $p = .01$, [0.33, 2.64]. There were no other main effects or interactions. Critically, there was no effect of False Belief Question Type, $\beta = -2.16$, $SE = 2.12$, $\chi^2 [1, N = 320] = 0.16$, $p = .31$, [-6.31, 1.99], nor any interaction between False Belief Question Type and Age, $\beta = 0.57$, $SE = 0.48$, $\chi^2 [1, N = 320] = 1.46$, $p = .23$, [-0.36, 1.51]. Even with the larger sample of 160 children created by combining across our experiments, we saw no evidence that children's ability to reason about false beliefs regarding objects differed from their ability to reason about false beliefs regarding emotions.

Figure 4*Children's performance on the false belief questions in Experiment 2*

Note. Dotted line indicates chance. Error bars reflect *SEM*. * $p < .05$, ** $p < .01$.

Finally, we more closely examined the failure of 4-year-olds in Experiments 1 and 2. As a group, these children performed at chance when reasoning about false beliefs about objects and false beliefs about emotions. This is consistent with two interpretations. One is that children were at chance with both story types, answering randomly across the two questions. The other is that half the children reasoned correctly about false beliefs about both objects and emotions (like the 5-year-olds), and the other half of the children reasoned systematically incorrectly about both objects and emotions (like the 3-year-olds). We found that among 4-year-olds, only one child in Experiment 1 and one child in Experiment 2 answered differently across the two story types.

The remaining children got either both questions right or both questions wrong, suggesting possible individual differences during this transitional time of ToM development.

General Discussion

Our aim in the current experiments was to ask whether the ability to track another agent's emotional state develops at the same rate as the ability to track another agent's belief about an object's location. In Experiments 1 and 2 we found that there was no difference between children's ability to track a false belief about someone's emotion and their ability to track a false belief about an object's location. Younger children systematically failed at both, older children succeeded at both, and children between 4 and 5 years were at chance on both. This suggests that false belief tracking may be domain general, in that the representation of a false belief can include contents about observable states of the world (e.g., objects' locations and features) and about invisible mental states (e.g., emotions).

One criticism of false belief tracking tasks comes from accounts that posit that success in the Sally-Anne task only requires that children remember where the object was located the last time Sally was present; they need not represent Sally's actual mental state (Butterfill & Apperly, 2013). Our task may be less susceptible to such an interpretation, because the false belief contents targeted in the emotion condition of Experiment 2 could not be readily observed. For example, children in Experiment 2 heard no mention of emotions until the Reality check and critical False Belief questions. In order to succeed, children had to have represented what happened in the story, infer the emotional consequence of these events, and then inhibit their own beliefs regarding the true state of the character's emotions in order to report the other character's false belief. Remembering an object's spatiotemporal history does not suffice to pass the emotion false belief task; thus the finding that children 4.5-years-old and older understood

that a character could have a false belief about someone else's emotions highlights their sophisticated mental reasoning.

An intriguing aspect of theory-of-mind research in the past several decades has been the dissociation between performance on explicit verbal tasks (like the ones we used here, and those by Wimmer & Perner, 1983, and many others) and implicit tasks that measure children's looking-time or brain responses when they track someone else's beliefs (e.g., Kamps, Parise, Csibra, & Kovács, 2015; Onishi & Baillargeon, 2005; Surian, Caldi, & Sperber, 2007). Whereas 3-year-old children systematically give the wrong response in explicit tasks (reporting that others will act in accord with reality, as opposed to their (false) beliefs), much younger children show evidence of successfully tracking false beliefs in implicit tasks. All of the current tasks with infants of which we are aware have tested infants' ability to track others' beliefs about objects (either their locations or their features). The present findings suggest that infants may also be able to represent others' beliefs about any content that infants themselves can represent. This could include false beliefs about quantities, as well as about others' goals, dispositions, or emotions. Future work should test this prediction.

In addition, recent work has brought into question the claim that beliefs are the most basic ToM representations. Phillips and colleagues (2020) argue that the ability to represent someone's knowledge is prior (in a developmental sense, as well as an evolutionary sense) to the ability to represent someone's beliefs. Understanding others' knowledge may be easier because it is impossible to have false knowledge (e.g. either you know an object is the basket or you do not). The ability to attribute knowledge states to others appears early in development; by 6 months, infants can infer what an agent might reach for, given the agent's perceptual access (Luo & Johnson, 2009). And 10-month-old infants can use knowledge about what a third party saw, or

was unable to see, to determine who they might later share with (Meristo & Surian, 2013). Given findings like these, it is possible that children younger than 4.5-years-old could succeed in the emotion conditions of our task if we asked them, “Does Anne know how Sally is feeling right now? Why or why not?” rather than “How does Anne think Sally is feeling? Happy or Sad?”. More broadly, previous empirical investigations of children’s ability to represent others’ knowledge are limited in the same way as investigations of their ability to represent others’ beliefs. Given the findings of Experiments 1 and 2 in the present work, we predict that children’s ability to represent others’ knowledge about objects and their ability to represent others’ knowledge about other entities (including knowledge of what people are feeling) should track together over development.

In sum, our work provides additional insight into young children’s ability to represent the mental states of others. Our findings suggest that children can track beliefs across domains by 4.5-years-old. As the degree to which entities are directly observable did not influence children’s ability to reason about their role in other people’s beliefs, we speculate that children readily represent beliefs about any contents that they themselves can represent.

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