

RESEARCH ARTICLE

Differential Development of Object and Location Processing is a Critical Factor to a Child's Passing or Failing Explicit False-Belief Tasks

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ABSTRACT

It is well-documented that 5-year-olds consistently pass explicit false-belief tasks—one of the most common tests for assessing “Theory of Mind” (ToM). But what about younger children? While some studies find that 3- and 4-year-olds fail explicit false-belief tasks, other studies find that these same age children pass such tasks, leading to confusion about exactly when, and why, children pass false-belief tasks. Traditionally, explicit false-belief tasks include scenarios with object changes (e.g., Smarties task) or location changes (e.g., Sally-Anne task). However, object and location information are prioritized differentially throughout development, with preschoolers weighting cues about objects over locations. Thus, here we ask whether a child younger than 5 years old could pass an explicit false-belief task about objects yet fail one about locations, hypothesizing that the development of information processing is a critical factor that contributes to false-belief performance. To directly test this hypothesis, 3- to 5-year-olds participated in a novel explicit false-belief task with independent object- and location-change trials. Consistent with our hypothesis, we found i) that all participants performed significantly better on object than location trials, and ii) a significant number of 3- and 4-year-olds who passed the object trials yet failed the location trials. These findings demonstrate that when testing the development of false belief (or potentially any other cognitive abilities using object and location information), one must consider developmental differences in information processing, since such differences can yield opposite answers and, crucially, opposite conclusions.

1 | Introduction

Children 5 years of age and older consistently pass explicit false-belief tasks—a test that assesses whether a child understands that others can hold beliefs that differ from their own, which is a key milestone in Theory of Mind (ToM) development. By contrast, many studies find that children 3 to 4 years of age fail explicit false-belief tasks, suggesting that children in this age range have not mastered this aspect of ToM. However, other studies report the complete opposite—children 3 to 4 years of age pass explicit

false-belief tasks—suggesting that children in this same age range achieve this milestone earlier than traditionally thought (for a review of these findings, see Rakoczy 2022; Wellman et al. 2001). These inconsistent findings in this younger age range are puzzling. What drives 3- and 4-year-old children to pass some explicit false-belief tasks, but fail others?

Indeed, prior studies have suggested many factors can influence whether children younger than 5 can pass explicit false-belief tasks. For example, manipulating the motive for false belief

Summary

- Object and location information are prioritized differentially throughout development, with preschoolers weighting cues about objects over location.
- Here we predict that this prioritization of object over location information will affect preschoolers' performance on explicit false-belief tasks.
- Indeed, we found that preschoolers performed better on explicit false-belief tasks that asked about objects than about location, with a significant number even passing the object tasks, yet failing the location tasks.
- Critically, these findings demonstrate that when testing false beliefs, one must also consider developmental differences in information processing.

(i.e., whether the transformation was done to actively deceive the protagonist or for some other reason); the salience of the protagonist's mental state to the child (i.e., if the child was explicitly told the protagonist's mental state or if the protagonist's mental state had to be inferred from their absence during the transformation); the presence of the target (i.e., whether the target is present or not when the false belief question is asked); or the level of participation in the task (i.e., if the child actively participates in the task or passively watches) can increase the likelihood that younger children perform better on false-belief tasks (Chandler et al. 1989; Ghrear et al. 2021; Hala and Chandler 1996; Ritblatt 2000; Rubio-Fernández and Geurts 2013; Sullivan and Winner 1993; for a review of these findings, see Wellman et al. 2001). Children also tend to perform better when there is a temporal marker in the false belief question (i.e., if they are explicitly asked about the protagonist's initial actions—"where will the protagonist go first?"—versus when there is temporal ambiguity—"where will the protagonist go?") (Siegal and Beattie 1991), or when the task is presented in narrative form (Rubio-Fernández 2019). Beyond these methodological concerns, others have suggested that the development of executive function, specifically the development of inhibitory control and working memory, influences performance on false-belief tasks (Baillargeon et al. 2010; Carlson et al. 1998; Carlson and Moses 2001; Frye et al. 1995; Ghrear et al. 2021; Hughes 1998; Rhodes and Brandone 2014; Sabbagh et al. 2006; for a review of these findings, see Devine and Hughes 2014; Perner and Lang 1999, 2000). Here, we ask whether there is yet another factor—that is, the *type of information* tested within the task—that may explain the inconsistent performance of younger participants on explicit false-belief tasks.

In fact, two of the most common types of false-belief tasks ask participants to make judgements using two different types of information. For instance, in the Smarties (or Unexpected Contents) task (Gopnik and Astington 1988; Perner et al. 1987) the false belief involves *object identification* (i.e., whether the Smarties box contains Smarties or pencils). By contrast, in the Sally-Anne task (Baron-Cohen et al. 1985; Wimmer and Perner 1983), the false belief involves *spatial location* (i.e., whether the marble is in the basket or the box). But why would the content

of the task possibly affect children's performance? Interestingly, multiple prior studies (not testing ToM) have found that when children are asked to solve a task using object and location information, preschoolers will prioritize object information over location information (Ayzenberg et al. 2021; Dessalegn and Landau 2008; Haun et al. 2006; Miller et al. 2017). For example, in one such study, 3-year-olds watched as a toy was hidden in one of three visually distinct containers, each occupying a unique spatial location (Haun et al. 2006). Then, behind an occluder, an experimenter switched two of the containers. This manipulation created two possibilities: the toy could remain in the original container, but move to a different location or remain in the same location, but inside a different container. Because either the container features or the spatial location could indicate the toy's location, the cues were equally ambiguous. Three-year-olds searched according to the container's original features rather than its spatial location, suggesting that featural (or object) information is prioritized over spatial (or location) information. Importantly, this prioritization was not due to the participants failing to encode the original featural or spatial information, revealing children of this age have access to this information but weight it differently (Haun et al. 2006). Other studies also find that preschoolers are more likely to describe scenes using featural, not spatial, vocabulary (Miller et al. 2017); confuse objects with different featural relations (e.g., a mirror reflection), but not objects with different features (Dessalegn and Landau 2008); and weight featural information over spatial information when distinguishing objects (Ayzenberg et al. 2021). Given this prioritization cuts across several studies using different tasks and investigating distinct domains, it is reasonable to predict that this prioritization may affect other tasks manipulating object and location information, including false-belief tasks (given the false belief in question traditionally concerns the object's identity or location). So, if preschoolers prioritize information about objects over location, perhaps better performance will be elicited on explicit false-belief tasks that ask about objects than locations.

Contrary to our hypothesis however, a prominent meta-analysis analyzing results of 178 explicit false-belief studies found that the type of information tested in an explicit false-belief task does not seem to affect performance (Wellman et al. 2001). However, this null finding could be a result of two factors. First, this meta-analysis did not distinguish between false-belief tasks that were pure object or pure location changes, and indeed some of the included studies did not have isolated featural or spatial changes (one motivation for our novel experiment). Second, and perhaps more importantly, many of the included studies differed in motive, salience, presence, participation, temporal marking, form, et cetera—other variables known to influence performance on false-belief tasks, as previously described. Thus, we predict that if these variables were controlled for, then perhaps children would perform better on the tasks about objects than locations (a second motivation for our novel experiment). On the other hand, and consistent with our hypothesis, some studies have actually tested participants on both types of explicit false-belief tasks and found that 3- to 5-year-olds tend to perform better on variations of the Smarties task (i.e., testing object information) than variations of the Sally-Anne task (i.e., testing location information) (Girli and Tekin 2010; Happé and Loth 2002; Jackson 2001). By contrast, other studies have found that 3- to 5-year-olds perform similarly on both types of explicit false-belief tasks (Grosse Wiesmann et al.

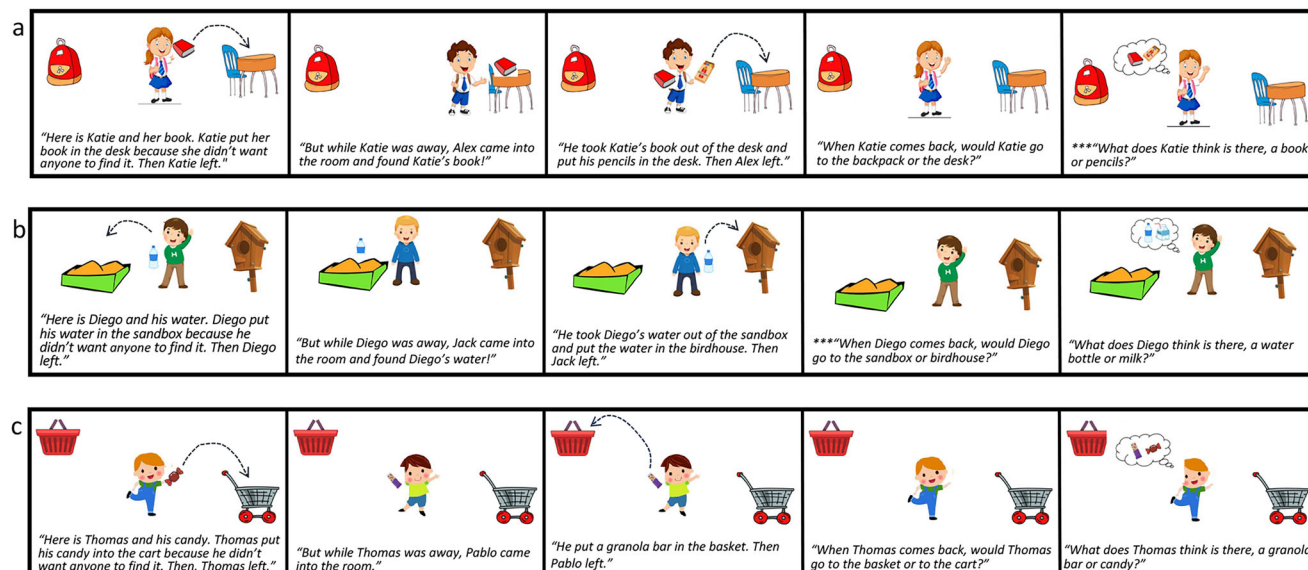


FIGURE 1 | Example object, location, and catch trials. Each participant received multiple object-change (a), location-change (b), and catch trials (c). Participants viewed each trial as a dynamic video (dashed arrows indicate the direction of movement on the screen) and heard a corresponding audio recording (indicated here by italicized text). Independent of trial type, children were asked both about object and location information. The critical object or location false-belief question is marked with asterisks.

2017; Jenkins and Astington 1996; Wellman and Liu 2004), or even better on location-change than object-change tasks (Holmes et al. 1996; Pesch et al. 2020). Critically, however, the explicit false-belief tasks in all the above studies not only differed in terms of what kind of information was tested, but also on many of the already discussed confounding variables, making it difficult to know whether the above results are truly about location and object information.

Thus, the question remains: Can 3- and 4-year-olds pass an explicit false-belief task about objects yet fail one about locations (all else equal), thus revealing that the differential development of information processing is yet another factor that explains why preschoolers perform inconsistently on such tasks and thus needs to be taken into consideration? Here, we directly address this question by designing a novel explicit false-belief task where some trials ask about *what* the person would expect to find (testing object information) and others ask about *where* the person would go (testing location information)—with no additional manipulation of motive, salience, presence, participation, temporal marking, or form (Figure 1). We hypothesized that if preschoolers prioritize object information over location information, then they should perform better on false-belief trials that involve an object change than those that involve a location change.

2 | Methods

2.1 | Participants

Twenty-nine typically-developing 3-year-olds (range = 36 to 47 months; 18 females), 31 4-year-olds (range = 48 to 59 months; 12 females), and 30 5-year-olds (range = 60 to 70 months; 8 females) participated in the experiment. Participants were recruited through the Emory University Child Study Center,

which is a mailing list of families in the greater Atlanta, GA area who are interested in participating in research at Emory University. All legal guardians of child participants gave informed consent. One child from each age group was removed from the analyses due to technical errors when accessing video recordings, resulting in a final sample of 28 3-year-olds, 30 4-year-olds, and 29 5-year-olds. Our final sample was predominantly White (56%) with the remaining participants reporting their race and ethnicity as Asian or Asian American (4%), Black or African American (9%), Hispanic or Latino (2%), or multiracial (16%), with 13% choosing not to report. This sample is comparable to recent census data for Fulton County, which is where Emory University is located (U.S. Census Bureau 2024). Socioeconomic data was not collected from participants, but the medium household income for Fulton County is around \$101,000 (U.S. Census Bureau 2024). All participants were typically developing and fluent in English.

2.2 | Design, Stimuli, and Procedure

All participants completed a novel explicit false-belief task presented on a computer screen. Half of the participants were tested in-person, in the lab ($n = 45$), while the other half of participants were tested online due to the COVID-19 pandemic ($n = 42$) (although this did not affect our findings, see [Supplemental Materials](#)). The task consisted of ten unique trials in a pseudo-randomized order (trial order also did not affect our findings, see [Supplemental Materials](#)). Each trial displayed a unique false-belief narrative. On each trial, participants viewed animated characters interacting with one another and listened to an audio recording describing the trial. Each participant heard three independent trial types: four location-change, four object-change, and two catch trials. Note that the catch trials were designed to test basic task understanding and attention, independent of false belief.

All trials followed the same basic narrative, reducing the possibility that differences in performance across trial type are due to how the false-belief trial was presented to the participant. The basic structure of each trial is as follows. The first character enters a room with two distinct locations (e.g., a sandbox and a birdhouse). This character puts an object in one of the locations (e.g., puts a water bottle in the sandbox), and then leaves. A second character enters the room, and either moves the object from the first location to the second location (a “location” trial) or exchanges the object for another object (an “object” trial). Then, the second character leaves, and the first character returns. In the “catch” trials, the original objects remain in their original locations throughout the scenario (Figure 1).

After each trial, participants were asked a series of questions by the experimenter (Figure 1). Each participant was asked where the first character would go (i.e., measuring the participant’s understanding of false belief in the location trials) and what the character thinks is there (i.e., measuring the participant’s understanding of false belief in the object trials). Thus, participants were always asked about location and objects, but depending on the trial, one question was the critical false-belief question while the other question was “irrelevant”. In addition to these two questions, a subset of the participants ($n = 31$; 10 3-year-olds, 9 4-year-olds, and 12 5-year-olds) was asked a series of control questions in order to verify they understood and were paying attention to the task (Baron-Cohen et al. 1985). These questions included naming questions (i.e., measuring if the participant could name the main character in the scenario; for example, “Who is this, Katie or Alex?”); reality questions (i.e., measuring if the participant understood the *true* location or *true* identity of the object; for example, “Where is the book really? The desk or the backpack?”); and memory questions (i.e., measuring if the participant remembered the *original* location or *original* identity of the object; for example, “What was in the desk at the beginning? The book or the pencils?”). Along with the catch trials, these control questions ensure that performance on the false-belief trials reflects true theory-of-mind reasoning rather than general cognitive or attention demands.

All questions were framed in two alternative force-choice (2AFC) format to minimize cognitive effort for the youngest participants especially; thus, chance performance for each individual question is 50% (with passing defined as greater than 50% and failing defined as less than or equal to 50%; note that chance performance for passing the overall location or object task is also 50%). Participants responded to all questions by verbal report, with a correct response coded as 1 and an incorrect response coded as 0. Every question was independently scored on every trial (i.e., both the critical false belief question and the irrelevant question were scored, but false belief performance was calculated based only on performance on the critical false-belief question for that trial). Thus, it was possible for a child to pass a false belief trial if they answered the false belief question correctly, but the irrelevant question incorrectly. However, to pass a catch trial, a child would need to answer both the location and object question correctly. Children were not given feedback. All children responded to all questions.

2.3 | Model Specifications

All analyses were conducted using generalized linear mixed-effect models (GLMMs) using the *lme4* package (Bates et al. 2015) in R (version 4.5.2) (R Core Team 2025), unless otherwise noted. All GLMMs were fit with a binomial distribution and logit link. The dependent variable was whether the participant answered the question correctly or incorrectly (i.e., 0 or 1). Fixed effects included age (continuous in months, and mean-centered), question type (2 levels, with the object question as the reference), and their interaction, with random intercepts for each participant (note that including random intercepts for each participant *and* trial yielded a singular fit, indicating overfitting, and thus trial was not included as a random effect). If the model revealed significant main effects but a non-significant interaction term, we created additional models removing the interaction term to investigate whether the main effects were conditional on the interaction term (see [Supplemental Materials](#)); however, no significant main effects were conditional on the interaction term in the model.

3 | Results

3.1 | Preschoolers Perform Better on Explicit False-Belief Tasks That Ask About Objects Than Locations

If preschoolers indeed prioritize object information over location information, then participants should perform better on false-belief trials that involve an object change than those that involve a location change. We directly investigated how performance on the two kinds of explicit false-belief trials develop between 3 to 5 years of age using a GLMM (see Methods) predicting overall performance on the critical false-belief question for each trial type (Figure 2).

First, this model revealed a significant main effect of age ($\beta = 0.13$, $SE = 0.03$, $z = 4.22$, $p < 0.001$), with participants more likely to pass the object false-belief question with age, consistent with previous literature suggesting performance on explicit false-belief tasks improves within this age range, and confirming the validity of our novel false-belief task. Note that changing the reference question to location also revealed a significant main effect of age, with participants more likely to pass the location false-belief question with age ($\beta = 0.15$, $SE = 0.03$, $z = 4.95$, $p < 0.001$). Second, this model revealed a significant main effect of question type, with participants more likely to pass the object false-belief question than the location false-belief question ($\beta = -1.96$, $SE = 0.25$, $z = -7.75$, $p < 0.001$), consistent with our hypothesis and the previous literature revealing the prioritization of object over location information across other, non-ToM, tasks within this age range. And third, this model failed to reveal a significant interaction ($\beta = 0.02$, $SE = 0.03$, $z = 0.74$, $p = 0.46$), suggesting similar age-related improvement on the location and object false-belief questions (Figure 2). Thus, these results reveal that although performance on the false-belief task improved with age, children nonetheless performed better on the object false-belief question than the location false-belief question.

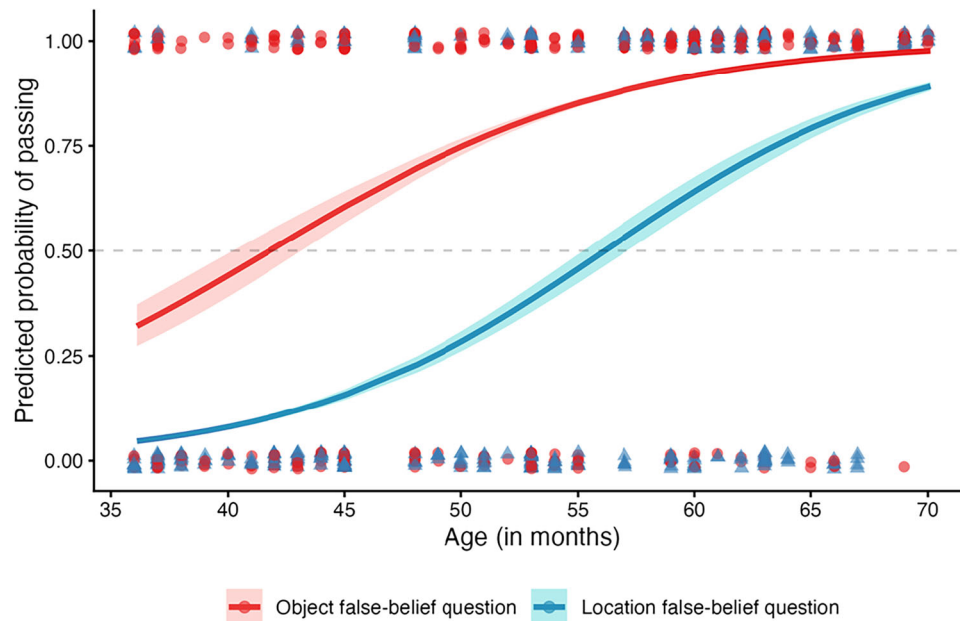


FIGURE 2 | Predicted probability of preschoolers passing object- and location-change false-belief questions. Predicted probability curves (solid lines) were derived from a GLMM with 95% confidence intervals (shaded lines) for the object (red) and location (blue) false-belief questions. Individual data is shown for each participant's observed performance on the object (red circles) and location (blue triangles) false-belief question. While the GLMM was modelled using centered age, the actual age of participants (in months) is plotted on the x-axis for visualization purposes. Hatched grey line at 0.50 indicates chance probability of passing. Although children are more likely to succeed with age ($p < 0.001$), children are more likely to pass the object than the location false-belief question ($p < 0.001$).

But could this pattern of results only emerge because children hold an incomplete understanding of the character's overall belief state (i.e., passing the critical false-belief question but failing the irrelevant question)? For example, in the object false-belief trials, although many children correctly report that a character would look for the correct object upon returning to a room, they may also report that the character would go to the incorrect location and thus do not hold a complete understanding of the character's belief state (see Methods for more information on scoring). To address this possibility, we conducted a follow-up GLMM restricted exclusively to trials where the irrelevant question was answered correctly. These strict criteria ensured that performance on the critical false-belief question indeed represented a completely accurate representation of the character's mind. Importantly, this subset analysis replicated our primary findings. The model revealed a significant main effect of question type ($\beta = -1.41$, $SE = 0.32$, $z = -4.44$, $p < 0.001$), confirming that children were significantly more likely to pass the object than the location false-belief question even when the irrelevant question was correctly answered. We also observed a significant main effect of age ($\beta = 0.13$, $SE = 0.05$, $z = 2.86$, $p < 0.01$) and a significant age $\times$ question type interaction ($\beta = 0.09$, $SE = 0.03$, $z = 2.76$, $p < 0.01$), with steeper age-related improvement on the location false-belief question ($\beta = 0.22$, $SE = 0.05$, 95% CI [0.13, 0.31], $OR = 1.25$) than on the object false-belief question ($\beta = 0.13$, $SE = 0.05$, 95% CI [0.04, 0.21], $OR = 1.13$). Thus, whether "passing" is defined only on passing the critical false-belief question or passing both questions, children continue to perform better on the object than location false-belief questions.

3.2 | But Does This Prioritization of Object Over Location Information Really Matter for Passing (or Failing) an Explicit False-Belief Task?

To directly test if the prioritization of object information over location information can truly affect whether one passes or fails a false-belief task, we first identified when children start to reliably pass the object and location explicit false-belief trials (i.e., when predicted probabilities of passing the critical false-belief question, with a 95% CI, exceed chance performance at $p > 0.5$). If this prioritization does not affect whether one passes or fails an explicit false-belief task, then children should start passing all explicit false-belief tasks at the same age, regardless of whether location or object information is tested within the task. However, that is not the case. In fact, model-derived predicted probabilities indicate that children are expected to perform above chance ($p > 0.5$) on the object-change false-belief trials at 44 months (i.e., 3.67 years old), but it is not until around 58 months (i.e., 4.83 years old) that children are predicted to perform above chance on the location-change false-belief trials (Figure 2). Because our participants began to pass these explicit false-belief trials—differing *only* in the type of information tested in the task—at different ages, this finding suggests that the prioritization of object over location information is another factor that affects the claim regarding whether (or not) a child can pass a false-belief task.

However, perhaps an even stronger test of whether the prioritization of object over location information can affect whether one passes or fails explicit false-belief tasks would ask if individual participants pass object yet fail location explicit false-belief trials.

TABLE 1 | Distribution of passing and failing object and location false-belief tasks.

		Location false-belief trials	
		<i>Failed</i>	<i>Passed</i>
Object false-belief trials	<i>Passed</i>	34% (<i>n</i> = 20/58)	19% (<i>n</i> = 11/58)
	<i>Failed</i>	43% (<i>n</i> = 25/58)	3% (<i>n</i> = 2/58)

Passing and failing was determined by how children answered the critical false-belief question on each trial. Each participant completed four location and four object false-belief trials; thus, passing indicates that the participant answered at least three of four trials correctly, while failing indicates that the participant answered two or fewer trials correctly.

Given that object information is prioritized, we first identified participants younger than 5-years-old who passed the object false-belief trials. Here we limited our analysis to our younger participants because our results (and prior literature) indicate that children 5 years of age and older perform well on (and pass) false-belief tasks involving either object or location information. Strikingly, within this young group, 34% of participants (*n* = 20/58) *passed* the object false-belief question, yet *failed* the location false-belief question (Table 1). Furthermore, only 3% of 3- and 4-year-olds (*n* = 2/58) showed the reverse pattern (i.e., failing object but passing location false-belief questions) (Table 1). This finding reveals that there are many cases of differential performance on explicit false-belief tasks, depending on the type of information (i.e., object versus location) that is being tested in the task. In other words, the type of information tested within a false-belief task is another factor that influences whether (or not) a child can pass an explicit false-belief task.

3.3 | Failure to Understand the Task or Remember the False Belief?

One alternative possibility is that children perform poorly on the location false-belief trials *not* due to the prioritization of object over location information, but rather because they do not understand or remember the information in the narrative. For example, a participant could respond incorrectly on the false-belief question simply because they do not remember the character's true belief. Traditionally, this possibility has been addressed by asking participants naming, reality, and memory control questions, which differ in conceptual complexity from false-belief questions and ensure participants have knowledge of the current identity or location of the object and accurate memory of the original identity or location of the object (Baron-Cohen, 1985). Thus, if a child answers the control questions correctly, but the false-belief question incorrectly, we can assume that the child understands that the object changed identity or changed location but does not yet understand false belief.

To directly address this possibility, we used a GLMM to model performance on the object and location critical false-belief questions in the subset of participants who were given the naming, memory, and reality control questions and answered them correctly (*n* = 28/31) (see Methods). This model revealed similar effects to the larger sample, including a significant main effect of age, with participants more likely to pass the object critical false-belief question with age ($\beta = 0.16$, $SE = 0.06$, $z = 2.87$, $p < 0.01$) (changing the reference question to location also revealed a significant main

effect of age; $\beta = 0.17$, $SE = 0.06$, $z = 2.99$, $p < 0.01$), a significant main effect of question type, with participants more likely to pass the object than location false-belief question ($\beta = -2.11$, $SE = 0.43$, $z = -4.87$, $p < 0.001$), and a non-significant interaction between age and question type ($\beta = 0.001$, $SE = 0.05$, $z = 0.02$, $p = 0.98$). Taken together, these results suggest that preschoolers understood and remembered the characters and events from the false-belief trials, but nevertheless performed worse on the location than the object false-belief trials.

But what about the rest of our participants who did not receive the naming, reality, and memory control questions? We created another GLMM including whether participants received these control questions (and answered them correctly) as an additional fixed effect, and modeled performance on the object and location false-belief questions over our entire participant sample. This model revealed that receiving the control questions (and answering them correctly) did not significantly affect performance ($p = 0.53$), nor did it interact with age ($p = 0.45$) or question type ($p = 0.58$). Furthermore, this GLMM (including the addition of control questions as a fixed effect) did not significantly improve model fit compared to the original GLMM (without the addition of control questions as a fixed effect) ($\chi^2(4) = .93$, $p = 0.92$). These findings suggest our results from participants who received the control questions (and answered them correctly) can be generalized to our full sample, and thus the poor performance on the location false-belief question in particular is not because children did not understand the task or did not remember the events in the trial.

3.4 | Differences in Inhibitory Control or Associative Cues?

Although we carefully tried to match our two tasks on as many methodological confounds as possible (as previously discussed), there were two “conceptual” variables we could not control for. Recall that in both types of trials, the two locations are always present on the screen. One possibility is that the location-change trials require more inhibitory control than the object-change trials because the participant must ignore the wrong location to select the correct one to pass the location false-belief trials; however, the second location is never involved in the narrative of the object false-belief trials. A related possibility is that the object-change trials may be easier because there is a clear associative cue between the character and the object (e.g., Katie is only ever holding one object, the book) which is missing from the location-change trials (e.g., Diego is depicted with two locations, the sandbox and the birdhouse). So, could unmatched inhibitory control demands or associative cues explain our finding that

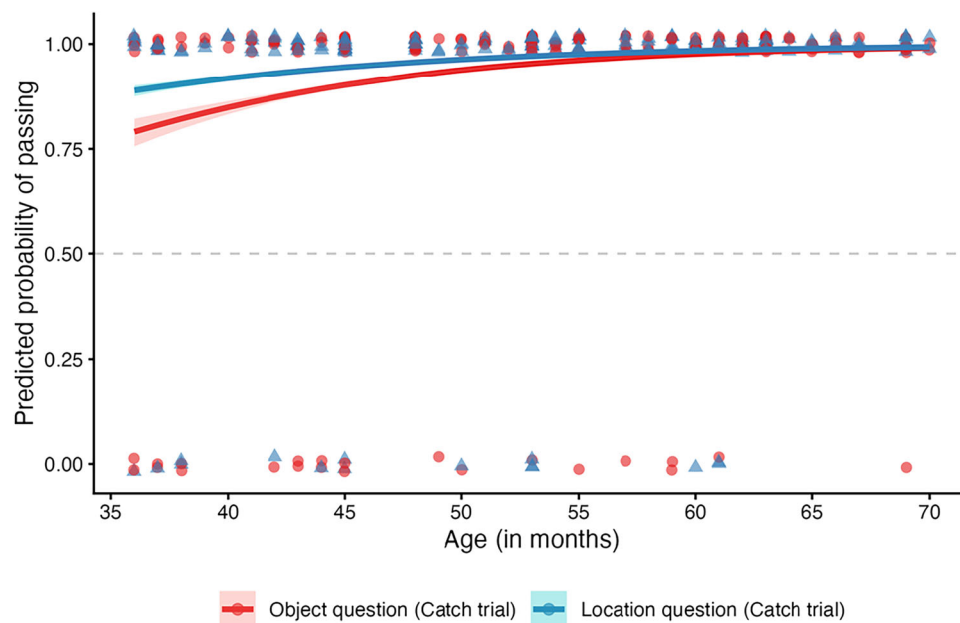


FIGURE 3 | Predicted probability of preschoolers passing the object and location questions on catch trials. Predicted probability curves (solid lines) were derived from a GLMM with 95% confidence intervals (shaded lines) for the object (red) and location (blue) question on the catch trials. Individual data is shown for each participant's observed performance on the object (red circles) and location (blue triangles) question. While the GLMM was modelled using centered age, the actual age of participants (in months) is plotted on the x-axis for visualization purposes. Hatched grey line at 0.50 indicates chance probability of passing either question. Children are not more likely to pass one question type over the other between 3 to 5 years of age ($p = 0.27$).

children perform better on object- than location-change false belief trials? We directly tested these possibilities in two ways. First, we examined performance on object and location questions on the *catch* trials—where the narrative also involves two locations but does not test false belief (see Methods). If children either perform poorly on the location question because they cannot inhibit the incorrect location—or better on the object question because there is a clear associative cue—then they should similarly perform worse on the location question than the object question in the catch trials. We directly investigated performance on catch location and object questions using a GLMM. Critically, this model did not reveal a significant effect of question type ($\beta = 0.50$, $SE = 0.45$, $z = 1.10$, $p = 0.27$), suggesting participants were likely to perform similarly on both questions in the catch trials (Figure 3). Also, note that this finding rules out the possibility that younger children especially were not paying specific attention to the location trials, and further supports the prioritization of object over location information when presented in a fragile or developing system, such as ToM (see Discussion for more details).

Second, and perhaps even stronger, we looked within the object-change false belief trials—where location is not relevant to the task—and compared performance on the object question to the location question (recall that we asked both object and location questions to participants on every trial). Again, if children either perform poorly on location questions because they cannot inhibit the incorrect location or perform better on object questions because there is a clear association between the agent and the object, then they should perform worse on the location question than object question within the object-change false-belief trial. However, a GLMM modeling performance on the two questions

within the object false-belief trial (i.e., the critical false-belief question and the location question) did not reveal a significant main effect of question type, with participants likely to perform similarly on the object and location questions ($\beta = -0.11$, $SE = 0.19$, $z = -0.58$, $p = 0.56$). Taken together, these findings suggest that children did not perform poorly on the location-change false-belief trials because of uneven inhibitory control demands or associative cues, but rather due to the prioritization of object over location information.

Finally, there are two additional ways that our object questions actually had greater inhibitory and memory demands than the location questions. As the location question was always asked before the object question (Figure 1), participants needed to both inhibit the location question and remember the object information in order to answer the object question correctly. However, either of these demands would predict that participants perform *worse* on the object than location questions, yet that is consistently not what we find (i.e., participants either perform similarly on both questions—as in the catch trials—or better on the object than location questions), further suggesting that unbalanced inhibitory or memory demands do not explain our results. A related possibility is that the fixed question order may have made the object question easier for participants; the first question (the location question) may have served as a quasi-practice question, reducing response generation demands for the second question (the object question) (Setoh et al. 2016). If this alternative possibility could explain our results however, we would expect to find better performance on the object question than location question on the catch trials as well, which we did not find. We would also expect performance to improve throughout the experimental session as children have more

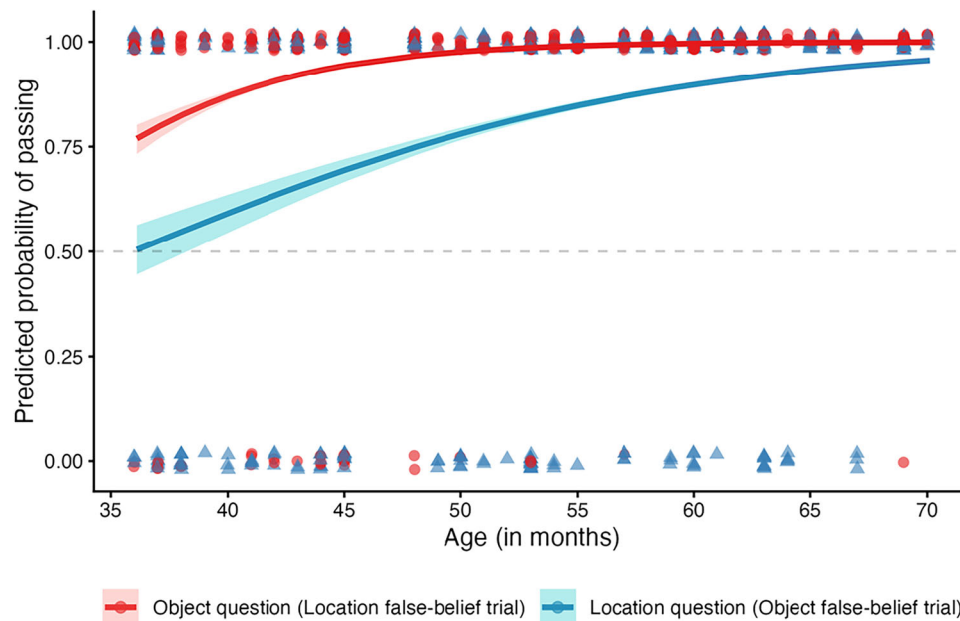


FIGURE 4 | Predicted probability of preschoolers passing the irrelevant object question (on the location false-belief trial) and location question (on the object false-belief trial). Predicted probability curves (solid lines) were derived from a GLMM with 95% confidence intervals (shaded lines) for the irrelevant object question (red) (on the location false-belief trial) and irrelevant location question (blue) (on the object false-belief trial). Individual data is shown for each participant's observed performance on the object (red circles) and location (blue triangles) question. While the GLMM was modelled using centered age, the actual age of participants (in months) is plotted on the x-axis for visualization purposes. Hatched grey line at 0.50 indicates chance probability of passing. Over 3 to 5 years of age, participants are more likely to perform better on the irrelevant object than location question ($p < 0.001$), although this difference in performance decreased with age ($p < 0.01$).

practice answering the test questions, which we did not find (trial order did not explain performance, see [Supplemental Materials](#)), suggesting that the possibility of reduced response generation demands do not explain our results either.

3.5 | Further Evidence That Preschoolers Indeed Prioritize Object Over Location Information

To further probe preschoolers' prioritization of object over location information, we examined their performance on the irrelevant questions on each trial (i.e., the object question in the location-change trial and the location question in the object-change trial). While our previous analysis revealed that children perform better on the object than location false-belief questions independent of their performance on the irrelevant questions, we nonetheless hypothesized that preschoolers may still perform worse on the irrelevant location question than the irrelevant object question, given prior evidence for the prioritization of object over location information within this age range. To directly test this hypothesis, we modeled performance on these irrelevant questions using a GLMM (Figure 4). This model revealed a significant main effect of age ($\beta = 0.18$, $SE = 0.04$, $z = 4.28$, $p < 0.001$) with participants more likely to pass the irrelevant object question with age (changing location to the reference question also revealed a significant main effect of age; $\beta = 0.09$, $SE = 0.03$, $z = 3.17$, $p < 0.01$); a significant main effect of question type ($\beta = -2.73$, $SE = 0.40$, $z = -6.86$, $p < 0.001$), with participants more likely to pass the irrelevant object question than location question; and a significant age $\times$ question type interaction ($\beta = -0.09$, $SE = 0.04$, $z = -2.54$, $p < 0.01$), with steeper age-related improvement on the

irrelevant location question ($\beta = 0.18$, $SE = 0.04$, 95% CI [0.10, 0.26], $OR = 1.20$) than the irrelevant object question ($\beta = 0.09$, $SE = 0.03$, 95% CI [0.03, 0.15], $OR = 1.09$) (Figure 4). Taken together, these results are consistent with prior literature suggesting that preschoolers weight object over location information, with this prioritization decreasing with age (Haun et al. 2006).

4 | Discussion

The present results provide evidence that children's performance on explicit false-belief tasks can be significantly affected by the *type of information* being tested within the false-belief task. Specifically, due to their prioritization of object information over location information, preschool-age children perform better on explicit false-belief tasks that ask about objects compared to false-belief tasks that ask about location, and even pass a false-belief task about objects earlier than a false-belief task about location when all other task demands are matched. This finding reveals that the development of information processing is another factor that contributes to why children of the same age do better on certain false-belief tasks than others—for example, perform better on object change false-belief tasks than location change false-belief tasks, as is the case here.

The precise mechanism underlying the prioritization of object over location information is unknown. However, other studies have suggested that although preschoolers undoubtedly have access to (i.e., can encode and recall) information about an object's identity and location, their preference for using identity information over location information may reflect other events

in cognitive development (Haun et al. 2006). In particular, language—thought to catalyze many aspects of human cognitive development (e.g., Spelke 2003)—may be a driving force behind this prioritization. Specifically, when children start to verbally identify objects, they also become better at remembering the features of the object (Farran and O’Leary 2016; Joh and Spivey 2012; Miller et al. 2016, Miller et al. 2017; Smith et al. 1996; Westermann and Mareschal 2014). For example, children tend to learn nouns (used to describe and classify objects based on their identity) before they learn verbs (used to describe how objects move through space; Gentner 1982). Thus, as children expand their production abilities during the first few years of life, language may serve as an attentional mechanism favoring featural information. Future work is needed to understand the precise role of language in this prioritization of object over location information, as well other mechanisms that may underlie differences in information processing in the preschool years.

Interestingly, infants prioritize *location* information over object information—the complete opposite as preschoolers (Ayzenberg et al. 2021; Haun et al. 2006; Wilcox 1999; Xu and Carey 1996). While the exact mechanism of the reversed prioritization is also unknown, theories of object perception posit that spatial information may be especially helpful in early object processing development because this information is necessary to first individuate objects from the background (for reviews, see Leslie et al. 1998; Xu and Chun 2009). Indeed, a wide literature of behavioral experiments demonstrate that infants discriminate between objects, index objects, and even reorient in space using spatial, and not featural, information (Ayzenberg et al. 2021; Baillargeon 1994; Coldren and Colombo 1994; Hermer and Spelke 1994; Leslie et al. 1998; Simon et al. 1995; Wynn 1992; Xu and Carey 1996). Taken together, location information may be especially useful—and salient—in early stages of cognitive development when infants are first learning to recognize objects, and then later on, featural information may take priority during the preschool years, at a time when young children are acquiring many more cognitive (including language, as described above) and social skills. Future research will explicitly explore this hypothesis as well as the causal relationship between information processing and acquisition of cognitive skills.

The reversed prioritization of location over object information during infancy leads to the intriguing possibility that infants perform better on *implicit* false-belief tasks that ask about location than those about objects. Indeed, several studies have found that infants actually perform well on implicit false-belief tasks that involve a location change (Kovács et al. 2010; Onishi and Baillargeon 2005; Song et al. 2008; Southgate et al. 2007; Surian et al. 2007), although no known studies have shown that infants perform poorly on an implicit false-belief task that involve an object change. In fact, one study (Scott and Baillargeon 2009) found that infants performed *well* on an implicit false-belief task involving a seemingly “object” change. Note, however, the object change was from an assembled toy (thus occupying one location in space) to a disassembled toy (thus occupying two locations in space). Thus, it is possible that the infant solved this task by encoding location information (one location vs. two locations) and not object information (assembled toy vs. disassembled toy). We predict that, if given an implicit false-belief task with an isolated object change, infants should perform worse on the task

that asks about the object change than a task that involves a location change. However, it is also important to note that there is also a significant number of failed replications of implicit location change false-belief tasks (for review, see Rakoczy 2022), and thus this hypothesis needs further investigation.

As discussed previously, the prioritization of object over location information in preschoolers is not due to a failure to encode, attend to, or remember location information, but rather only emerges when such information is asked about in particularly challenging or ambiguous tasks (Ayzenberg et al. 2021). Thus, in our case as ToM abilities are continuing to develop during the preschool years, it is perhaps unsurprising that young children especially demonstrate this prioritization of object over location information when then tested in a challenging false-belief task. By contrast, as ToM abilities become more advanced, we hypothesize that this prioritization becomes less relevant and children perform well on false-belief tasks, independent of the type of information tested within the task. Importantly, the claim here is not that there are different false belief systems (i.e., one for object changes and one for location changes), but rather that the relative prioritization of object over location information undoubtedly influences other developing systems, like ToM. Similarly, it is not surprising that children perform well on both the object and location questions in the catch trials, as the catch trials do not manipulate false belief (and thus should not be particularly challenging for the child).

Our results may initially seem in contrast to other studies that find that 3-year-olds can pass false beliefs tasks about location (Ghreear et al. 2021; Rubio-Fernández and Geurts 2013; Setoh et al. 2016; Siegal and Beattie 1991; Surian and Leslie 1999). However, we also found several 3-year-olds in our own sample who passed our location-change task, yet many more 3-year-olds passed our object-change task. Furthermore, the studies that demonstrate early success in location-change false belief tasks manipulated other variables known to improve performance, like wording of the test question (Siegal and Beattie 1991; Surian and Leslie 1999), reducing inhibitory demands (Setoh et al. 2016), or emphasizing the agent’s perspective (Rubio-Fernández and Geurts 2013). Thus, when location information is stressed or easier to use, younger children are more likely to pass—exactly what one would predict if preschoolers have access to location information, yet their prioritization of object over location information impedes performance on challenging false-belief tasks.

Finally, while the current experiment was inspired by the traditional Smarties and Sally-Anne tasks, there are several important distinctions—beyond methodological differences—between these traditional tasks and the current study. More specifically, the Smarties task concerns an appearance-reality distinction, whereas our object-change false-belief task does not. This omission was done intentionally in order to match our object- and location-change tasks on as many conceptual demands as possible. Indeed, unlike the Smarties task, the traditional Sally-Anne task does not require understanding of representational change or appearance-reality conflicts, making it difficult to isolate information processing from other conceptual factors that may differ across tasks. By removing these conceptual differences, we have equated the two types of tasks on as many factors as possible—except the type of information

being manipulated in the false belief. The current study then uses ToM and false belief as a means to investigate preschoolers' prioritization of object over location information across domains, while nonetheless informing research on ToM.

In conclusion, here we find that preschoolers, especially 3- and 4-year-olds, perform better on (and even pass) explicit false-belief tasks that ask about objects than those that ask about locations (which they fail), revealing that one reason why children at this age perform inconsistently on false-belief tasks is due to the information that is being tested in the task. Thus, these results should be taken as a cautionary tale that, when testing developing abilities such as false belief, it is critical to also consider the development of information processing because this development can give strikingly different conclusions—for example, a three-year-old can pass an explicit false-belief task versus a three-year-old cannot pass an explicit false-belief task.

Author Contributions

Rebecca J. Rennert, Annie Cheng, Virginia Chambers, Sabrina Flores, and Güldehan Durman collected and analyzed data and was supervised by Daniel D. Dilks. **Annie Cheng** and **Daniel D. Dilks** conceived of the study. **Rebecca J. Rennert, Annie Cheng, and Daniel D. Dilks** designed the study. The manuscript was drafted by Rebecca J. Rennert and Virginia Chambers. Rebecca J. Rennert, Annie Cheng and Daniel D. Dilks provided critical revisions. All authors approved the final version of the manuscript for submission.

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Ethics Approval

All procedures were approved by the Emory University IRB (Protocol #69523) and the study conforms to recognized standards according to the Declaration of Helsinki.

Conflicts of Interest

No authors report conflicts of interest.

Data Availability Statement

The data, analytical code, and materials necessary to reproduce the analyses presented here are publicly accessible and available at <https://osf.io/a9usb/>. All materials were created by the authors (no materials were reproduced from other sources).

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Supporting Information: desc70250-supp-0001-SuppMat.docx