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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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An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
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Abstract

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It is well-documented that children 5 years of age consistently pass explicit false-belief tasks, while children around 3 years of age (and some even at 4 years of age) do not – suggesting that children younger than 5 years of age may not have "Theory of Mind" (ToM). Traditionally, false-belief tasks have included scenarios with *location* changes (e.g., the Sally-Anne task), *object* changes (e.g., the Smarties task), or both. However, location information and object information are prioritized differentially throughout development, such that preschoolers weight cues about object identification over location information. As such, here we ask whether the traditional false-belief tasks may have critically ignored developmental differences in location and object processing, and thus may affect such claims as children younger than 5 years of age do not have ToM. To directly test this hypothesis, we tested children between 3 and 5 (27 3-year-olds; 28 4-year-olds; 28 5-year-olds) on a novel false-belief task involving an equal number of independent location- and object-change scenarios. Not surprisingly, 5-year-olds pass the explicit false-belief tasks involving both location- and object-change scenarios, yet performed significantly better on object-change scenarios compared to the location-change scenarios. By contrast, the 4-year-olds pass the explicit false-belief task involving an object change, yet fail on the location change, with a significant difference between the two scenarios. Finally, while 3-year-olds fail the explicit false-belief tasks involving both location- and object-change scenarios, they nonetheless performed significantly better on the object-change scenarios compared to the location-change scenarios. These results reveal that when testing the development of false-belief, one must first consider potential developmental differences in information processing, since such differences reveal opposite answers (e.g., 4-year-olds pass false-belief tasks on object changes, but not on location changes) and opposite conclusions (e.g., 4-year-olds do have ToM versus 4-year-olds do not have ToM).

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1. Introduction

1.1. Theory of Mind

Theory of Mind (ToM) is a cognitive ability that allows us to understand and interpret the mental state of others (Premack & Woodruff, 1978). ToM ability encompasses aspects of social interpretation such as beliefs, emotions, desires, and intentions (Baron-Cohen, 1985). To develop social cognition, ToM is a critical, fundamental skill for social interaction, communication, and cooperation (Seyfarth & Cheney, 2013). This concept has been studied across disciplines, including the cognitive sciences and philosophy. According to the classical interpretation of ToM, individuals develop the ability to attribute mental states to others by the age of five through observing and interpreting others' behavior (Wellman et al., 2001). The absence of a ToM may also lead to difficulties in communication, as having a ToM is essential in understanding the intentions and emotions conveyed by language and nonverbal cues. In particular, understanding forms of figurative language may be difficult for those who lack a ToM (Hughes & Leekam, 2004). This ability is considered a critical milestone in children's cognitive and social development, as it allows them to understand and predict others' behaviors and adjust their own behavior accordingly.

Accurately determining whether a child has developed a ToM is necessary for several reasons. First, it helps parents, educators, and clinicians identify children who may experience social deficits. It is common for children with Autism Spectrum Disorder to exhibit impairments in ToM, which may affect their communication, bonding, and other social abilities (Baron-Cohen et al., 1985). Secondly, understanding the development of ToM can inform educational and therapeutic interventions to support children's social and cognitive growth. For example, teaching children to interpret facial expressions and body language can improve their ability to respond to the mental states of others (Denham et al., 2012). ToM is a critical concept with widespread social and cognitive development implications. By understanding its development and accurately assessing children's ToM abilities, we can better support their growth and development.

1.2. Assessing Theory of Mind in Children

There are two main types of ToM assessments that are used to examine the ability to understand and interpret the mental states of others: implicit and explicit tasks. Implicit tasks rely on the individual's ability to spontaneously and automatically interpret social cues that reflect other people's mental states (Wang & Leslie, 2016). Implicit tasks are measured using nonverbal markers, such as eye movements (Gergely & Csibra, 2003). Violation of Expectation and Anticipatory Looking paradigms are common methods used to track gaze during implicit ToM tasks (Luo & Baillargeon, 2005; Onishi & Baillargeon, 2005). These measures are used to test infants as young as six months old, where more demanding measures (i.e., verbal response, reaching) may not be appropriate (Brooks & Meltzoff, 2005).

Explicit ToM tasks require the individual to explicitly and consciously infer and reason about other people's mental states (Wellman & Liu, 2004). These tasks typically involve presenting individuals with a scenario or visual display and asking them to explicitly make predictions about the mental states of the characters involved via pointing or verbal responses (Baron-Cohen et al., 1985; Flavell et al., 1986; Gopnik & Astington, 1988; Perner & Leekam, 2008; Onishi & Baillargeon, 2005; Wimmer & Perner, 1983).

The specific age ranges tested for implicit and explicit ToM vary depending on the study design and research question. While implicit tasks can be useful for studying ToM in infants and younger children, explicit tasks are often preferred for assessing children 3-5-years-old because these tasks can provide detailed information about the child's ToM abilities (Sabbagh et al., 2006). Importantly, the present study uses an explicit ToM task because they provide more reliable indicators of a child's understanding of mental states than implicit tasks that rely on nonverbal responses such as looking-time or reaching behavior (Wellman et al., 2001). Additionally, explicit tasks can provide more detailed information about the nature of children's ToM abilities.

Some explicit tasks assess sociality, interpreting social outcomes, and understanding emotions. These tasks include the Strange Stories paradigm (Happé, 1994), the Emotion Attribution task (Denham, 1986), the Emotion Situation task (Pons et al., 2004), and the Interpersonal negotiation task (Selman & Byrne, 1974). These assessments draw on the understanding of social cues by asking the participant to indicate their interpretation of the characters' emotions verbally.

Other ToM assessments target the true (or untrue) interpretation of events in the environment rather than emotions. For example, the most abundantly used explicit tasks target the understanding that others can hold beliefs that are contrary to reality, referred to as false-belief (Wimmer & Perner, 1983). Some explicit tasks also assess children's understanding of false-belief through intentional deception.

The Appearance-Reality task is a classic example of an explicit deception task. In the Appearance-Reality task, children are shown an object that appears to be one thing but is actually something else (Flavell et al., 1986). For example, if a child is shown a glass of milk and is asked what the object looks like, preschoolers will (correctly) answer that the glass of milk looks like a glass of milk. Then, the glass of milk is placed behind a red-colored filter such that the glass *appears* to contain a red liquid. The child is subsequently asked about the appearance of the glass. If a child understands the false-belief about the appearance of the glass, they will answer that the glass now appears to contain fruit punch, even though – in reality – the glass of milk is still a glass of milk. However, if the child does not understand the false-belief, they will answer that it still appears like milk. Thus, a child "passes" this false-belief assessment – and thus has ToM – when they say the glass of milk now appears to be a glass of fruit punch. This task is a measurement of ToM because it assesses a person's ability to understand that beliefs about appearance can differ from beliefs about reality.

Another commonly used false-belief task that also investigates false appearances is the Smarties, or the Unexpected Contents, task (Gopnik & Astington, 1988). This task is a classic ToM assessment that involves understanding the relationship between an object's appearance and its contents. In this task, a child is presented with a box of Smarties (or a similar type of candy) that contains something unexpected, such as pencils. The Smarties box is opened so the child can see that it does *not* contain candy, but rather pencils. The child is then asked to make a prediction about what another person, unaware of the box's actual contents, will expect to find inside the box when they open it. A child with an understanding of the false-belief about the contents of the box will answer that the third party expects Smarties to be in the box. However, if the child does not understand the false-belief, they will answer that the third party will expect to find pencils in the box. A child passes the Smarties false-belief task, and thus has a ToM, when they answer that the third party will expect to find Smarties, not pencils, in the box since that is what the box appears to contain. By assessing an individual's ability to comprehend that other people can hold beliefs that are distinct from reality, and that these beliefs may impact their actions, this task serves as a measure of ToM.

The Sally-Anne task is the most common measure used to assess the milestone of understanding false-belief in ToM (Baron-Cohen et al., 1985). As part of this task, children are presented with a scenario that involves two characters, Sally and Anne. They are asked to predict what one of the characters will do based on their belief about a certain object or situation. In the classic example, Sally puts a marble in a basket and leaves the room. While Sally is gone, Anne takes the marble out of the basket and puts it in a separate box. Participants were then asked where Sally would look for the marble when she returned to the room. If a child understands the false-belief, they will answer that Sally will look for the marble in the basket even though the marble is really in the box; unlike the child, Sally didn't see the marble move. If the child does not understand the false-belief, they will incorrectly predict that Sally will look for the marble in its current location. Thus, the false-belief in the task is Sally's incorrect belief about the marble's location, and the child must understand that this incorrect belief may lead to unexpected behavior (i.e., Sally looking in the wrong place for the marble). Children who pass the Sally-Anne task understand the false-belief. Those who pass this task are said to have developed a ToM by understanding that others can hold false beliefs that may influence their behavior.

1.3. Inconsistent Conclusions Across Explicit False-Belief Studies

When analyzing tasks that involve physical items rather than emotional reasoning, such as the Sally-Anne task and the Smarties task, research widely agrees that 3-year-olds do not have a developed explicit ToM. Wimmer & Perner (1983) found that 3-year-olds failed 85% of cases in their original paradigm, similar to the Sally-Anne task. Gopnik and Astington (1988) found that 3-year-olds have some understanding of appearance-reality distinctions, but their ability to understand representational change is a limiting factor in their ToM development. While it is common for studies to report individual variation among participants in their sample, findings overwhelmingly suggest that 3-year-olds do not pass explicit false-belief tasks. Therefore, the conclusion is that 3-year-olds do not have an explicit ToM when tested on explicit false-belief tasks.

It is also widely agreed upon that 5-year-olds *do* have an explicit ToM. Baron-Cohen et al. (1985) found that only 15% of their 5-year-old sample failed to predict where Sally would look for her marble. In a task similar to "Sally-Anne," Wimmer and Perner (1983) found that only 28% of their 5-year-old sample failed to predict that a character would look for their chocolate bar in its original location rather than in its new, hidden location.

However, whether 4-year-olds have a ToM has been a topic of debate among researchers. Many research teams have reported inconsistent results. Several studies have reported that around only 20% of 4-year-olds fail explicit false-belief tasks like the Sally-Anne task (Baron-Cohen, 1985; Wellman & Liu, 2004). However, other studies have reported higher failure rates for 4-year-olds on explicit false-belief tasks, suggesting they may not yet have a fully developed ToM. For example, Perner and Leekam (2008) found that 55% of 4-year-olds failed the Smarties task. Gopnik & Astington (1988) also found that 4-year-olds had some success with an appearance-reality distinction task, but nearly 80% failed the false-belief and representational-change tasks where children were asked to predict what another person would perceive if contents of a box were rearranged unknowingly.

1.4. Explicit False-Belief Task Content

What could be underlying this disagreement surrounding whether 4-year-olds have a Theory of Mind? Are there attributes within these tasks that could explain differing findings and conclusions? Here, we look at the contents of classic false-belief tasks as a potential explanation.

In every explicit false-belief task above, participants are shown a scenario in which a character holds a belief different from reality. They are asked to predict how the character in the scenario will act based on their false-belief. These scenarios often use object identity information (i.e., a sponge painted to look like a rock in the Appearance-Reality task (Flavell et al., 1986), pencils inside a candy box in the Smarties task (Gopnik & Astington, 1988)). These scenarios also heavily rely on location information to track these objects as they are displaced, including variations of the Smarties task where the experimenter performs actions on the box, like dumping its contents to replace them with other items (Onishi & Bailllargeon, 2005). The utility of object and location information is perhaps best illustrated in the Sally-Anne task (Baron-Cohen et al., 1985). The correct answers to probe questions asked in the Sally-Anne task ("Where would Sally go? What does Sally think is there?") require the child to understand that Sally holds a false-belief about the location of the marble. Sally believes that the marble is still in the basket when, in fact, it has been moved to the box. The participant must use their understanding of Sally's false-belief to predict that she will look in the basket for the marble, even though it is actually in the box. In this scenario, the object (the marble) and the location (the basket and the box) create a conflict between Sally's belief and reality, which the participant must understand to answer these probe questions correctly.

1.5. Differential Prioritization of Information Processing

Ayzenberg et al. (2021) suggest there are developmental differences in how children prioritize location information and object information when viewing visual arrays. Specifically, 12-month-old infants tend to prioritize location information over object information. This means infants are more likely to attend to and remember information about the spatial relationships between objects (such as their relative distance and orientations) than information about the individual objects themselves.

In contrast, preschoolers tend to prioritize object information over location information (Ayzenberg et al., 2021). This means that young children tend to pay more attention to and remember information about the shape and color, and other identifying features, of individual objects rather than their location in space.

Thus, perhaps this developmental shift in informational prioritization is due to changes in how children process and integrate visual information over time. Specifically, Ayzenberg et al. (2021) suggest that infants may prioritize the spatial relationships between objects, while preschoolers prioritize object information over such spatial relationships. Later in development, older children and adults better integrate object and location information to form more complex representations of visual information. Overall, this framework provides a useful way to understand the developmental changes in how children prioritize and process information in visual presentations.

Could this differential prioritization in information processing be affecting the incongruent false-belief results seen in 4-year-olds? As discussed earlier, 4-year-olds tend to prioritize object information over location information when processing visual stimuli. This means they may be more likely to attend to and remember information about individual objects in a scene rather than information about where those objects are located in the scene. This could impact their performance on explicit false-belief assessments that rely heavily on location information, such as the classic Sally-Anne task. Specifically, if children under 4 years of age are less likely to attend to and remember location information, they may struggle with the Sally-Anne task and perform poorly. By contrast, 4-year-olds may perform better if the task relies heavily on object information.

1.6. Hypotheses

Previous literature investigating explicit false-belief tasks in children has not carefully controlled for the use of location information and object information within the paradigms used. Here, we propose that false-belief tasks that include both location changes and object changes are ignoring these developmental differences in location and object processing. To explore this possibility, we created a novel explicit false-belief assessment to separate location-change and object-change scenarios for separate analysis.

Aim One:

If our novel explicit false-belief task has strong concurrent validity, then after collapsing location- and object-change scenarios into one analysis, 5-year-olds will pass and 3-year-olds will fail. This hypothesis focuses on 3- and 5-year-olds because there is little contention regarding whether these groups traditionally pass or fail explicit false-belief tasks. After establishing that the present task replicates agreed-upon findings that 3-year-olds perform significantly worse on explicit false-belief tasks than 5-year-olds, we can move forward with further analyses.

Aim Two:

If the age-related prioritization of location and object information is affecting performance on explicit false-belief tasks, then 1) 3-year-olds will fail both location- and object-change conditions. 2) 5-year-olds will pass across both location- and object-change conditions. 3) 4-year-olds will fail the location-change condition, but pass the object-change condition.

2. Methods

2.1. Participants

Twenty-seven 3-year-olds (*M* = 41.37 months; *SD* = 3.54; range = 36 to 47 months; 18 females), twenty-eight 4-year-olds (*M* =53.72 months; *SD* = 3.60; range = 48 to 59 months; 12 females), and twenty-nine 5-year-olds (*M* = 64.07 months; *SD* = 3.16; range = 60 to 70 months; 8 females) participated in the study, either in-person (*N* = 45) or virtually (*N*=41).

All participants were typically developing and fluent in English. Participants were recruited from a mailing list of parents interested in child studies through the Emory Child Study Center database. Each participant received a $10 Amazon gift card and a gift bag of small toys as compensation for their time in the hour-long study.

One 5-year-old was removed from the analyses due to technical errors when accessing video recordings, resulting in a final sample of twenty-eight 5-year-olds and 83 total participants. The Emory University Institutional Review Board approved study procedures, and all participants' parents provided written informed consent before beginning.

2.2. Materials

The novel false-belief assessment. Theory of Mind ability was measured using a novel false-belief assessment. The assessment consisted of ten trials. Each trial displayed a unique false-belief scenario. Participants viewed animated characters interacting with one another while listening to auditory narration (see Appendices). Each scenario is followed by a series of questions related to the previously depicted scenario (see Appendices). Four trials depict location-change false-belief scenarios (see Appendix A). In these scenarios, an object changes location by being moved from its original position. Four trials depict object-change false-belief scenarios (see Appendix B). In these scenarios, an object is exchanged for another in the same location. Two trials serve as a catch measure with no false-belief element (see Appendix C). In these scenarios, an original object remains in its original location for the duration of the trial, involving no location or object change.

This novel false-belief assessment features two alternative forced-choice answer options following every question to limit cognitive strain for young participants (and thus rendering chance performance to 50%). The false-belief assessment also features control questions that ensure the participant understands the scenario's logistics (see Appendices). Naming-control questions measure the ability to correctly name the main character; for example, "Who is this character? Diego or Jack?" Reality-control questions measure the ability to correctly state the present location of the object; for example, “Where is the water bottle really? The sandbox or the birdhouse?” Memory-control questions measure the ability to correctly state the object's location at the story's beginning, for example, “Where was the water bottle in the beginning? The sandbox or the birdhouse?”

2.3. Procedure and Design

This study was conducted both in person at the Emory Child Study Center and virtually through Zoom. Prior to the commencement of the study, the child’s guardian provided written, informed consent and demographic information. The child first completed the novel false-belief assessment. Subsequently, 4-and 5-year-old participants were required to complete a general IQ assessment with two subscales of Verbal and Nonverbal Knowledge (KBIT-2; Kaufman & Kaufman, 2004b). The KBIT-2 does not accommodate a 3-year-old assessment. The assessments were paused if the participant requested a break. After completing the assessments, the participant was provided with a debriefing and compensation. The participants’ responses were transcribed verbatim. If the participant accurately answered the critical false-belief question and the naming-, reality-, and memory-control questions, their response was considered correct. To ensure interrater reliability, congruent coding methods were employed by the researchers. The hypotheses analysis was conducted using RStudio 2022.07.01.

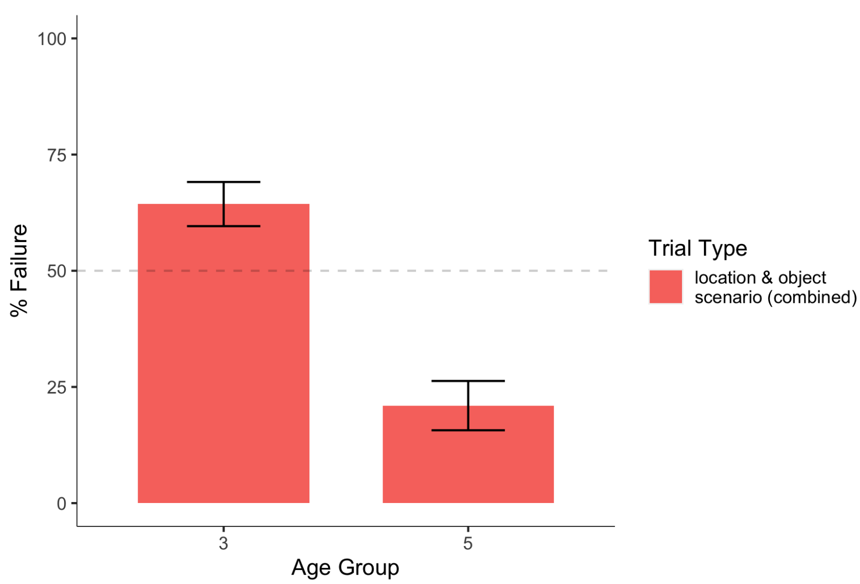
3. Results

3.1. Aim One

We first addressed our hypothesis that if our novel explicit false-belief task used in the present study has strong concurrent validity, then 5-year-olds will pass and 3-year-olds will fail when collapsing performance on location- and object-change scenarios into one analysis. We compared each age group's mean performance to chance (i.e., 50%) with a paired sample t-test. The results demonstrate that 3-year-olds performed significantly worse than chance when combining across scenarios ($t(26) = 3.02$, $p = 0.003$), with a mean failure rate of 64.35% (SD = 24.69%). However, 5-year-olds performed significantly better than chance when combining across scenarios ($t(27) = -5.47$, $p = 4.31e-6$), with a mean failure rate of 21.00% (*SD* = 28.07%). Additionally, we conducted an independent sample t-test to test whether 5-year-olds' performance is significantly different from 3-year-old performance when combining location- and object-change scenarios. The results demonstrate that 5-year-olds have a significantly lower failure rate than 3-year-olds ($t(52.57) = -6.09$, $p = 6.67e-8$). Therefore, 5-year-olds performed better overall than 3-year-olds on the novel explicit false-belief task, and the task has strong concurrent validity, as shown in Figure 1.

Figure 1.

3-year-old and 5-year-old failure rate of combined location- and object-change scenarios



Note. 3-year-olds performed significantly worse than chance (t(26) = 3.02, p = 0.003), (M = 64.35%, SD = 24.69%). 5-year-olds performed significantly better than chance when combining across scenarios (t(27) = -5.47, p = 4.31e-6), (M = 21.00%, SD = 28.07%).

3.2 Aim Two

Next, we analyzed our second hypothesis that if age-related prioritization of location and object information is affecting performance on explicit false-belief tasks, then this differential prioritization would be evident in performance across age groups. We analyzed this hypothesis in the following ways:

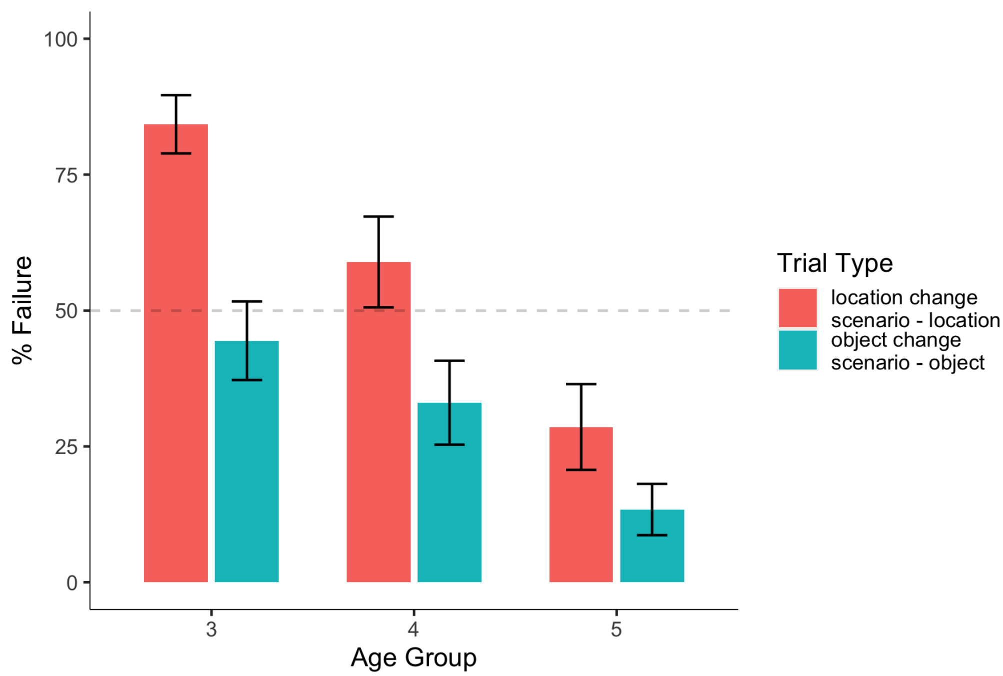
First, we assessed whether 3-year-olds will fail across both location- and object-change conditions. To analyze this, we conducted two paired-sample t-tests, first comparing the failure rate on location-change scenarios to chance (i.e., at 50%), and then the failure rate on object-change scenarios to chance. The results demonstrate that 3-year-olds performed significantly worse than chance on location-change scenarios (t(26) = 6.39, p = 4.55e-7), with a mean failure rate of 84.26% (SD = 37.55%), and object-change scenarios (t(26) = -0.77, p = 0.45), with a mean failure rate of 44.44% (SD = 39.53%). Then, we conducted a paired-sample t-test to assess whether there is a significant difference in performance between the two conditions. The results demonstrate that 3-year-olds' performance on location-change scenarios was significantly worse than object-change scenarios (t(26) = 4.70, p = 3.67e-5). Therefore, 3-year-olds do not pass either location- or object-change scenarios but do perform better on object-change scenarios than location-change scenarios (*Figure 2*).

Secondly, we assessed whether 5-year-olds will pass both location- and object-change conditions. To analyze this, we conducted two paired-sample t-tests comparing failure rates on both location-change and object-change scenarios to chance. The results demonstrate that 5-year-olds performed significantly better than chance on both location-change scenarios ($t(27) = -2.71$, $p = 0.006$), with a mean failure rate of 28.57% (SD = 41.79%) and object-change scenarios ($t(26) = -7.75$, $p = < 1.22e\text{-}8$), with a mean failure rate of 13.39% (SD = 24.98%). Then, we conducted a paired-sample t-test to assess whether there is a significant difference in performance between the two conditions, comparing performance on location-change scenarios and performance on object-change scenarios. The results demonstrate that 5-year-olds' performance on location-change scenarios was significantly worse than object-change scenarios ($t(27) = 2.01$, $p = 0.027$). Therefore, while 5-year-olds pass both location- and object-change scenarios, they perform significantly better on object-change scenarios compared to the location-change scenarios (*Figure 2*).

Critically, we lastly assessed whether 4-year-olds will fail the location-change condition, but pass the object-change condition, performing significantly greater than chance on location scenarios and at chance or lower than chance on object-change scenarios. To analyze this, we conducted two paired-sample t-tests comparing the failure rate on both location-change scenarios to chance at 50%, then object-change scenarios to chance at 50%. The results demonstrate that 4-year-olds performed no different than chance on location-change scenarios ($t(27) = 1.07$, $p = 0.29$), with a mean failure rate of 58.93% (SD = 44.21%), but performed significantly better than chance on object-change scenarios ($t(27) = -2.20$, $p = 0.018$), with a mean failure rate of 33.03% (SD = 40.86%). Then, we conducted a paired-sample t-test to assess whether there is a significant difference in performance between the two conditions, comparing performance on location-change scenarios and performance on object-change scenarios. The results demonstrate that 4-year-olds' performance on location-change scenarios was significantly worse than object-change scenarios ($t(27) = 2.78$, $p = 0.005$). Therefore, while 4-year-olds perform significantly better on object-change scenarios than on location-change scenarios, they pass object-change scenarios, and they fail location-change scenarios (*Figure 2*).

Figure 2.

3-, 4-, and 5-year-old failure rate by scenario type (location-change or object-change)



Note. 3-year-olds failed both location- and object-change conditions. 4-year-olds performed no different than chance on the location-change condition and passed the object-change condition. 5-year-olds passed both conditions.

Recall that each location- and object-change scenario contained one question that asked about location information and one question that asked about object information within the scenario. For a more comprehensive view of performance within scenario types, please visit the plot of failure rates of location and object questions per scenario type located in the Appendix. (see Appendix D).

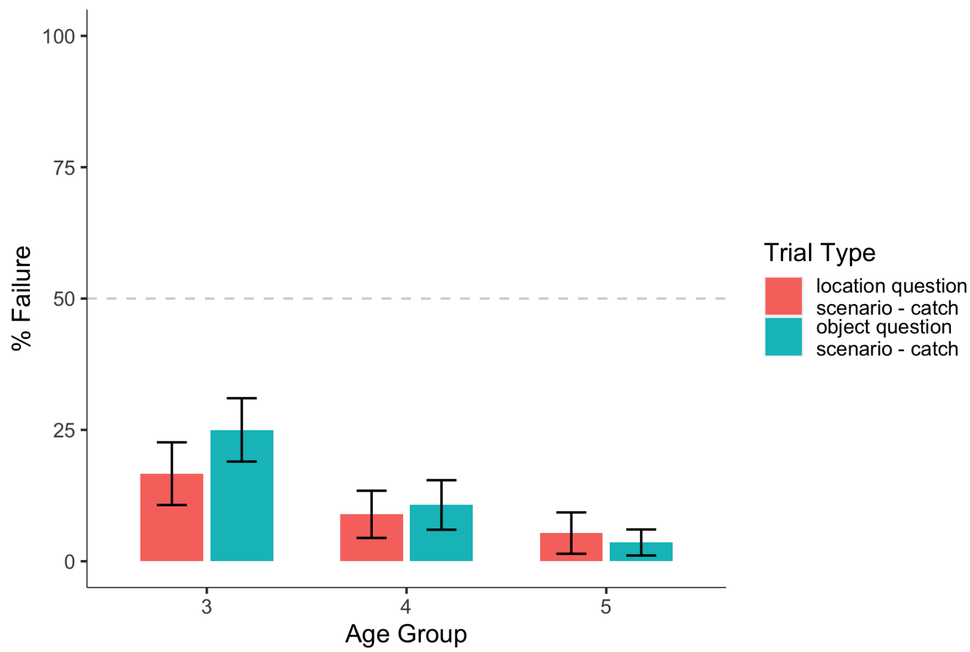
3.3. Exploratory and Post-Hoc Analyses:

Exploratory analyses were conducted to investigate potential factors that may have influenced the results. One possibility is that children simply do not understand the location question; for example, "Where did Diego put the water bottle? In the sandbox or in the birdhouse?" To investigate this possibility, we assessed the performance on object and location questions within the catch scenarios in all three age groups. Recall that the catch scenarios do not involve a location or an object change. The trial asks where the character will look for the object and what the object is. Thus, by analyzing performance on location and object questions, we can investigate if children are truly not understanding the nature of the question. We ran paired sample t-tests to assess performance on location questions within catch scenarios and performance on object questions within catch scenarios compared to chance. All age groups passed the catch scenarios, suggesting that 3-, 4-, and 5-year-olds respond correctly when the scenario does not involve a false-belief. Specifically, we found that 3-year-old performance was significantly better than chance on both location ($t(27) = -5.56$, $p = 3.608e-6$), with a mean failure rate of 16.67% (SD = 31.01%) and object questions within catch scenarios ($t(27) = -4.14$, $p = 0.0002$), with a mean failure rate of 25% (SD = 31.91%). We also found that 4-year-old performance was significantly better than chance on both location ($t(27) = -9.14$, $p = 4.72e-10$), with a mean failure rate of 8.93% (SD = 23.78%) and object questions within catch scenarios ($t(27) = -8.34$, $p = 3.009e-9$), with a mean failure rate of 10.71% (SD = 24.93%). And lastly, we found that 5-year-old performance was significantly better than chance on both location (t(27) =

-11.35, *p* = 4.391e-12), with a mean failure rate of 5.36% (SD = 20.81%) and object questions within catch scenarios were significantly better than chance (t(27) = -18.74, *p* = 2.2e-16), with a mean failure rate of 3.57% (SD = 13.11%). Shown in Figure 3.

Figure 3.

3-, 4-, and 5-year-old performance on location and object questions within catch scenarios



Note. All age groups passed both location and object questions within the catch condition.

4. Discussion

The results from the present study suggest that 4-year-old children performed significantly better on false-belief tasks that involve object changes compared to those that involved location changes, suggesting they prioritize object information over location information. In contrast, 5-year-olds passed both types of scenarios. While they performed worse on location-change scenarios, both location- and object-change conditions had very low failure rates, suggesting they were better able to take both object and location information into account when processing information. Finally, 3-year-olds failed both types of scenarios, but performed significantly better on object-change scenarios compared to location-change scenarios, again suggesting that they prioritize object information over location information.

These results are consistent with a vast body of research on the explicit understanding of false-belief in children aged 3 to 5 years. Specifically, previous research has consistently shown that children 5 years of age routinely pass explicit tasks on false-belief, while children around 3 years of age do not. In a meta-analysis of 178 studies on false-belief understanding, it was found that 5-year-olds performed better than younger children across studies on explicit false-belief tasks (Wellman et al., 2001). Additionally, Wellman's meta-analysis revealed that 3-year-olds have a limited understanding of false-beliefs, such that they are not able to consistently pass explicit false-belief tasks. In particular, the analysis found that 3-year-olds' performance on explicit false-belief tasks was significantly lower than that of 4- and 5-year-olds. The findings from the present study reflect these conclusions.

Further, a vast amount of literature reports conflicting data as to whether 4-year-olds do or do not have a ToM. In several studies involving variations of the Sally-Anne task, researchers found that some 4-year-olds were able to correctly predict that the character would look in the location that the object was in originally (Apperly & Butterfill, 2009; Wimmer & Hartl, 1991). In contrast, many studies have found that 4-year-olds struggle with explicit false-belief tasks and do not have a fully developed ToM. These conflicting findings report 4-year-olds' inability to correctly predict that the character would look in the item's original location (Carlson et al., 2002; Happé & Loth, 2002; Perner et al., 1987; Perner & Leekam, 2008). Our findings show that 4-year-olds passed the novel explicit false-belief task when the scenario involved an object-change, but failed when the scenario involved a location change. If a study is skewed to favor scenarios that involve changes in location rather than objects, then that study might conclude that 4-year-olds fail the explicit false-belief task, and would therefore conclude that this age group does not have a ToM. However, if a study is skewed to prefer scenarios that involve object changes rather than location changes, then the conclusion might be that 4-year-olds pass the explicit false-belief task, and, therefore, must have a ToM. The results from the present study reflect the inconsistent findings reported in previous literature.

The present study adds to our understanding of the role of object and location processing in the development of ToM by demonstrating that developmental differences in information processing affect performance on these tasks. By considering these developmental differences, researchers can better understand the timing of ToM development. The study highlights the importance of considering potential developmental differences in information processing when assessing the development of ToM in young children.

4.1. Implications

The implications of the present research are significant from both theoretical and practical perspectives. From a theoretical perspective, the findings suggest that false-belief tasks may not be measuring a singular, independent construct of Theory of Mind. Instead, these tasks may be tapping into different cognitive processes that develop at different rates. This highlights the need to carefully consider the types of false-belief tasks researchers use in their studies and to account for developmental differences in information processing when interpreting these results.

From a practical perspective, these findings have significance for educators and clinicians working with younger populations. The differential prioritization of information processing regarding location and object information may influence children's understanding of false-belief scenarios in real-world contexts, such as interpreting others' intentions and predicting their behavior. Understanding differences in information processing may help those who work with younger populations to modify their instruction to better meet the needs of children at different developmental stages.

Overall, the implications of this research underscore the need for a more nuanced and context-specific approach to understanding false-belief comprehension and ToM development. By taking into account the differential prioritization of information processing between location and object cues, researchers and practitioners can gain a more comprehensive understanding of how these cognitive processes develop in childhood and how they impact real-world social interactions.

4.2. Future Directions

These findings have highlighted the importance of considering the differential prioritization of information processing in false-belief tasks. Some potential future directions for research in this area include: 1) Investigating the impact of different types of false-belief scenarios on children's performance, such as those that involve both location and object changes in the same scenario, or those that involve more complex social situations. 2) Examining the impact of individual differences, such as culture, language ability and multilingualism, or socioeconomic class, on children's performance on false-belief tasks. 3) Using neuroimaging techniques to investigate the neural mechanisms involved in false-belief understanding and information processing development. Conducting neural data on participants from the behavioral sample would allow future research to directly investigate individual neural processing and performance on false-belief tasks. 4) Comparing the development of explicit and implicit false-belief understanding and investigating whether the differential prioritization of information processing is observed in both types of tasks. 5) Exploring the relationship between false-belief understanding and information processing development in childhood, and how individual differences and environmental factors may impact this development.

By continuing to explore these questions, researchers can gain a more nuanced understanding of how false-belief comprehension and information processing develop.

4.3. Conclusion

The importance of false-belief tasks in the history and current research of Theory of Mind cannot be overstated. These tasks have played a critical role in assessing children's understanding of others' beliefs that conflict with reality, which is considered a crucial aspect of ToM development. The emergence of false-belief tasks sparked a paradigm shift in ToM research, allowing researchers to study ToM more comprehensively and nuanced, leading to it becoming the most widely used method for assessing ToM in children. False-belief tasks have provided important insights into the cognitive and neural processes underlying ToM development, but the classic explicit false-belief task structure ignores critical developmental differences in location and object information prioritization.

The differential prioritization of object and location information when processing visual information has been found to be a significant factor for the outcomes of false-belief tasks and the conclusions drawn about the development of ToM in children. Testing false-belief development requires considering potential developmental differences in information processing to avoid drawing incorrect conclusions. By considering these developmental differences, researchers can gain a more nuanced understanding of the development of ToM in children.

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Appendix A

Location-Change Scenario Example

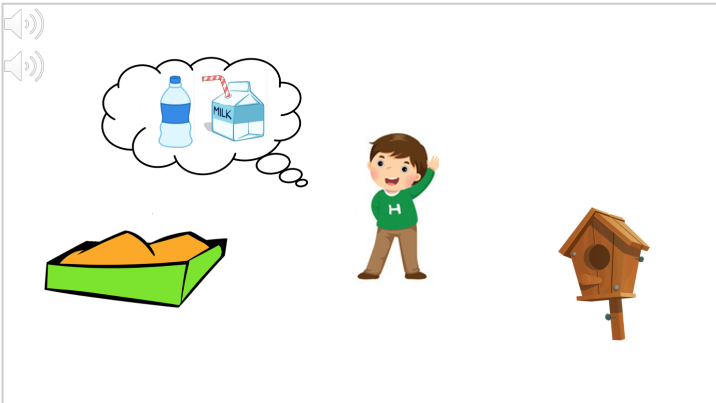

Figure A1. *Visual presentation of Diego & Jack scenario*

Scenario	Scenario Script
Diego & Jack	Here is Diego and his water. Diego put his water in the sandbox because he didn't want anyone to find it. Then Diego left. But while Diego was away, Jack came into the room and found Diego's water! He took Diego's water out of the sandbox and put the water in the birdhouse, and then Jack left. When Diego comes back, what happens next?

Question Type	Questions Script
Critical false-belief; location question	Would Diego go to the sandbox or the birdhouse?
Object question	What does he think is there? A water bottle or milk?
Naming-control	Who is this character? Diego or Jack?
Reality-control	Where is the water bottle really? The sandbox or the birdhouse?
Memory-control	Where was the water bottle in the beginning? The sandbox or the birdhouse?

Table A1. *Location-change scenario script: Diego & Jack*

Appendix B

Object-Change Scenario Example

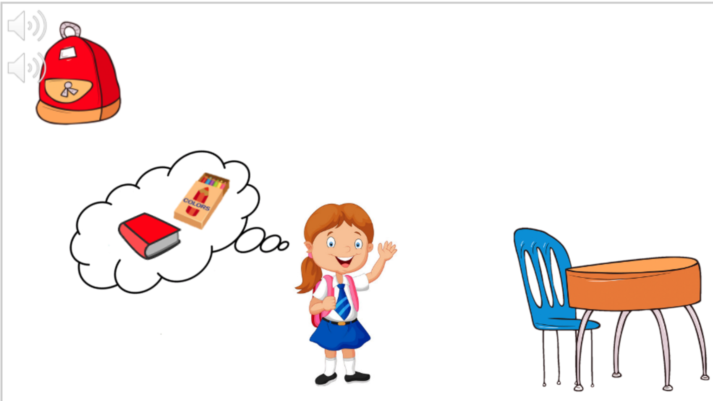

Figure B1. *Visual presentation of Katie & Alex scenario*

Scenario	Scenario Script
Katie & Alex	Here is Katie and her book. Katie put her book in the desk because she didn't want anyone to find it. But while Katie was away, Alex came into the room and found Katie's book! He took Katie's book out of the desk and put his pencils in the desk. Then Alex left. When Katie comes back, what happens next?

Question Type	Questions Script
Location question	Would Katie go to the backpack or the desk?
Critical false-belief; object question	What does Katie think is there? The book or pencils?
Naming-control	Who is this character? Katie or Alex?
Reality-control	What is in the desk really? The book or pencils?
Memory-control	What was in the desk in the beginning? The book or pencils?

Table B1. *Object-change scenario script: Katie & Alex*

Appendix C

Catch Scenario Example

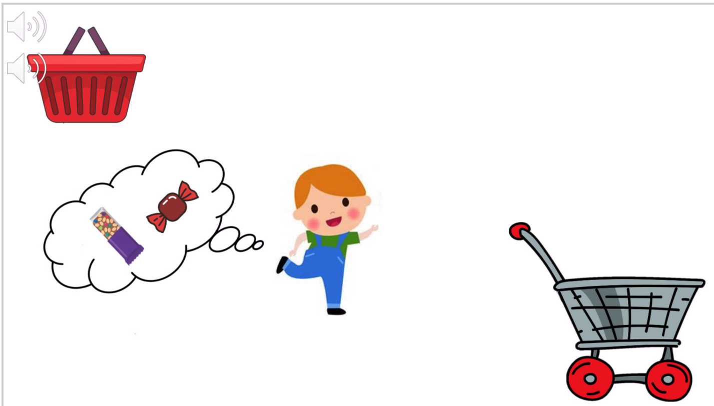

Figure C1. *Visual presentation of Thomas & Pablo scenario*

Scenario	Scenario Script
Thomas & Pablo	Thomas came into the room, left his candy in the cart, and then he left. While he was gone, Pablo came into the room. Pablo put a granola bar in the basket. Then Pablo left. When Thomas comes back, what happens next?

Question Type	Questions Script
Location question within catch condition	Would Thomas go to the basket or to the shopping cart?
Object question within catch condition	What does Thomas think is there? A granola bar or candy?
Naming-control	Who is this character? Thomas or Pablo?
Reality-control	What is in the shopping cart really? The granola bar or candy?
Memory-control	What was in the shopping cart in the beginning? The granola bar or candy?

Table C1. *Catch trial scenario script: Thomas & Pablo*

Appendix D

3-, 4-, and 5-year-old failure rate of location and object questions within location- and object-change scenarios

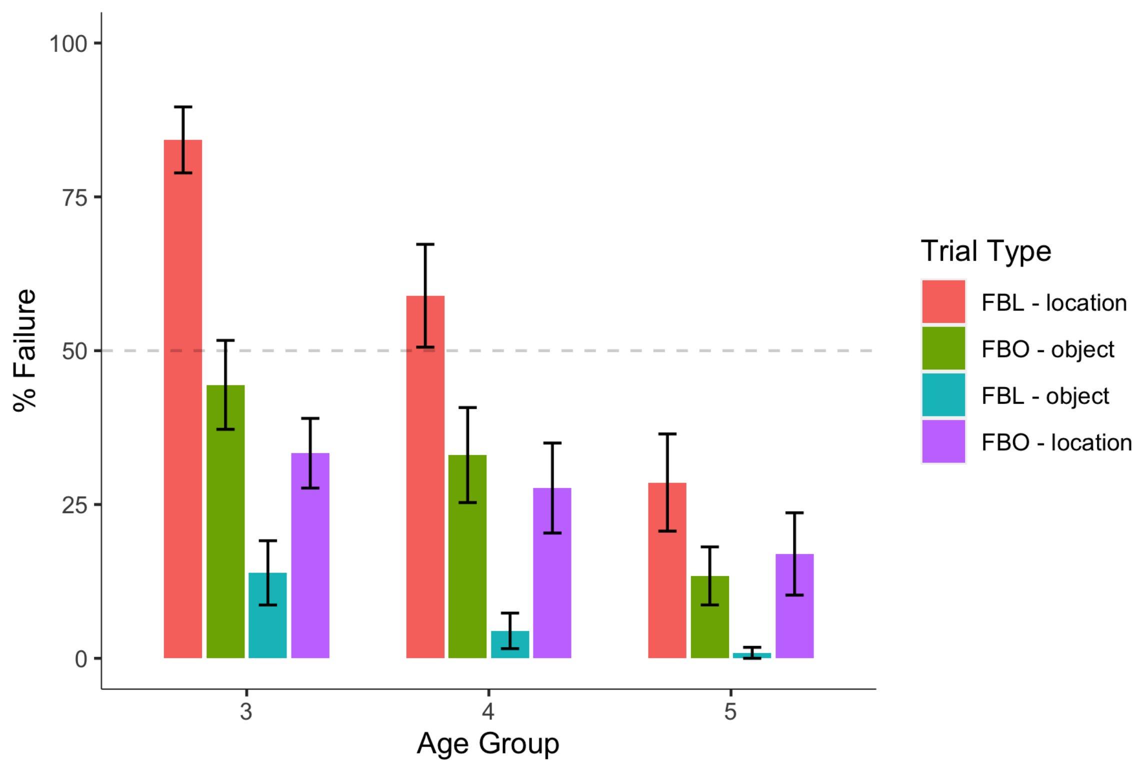

Figure D1.

Note. The present figure displays the failure rate of location and object questions within the False-Belief Location (FBL) and False-Belief Object (FBO) scenarios.