The Impact of Knowledge on False Belief Reasoning in Young Children

by

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Abstract

Studies have shown that adults are susceptible to a cognitive bias to attribute their own knowledge of an outcome to an uninformed person when they have a plausible reason to do so. The present research examines whether the plausibility of privileged knowledge of an outcome also influences 7-year-old children's false belief reasoning by making them susceptible to a bias to extend this knowledge to an uninformed person. Eighty-eight children aged 7 years were randomly assigned to one of 6 conditions on a modified false belief displacement task. The plausibility of children's knowledge of an outcome was manipulated in 6 different conditions. Results showed that at 7 years of age, children are aware of the plausibility of their own knowledge of an outcome in relation to other potential outcomes. However, children were susceptible to a bias to attribute their own knowledge to a naïve protagonist only under conditions where the implausibility of their own knowledge was ambiguous or not well defined. These findings were discussed in light of two theories proposed to explain false belief reasoning: a fluency misattribution hypotheses and executive functioning.

Keywords: false-belief reasoning; plausibility; curse of knowledge; theory of mind

Dedication

To lifelong learners who, from the beginning of time, have considered it a privilege and a delight to understand the how and the why of the world's social and natural phenomena.

To my mother, who taught me the value of commitment, and continued learning.

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I am grateful to the hosts and keepers of this land. I acknowledge that I am here uninvited but welcome in the unceded traditional territory of the Coast Salish Peoples, specifically the shared traditional territories of the Sḵwx̱wú7mesh Úxwumixw (Squamish), Tsleil-Waututh, and xʷməθkʷəy̓əm (Musqueam) and Kwikwetlem First Nations, where the campuses of Simon Fraser University are located. I respect the indigenous traditions and the peoples' profound knowledge and love for this land.

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Interest in this topic was seeded as a result of daily interactions with young students on the Autism Spectrum. From a privileged position, I have witnessed these children's difficulties in appreciating the perspective of others. They have often inadvertently shared their successes and struggles with me. This research has given me a greater insight into the differences children face when interacting within a complex social world. For this, I am sincerely grateful.

Words cannot express my gratitude to my partner, and biggest supporter, David. He has been a constant in my pursuit of this academic endeavour. This work was possible only after countless hours of reading, re-reading, and negotiating the meaning of words and sentences that made sense.

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List of Acronyms

EVT	Event Related Potential
FB	False Belief
FBT	False Belief Task
FM	Fluency Misattribution
HB	Hindsight Bias
IC	Inhibitory Control
IgL	Ignorance-Location
IgLL	Ignorance-Location/Label
ImL	Knowledge-Implausible-Location
ImLL	Knowledge-Implausible-Location/Labels
PAR	Perceptual Access Reasoning
PsL	Knowledge-Plausible-Location
PsLL	Knowledge-Plausible-Location/Labels
RT	Reaction Time
SES	Socioeconomic Status
TB	True Belief
ToM	Theory of Mind
WM	Working Memory

Chapter 1.

Introduction

A complete understanding of people as psychological beings requires a representational theory of mind (ToM; Premack & Woodruff, 1978), in which people do not act in response to an objective fact or truth but according to their own subjective beliefs, intentions, and desires or perspectives of reality (Wimmer & Perner, 1983; Dennett, 1987; Tomasello, 2018). Reasoning using ToM also relies upon an understanding that a subjective perspective, whether one's own perspective or that of another person, may not represent the "true" situation (or whatever anyone observing the situation objectively would agree is happening). A key indicator of ToM understanding used widely in child development research has been performance on a false belief (FB) task, where children are asked to predict whether an uninformed person will act in accordance with a belief that they alone know misrepresents reality (Wimmer & Perner, 1983). Put another way, a person with a false belief is likely to act in accordance with their misrepresentation of the state of affairs; therefore, false belief understanding represents a competency in reasoning about one's own and other's minds.

Although several tasks that tap false belief understanding are currently available (for a review, see Fabricius et al., 2021) a classic change of location false belief task has historically been used most extensively in child development research (Baron-Cohen et al., 1985; Wimmer & Perner, 1983). This task requires children to attend to a story where the protagonist, Maxi, a child of approximately their own age, puts a bar of chocolate in cupboard A and leaves the room to play on the playground. In Maxi's absence, Maxi's caregiver moves the chocolate bar to another cupboard (B) and then goes outside to the garden. When Maxi returns to the room, children are asked: "Where will Maxi look for the chocolate bar?" Children who respond that Maxi will look in cupboard A are assumed to be making this prediction based on their knowledge that Maxi holds a false belief that this is where the chocolate bar is located. They put aside their own perspective that Maxi's chocolate was moved to cupboard B, where it remains and, therefore, represents the current, true situation, to focus on the false belief of Maxi.

In a meta-analysis of 178 studies of false belief reasoning in preschool-aged children, Wellman et al. (2001) report that by 4.5 to 5 years of age, most children pass a classic change of location false belief task and predict that the protagonist will act according to their false belief that the object is where they had left it. However, younger children aged 2.5 to 4 years tend to erroneously predict that a naïve protagonist will act in accordance with their own informed perspective and look for the object where it had been moved. Wellman et al. report that the high pass rate among 5- and 6-year-olds (75% and 90%, respectively) represents a ceiling effect on the many variants of the classic false belief reasoning task. These findings led researchers at the time to conclude that by 5 years of age, most children come to understand that a person's mind can misrepresent reality. This critical achievement is thought to shift how children think about people, their intentions, beliefs, and actions in the social worlds around them. However, since the publication of this meta-analysis, a growing body of research indicates that a conclusion that children's reasoning about the beliefs of others is fully mature by this age is debatable on both theoretical and empirical grounds.

The remainder of this chapter reviews this body of research to provide a rationale for a study of the nature of false belief reasoning in children as they transition to middle childhood. The chapter is divided into two main sections. In the first section, several lines of research are reviewed that support a general need to continue to investigate false belief reasoning in children who are transitioning into middle childhood. The second section reviews research findings that together, provide the theoretical justification for a study of the impact of knowledge plausibility on false belief reasoning of 7-year-old children. The chapter concludes with a description of research questions and hypotheses that guide the study.

1.1. ToM and False Belief Reasoning in Middle Childhood

Two avenues of recent research provide converging evidence that children’s ToM, including their false belief reasoning, is not fully mature at 5 years of age and continues to develop during the transition to middle childhood. One group of studies questions the extent to which classic FB tasks tap into young children’s understanding of a representational ToM and presents evidence that the emergence of advanced understandings of false (and true) beliefs may be delayed after the age of 5 years (Fabricius et al., 2010; Fabricius & Khalil, 2003; Fabricius & Imbens-Bailey, 2000).

Another corpus of studies has documented that as children transition to middle childhood, their social cognition and reasoning about their own and others' beliefs represents a highly integrated cognitive system.

1.1.1. Changes in a Representational ToM

A growing number of studies suggest that most children do not have a full understanding of the nature of false beliefs until middle childhood (Fabricius & Khalil, 2003; Rakoczy & Oktay-Gür, 2020). For example, one paradoxical finding shows that once young children begin to master FB tasks, they begin to fail true belief (TB) tasks, and it is not until the age of 8 to 10 years that children pass both FB and TB tasks (Fabricius et al., 2010; Fabricius & Khalil, 2003; Hedger & Fabricius, 2011; Oktay-Gür & Rakoczy, 2017). The finding that children may fail TB but not FB tasks has been attributed to the pragmatic requirements of the TB task itself, such as the nature of true-belief questions that may appear trivial and confusing (Oktay-Gür & Rakoczy, 2017). Alternatively, other theorists argue that at the age of 4 years, children use perceptual access reasoning (PAR; Fabricius & Imbens-Bailey, 2000), not false belief reasoning, to pass a FB task. During PAR, children focus on what they see before them to decide what they know at that moment. This in the moment knowing is represented by a simple heuristic that differs from knowing that arises from belief reasoning or from memory of previous events after the situation changes (Fabricius et al., 2010; Fabricius & Khalil, 2003). In the context of the classic change of location false belief task, when Maxi returns to look for the chocolate, children who are PAR-users reason only about visible objects and events in the current context (i.e., the chocolate is in cupboard B). They do not consider prior events such as when Maxi put the chocolate in cupboard A, because they have no perceptual access to these past events. Children reason that Maxi does not see (and therefore, does not know) that the chocolate is in cupboard B; therefore, Maxi is not expected to search for the chocolate in cupboard B. By default, Maxi is predicted to look in cupboard A and as a result, children pass the false-belief task without attributing a false belief to Maxi.

In a series of experiments that investigated whether young children rely upon a PAR heuristic, Fabricius and Khalil (2003) administered 3 change of location FB tasks that varied in the type and order of questions asked. Each version of the task presented children with 3 possible locations to consider when predicting where a protagonist would look for an object after placing the object in one location, leaving the room (when the location of the object was changed), and then returning to the room. Having a third location added to the FB task ensured that a default response was not available. In addition to the 3 location-tasks, the researchers administered a classic 2-location FB task. A passing rate of 20% was reported among children 4.5- to 5.5-year-old children, and 47% among children aged 5 years 8 months to 6.5 years on the 3-location FB tasks, compared to a pass rate of 48% and 75% on a classic 2-location FB task. The finding that children's performance on the 3-location FB task was attenuated relative to the 2-location FB task provides initial support for the view that children may be using a PAR heuristic to solve a classic 2-location FB task; however, this finding also shows that false belief reasoning of children continues to improve as they transition to middle childhood (6- to 8- year-olds.

1.1.2. Errors in False Belief Reasoning

Other studies that provide strong evidence that false belief reasoning is not fully mature once children can pass a classic, change of location false belief task (i.e., 4-5 years) have focused on the persistence of errors in false belief reasoning that occur over the lifespan when more challenging variants of FB tasks are administered. Errors have been reported among 3-6-year-old children (Ghear & Baimel, et al., 2021), extend to children in middle childhood (Massaro et al., 2014), and to young adults (Birch & Bloom, 2007). To examine the extent to which a cognitive bias to assign one's own privileged knowledge to an uninformed person occurs over the lifespan, Bernstein (2021) administered a False Belief Sandbox task with 708 participants between the ages of 3 and 98 years. This task measures variation in false belief reasoning on a continuous scale rather than as a categorical pass/fail response. In this task, participants observe a person placing a toy at one end of a Styrofoam-filled box (152 cm long by 45.7 cm wide and 30.5 cm deep) and then leaving the room. In the person's absence, the toy is moved to a location at the other far end of the box. When the protagonist returns, the participants are asked to predict where the naïve person would look for the toy. The magnitude of cognitive bias to ascribe privileged knowledge about the final location of the toy to the uninformed person is predicted by the distance between the final location of the toy and the predicted location where the person would look for it. A bias to consider the false belief of the naïve person was estimated as the distance between the first location of the toy and the predicted location. Unexpectedly, the results showed that after controlling for age and executive functions, differences in the bias to predict that a naïve protagonist would act in accordance with one's own privileged knowledge or with a false belief were not statistically detectible. However, visual inspection of the results indicated more variability in the predictions made by younger children compared to older children and adults on this false belief task. Explicitly, the results showed that a tendency to make errors in false belief reasoning were present and remained relatively constant from preschool age to late adulthood.

1.1.3. Social Cognition and Advanced ToM in Middle Childhood

It is well-documented that as children enter middle childhood, they interact with others in expanded social networks (Bosacki et al., 2019). This context coincides with several notable shifts in ToM reasoning. Following Dennett (1978), Tomasello (2018) posits that as children take part in collaborative social interactions, they have increased opportunities to engage in shared intentionality, where they coordinate their own subjective perspective with the perspectives of others and with the same objective reality. Relatedly, other theorists argue that the emergence of an interpretative theory of mind, that is, coming to know and understand that different people may have multiple perspectives on the same reality (Carpendale & Chandler, 1996) is shaped by their experiences in sociocultural practices.

In a study of developmental change in interpretative theory of mind, Lagattuta, Sayfan, et al. (2014) investigated 4- to 10-year-old children and adults' judgements about how a small, ambiguous section (e.g., a wavy line) of an occluded image could be interpreted by persons who had not viewed the image in its entirety. First, the study required participants to think about interpretations of the picture other people would provide. Second, participants were asked to assign probability ratings on a scale ranging from 1 (less likely) to 10 (most likely) to pictures that could be behind the ambiguous image. The alternative pictures presented to participants were carefully selected and previously categorized by the researchers as probable, improbable, or impossible. For instance, a curved line, a probable option could be a picture of the sun; improbable, a picture of an umbrella; and an impossible, a picture of a television set.

Further, the study also examined how privileged knowledge of the actual pictures could impact participants' reasoning about others' perspectives. To undertake this, the study design included two experimental conditions and one control condition. The first was the knowledge condition in which participants had access to the actual pictures before being occluded (i.e., castle or cloud). The second was the uninformed condition in which participants only had access to the unidentifiable portion of the picture through a small window and were informed that there was a picture of an actual object behind the occluder. In the control condition, participants saw a cropped picture showing a panda bear's face (i.e., which was clearly identifiable as a panda bear).

The findings showed that when provided with an ambiguous section of a picture, older children (6- to 7- years of age), but not the younger group (4- to 5-year-olds), anticipated that other people would interpret the picture shown in novel ways. Children 6 to 7 years or older understood that the same situation could have different interpretations. The other important finding of this study was that knowledgeable participants of all ages overestimated the likelihood that naïve individuals would guess the actual picture. By contrast, uninformed participants were not biased when rating the probability that other people would guess the pictures. Specifically, uninformed participants rated the actual pictures (i.e., castle and cloud) with similar probabilities as those considered improbable.

Other studies have examined the biasing effect of having privileged knowledge about an object's identity when reasoning about a more naïve perspective (Bernstein et al., 2004). Bernstein et al. (2004) conducted two experiments that employed an object identification task, to examine this effect among 3- to 5-year-olds and adults. In this study, participants first saw a degraded image of an object on a computer screen. Evolving images were then presented to the participants. They were then asked to pinpoint when they could recognize the object behind the image. Following that, children estimated when a naïve person would identify the object behind the image. In half of the trials, participants had access to the actual image beforehand (knowledgeable condition). In the other half, they only saw the blurred, pixeled, or cropped image of the object (uninformed condition). In both experiments, all participants in the knowledge trials overestimated the likelihood that an uninformed person would know the object's identity at a level of degradation that even the participants were unable to distinguish. The first experiment provided evidence of a decrease in cognitive bias with age.

However, in the second experiment, there was no evidence of this bias declining with age. Hence, studies employing visual stimuli have demonstrated the pervasive effect of knowledge when individuals (of all ages) reason about the naïve perspective of others.

These and other studies unveil developments in children's social cognition beyond false belief reasoning in preschoolers. As children transition to middle childhood (6-7 years of age), the scope and complexity of their reasoning about the minds of others, including false beliefs, expand. Children at this age reliably engage in reasoning about thought probability (Lagattuta, Sayfan, et al., 2014); they interpret ambiguous social information (Bosacki & Wilde Astington, 1999; Devine & Hughes, 2013); they engage in more-complex perspective-taking and learn to successfully reason about people's behaviours in social and moral contexts (Carpendale & Chandler, 1996; Lagattuta et al., 2015).

Studies have also shown advances in ToM reasoning when children are asked to: justify their responses on ToM tasks using explicit mentalistic terms (Massaro et al., 2014), consider past histories when attending to the false beliefs of others to predict their emotions (Seidenfeld et al., 2017), and engage in counterfactual reasoning associated with false beliefs (Rafetseder et al., 2021). In addition, correlational studies haves shown links between FB understanding and children's emerging awareness of sarcasm as humour (Lee et al., 2021).

Although the content of these tasks varies (for a comprehensive review, see Osterhaus & Bosacki, 2022), there is mounting evidence from studies using factor analytic methods that a single, underlying latent factor accounts for variance in ToM task performance throughout early and middle childhood (Devine & Hughes, 2016). Evidence from meta-analyses of functional brain imaging studies also suggests that the left dorsal temporoparietal junction, which is associated with a domain-general ability to focus on task-relevant representations when self-related and other-related representations conflict (Quesque & Brass, 2019), is engaged during false belief reasoning (Schurz et al., 2013).

While ToM appears to be a unitary, domain-general construct for children in early and middle childhood, individual variation on how older children in this age range reason with a ToM is not well understood. One possibility is that as children begin to subordinate reality to possibility when thinking about their own and other's perspectives

(Lagattuta et al., 2010), they may also begin to engage in more interpretative reasoning on complex FB tasks that require them to evaluate the plausibility of a protagonist's actions.

Following the theoretical (Birch, 2005; Birch & Bloom, 2003, 2004) and empirical work of Birch and Bloom (2003, 2007), the present research is grounded in the theory that posits that access to privileged knowledge potentially biases reasoning about the perspectives and actions of more naïve others. While most children at 7 years of age easily set aside their own knowledge to consider the more naïve perspective of the protagonist on a 2-container change of location false belief task, they may engage in more interpretative reasoning with more complex FB tasks. For example, Birch and Bloom (2007) found that even adults are susceptible to a cognitive bias to attribute their own perspective to a naïve protagonist when they had a plausible reason (in their own minds) to do so. Using a measure adapted from Birch and Bloom's study with adults, the present study examines whether the plausibility of knowledge (interpreted from the child's perspective) also influences false belief reasoning among 7-year-old children. The following section of the chapter reviews research that provides a context for the current study.

1.2. The Curse of Knowledge

Birch and Bloom (2003, 2004) propose that young children's errors on false belief tasks occur when children fail to ignore their own privileged knowledge (i.e., about the true state of affairs) when considering the naïve or uninformed perspective of others who hold a false belief. Following Camerer et al. (1989), the authors refer to this cognitive bias as the "curse of knowledge." Camerer et al. initially used this term to represent their findings that sales agents who had knowledge of a company's earnings could not ignore this information when predicting what uninformed people would think about the company's earnings. The sales agents were biased or "cursed" by their privileged knowledge about their company and were subsequently inaccurate in their predictions about what less informed people knew. A cognitive bias to refer to one's knowledge when reasoning about the minds of others has been described using different terms. Expressions such as 'epistemic egocentrism' (Royzman et al., 2003), 'creeping determinism' (Fischhoff, 1975), 'hindsight bias' (Fischhoff, 1975), 'realist bias' (L. M. Taylor & Mitchell, 1997), the 'knew-it all-along effect (Wood, 1978) and 'outcome bias'

(Baron & Hershey, 1988), describe the tendency to be biased by the knowledge individuals possess when judging what others know and predicting their actions. The term "curse of knowledge" is routinely adopted by developmental psychologists (Ghrear, Fung, et al., 2021).

Although Birch and Bloom’s (2003, 2004) description of “the curse of knowledge” has been studied extensively among adults, comparatively few studies have examined the impact of this cognitive bias on children’s social cognition. However, research has shown that young children show this bias to a greater degree than older children and adults (e.g., (Bernstein et al., 2007; Birch & Bloom, 2003; Ghrear, Baimel, et al., 2021). This finding suggests that as children grow older, attributing mental states to others whose naïve perspective differs from one's informed perspective is expected to become more accessible.

The cognitive mechanism(s) that explain why younger children, relative to older children and young adults, are less able to put aside their own knowledge when appreciating a more naïve perspective is not well understood. One possibility is that relative to younger children, older children and adults have a greater capacity to access a suite of executive functions (e.g., inhibitory control, working memory) that, together, are necessary to overcome a bias to privilege their own knowledge so they can focus on the beliefs of uninformed others (Bayen et al., 2007; Birch & Bernstein, 2007; Lagattuta et al., 2014; Lagattuta et al., 2010; Pohl et al., 2003). A positive association between false belief task performance and tasks measuring inhibitory control has been reported in behavioural studies in both children (Carlson et al., 2002, 2015; Devine & Hughes, 2014; Moses & Tahiroglu, 2010) and adults (Bernstein, Thornton, et al., 2011). Further, as children grow older, the executive system that is foundational to performance on more complex FB tasks not only expands to accommodate processing involved with inhibiting attention to their knowledge (Carlson & Moses, 2001) but also to coordinate their own perspective with other psychological inferences about the mental states of others (Lagattuta, Sayfan, et al., 2014).

Another account researchers have used to explain the cognitive mechanism (s) underlying the ‘curse of knowledge’ is fluency misattribution (Birch et al., 2017). According to the fluency misattribution account (i.e., FM), when individuals subjectively interpret a piece of information effortlessly, they may take this fluency as an indicator of how objective and widely known this knowledge may be to others (Birch et al., 2017). Put another way, individuals may not accurately identify that their feelings of fluency with a piece of information have their origins in previous or recurring experiences with that knowledge and not with the availability of this knowledge to others. Subsequently, people may misattribute this subjective fluency to others and reason that they may also possess this knowledge. Therefore, when individuals are asked to judge what others know about a subject, they mistakenly assume that if this information is fluently processed, easy to recall, or familiar, others may also know that (Bernstein et al., 2018; Birch et al., 2017; Harley, 2007).

Birch et al. (2017) conducted 3 studies on the impact of fluency and content knowledge on adults' reasoning about how common specific content knowledge is to naïve peers. These researchers were interested in investigating whether FM would contribute to the curse of knowledge bias and whether this bias would occur even in the absence of knowledge. The findings in the 3 experiments showed that FM could independently and sufficiently account for the curse of knowledge bias.

Ghrear, Fung, et al.(2021) contend that knowledge that is well known to individuals because of previous exposure would contribute to the curse of knowledge. Conversely, unfamiliar knowledge that people have briefly encountered may be a factor in minimizing the curse of knowledge bias. Consequently, the curse of knowledge bias may result from the subjective feelings of fluency caused by familiarity and subsequent facility with which the information comes to mind (Birch et al., 2017; Ghrear, Fung, et al., 2021).

To demonstrate the impact of familiarity with knowledge on children's prediction of others' knowledge state, Ghrear, Fung, et al. (2021) conducted 3 experiments with young children (i.e., aged 4 to 7 years). In the first experiment, researchers found that children with access to novel information did not overestimate that other children would know this information. This effect decreased with age, as older children were less likely to predict that other peers would also possess this knowledge. The researchers concluded that the curse of knowledge was not observed in this first group of children because the information was not fluent and was basically new to the participants.

To confirm these findings, the authors conducted two more experiments to test whether familiarity with the information was a decisive factor in influencing children's predictions about what other peers would know. The results in experiments 2 and 3 demonstrated that when children were familiar with knowledge (i.e., researchers specifically provide participants with seemingly familiar [but inaccurate] information), they overestimated that others would also know this familiar information. Conversely, children who were only told a set of new but unfamiliar facts, did not present with a biased perspective of what other children would know. The authors concluded that these findings supported the fluency misattribution account to explain the curse of knowledge bias. Notably, Ghrear, Fung, et al. (2021) demonstrated that the familiarity with which children had access to new information caused a biasing effect on their reasoning about others' perspectives and actions. For the purpose of the present study, it is critical to appreciate how the curse of knowledge bias in children may be associated with the fluency with which individuals process the information.

1.2.1. Sensitivity to Conflicting Knowledge States

If access to privileged knowledge biases children's reasoning about beliefs and other mental states of less informed persons, this bias is expected to influence performance on a wide range of memory and reasoning tasks when children are informed but not when they are ignorant. The research findings available affirm that by 5 years of age, most children are sensitive to differences between knowledge and ignorance states (Bernstein et al., 2007; Birch & Bloom, 2003; Sabbagh & Baldwin, 2001). This sensitivity to different knowledge states applies to situations where children discriminate their current knowledge from their own earlier, naïve state (as in hindsight bias) or their own knowledge in relation to the knowledge of naïve others (as on a change of location FB task).

Children's sensitivity to differences between their own and others' knowledge is manifested at a very young age. In a study of children aged 3 to 5 years, Birch and Bloom (2003) found that access to privileged knowledge biased children's reasoning about the content of uninformed others' knowledge. In their research, children were asked to judge whether a puppet, "Percy," knew about the contents of unfamiliar toys. Children who had knowledge of the unfamiliar toy's contents were more likely to judge that Percy shared their knowledge than children who were ignorant of the toy's contents.

At 3 years of age, children overestimated the probability that Percy shared their knowledge, yet they did not overestimate that Percy shared their ignorance. As predicted by the researchers, 5-6-year-old children were less susceptible to this cognitive bias than 3-year-old children, and they were better able to attribute a knowledge state that differed from their own to Percy. Birch and Bloom interpreted this finding as evidence that the strength of the cognitive bias to attend to their own privileged knowledge was greater among 3-year-olds, whereas this cognitive bias was attenuated among older children.

Studies that have investigated developmental variation in performance on hindsight bias tasks have also shown that children are more susceptible to this bias than adults (Bayen et al., 2007; Bernstein, Erdfelder, et al., 2011; Pohl & Haracic, 2005) and younger children are more susceptible than older children (Bernstein et al., 2004; Birch & Bloom, 2003; Taylor et al., 1994). A more thorough review of the hindsight bias research to provide further context for this research is presented in chapter 2; however, the current discussion emphasizes a review of studies that provide strong evidence that a cognitive bias to attend to one's own informed state influences one's reasoning about perspectives and predict the actions of more naïve others.

1.2.2. Knowledge and False Belief Reasoning

Two selected studies provide strong evidence that a cognitive bias to assign one's own privileged knowledge to a naïve other constrains false belief reasoning. Following Birch and Bloom (2007), Ghrear, Baimel, et al. (2021) examined the impact of having privileged knowledge on false-belief reasoning among 3–6-year-old children. Children completed a modified change of location FB task where they observed a picture of 4 containers, each a different colour, arranged in a row. An adult used stick figures to highlight and draw children's attention to significant events as the story narrative was read aloud to them. Children heard 4 different stories that represented a false belief paradigm; each story manipulated children's knowledge of the outcome (Ignorance, Knowledgeable) on 4 trials. On two of the trials, children were told where the target object was placed after the displacement (Knowledgeable). In the remaining two trials, children were only told that the object was moved to "another" container without specifying which container. After completing a trial, children were asked to predict where the protagonist would look for the object (e.g., "Where will Bill look for the chocolate bar?"). Then, children were asked two memory (control) questions (i.e., “do you know where the chocolate bar really is?” and “did Bill see Jane moving the chocolate bar?”). The data were submitted to mixed effect logistic regression analyses with participant as the random intercept. The final model reported that younger, 3-year-old children performed as well as older children, 4-6 years of age, when the location of the object was unknown, but their performance declined when the outcome was known. While younger children were more susceptible to “the curse of knowledge,” it is important to note that 5- and 6-year-old children passed both Outcome Known and Outcome Unknown trials at a much lower rate than reported in previous research where a pass rate of 65% and 75% (average) respectively had been reported on classic false belief tasks (Wellman et al., 2001). Taken together, these results suggest that even older children are susceptible to a cognitive bias to privilege their own knowledge when thinking about perspectives of less informed others. However, this bias impacts their reasoning to a lesser degree than younger children.

Another possibility is that as older children transition to middle childhood, they engage in more complex reasoning that may make them more susceptible to the "curse of knowledge" on more complex false belief reasoning tasks. As previously mentioned, Birch and Bloom (2007) showed that adults are susceptible to a curse of knowledge when they have a plausible reason to ascribe their own knowledge to a naïve person who holds a false belief. In their research, adults were shown an illustration where Vicky, the protagonist of the story, held a violin and stood in front of four coloured containers in a semi-circular arrangement. The adults who participated in the research read a script that described a sequence of actions: Vicky first plays the violin, then places it in the blue container, and leaves the room. A second illustration and corresponding script describe the following actions: Denisse, Vicky's sister, enters the room. At this point, the stories differed as to three experimental conditions: In the Ignorance condition, adults read that Denisse had moved the violin, but no information was provided about where the violin had been moved. Then Denisse rearranged the containers. In the Knowledge-Plausible condition, adults read that Denisse moved the violin to the red container, which, after rearrangement, was placed where the blue container was initially located. In the Knowledge-Implausible condition, adults read that Denisse had moved the violin to the purple container, which after rearrangement, had no association with the blue container's original location. Then, adults were asked to provide probability ratings to indicate the likelihood that Vicky would look in each container when Vicky returned. The results showed that only adults in the Knowledge-Plausible Condition, and not adults in the Knowledge-Implausible Condition, overestimated the probability that Vicky would search for her violin in the container where the adults knew the violin was located. Birch and Bloom interpreted these findings as evidence demonstrating that adults are likely to ascribe their own knowledge to more naïve others when they have a plausible rationale for inflating their estimates of what others know. However, the authors caution that learning new information is not enough to invoke the curse of knowledge for adults. Instead, consistent with a fluency misattribution account, the information must make sense and align with what adults already know so that the information is perceived as evident. Therefore, adults misattribute this information to the protagonist with ease (Birch et al., 2017).

Birch and Bloom’s (2007) findings were only partially replicated by Ryskin and Brown-Schmidt, (2014). Their study included 7 replications; however, they reported a significant curse of knowledge bias effect in only three of these replications. The average effect size across seven studies was 0.20 (Cohen’s d), which is considerably smaller than the 0.469 estimated from Birch and Bloom’s data. In contrast, most studies that have used the Birch and Bloom (2007) paradigm report results consistent with the Birch and Bloom findings. In another study, Farrar and Ostojić (2018) tested whether the social distance between the adults in the research and the protagonist shown in the illustration on the FB task could moderate differences in the magnitude of effect sizes obtained by Ryskin and Brown-Schmidt and found no significant effect. Rather, the authors report effect sizes aligned more closely with those originally estimated by Birch and Bloom (2007).

Support for Birch and Bloom's results has been reported in 3 additional studies. Converse et al. (2008) used the paradigm to examine how mood modulated ToM reasoning. In another study, researchers employed Birch and Bloom’s (2007) false belief paradigm to investigate how thermal experiences (i.e., cooler or warmer temperatures) would moderate perspective taking in young adults (Sassenrath et al., 2013). The third example is the study conducted by Dębska and Komorowska (2013). The study introduced a modification to the Birch and Bloom (2007) paradigm to examine whether priming could explain the findings reported by Birch and Bloom. The researchers contended that in the Birch and Bloom study, adults' attention was explicitly directed to the container representing a plausible outcome (i.e., the red container). They asserted that this information may well have had a priming effect that ultimately influenced participants' responses. However, after they experimentally tested different forms of priming, the researchers concluded that priming did not account for the Birch and Bloom research findings. Instead, they reported that, like Birch and Bloom, the biasing effect of knowledge could better explain the observed results. In other words, adults in this study confirmed that the “curse of knowledge” described by Birch and Bloom (2007) experiment was also a valid explanation for their findings.

1.3. Study Objectives and Hypotheses

In summary, the selected research reviewed in this chapter demonstrates a need for further research on the false belief reasoning of children as they transition to middle childhood. As there is sufficient evidence that at this age, children are sensitive to differences between their own and other’s knowledge states (Rohwer et al., 2012) and they also appear to have a basic understanding of the concept of plausibility (Yacovone, 2021), the reasonable assumption is that by 7 years of age, children have the capacity to attend to the plausibility of their own and other’s knowledge. Therefore, this assumption is tested by the first hypothesis in the present research that posits children at 7 years of age are sensitive to the plausibility of their own and other’s knowledge.

Whether a sensitivity to the plausibility of conflicting knowledge states influences false belief reasoning among children as previously shown with adults remains unresolved. However, as the research findings discussed in the chapter show that ToM reasoning continues to develop long after children reach an age where they pass a classic false belief task, it seems reasonable to assume that as with adults, a bias to attribute one’s own privileged knowledge to a naïve other may emerge when children have a plausible reason to do so. Therefore, the second hypothesis tested in this research posits that 7-year-old children will attribute their own knowledge to naïve others when they have a plausible reason to do so.

In Chapter 2, an expanded literature review on the impact of privileged knowledge in reasoning about the perspectives of uninformed others, and the cognitive mechanisms that potentially explain this cognitive bias provides further context for the present research.

Chapter 2.

Literature Review

An essential part of human social interaction lies in people's ability to infer accurately what others know or what is not available to them. Effective social communication requires people to constantly anticipate another's information state to achieve mutual understanding. Further, humans are genetically predisposed to construct new knowledge (Birch & Bernstein, 2007). However, once new knowledge becomes available; people may find it difficult to ignore it when judging what they previously knew or what others with more, less, or different information would know (Ghrear, Baimel et al., 2021; Hoffrage et al., 2000). Essentially, what people know may bias their reasoning about a naïve perspective, whether this is their own, earlier perspective or the current perspective of an uninformed person (Birch, Brosseau-Liard, et al., 2017; Birch, Li, et al., 2017).

As mentioned in Chapter 1, researchers have described this cognitive bias in different ways, depending on the research discipline or the specific context that is being examined. These terms include: “hindsight bias” (Bernstein & Harley, 2007), "knew it all along" effect (Wood, 1978), “epistemic egocentrism” (Royzman et al., 2003), “creeping determinism” (Fischhoff, 1975), and “realist bias” (Taylor & Mitchell, 1997). This chapter reviews the body of research that has examined the curse of knowledge and its impact on social cognition of children and adults. Two theoretical accounts used in the research to explain the cognitive mechanism that accounts for this cognitive bias are also discussed: a fluency misattribution hypothesis and explanations associated with developmental or individual differences in an executive system.

2.1. Impact of Knowledge on Social Cognition

The broad impact of privileged knowledge on social cognition has been studied extensively among adults but less so in children (Bayen et al., 2007; Birch, Brosseau-Liard, et al., 2017). In a seminal study, Fischhoff (1975) investigated the impact of outcome knowledge on adults' judgements of the probability of occurrence of these outcomes. All adults in this research first read a narrative describing two unfamiliar historical events. The first event described was a battle between the British Army and the Gurka troops of Nepal in the northern frontier of Bengal in 1814. The second event was related to the riots occurring in Atlanta, Georgia, in 1967, which were racially motivated. All the participants were provided with four possible outcomes and asked to judge the likelihood of each of these resolutions. However, a group of participants had access to the actual "true" outcome of each event but were told to *ignore* this information when evaluating the likelihood of each of the four possible resolutions.

In contrast, adults in the control group were not provided with any additional information about the actual outcome of each event. The results showed that adults who had knowledge of the event's outcome selected an ending that aligned with this knowledge; however, adults unfamiliar with the event's outcome responded randomly and predicted each of the four endings as equally probable. Further, adults who knew the outcome were unaware that this knowledge had biased their judgments. This observation led the authors to conclude that privileged information was integrated automatically and immediately into adults' memory, and therefore, this effect was unavoidable (Fischhoff, 1975).

Most studies that have examined a bias to attend to one's own knowledge when considering a naïve perspective in the adult literature have relied upon hindsight bias tasks. Hindsight bias refers to a tendency to consider updated knowledge when recalling one's own naïve perspective (Fischhoff, 1975; R. F. Pohl, 1998). Of specific interest to the present research is Wasserman et al. (1991)'s study that examined whether variance in having a reasonable explanation for a known outcome reduced the biased judgements in adults' estimations of the likelihood of various outcomes of historical events. Researchers predicted that participants with a less plausible explanation of the outcomes would present with a less biased judgement than the group of participants with more plausible explanations and those with knowledge of the event's outcome but no explanation of the causal factors. Thus, the study manipulated the plausibility of explanations for a known outcome in 3 conditions, chance, or random outcome (low plausibility), deterministic outcome (high plausibility), actual outcome without explanation. In a low plausibility condition, the outcome was described as a *chance* event (e.g., the British won the battle against the Gurka because of an earthquake or a monsoon). In a plausible condition, the explanation for the outcome was deterministic and relatively more plausible (e.g., British troops' success was a result of the troops' high discipline). In the third control condition, individuals had access to the actual outcome of the events but were not provided with explanations to justify the outcome. Adults in each condition were subsequently asked to estimate the likelihood of each outcome by writing the probability of its occurrence on a value from 0 to 100. The results of this study showed that hindsight bias could be attenuated or even eliminated when the plausibility of the explanation for the event's outcome was random. Specifically, adults in the condition where the known outcome was described as a random event reported more accurate and unbiased judgements of a situation than adults in the second condition who had been provided with deterministic explanations of the known outcome. Further, adults in the condition with a random explanation also manifested significantly less bias in their judgements than those with knowledge of the actual outcome but no explanation.

As discussed in Chapter 1, studies have also shown that among adults, a bias to ascribe one's own knowledge to an uninformed person is more likely to occur if adults have a plausible reason to do so (Birch & Bloom, 2007; Converse et al., 2008; Dębska & Komorowska, 2013; Farrar & Ostojić, 2018; Ryskin & Brown-Schmidt, 2014). Research findings from the child development literature suggest that under conditions where children's privileged knowledge is plausible, they may also be susceptible to a cognitive bias to extend their own knowledge to uninformed others.

Studies of the impact of privileged knowledge on reasoning about a naïve (ignorant) perspective have shown that at a young age, children are sensitive to their own, and others' knowledge and ignorance states (Bernstein et al., 2007; Birch & Bloom, 2003; Sabbagh & Baldwin, 2001). Taylor and colleagues (1994) found that by the age of 5 years, children distinguished present and earlier knowledge states and were aware that their present, updated knowledge could differ from their earlier knowledge. Further, 5-year-old children also recognized that an uninformed age-peer would have a naïve perspective that differed from their own updated perspective; younger, 4-year-old children reported they would share the same knowledge.

Other research has examined whether susceptibility to a bias to attribute one's own knowledge to an uninformed person varies among older children and adults (Dumontheil et al., 2010; Epley et al., 2004; Keysar et al., 2003; Symeonidou et al., 2016). Epley et al. (2004) designed a perspectival cognition task to examine this issue. Children aged 4 to 12 years old (mean = 6.2), and adults were first shown a shelf with an array of boxes in which different toys were located. Some boxes were occluded to the view of a “director” who was a research assistant sitting behind the shelf. The director showed each participant a picture of the boxes with objects that were occluded from the director’s point of view and then instructed the participants to move the objects to different boxes. To respond accurately to the director’s instructions, participants had to consider that the director's perspective differed from their own more informed perspective. For example, to respond accurately to the director's request to "move the small truck," children and adults had to consider that although they saw 1 large truck and 2 small trucks in different boxes on the shelf, only the box with the large truck and another box with 1 of the 2 small trucks was visible to the director. Researchers used eye-tracking technology to collect participants' responses. The data analysis showed that as children and adults considered a response to the director's instruction, they were inclined to look first at objects in their own view but hidden from the director; however, compared to adults, children were slower in switching their eye-gaze to an object within the view of the director to follow the director’s instructions. Further, children were more likely than adults to move objects according to their own perspective and not consider the director's point of view.

Cross-sectional and longitudinal studies of age-related or developmental change in susceptibility to becoming biased by one's own knowledge when considering a naïve perspective have mainly focused on variation in performance on hindsight bias tasks. In general, studies have reported a U-shaped developmental curve that represents younger children, and older adults are more susceptible to hindsight bias than older children and young adults (Bernstein et al., 2004; Bernstein, Edfelder et al., 2011; Birch & Bloom, 2003; Taylor et al., 1994; Pohl et al., 2018). Further, in a recent study with a large sample (N = 708; Range age 2.6 to 98 years), Bernstein (2021) documented evidence to support this U-shaped trajectory of hindsight bias. However, a more sensitive measure for false belief (i.e., Sandbox task) yielded evidence of an egocentric bias across all age groups. That is, individuals across all ages who had access to privileged knowledge used this knowledge to predict the actions of the naïve protagonist.

2.2. A Fluency Misattribution Hypothesis

Although this growing body of research has shown that access to privileged knowledge continues to impact children’s reasoning about a naïve perspective past age

5, the cognitive mechanism that explains this result remains largely hypothetical. A fluency misattribution hypothesis posits that when a person senses that their own knowledge is easy to recall or this new knowledge aligns well with their prior knowledge, they are susceptible to a bias to consider it common knowledge that is equally fluent (familiar) to everyone, including a person with a naïve perspective (Bernstein et al., 2018; Bernstein & Harley, 2007; Birch, Brosseau-Liard, et al., 2017; Harley et al., 2004). Put another way, when children's knowledge comes with ease to mind, they are likely to make a metacognitive judgement that this knowledge is also familiar and easily accessible to naïve others.

As conceptualized in a fluency misattribution hypothesis, a sense of fluency is a ubiquitous metacognitive cue that has a role in many human decisions and judgements (Alter & Oppenheimer, 2009). It contributes to decisions of liking (Reber et al., 1998); judgments of fame (Jacoby et al., 1989), stocks value (Alter & Oppenheimer, 2006); companies value (Hertwig et al., 2008), and even perceptions of fairness (Greifeneder et al., 2011). Unkelbach and Greifeneder (2013) suggested that people use a sense of fluency experienced with almost any mental process to make decisions about what, at that moment, has unknown certainty. The authors describe "fluency" within the context of the "lens model" proposed by Hammond (1955). This model purports that people use proximal cues readily available to understand distal criteria, which features are non-accessible. For example, a proximal cue to judge intelligence (a distal criterion) can be school grades or intelligence test results (proximal cues). School grades or a test of intelligence have a probabilistic relationship with the construct of intelligence, but it is not intelligence. Instead, the extent of this correlation depends on the weight individuals place on the cue when inferring or judging the distal criterion. In the case of fluency, people use their metacognitive judgement of the ease of fluency as a proximal cue to judge a distal criterion for which there is no direct available input. Specifically, a sense of fluency is a metacognitive cue that is readily available in any ongoing mental process. People consider fluency of the ongoing event when judging its distal properties to make a judgement (how pretty, how frequent, how famous, how true the statement can be).

In studies that have examined the impact of plausibility of knowledge on false belief reasoning, it is assumed that high plausibility of a person's own knowledge serves as a proximal cue for the person to judge what naïve others may know (Ghrear, Fung, et al., 2021; Birch, Brosseau-Liard et al., 2017). Birch and Bloom's (2007) study of the impact of knowledge plausibility on adults' false belief reasoning is illustrative. In the false belief-displacement task used in the research, adults read a story with two characters: Vicky, the protagonist, and Denisse, the protagonist's sister. The adult read that Vicky placed her violin in the blue container and left the room. In Vicky's absence, Denisse entered the room, moved the violin to the red container, and rearranged the boxes. When Vicky returns to the room, the red container is a highly plausible place for Vicky to look for the violin because it is now placed where the blue container was initially located. Theoretically, as knowledge that the violin is in the red container is highly plausible, it is likely to come easily to mind and interpreted as common knowledge also available to the naïve protagonist. Adults may have erroneously misattributed the familiarity of their own knowledge to the naïve protagonist and put aside their knowledge that the protagonist holds a false belief that the violin is in the blue container.

Birch, Brosseau-Liard, et al. (2017) further examined how knowledge familiarity impacts a person's judgements about how widespread that knowledge could be among the general population. In the first experiment, participants were presented with unfamiliar words and trivia questions. The researchers manipulated the familiarity of participants' knowledge by teaching them the answers to some of the trivia questions and providing the meaning for some of the unfamiliar words. They also manipulated the time delay (the same day or a week apart) between adults' access to knowledge of the answers/meanings and their predictions about what a naïve peer would know. Results showed that adults overestimated how widespread their knowledge was shared with uninformed peers; however, the effect was more significant after a one-week delay than compared to the same day. The results showed that adults were more susceptible to a bias to attribute their own knowledge to uninformed peers when their knowledge represented meanings that were forgotten than for meanings remembered. One interpretation of this finding was that experience, rather than the stability of a memory trace, accounts for the sense of fluency or familiarity associated with knowledge. In a second experiment, these findings were replicated with a different sample of adults. Then to corroborate the results of these 2 experiments, researchers conducted a third experiment. The third experiment presented 3 different lists of questions to the participants: First, participants were given a list of trivia questions with the corresponding answers and were asked to memorize each item (known items). Then, a second list of questions was presented to the participants but this time without the answers (fluent items). Both sets of questions were presented three additional times to the participants (exposure). During the test condition, a week later, the two lists of items (fluent and known items) were presented with a third list of new questions with no answers (control items). The experiment's results aligned with the outcomes observed in the first and second experiments. Notably, this experiment found that participants overestimated peers' knowledge of the fluent items, even when they themselves ignored the answers to these questions. That is, familiarity with the questions, even without knowledge of the answers, biased adults' judgement of how foreseeable this knowledge would be to others. Taken together, these experiments illustrated that overestimation of the knowledge of others might not necessarily be related to privileged knowledge the reasoner holds but to the ease with which the questions come to mind may suffice to produce the curse of knowledge bias.

To further examine the validity of a fluency misattribution hypothesis and extend it to account for the auditory hindsight bias, Bernstein et al. (2018) examined whether a clearly articulated auditory stimulus heard prior to hearing a distorted version of the same stimulus would make adults susceptible to hindsight bias. To this end, the researchers manipulated auditory fluency in 2 different phases: exposure and test. In the exposure phase, all participants heard a clear pronunciation of a word, 1, 2, 3, or 6 times. Then the test phase involved 2 experimental conditions. In the first condition, the clear-distorted condition, participants heard a clear pronunciation of the word before hearing the distorted version of the word. In the second test condition, the distorted-only condition, participants only heard distorted versions of the spoken word. Following the test phase, participants estimated how many out of 100 peers could identify the distorted words. The results showed that in the distorted-only condition, participants identified more words when participant heard more repetitions. That is, there was a significant effect for perceptual priming. However, for participants in the clear-distorted condition, who distinctly heard the word before the distorted version, the number of exposures did not have a differential effect on the participants' estimates of their peers' ability to identify the words. Specifically, regardless of the number of presentations, participants overestimated their peers’ ability to identify the words. The researchers concluded that insensitivity to the number of presentations supported the fluency misattribution account. The absence of additive effects of perceptual priming could indicate that the effects funnelled into a single and common mechanism, fluency misattribution.

In a series of studies, Bernstein and Harley (2007) also used the ambiguity of a stimulus (in this case, visual stimulus) to investigate whether making the source of enhanced fluency evident to participants would eliminate, reduce, or reverse hindsight bias (HB). Researchers employed pictures of celebrities that were either initially degraded but further clarified or initially clear and further degraded on a computer screen. This study had 2 conditions, forward and backward hindsight bias, and 2 parts, baseline, and “surprise” test. In the forward HB condition, participants at the outset viewed the blurred images of celebrities and indicated when clarification of the degraded image became identifiable. Later, during the “surprise” test, observers viewed the same images in a different order and with the added identifier provided by the participants (name, character, movie) on the base of the picture. Participants were then asked to adjust the level of degradation of each celebrity image to match it with the level of degradation at which they initially (in baseline) recognized the famous person behind the picture. In the second condition, backward HB, during baseline, instead of viewing first a blurred image, participants saw a clear image that slowly became blurred and unidentifiable. Participants were asked first about the celebrity's identity; then, they were asked to indicate at what point of the evolving image degradation the celebrity became no longer identifiable. Later during test conditions, the clear pictures were presented in a different order. Participants were asked to adjust the blur level to match it with their baseline judgement as to when they considered the face no longer recognizable.

The results of the study showed that in the forward HB (blurred then clearing image), participants presented with hindsight bias. That is, participants, on average, overestimated their naïve knowledge and adjusted the celebrity images to a more degraded level than the level at which they did in baseline. In contrast, participants in the backward HB (clear images to being blurred) did not exhibit hindsight bias. Specifically, in the test condition, these participants selected the images at the exact degree of degradation when they were no longer identifiable as they did during baseline.

The researchers concluded that in the forward condition, the initial exposure and identification of the faces of the celebrities caused participants to process the images fluently during the memory test. However, adults in this condition were not aware of the source of the fluency. They misattributed this fluency to having identified the images at a more degraded point than they did during their prior naive knowledge state. In contrast, participants in the backward condition, who watched the degradation process of the celebrity's image (from clear to blurred), were aware of the source of their sense of fluency. Even when they may have processed the faces fluently, they did not present hindsight bias. This led researchers to conclude that fluency misattribution could account for the experiment's findings (forward and backward HB). Further, when people have advanced knowledge (clear faces) of the stimuli, they can process the degraded forms of these stimuli fluently and, therefore, are able to discount their feelings of fluency and avoid hindsight bias.

A previous study (Harley et al., 2004) contended that FM could account for visual hindsight bias. Like Bernstein and Harley (2007), participants were administered a visual HB task that measured the strength of a bias when estimating the knowledge of a naïve peer. When the participants were exposed a priori to clear faces of famous people, in the hindsight test condition, they processed these faces fluently and misattributed this sense of ease with which the actual picture of the celebrity came to their minds as knowledge that was also familiar to peers who were naïve to the picture. Researchers claimed that participants were unaware of the source of this fluency enhancement, and this caused them to misjudge the knowledge of uninformed peers.

Although evidence from these studies of adults supports a fluency misattribution hypothesis, among children, age- or individual variation in working memory capacity or processing efficiency within an executive system may also, in part, explain susceptibility to a cognitive bias to attribute one’s own privileged knowledge to others who have a naïve perspective (Birch, Brosseau-Liard, et al., 2017).

2.3. The Role of an Executive System

A cognitive system of executive resources has been shown to facilitate children's ability to negotiate the demands of complex social contexts where they are required to judge and predict others’ actions (Sabbagh & Benson, 2017). These resources include working memory, inhibitory control, and attentional flexibility, although differentiation of these resources in the executive system only fully occurs once the children reach the age of 7- to 8 years (Miyake et al., 2000). Access to this highly integrated executive system occurs when people access new thoughts, beliefs or other representational mental states and integrate this new information with information stored in long-term memory. Apperly et al., (2011) describes the role of executive functions in theory mind cognition metaphorically as the mortar that holds together different mental concepts, thus, allowing individuals to reason about the content of other people's minds.

Several theorists have posited that prior to the age of 4 years, children fail a classic false belief task because of age-related limitations in an executive system (Benson et al., 2013; Sabbagh & Benson, 2017) to reason about the beliefs to predict the action of a naïve person successfully (Carlson & Moses, 2001; Carlson et al., 2015). Evidence in support of this view comes primarily from studies that show age-related differences in performance on measures of inhibitory control and working memory that explain the variance in false belief reasoning after controlling for variables such as age and verbal ability (Carlson & Moses, 2001; Devine & Hughes, 2014; Moses, 2001). Devine and Hughes's (2014) undertook a meta-analysis of 102 studies of children aged 3 to 6 years; the researchers reported a medium to large effect size (r =.38). The study described the association between preschool-aged children's recognition of the false beliefs of others and their performance on a range of executive function tasks. Further, when Devine and Hughes used studies in which age and verbal ability were controlled (48 studies), a small to medium effect size persisted (r = .22).

Studies of older children and adults also suggest that working memory and inhibitory control are associated with performance on interpretative theory of mind tasks that tap a person's ability to recognize that others may have a perspective that differs from their own when thinking about the same information. Lagattuta et al. (2010) conducted a study with children aged 4 to 9 years old and adults and found an association between inhibitory control and verbal working memory and the frequency of errors in perspective-taking made on a range of interpretive theory of mind tasks.

Additional support for the view that an executive system is necessary for reasoning about the minds of naïve others comes from neuroimaging studies showing that among adults, activity in the brain regions associated with false belief and executive functioning are activated during false belief reasoning (Saxe et al., 2006). Other studies conducted on adults with focal brain injuries in areas linked to executive function have documented error patterns in false belief reasoning that are similar to those found among preschool children (Samson et al., 2005).

A related line of research that is important to understanding the role of the executive system on false belief reasoning examines the nature of processing knowledge and other sources of information within this executive system. In a seminal study that examined the role of knowledge on cognition, Chi (1978) compared the relative ability of 6 school-aged (3rd to 8th grade) chess experts and adult chess novices with only a familiarity with chess to remember lists of digits and the positions of chess pieces on a chess board. As expected, adults outperformed children on the digit recall task; however, children dramatically outperformed adults on the recall of the spatial location of chess pieces. These findings affirm that knowledge impacts an executive system; however, the reverse is also likely true. To detangle the nature of this relationship, studies have focused on two theoretical accounts of the relations between knowledge and an executive system. The first hypothesis posits that individual differences in these relations are associated with general working memory capacity. The second theoretical position emphasizes that either attentional processing efficiency in general or processing efficiency specifically related to inhibitory control is critical.

2.3.1. Working Memory Capacity

Working memory capacity refers to the small amount of information that is held in mind while a person carries out a cognitive task (Baddeley & Hitch, 1974; Baddeley, 1986). Without sufficient working memory capacity, there is no possibility of retaining partial information. For example, when responding to a classic false belief task, there would be no possibility of retaining the naïve perspective in mind while simultaneously thinking about one’s own privileged knowledge to predict a naïve person’s actions. Developmental growth in working memory capacity has been studied extensively, including whether it can be explained entirely by knowledge available from experience. Cowan et al. (2015) examined the growth in working memory capacity of English-speaking children in first through seventh grades and adults, using a task where the familiarity of knowledge was manipulated by briefly presenting arrays of familiar English letters and unfamiliar characters, after which, a letter or character was presented, and children indicated whether the letter/character was in the array. The task's difficulty was also manipulated by increasing the number of letters/characters in each array. The results showed that most children in the first grade could not complete the task because their knowledge of English letters was low. The performance accuracy of older children and adults was superior for letters compared to characters; however, the rate of developmental change in working memory was similar for both letters and characters. Taken together, the results suggest that knowledge familiarity mediates individual differences in working memory capacity; however, developmental change in working memory capacity occurs irrespective of knowledge due to prior experience. Further analyses showed that whereas children aged 7-9 years held approximately 1.89 chunks of information (in this case, English letters) in mind at a time, young adults in college held 4.4 chunks of information. Other studies have affirmed these findings with different stimuli, including short sentences (Gilchrist et al., 2009), coloured shapes (Cowan et al., 2010) and temporospatial relations among shapes (Cowan et al., 2011).

2.3.2. Efficiency of Attentional Processing

An alternative account posits that rather than individual differences in working memory capacity, the efficiency of attentional processing within the executive system explains, at least in part, individual differences in the role of knowledge on false belief reasoning. In this view, the accuracy of false belief reasoning is attributable to focusing attention on the critical information associated with a naïve perspective while ignoring one's own privileged knowledge and other irrelevant task information required to predict the actions of the naïve person. Research by Vogel et al. (2005) examined the relationship between working memory capacity and the ability to control attention to task-relevant while, at the same time, ignoring task-irrelevant information. In the research, participants were asked to attend to 2 targets (i.e., the spatial orientation of 2 red bars) in an array that included 2 distractors (e.g., 2 blue bars) or 4 targets. Event-related potential (EVP) brain signals were used to estimate memory load under these conditions. Results showed that participants with greater working memory spans were able to focus attention on the targets and ignore distractors. Therefore, the EVP indicated the working memory load was greater with 4 targets than with 2 targets. Participants with smaller working memory spans had fewer items in working memory, and therefore the EVP indicator of differences in working memory load with 2 and 4 targets was smaller. One interpretation is that lower-capacity participants were trying to store both targets and distractors in working memory, making the processing of information within working memory more difficult. Another possibility is that lower-span participants were unable to inhibit attention to memory of the distractors while simultaneously attending to the targets. Both explanations are likely crucial to mental theorizing about the minds of naïve others.

Lagattuta, Sayfan, et al. (2014)'s research provides some support for this interpretation. This study examined the role of inhibitory control and visual working memory on the reasoning of knowledgeable 4- to 10-year-old children and adults about how a naïve person would interpret ambiguous pictures. Knowledgeable participants were displayed a full picture of objects (a cloud and a castle) that subsequently were occluded to show only a small, ambiguous portion of the picture. Uninformed participants were only shown the occluded unclear picture of the object (visible arc and a right angle). Then, participants were asked to estimate how a naïve person would interpret the visible portion of the occluded picture. Participants were also required to estimate the probability with which the naïve person would rate a series of potential images ranging from probable (circle and square) to improbable (raccoon [visible arc] and television [right angle]), to impossible (a bolt of lightning [visible arc] and a bicycle [right angle]). Findings showed that all age groups with previous access to the actual pictures overestimated the probability that uninformed characters who would only see the ambiguous section of the pictures would guess the actual images. Analyses examining the connections between individual differences in executive functioning measures (IC and visual WM) yielded the following results: In the knowledgeable condition, higher inhibitory control (lower RT and fewer errors) and higher performance on working memory tasks predicted fewer indications that the actual picture was behind the obstructed portion, more guesses that the prototypical shape would be behind the occlude and higher likelihood rates for these prototypical images (circle and square). In sum, all age groups in the knowledgeable conditions with higher scores in inhibitory control and visual working memory presented fewer errors in perspective taking on the interpretive false belief task than participants with lower scores in inhibitory control and working memory.

2.3.3. Processing Speed

Several studies have reported that the speed of processing information is slower among young children compared to older children and young adults (Kail & Salthouse, 1994). Processing speed refers here to the rapid switching of attention to different content (i.e., individual chunks of information) in working memory. The speed at which this switching of attention takes place is thought to predict the amount of information held in working memory, as faster processing would allow for more efficient processing of more information. Another possibility is that rather than a general speed of processing information within working memory, the speed of encoding information into working memory may vary among children and adults (Vogel et al., 2006). Cowan et al. (2010) tested this hypothesis by presenting 2 coloured circles and 2 coloured triangles, 1 item at a time at the rate of 1 second per item rather than concurrently. At 7 years of age, children were as successful as adults at directing attention to the specific shape on a trial; however, they recalled fewer shapes overall than adults. These findings suggest that processing efficiency alone was not sufficient to explain age-related performance differences on complex working memory tasks. As all novel theory of mind tasks, including false belief tasks, can be conceptualized as variants of working memory tasks, these findings suggest that processing efficiency due to the speed of encoding is not sufficient alone to explain individual or age-related differences in performance on these tasks.

Apperly et al. (2011) investigated whether age-related capacity in an executive system or processing efficiency (speed of encoding and accuracy of response) within this executive system influenced belief-desire reasoning of children and adults. Specifically, this research aimed to measure the processing cost involved in belief-desired reasoning tasks. To achieve this purpose, researchers recruited children (6- to 11-year-olds) and young adults (mean age 21 years) to complete a series of belief-desire tasks that were slightly adapted for grown-ups. At these ages, all participants are expected to pass the belief-desire tasks; thus, the investigation was intended to measure the reaction time (RT) and accuracy of responses.

The tasks included different combinations of true belief (B+) and false belief (B-), positive desire (D+) and negative desire (D-) that resulted in 4 belief-desire reasoning conditions. This investigation reduced the cognitive demands of the task by informing participants at the outset of the true location of the objects and the protagonist's mental state (i.e., beliefs and desires). Participants were asked to predict the protagonist's actions. On each trial, the response accuracy and RT was measured. On a computer screen, participants viewed a sequence of 3 images depicting a table with 2 coloured boxes on top (red and green). As the sequence progressed, they heard 3 sentences that matched the pictures. The first sentence described the situation (i.e., The apples are in the green box); the second sentence the belief (true or false) of the protagonist ("I think the apples are in the green/red box); the third sentence described the desire (positive or negative) "I like/don't like apples." After hearing the 3 sentences in a sequence with the images on the screen, children were required to press the key corresponding to the box they predicted the protagonist would open. When the participants pressed the corresponding key, the computer automatically saved the RT and response accuracy (either correct/incorrect).

The study's findings revealed that belief-desire tasks that have been difficult for preschoolers (false belief-negative desire) are also difficult for older children and adults. Further, this difficulty persisted even when the task demands were simplified, and participants did not have to reason about the type of belief the protagonist holds (B+ or B-) or the desire (D+ D-). The third important finding is that speed and accuracy improved with age. However, a pattern of difficulty was relatively stable at all ages (B+ < B-, D+ < D-) and aligned with previous findings on adults (German & Hehman, 2006). Notably, the 6- to 7-year-olds presented with more errors on the false belief trials than the true belief ones. Similarly, they have more errors on the negative desire trials than those involving positive desires. This pattern of errors also matched the RT patterns of difficulty (slower responding on B- and D-). The researchers concluded that young children's increased number of errors and slower RT may indicate they have yet to develop some of the nuances in the four belief-desire reasoning combinations. However, it is also possible that since this study was not aimed to establish the age at which children would succeed on belief-desire tasks, the pattern of errors and analysis of RT in young children and adults can be interpreted as a manifestation of the processing cost of the different belief-desire situations. Taken together, the findings of this study indicated that false belief and negative desire tasks had an increased processing cost compared to true belief and positive desire. Higher demands exert pressure on response inhibition and processing speed, making participants more prone to slower reaction time and decreased accuracy.

A more recent investigation (R. F. Pohl et al., 2018) also found that encoding of a stimulus through multiple modalities (i.e., auditorily, visual representation on a computer screen, and printed on paper) had a more significant impact than encoding using only an auditory presentation on the accuracy of recall of an earlier, uninformed knowledge state; further, this effect was more pronounced in younger children and elderly adults relative to older children and young adults.

To conclude, the subjective feelings of speed, ease, and accuracy with which individuals process stimuli are described as fluency. Repeated, longer, or perceptually clearer stimuli may result in a feeling that is metacognitively described as "familiar." Further, research has shown that it is possible to enhance this subjective feeling of fluency via increasing clarity, recurrent presentation, and/or extending the duration of stimuli. Nevertheless, people may not be aware of the source of this ease in their processing experience when they make cognitive, perceptual, and affective judgements about the world, misattributing this fluency. Therefore, this sense of fluency may account for adults' cognitive bias when judging the knowledge state of others. Regarding children reasoning about others' knowledge or beliefs, they will process the information using their cognitive abilities; however, their processing efficiency may not lead to this sense of fluency; rather, it may be mediated by children’s executive functioning system.

Chapter 3.

Methodology

3.1. Research Design

This research incorporates an experimental design with 6 conditions where the plausibility of knowledge was manipulated. In the 2 control conditions, children were ignorant of the final outcome and in the 4 remaining conditions, children had privileged knowledge of the final outcome.

Following Birch and Bloom (2004, 2007), each condition is represented by a different version of a false belief displacement task that was designed for children and that is presented in a digitalized video format (see Appendix A for a storyboard of a version of the video for each condition). In all 6 conditions, the video shows a young child, who is the protagonist of the story, playing with a doll in a room where 4 coloured containers were arranged in a semi-circle as shown in Figure 3.1. The protagonist places the doll in the blue container and then leaves the room. In the protagonist's absence, an adult enters the room, removes the doll from the blue container and places it in another container. The adult then rearranges the containers as shown in Figure 3.2 into a final array and leaves the room. When the protagonist re-enters the room, children respond to a series of questions: "Where will Ann look for the doll first?" "Why would they look for the doll first in (child's choice) container? "If the doll is not in the (first ranked container), where will Ann look for the doll next?" "If the doll is not there, where will Ann look for the doll next?" Lastly, to confirm that the child was attending to the video, they are asked "Where did Ann leave the doll before leaving the room?" and "Did Ann see the doll moved to another box?"

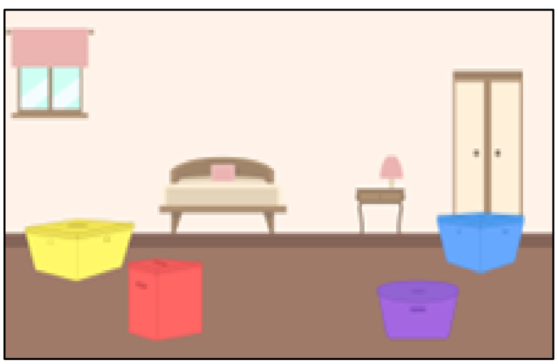
In the “Ignorance-Location” condition, children have no knowledge of the final outcome. The plausibility that the doll was placed in a container other than the blue container where it was last seen is inferred from a comparison of the spatial organization of the containers before and after rearrangement. After rearrangement, the yellow container is in the place of the blue container.

Figure 3.1

Initial Arrangement of Containers (all conditions)

Figure 3.2

Final Arrangement of Containers (all conditions)



Children assigned to the "Ignorance-Location/Labels" condition have no knowledge of the final outcome. The plausibility that the doll is in a container other than the blue container where it was last seen is inferred from a comparison of the spatial organization of containers with labels that represent the contents of the containers before and after rearrangement. After rearrangement, the yellow container labelled "toys" is in the place where the blue container.

In the "Knowledge-Plausible-Location" condition, children have privileged knowledge of a plausible outcome. Plausibility is inferred from the spatial organization of the containers prior to, and after rearrangement. After rearrangement of the containers, children are aware that the doll is in the yellow container and the yellow container has been placed where the blue container was originally located. The blue container is where the naïve protagonist last saw the doll.

Children assigned to the “Knowledge-Plausible-Location/Labels” condition have privileged knowledge of a plausible outcome. Plausibility is inferred from information about the label on the container and/or from a comparison of the spatial organization of the containers before and after rearrangement. After rearrangement of the containers, children are aware that the doll is in the yellow container labelled “toys” and the yellow container has been placed where the blue container was originally located. The blue container is where the naïve protagonist last saw the doll.

In the “Knowledge-Implausible-Location” condition, children have privileged knowledge of an implausible outcome. Implausibility is inferred from a comparison of the spatial organization of the containers prior to and after rearrangement. After rearrangement of the containers, the purple container has been placed far from where the blue container was originally located. The blue container is where the protagonist last saw the doll.

Children assigned to the “Knowledge-Implausible-Location/Labels” condition have privileged knowledge of an outcome that is implausible. Implausibility is inferred from information about the label on the container and/or from a comparison of the spatial organization of containers prior to and after rearrangement. After rearrangement of the containers, the purple container labelled “hats” is located far from where the blue container was originally placed. The blue container is where the protagonist last saw the doll.

3.2. Participants

After obtaining SFU Research Board ethics approval, the participants in the research (n=88) were recruited in two ways. First, anonymized data from 69 children participating in a longitudinal study of the development of executive functions in young children (Hoskyn & Moore, 2016) were collected. This dataset included children’s age from a demographic survey administered to parents, children’s responses to the False Belief Displacement Task for Children and the Stanford Binet 5th Edition Object/Matrices and Vocabulary subtests. An additional 19 participants were recruited from local schools in a school district that was also represented in the longitudinal study. The children in local schools were administered the False Belief Displacement Task for Children and the Stanford Binet 5th Edition Object/Matrices and Vocabulary subtests. Parents completed a brief demographic survey.

Setting an alpha of 0.5, the given sample size (N=270) was considered sufficient to detect a medium-size effect (*d* = .25; Cohen, 1988), as computed by “G Power” (Faul et al., 2009). However, data collection was halted, in line with the restrictions in schools due to the SARS2-CoV-19 pandemic.

3.3. Materials

3.3.1. The False Belief Displacement Task for Children

The False Belief Displacement Task for Children described earlier in this chapter was adapted from Birch and Bloom's (Birch & Bloom 2004, 2007) false belief displacement task for adults. Several modifications were made to adapt the measure for use with children. First, to minimize the influence of developmental constraints in language proficiency on task performance, the task was presented visually as a digitalized video without narration, but that included sound effects (e.g., opening boxes, vacuuming). Second, to increase the salience of a plausible outcome for children, the containers in 3 conditions were shown with labels (i.e., "shoes,” “hats,” “toys,” and “books”). Third, rather than asking children to estimate the probability that a protagonist would first look into each container, they were asked to rank order the probability (i.e., first to fourth) that each container would be selected. The child's first selection represented the container children believe the protagonist would most likely look at first. In contrast, the second, third, and fourth choices represent containers the child feels are equal to or increasingly less probable.

Children's understanding of the concept of ordinality and its application to describing a sequence of events develops gradually from preschool to school-age years. Early in life, young children can perceive a serial order in events (Lewkowicz, 2004, 2013). However, three- to four-year-old children have difficulties understanding the relational structure of the elements of a sequence (Lewkowicz, 2004, 2013). That is, they cannot perform tasks that involve explicit ordinal labels but implicitly, they understand ordinality. As the child develops language and other cognitive abilities, they represent their knowledge of ordinality with linguistic labels. By the time they enter school, children can clearly grasp and use a relational ordinal-label system (Marcovitch & Lewkowicz, 2015).

3.3.2 Visual-Fluid Reasoning and Verbal-Crystalized Reasoning

The Stanford Binet - Fifth Edition (G H. Roid, 2003), Abbreviated Fluid and Crystalized Reasoning Battery (ABFQR) is based on two routing subtests—one nonverbal (Object Series/Matrices) and one verbal (Vocabulary). The ABFQR provides a quick estimate of two major cognitive factors: fluid reasoning and crystallized ability. Object Series/Matrices requires the examinee to identify patterns or series of objects and pictures, and to solve novel pictorial problems presented in the matrix-analogy format. The Vocabulary subtest requires examinees to use their verbal knowledge, acquired and stored in memory from previous exposure to spoken English in The ABIQ has been reliably used in assessments such as neuropsychological examinations, in which a battery of tests supplements the SB5, or for quick yet reliable assessments to verify the general cognitive status of an individual. The ABIQ measures the areas of Nonverbal Fluid Reasoning and Verbal Knowledge and includes two of the most important abilities predictive of academic and social outcomes. Internal consistency reliability estimates for the two subtests range from .90 to .92 across ages.

3.4. Procedures

The anonymized data set from the Hoskyn and Moore longitudinal research included: Age of child; False Belief Displacement task (ranks assigned to each coloured container), and standard scores obtained on the Object/Matrices Vocabulary subtests of the Stanford Binet Intelligence Scales, Fifth Edition (G.H. Roid, 2003). Additional participants were also recruited from local schools. Parents of participating children in both the longitudinal study and in the school-based research signed consent forms and filled out demographic surveys. All children participants were randomly assigned to 1 of the 6 conditions in the experimental design. The author of this dissertation research administered the false belief displacement task, as a research assistant in the longitudinal study and as a primary investigator for the research in the schools. The Object/Matrices and Vocabulary subtests of the Stanford-Binet Intelligence Scales, Fifth

Edition were administered to participants by a graduate level research assistant. The total amount of time taken to administer the tasks to participants in the research was 30 – 35 minutes.

3.5. Data Analyses

3.5.1. Analysis of Experimental Manipulations

As the study used rank-ordered, ordinal data, non-parametric analyses with the Mann-Whitney U test were conducted. A Mann-Whitney U test is the non-parametric equivalent to the two-sample t-test. It allows researchers to compare whether there is a statistically detectable difference in the dependent variable in two independent groups. In this study, the Mann-Whitney U test was used to examine the ranks assigned to a specific container between conditions. Within- and between-condition estimates of the frequency that a specific rank was assigned to a container were analyzed using Chi-Square analyses.

First, a descriptive analysis of children's responses to all 6 conditions was conducted. Median ranks and frequency counts for each condition are reported and discussed. Following this general description, a series of analyses were conducted to examine the specific between condition comparisons that informed the research questions.

To determine whether children were sensitive to the variation in the plausibility of different outcomes Mann-Whitney U tests were undertaken to compare ranks assigned to each container within-Ignorance-Location and Ignorance-Location/labels conditions. Chi-square analyses were conducted to compare the frequency that each rank was assigned to a container within and across conditions. To further determine whether adding labels to containers had an effect on children's predictions beyond that attributable to a comparison between the location of the containers prior to and after rearrangement, Mann-Whitney U tests were used to compare the distribution of ranks assigned to a specific container between the Ignorance-Location and Ignorance-Location/Labels conditions.

Further, to examine whether children were susceptible to a bias to attribute their own knowledge of a plausible outcome to an uninformed protagonist, ranks assigned to the yellow container in Knowledge-Plausible-Location and Knowledge-Plausible-Location/Labels conditions were compared to ranks assigned by children who were naïve to the outcome in the 2 corresponding Ignorance conditions (i.e., Ignorance-Location and Ignorance-Location, respectively).

The next analyses examined whether children were susceptible to a bias to extend their own knowledge to an uninformed protagonist when they had privileged knowledge of an implausible outcome. Ranks assigned to the purple container in Knowledge-Plausible-Location and Knowledge-Plausible-Location/Labels conditions were compared with the corresponding condition where children had no knowledge of the outcome (i.e., Ignorance-Location and Ignorance-Location, respectively).

A primary aim of the research was to examine whether the magnitude of any cognitive bias to ascribe one's own knowledge to a naïve other was sufficient to attenuate the reasoning about the false beliefs of the uninformed person. Therefore, ranks assigned to the blue container (which represented the protagonist's false belief that the doll was in this container) in the 4 conditions where children had knowledge of the outcome (i.e., Knowledge-Plausible-Location; Knowledge-Plausible-Location/Labels; Knowledge-Implausible-Location; and Knowledge-Implausible-Location/Labels conditions) were compared to the ranks assigned to the blue container in the corresponding conditions where children had no knowledge of the outcome (Ignorance-Location and Ignorance-Location/Labels).

3.5.2 Qualitative analysis of Children's Explanations

To further examine whether the manipulation of plausibility using the False Belief Task for Children was valid, children were asked to explain why they ranked a specific container as the most likely place where the protagonist would look for the doll first. These explanations were sorted into thematic categories that represented similar explanations. First, the responses were reviewed to eliminate any responses that were highly ambiguous. As no ambiguous reasons were stated, all responses were viewed in random order (i.e., without information about the condition from which they emerged) and a new code was assigned to represent each new category of explanation. After the codes were established, a second rater was given all responses to assign to the categories. Interrater reliability was estimated on 10% of sample responses through percentage agreement between the first and second coder. Reliability of coding was 90% for all explanations. The frequency with which explanations were provided by children in each of the 6 conditions was analyzed in the research.

Chapter 4.

Results

This chapter describes the results of analyses that inform the adequacy of the predictions hypothesized in Chapter 1. Of primary interest are analyses that examine children's sensitivity to variation in knowledge plausibility and whether having a plausible reason to attribute their own knowledge to naïve others biases their false belief reasoning.

4.1. Sample Characteristics

As shown in Table 3.1, the final sample was comprised of 88 children, 31 females and 57 males (*M* = 7.4 years; *SD* = 2.12 months). All children lived in linguistically and culturally diverse, urban neighbourhoods and attended schools where English was the language of instruction. Mean standard scores of sample children on the Stanford Binet 5th Edition Intelligence Scales (G. H. Roid, 2003) suggests that on average children's verbal and visual reasoning fell at the average range and ranged from below average to well above average relative to age peers in the test normative sample.

Table 4.1

Sample Characteristics (n=88)

Variable	Mean	SD
Age (in years)	7.4	2.2 months
Vocabulary	9.68	2.59
Object Series/Matrices	10.38	3.23

Note: subtest standardized scores on the Object Series/Matrices and Vocabulary subtests on the Stanford Binet-5th Edition have a mean of 10 and a standard deviation of 3, relative to 7-year-old children the test normative sample. The Stanford Binet subtests were administered to children represented in the dataset from the longitudinal research.

4.2. Analysis of the Experiment

4.2.1. Sample Response to Experimental Conditions

As shown in Table 4.2 and in Appendix B, the distribution of ranks assigned by children to the 4 containers varied within and among the 6 conditions. The median rank assigned to the blue container, which represented the protagonist's false belief that the doll was located where it was last seen, ranged from 1 in Ignorance-Location and the Knowledge-Plausible conditions, to 2 in the remaining 4 conditions (Ignorance-Location/Labels, Knowledge-Plausible/Labels, Knowledge-Implausible-Location/Labels and Knowledge-Implausible-Location conditions). Thus, most children in the sample (48/88; 54.5%) predicted that the protagonist would act in accordance with a false belief and look for the doll first in the blue container. However, 30/88 (34%) of children in the sample ranked the yellow container (a plausible location for the protagonist to look for the doll either due to its final location and/or label) first. Median ranks assigned to the yellow container ranged from 1 in the Ignorance Location/Labels and Knowledge-Plausible/Location condition to 3 in the Knowledge-Implausible-Location condition. The median rank assigned to the purple container ranged from 2 to 4, and for the red container was 3 across all the conditions. In general, the purple and red containers were not considered by children in the sample as a likely place for the protagonist to look for the doll. In the following analyses, the statistical significance of differences between ranks assigned to specific containers in different conditions was examined.

Table 4.2.

Median Ranks Assigned to Containers by Condition

Condition	Containers			
	Blue	Yellow	Purple	Red
Ignorance Location	1	2	3	3
Ignorance Location/Labels	2	1	3	3
Knowledge Plausible Location	1	2	3	3
Knowledge Plausible Location/Labels	2	1	4	3
Knowledge Implausible Location	2	3	2	3
Knowledge Implausible Location/Labels	2	2	3	3

4.2.2. Sensitivity to Plausibility

To examine whether at 7 years of age, children were sensitive to the concept of plausibility and whether the labels and/or the final location of containers differentiated the plausibility of an outcome, ranks assigned to the 4 containers in the Ignorance-Location and Ignorance-Location/Labels conditions were statistically compared. In both conditions, children had no knowledge of the outcome. The blue container represented a plausible location for the protagonist to look for the doll because it is commonly understood that objects can be found where they were last seen. The yellow container was also a plausible location for the protagonist to look for the doll because, after rearrangement, the yellow container was located where the blue container was originally placed. As there was no information to suggest that the purple and red containers were plausible locations for the protagonist to look for the doll, ranks assigned to these containers were expected to be higher than the blue or yellow containers. A similar pattern of results was expected in the Ignorance-Location/Labels condition, because in this case, the yellow container was labelled "toys," whereas the labels on other containers were not associated with a doll (i.e., “shoes,” “hats,” and “books”).

As reported in Table 4.2 and 4.3, median ranks and frequency counts of ranks assigned to the blue and yellow containers in the Ignorance-Location (Mdn $rank_{blue}$ = 1; Mdn $rank_{yellow}$ = 2) and the Ignorance-Location/Labels (Mdn $rank_{blue}$ = 2; Mdn $rank_{yellow}$ 1) conditions indicate that children viewed the blue and yellow containers as plausible locations for the protagonist, who was also naïve to the outcome, to look for the doll. As shown in Table 4.2, this result is affirmed by the finding that most children in the Ignorance-Location condition (14/15; 93.33%) ranked either the blue (10/15; 66.66%) or yellow (4/15; 26.66 %) container as the most likely place for the protagonist to look first for the doll. In the Ignorance-Location/Labels condition, this pattern of response was reversed: All children ranked the yellow (8/14; 57.14%) or blue (6/14) containers as the most likely place that the protagonist would first look for the doll first. Critically, a Chi-Square Goodness of fit test showed that the differences between Ignorance-Location and Ignorance-Location/Labels condition in the percentage of children who selected either the blue or yellow containers first were not statistically detectible (X^2 (1, N = 28) = 2.33, p = .127). These results align well with a series of Mann-Whitney tests that showed that between Ignorance-Location and Ignorance-Location/Labels conditions, differences in ranks assigned to the blue, U (29) = 88.50, p = .477; yellow, U (29) = 71.00, p = .146; purple, U (29) = 90.00, p = .533; and red, U (29) = 64.00, p = .077; containers were not statistically detectible.

Taken together, these results suggest that in the absence of privileged knowledge of the final outcome, children in both the Ignorance-Location and Ignorance-Location/Labels conditions considered that the protagonist held a belief (as did they) that the blue and yellow containers represented more plausible locations to look for the doll than the purple or red containers.

Table 4.3

Frequency Counts of Ranks: Ignorance-Location, Ignorance-Location/Labels Conditions

Rank	Ignorance-Location (n=15)				Ignorance-Location/Labels (n=14)			
	Blue (%)	Yellow (%)	Purple (%)	Red (%)	Blue (%)	Yellow (%)	Purple (%)	Red (%)
1	10	4	0	1	6	8	0	0
	(67)	(27)	(0)	(6.7)	(42.9)	(57.1)	(0)	(0)
2	1	7	1	6	5	4	3	2
	(6.7)	(47)	(6.7)	(40)	(35.7)	(28.6)	(21.4)	(14.3)
3	0	1	9	5	0	1	7	6
	(0)	(7)	(60)	(33)	(0)	(7.1)	(50)	(42.9)
4	4	3	5	3	3	1	4	6
	(27)	(20)	(33)	(20)	(21.4)	(7.1)	(28.6)	(42.9)

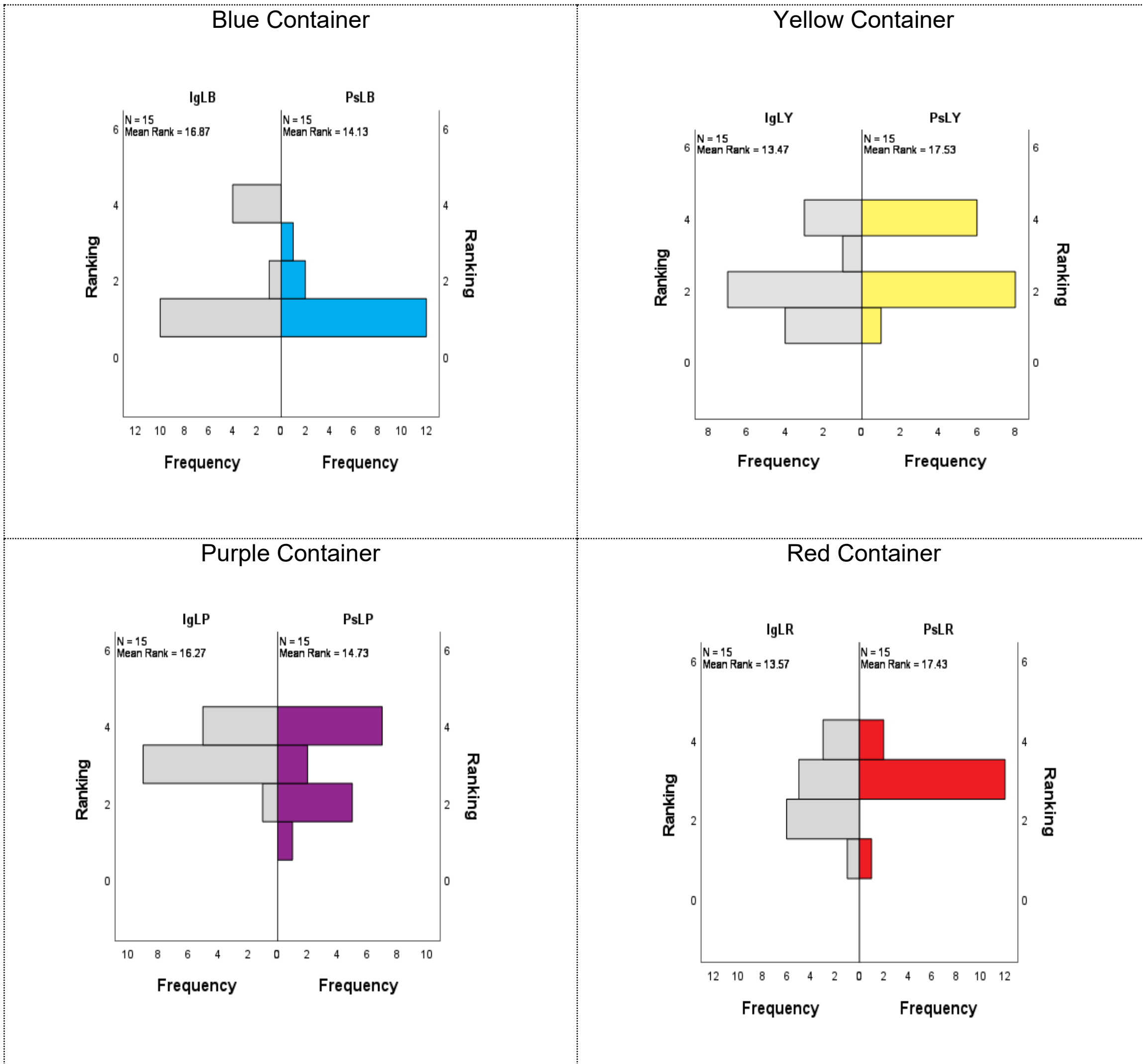
Note: Ranks are ordered so that a rank of 1 to 4 indicates a range from the most to the least likely place that the agent would look for the doll.

4.2.3 Analysis of Knowledge of a Plausible Outcome

The subsequent analyses examined whether having a plausible reason to attribute their own knowledge to the naïve protagonist influenced children's reasoning about the beliefs and actions of the protagonist. Children in the Knowledge-Plausible-Location condition had privileged knowledge that in the protagonist's absence, the doll was moved from the blue to the yellow container (which after rearrangement was located where the blue containers was initially placed). In the Knowledge-Plausible-Location/Labels, the yellow container was labelled "toys," whereas other containers had labels that were not semantically associated with a doll (i.e., "shoes," "hats," "books").

Figure 4.1

Distribution of Ranks: Plausible-Location and Ignorance-Location Conditions

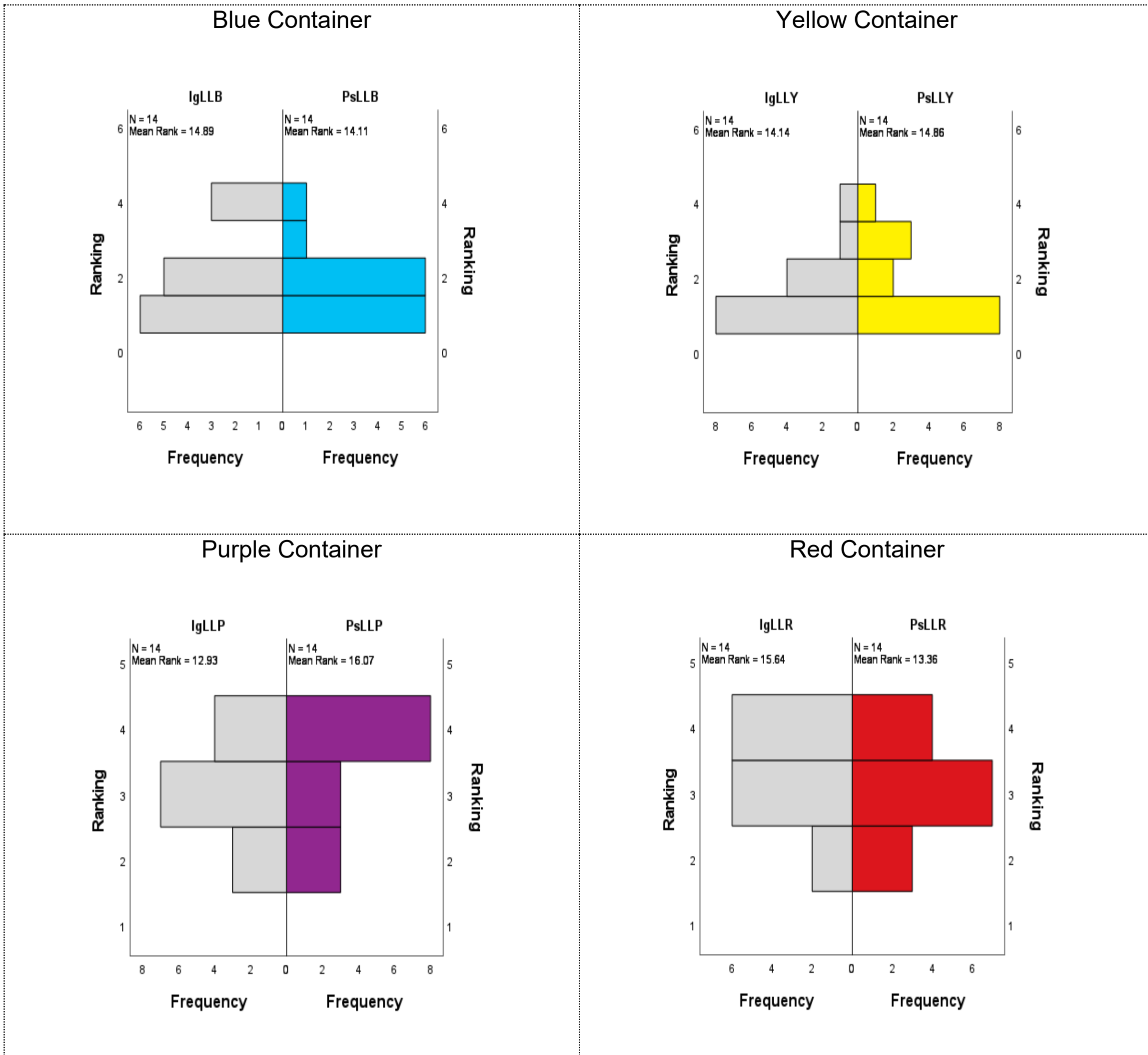


Note: IgL = Ignorance-Location condition, PsL = Knowlege-Plausible-Location condition; Ranks from 1-4 represent the most to least likely place where the agent would look for the doll.

Ranks assigned to the yellow container in the Knowledge-Plausible-Location and Ignorance-Location conditions are illustrated in Figure 4.1. A Mann-Whitney *U* test showed differences in ranks assigned to the yellow container between the Knowledge-Plausible-Location (*Mdn* = 2.0 *n*= 15) and the Ignorance-Location condition (*Mdn* = 2.0, *n* =15), $U = 82.0$ p=.217 are not statistically detectible. Similarly, Figure 4.2 describes

Figure 4.2

Distribution of Ranks: Plausible- Location/Labels and Ignorance-Location/Labels



Note: IgLL = Ignorance-Location/Labels condition, PsLL = Knowlege-Plausible-Location/Labels condition; Ranks from 1-4 represent the most to least likely place where the agent would look for the doll.

the ranks assigned to the yellow container in the Knowledge-Plausible-Location/Labels and Ignorance-Location/Labels conditions. Ranks assigned to the yellow container between the Knowledge-Plausible-Location/Labels (*Mdn* 1.0, *n*=14) and Ignorance-Location/Labels (*Mdn* = 1.0, n=14) conditions showed no statistical differences, *U* = 103.0, *p*=.839. Taken together, these results suggest that having a plausible reason to share their own privileged knowledge (that the doll was in the yellow container) with a naïve protagonist had no appreciable impact on children's reasoning about the protagonist's beliefs and actions. Children put their own knowledge of the outcome aside and ranked the likelihood the protagonist would look in the yellow container, with or without labels, in the same way as children who had no knowledge of the outcome.

Further, to determine the impact of knowledge plausibility on children's reasoning about the false beliefs of naïve others ranks assigned to the blue container between the Knowledge-Plausible-Location (*Mdn* = 1.0, *n*=15) and Ignorance-Location (*Mdn* = 1.0, *n*=15) conditions were compared. The Mann-Whitney *U* test results (*U* = 92.0, *p*=.412) indicate that the differences were not statistically significant.

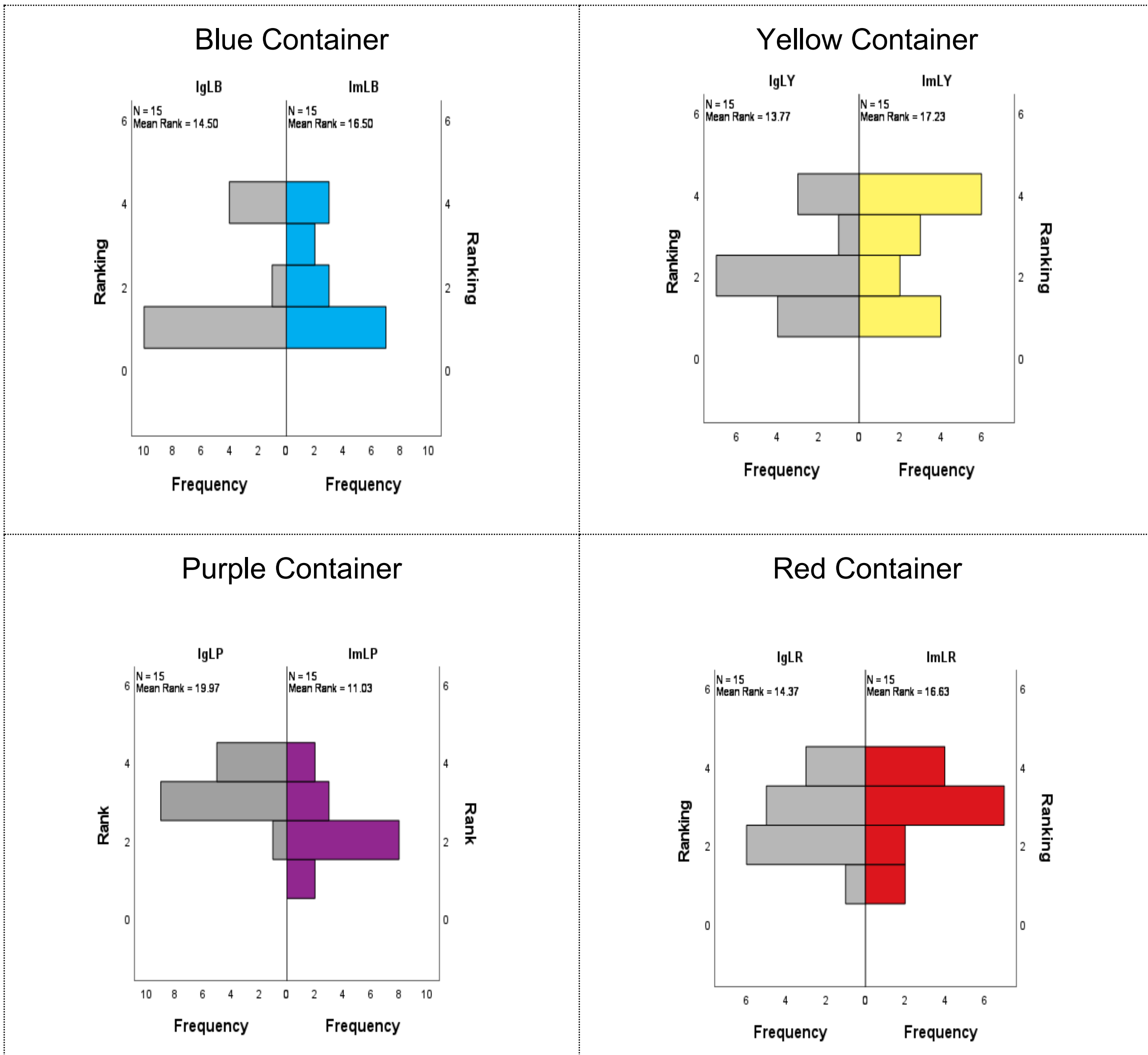
4.2.4 Analysis of Knowledge of an Implausible Outcome

Children in the Implausible-Location condition knew that the doll was removed from the blue container (where the protagonist last saw the doll) and placed in the purple container. However, the available information to guide children's inferences about whether the purple container was a plausible (or implausible) location for the protagonist to look for the doll was relatively sparse. Children observed that after rearrangement of the containers, the purple container was in the location that was most distant from where the blue container was originally placed. The distribution of ranks in the Knowledge-Implausible-Location and Ignorance-Location conditions are illustrated in Figure 4.3. Importantly, differences in ranks assigned to the purple container in the Implausible-Location (*Mdn* = 2.0, *n*=15) and Ignorance-Location condition (*Mdn* =3.0, n=15) are statistically detectible, *U* = 45.50, *p*=.004. This result suggests that children may be more susceptible to a bias to attribute their own knowledge to the protagonist when the implausibility of their knowledge is not well defined or possibly ambiguous. However, differences in ranks assigned to the blue container in the Knowledge-Implausible-Location (*Mdn* = 2.0, *n*=15) and Ignorance-Location (*Mdn* = 1.0, *n*=15) conditions were not statistically detectible, *U* = 127.5, *p*=.539. Taken together, the results indicate that the bias to attribute one's knowledge to the protagonist was not sufficient to attenuate children's predictions about whether the protagonist would act in accordance with a false belief and look for the doll in the blue container.

In the Knowledge-Implausible-Location/Labels condition, the implausibility of the doll being placed in the purple container labelled "hats" is clearly defined for children. In this case, differences in the ranks assigned to the purple container between the Implausible-Location/Labels (*Mdn* =3.0, *n*=15) and the Ignorance Location/Labels

Figure 4.3

Distribution of ranks: Implausible-Location and Ignorance-Location

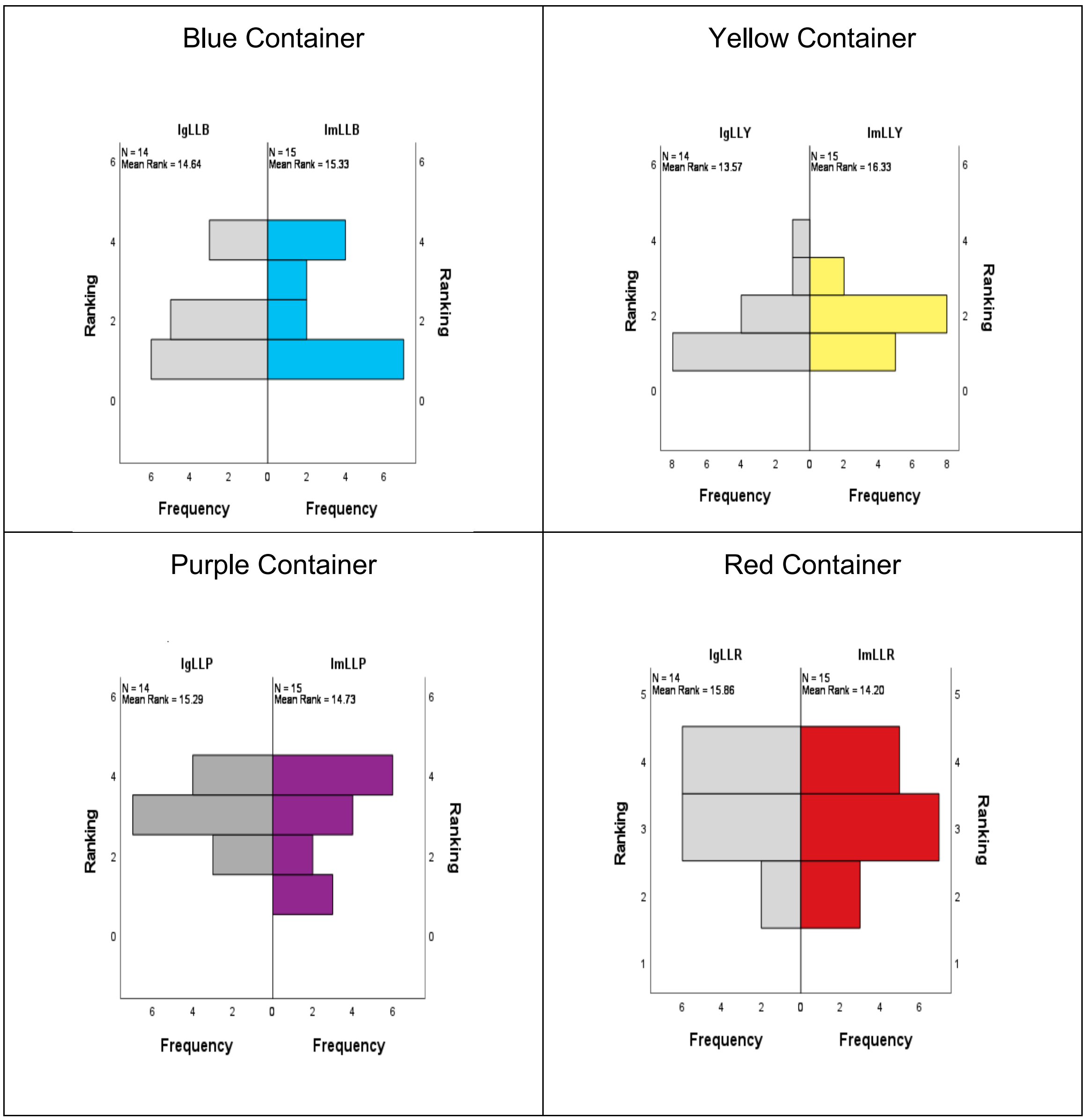


Note: IgL = Ignorance-Location condition, ImL = Knowlege-Implausible Location condition. Ranks from 1-4 represent the most likely place where the agent would look for the doll.

(*Mdn*= 3.0, *n*=14) conditions were not statistically detectible, *U*= 101.0 *p*=.880. Further, ranks assigned to the blue container between the Knowledge-Implausible-Location/Labels (*Mdn* = 2.0, *n*=15) and Ignorance-Location/Labels (*Mdn* = 2.0, *n*=14) conditions were not statistically detectible, *U* = 110.0, *p*=.847. These results indicate that having privileged knowledge of an implausible outcome (that the doll has been placed in a box with a label “hats”) had no appreciable impact on children’s predictions about whether the agent would act in accordance with a false belief and look for the doll in the blue container. The distribution of ranks in the Knowledge-Implausible-Location/Labels and Ignorance-Location/Labels conditions are described in Figure 4.4.

Figure 4.4

Distribution of ranks: Implausible- Location/Labels and Ignorance Location/Labels



Note : IgLL = Ignorance-Location/Labels condition, ImLL = Knowlege-Implausible Location/Labels condition. Ranks from 1-4 represent the most likely place where the agent would look for the doll.

4.3 Qualitative Analyses of Children's Reasoning

As shown in Table 4.4 examples of children's responses to the question "Why would they look for the doll first in (child's choice) container" yielded five explanations that thematically, wove through the 6 conditions.

"False Belief" represents an explanation where children indicate that the naïve protagonist would likely act on a false belief that differed from their own informed perspective. Specifically, children explained that the protagonist would act upon a belief that did not align with their own informed perspective about where the doll was located.

"Plausible Location" explanations occurred when children referred to the spatial organization of the containers, prior to and after rearrangement as the reason for the protagonist to look first in a container. For instance, a justification would be coded as "Plausible Location" if children selected the yellow container - with or without the doll – because, after rearrangement, this container was placed in the original position of the blue container.

"Plausible Labels" explanations were responses where children predicted the naïve protagonist's actions, based on the information provided by the labels and images attached to the containers. In their explanations, children considered how an expectation about of the contents of a labelled container influenced the protagonist's actions.

"Outcome Knowledge" explanations occurred when children attributed their own privileged knowledge to the naïve protagonist.

"Imagination" was an explanation where children referenced images or interpretations not shown in the digital video. For example, children may have added elements to the story or properties to characters or objects in the story.

Explanations were coded as "Don't Know" when children indicated that they did not have reason for making their prediction.

As reported in Table 4.5, the frequency that an explanation was used for predicting that the protagonist would look first in a container aligned well with the manipulations of plausibility in the experimental design. That is, the explanation for selecting the blue container first in all conditions was consistently related to an understanding that the naïve protagonist held a false belief, as they had last seen the doll placed in the blue container.

Table 4.4

Examples of Children's Explanations by Condition

	Focus of the Explanation				
Condition	False belief	Plausible Location	Plausible Labels	Outcome Knowledge	Imagination
Ignorance-Location	"Because she put her doll inside the blue box."	"Because her mother switched the boxes up."	-	-	-
Ignorance-Location/Labels	"She last put her doll there."	"Because the blue box was on that spot."	"Because that's where all the toys are supposed to go."	-	-
Plausible Location	"Because she put it in the blue (box)."	-	-	"Because her mom put it there"	"Because it's smaller, the doll is small!"
Plausible Location/Labels	"Because that's where she left it."	-	"Because it says toy and if you have a toy, you'd put it in there."	"I think she put it there."	-
Implausible Location	"She put it over there in the first place."	"Because that's (place) where she put the doll first."	-	"Maybe she was pecking to see where the doll was."	"Might think it change colour"
Implausible Location Labels	"Because that's the last place she put it."	"Because that box (blue) was there."	"Because that's where all the toys should be."	"Because mom put it there."	-

In comparison, reasons children provided for ranking the yellow container first varied in accordance with the manipulation of plausibility of their privileged knowledge in the condition. When children were ignorant of the final outcome, most children in the

Ignorance-Location condition explained that the yellow container had been moved to the original location of the blue container, whereas in the Ignorance-Location/Labels condition, children justified ranking the yellow container first based on it's new location or its label ("toys") with equal frequency.

Table 4.5

Frequency of Explanations

			Explanation					
	Container	*N*	False belief	Plausible Location	Plausible Labels	Outcome Knowledge	Imagination	Don't Know
IgL	Blue	10	10					
	Yellow	4		4				
	Purple	0						
	Red	1						1
IgLL	Blue	6	6					
	Yellow	8		4	4			
	Purple	0						
	Red	0						
PsL	Blue	12	12					
	Yellow	1				1		
	Purple	1					1	
	Red	1						1
PsLL	Blue	6	5					1
	Yellow	8			6	2		
	Purple	0						
	Red	0						
ImL	Blue	7	7					
	Yellow	4		3			1	
	Purple	2				1		1
	Red	2					1	1
ImLL	Blue	7	7					
	Yellow	5		2	3			
	Purple	3				3		
	Red	0						

Note: IgL= Ignorance Location; IgLL= Ignorance-Location/Labels; PsL= Knowledge- Plausible Location; PsLL= Knowledge-Plausible Location/Labels; ImL = Knowledge- Implausible Location; ImLL – Knowledge-Implausible Location/Labels.

In the Knowledge-Plausible-Location condition, where children knew that holding a belief that the doll was in the yellow container represented the "true" situation (at least in their own minds), only 1 child ranked the yellow container first. Critically, their reasons for doing so had no direct link to the plausibility of their own knowledge. Rather, this child showed that their own knowledge of the outcome (regardless of its plausibility) biased their rank; the child explained, “Because her mom put it there.”

In the Knowledge-Plausible-Location/Labels condition, most children (8/14; 57.14%) ranked the yellow container first, and 6 of these children justified their rank by referring to the yellow container’s label "toys," and the remaining 2 children reasoned that the protagonist would act first in accordance with their privileged knowledge that the doll was in the yellow container.

In the Knowledge-Implausible and Knowledge-Implausible/Labels conditions, the reasons provided by the 8 children who predicted that the protagonist would look first in the yellow container also aligned with the plausibility of this outcome, due to its location and/or its label. Compared to the blue and yellow containers, very few children predicted that the protagonist would look first for the doll in the red or purple containers. A single child in the Knowledge-Implausible-Location and the 3 children in the Knowledge-Implausible-Location/labels conditions explained that the protagonist would act in accordance with their knowledge of the “true” outcome and look first in the purple container first. Of the 2 children who ranked the red container first, one child gave a reason based on the protagonist thinking, "Maybe she'll think it is there," and the other child could not articulate a reason for their decision.

4.4 Summary

The main results that emerged from analyses described in this chapter and that will be discussed at length in Chapter 5 include: 1) ranks assigned to the blue container, (which represented a false belief of the protagonist that the doll was located where it was last seen) and to the yellow container with or without labels, (which after rearrangement, was placed where the blue container was originally located) were statistically the same and lower relative to ranks assigned to the purple and red containers in conditions where children had no knowledge of the outcome; 2) ranks assigned to the blue and yellow containers were statistically the same as in the corresponding Ignorance (control) conditions, when children’s knowledge of the outcome was plausible (i.e. the doll was placed in the yellow container); 3) ranks assigned to the purple container when children had knowledge that this was an implausible outcome due to the location of the container were statistically lower than ranks assigned by children with no knowledge of the outcome; 4) ranks assigned to the purple container when children had knowledge that this was an implausible outcome due to the label on the container as well as its location were not statistically different than ranks assigned by children with no knowledge of the outcome; 5) children's explanations for why they predicted the protagonist would look first in a specific container aligned either with the false belief of the protagonist or the plausibility of an alternative outcome.

Chapter 5.

Discussion

The present research aimed to examine whether the plausibility of children's privileged knowledge influences their reasoning about the beliefs and predicted actions of naïve others. Research that has investigated this issue to date has, for the most part, relied upon classic false belief tasks, during which children are presented with a problem where the perspective of the protagonist in the story narrative is seemingly incompatible with their own perspective on the same situation (Perner & Roessler, 2012). Findings from this body of research show that, in general, by the age of 4-5 years, most children pass a classic false belief task by acknowledging that the perspective of the protagonist is misaligned with their own informed perspective of the “true” situation (Wellman et al., 2001). However, studies also show that older children and even adults continue to make errors in false belief reasoning when the false belief task is made more challenging (Bernstein, 2021; Birch & Bernstein, 2007; Dumontheil et al., 2010; Epley et al., 2004; Ghrear, Fung, et al., 2021). Of specific interest to the current study is Birch and Bloom’s (2007) finding that adults are susceptible to a cognitive bias to assign their own knowledge to a naïve other when they have a plausible reason to do so. The present study extends this research by evaluating whether the plausibility of their own knowledge also influences 7-year-old children’s reasoning about the beliefs and predicted actions of uninformed others.

5.1. Sensitivity to Knowledge Plausibility

As discussed in the introductory chapter, the first hypothesis tested in the study posits that children of this age are sensitive to variation in the plausibility of different knowledge states. The results affirm that by 7 years of age, children appear to know and understand the basic concept of plausibility. Children who had no knowledge of the outcome rated the likelihood that the protagonist was likely to look first in either the blue or yellow container. While there was consensus among children in both Ignorance conditions that the reason the protagonist would look first in the blue container was due to a common behavioural expectation that people look for objects where they were last seen, the reasons provided for why the protagonist would look in the yellow container first were far more varied. For instance, some children attended to the previous location of the container where the protagonist left the doll (“because it [the blue box] was in that spot"). Other children referred to the labels attached to the container ("Because it [the doll] may be in the toy bin), while some children gave more tangential reasons ("Because her doll is for toys, not shoes, if it's in shoes it's like a doll shoe"). Further, some children use "fairylike" or imaginative reasoning that adults would not use ("it left [the doll], landed on an alphabet rhyme, and it is lucky").

Taken together, these findings indicate that 7-year-old children are sensitive to the basic concept of knowledge plausibility and can infer the relative plausibility of different outcome events from diverse information sources in much the same way as older children (Mazzoni et al., 2001) and adults (Birch & Bloom, 2007). To justify their estimates of the plausibility of an outcome, children appear to draw upon prior experience in social situations where behavioural expectations for people's actions are familiar (i.e., people store objects where they belong; people look for objects where they were last seen). However, they also engaged in more complex reasoning about the spatial relationship among objects and the motivations and intents of adults' actions.

5.2. Plausible Knowledge and False Belief Reasoning

Although children were sensitive to the manipulations of plausibility on the false belief displacement task used in this research, evidence was not available to support the second hypothesis of the research, which posited that children would misattribute their own knowledge of the “true” situation to the naïve protagonist when they had a plausible reason to do so. In contrast to findings from studies of adults (Birch & Bloom, 2007; Converse et al., 2008; Dębska & Komorowska, 2013), children put aside a plausible explanation to consider that the naïve protagonist might reasonably act in accordance with their own knowledge (which in their minds was the "true situation") even when it did not match the current situation. Explicitly, ranks assigned to the yellow container in the two Knowledge-Plausible conditions were not inflated by the knowledge that the doll was in this container; rather, ranks were statistically the same as in the corresponding Ignorance conditions where children had no knowledge of the outcome. Further, there was no evidence to suggest that a cognitive bias due to having privileged knowledge of a plausible outcome attenuated children's reasoning about the false belief of the naïve protagonist. Ranks assigned to the blue container (i.e., representing the protagonist’s false belief) in the two Knowledge-Plausible conditions and their corresponding Ignorance conditions did not statistically differ. Put another way, these results show that 7-year-old children recognized that the naïve protagonist on this false belief displacement task could reasonably act in accordance with a false belief about the doll's location, regardless of whether another outcome was equally plausible.

The question that arises is why having a plausible reason to ascribe one's own knowledge to uninformed others has been shown in prior research to bias false belief reasoning of adults (Birch & Bloom, 2007; Converse et al., 2008; Dębska & Komorowska, 2013; Farrar & Ostojić, 2018; Ryskin & Brown-Schmidt, 2014), but not false-belief reasoning of 7-year-old children in this study. As discussed in previous chapters, a fluency misattribution hypothesis may theoretically explain, at least in part, these discrepant findings. That is, knowledge of a highly plausible event or outcome is likely to feel familiar and come more easily to mind among adults compared to children. This sense of fluency, in turn, theoretically makes adults more susceptible to a cognitive bias to consider that their knowledge is common knowledge shared among others. The sense of fluency experienced by children as they consider their own knowledge of the outcome is limited for several reasons. First, the processing demands associated with reasoning about the plausibility of one's own (and other's) knowledge may require a significant cognitive effort, constraining any sense of fluency children experience when thinking about their own knowledge, even when this knowledge is highly plausible. At 7 years of age, children's sensitivity to variation in the plausibility of knowledge emerged as they attended to multiple sources of information within the video as the story unfolded. Allocating attention to and updating the specific information necessary to estimate the plausibility of their own (and others) knowledge may have been cognitively demanding and effortful, which in turn, disrupted the ease with which they felt their own knowledge came to mind. Without a sense of fluency, a bias to consider their own knowledge as common knowledge shared with the protagonist is not likely to result.

Alternatively, a sense of fluency may be less among children than adults because children are less familiar than adults are with the concept of plausibility. Therefore, encoding information about the plausibility of their knowledge may be slower or less efficient than it is with adults. Seven-year-old children have less experience than adults in estimating the plausibility of their own and others' knowledge in varied social contexts. It follows, then, that the mental representations of the plausibility stored in long-term memory may be less stable and accessing these mental representations to process novel, task-related information about their own knowledge may be slower and not automatic, leading children to sense that this knowledge is somewhat unfamiliar. According to the fluency misattribution hypothesis, unfamiliar knowledge is less likely to come to mind easily and, consequently, is less likely to be considered common knowledge, shared among others.

This interpretation aligns well with findings from a series of experiments conducted by Ghrear, Fung, et al. (2021) that showed familiarity with children's own knowledge influenced their estimates of how widespread this knowledge would be among age-peers. Children aged 4- to 7 years were shown 8 factual questions. Four of the 8 trials were "Knowledgeable," where children were given the answers to the questions before estimating whether uninformed children would know the answers. On the 4 remaining "Ignorance" trials, children were not given the answers to the trial questions. In the Ignorance trials, the factual questions asked in the first experiment were selected because the content was unfamiliar to most children (e.g., “The greater wax moth has the best hearing). Therefore, children were unlikely to know the answers. Likewise, the facts taught on the Knowledgeable trials would also be uncommon. A second experiment used the same design and questions; however, on the Knowledgeable trials, children were taught inaccurate answers to the questions yet familiar (e.g., "The bat has the most hearing"). This procedure allowed the researchers to manipulate knowledge familiarity between Knowledgeable and Ignorance trials between the 2 experiments. To obtain the magnitude of bias scores, researchers subtracted each participant's peer estimate (PE) in the knowledge trails by the average PE in children's ignorance trials to each question related to factual information. Following this, the magnitude bias average over the factual questions was calculated and examined whether this average yielded a statistically detectible difference. Results of a multiple regression analysis that investigated the effect of experiment (Exp 1 vs Exp 2) and age on the magnitude of bias showed a significant effect for "experiment" after controlling for age. Explicitly, when children learned familiar answers to factual questions (even when inaccurate) on Knowledgeable trials, their predictions that other children would also know these answers were more significant on Knowledgeable trials compared to the Ignorant trials. Ghrear, Fung, et al. findings showed that familiarity was critical for children's estimations of how widespread this knowledge would be for other peers.

Lastly, children may sense their own knowledge comes to mind less easily than adults due to developmental constraints in working memory capacity rather than processing efficiency of the information within this executive system. However, the results in the present research provide only partial support for this interpretation. In all 6 conditions, knowledgeable children ranked the likelihood that the protagonist would act on a false belief in the same way as children who had no knowledge of the outcome. If the analysis had stopped at this point, a reasonable conclusion could be that 7-year-old children have sufficient working memory capacity to control attention to the plausibility of knowledge of the outcome and put aside any bias to extend their privileged knowledge to the protagonist who holds a false belief. However, the pattern of results found when children's knowledge of the outcome was implausible suggests that this conclusion may be somewhat premature. Although the results showed that when the implausibility of children's own knowledge is well-specified, they reliably put this information aside, this was not the case under conditions where the implausibility of their own knowledge was ambiguous or under-specified. Age-related constraints in working memory capacity may possibly limit 7-year-old children's ability to inhibit attention to their own knowledge when the plausibility of their knowledge of the outcome is not explicit but inferred from information about the relative plausibility of different outcomes. The following section discusses this pattern of results in more detail.

5.3. Implausible Knowledge and False Belief Reasoning

As documented in previous research with adults (Birch & Bloom, 2007), results in the present study show that when children have a justifiable, well-specified reason to explain why an uninformed protagonist would *not* act in accordance with their own informed perspective, they reliably set aside their own knowledge to consider the false beliefs of the protagonist. In the Knowledge-Implausible-Location/Labels condition, the implausibility of children's own knowledge that the doll was in the purple container was explicit and could be inferred unequivocally from two information sources directly associated with the outcome: First, after rearrangement, the purple container, where the doll had been placed, was distant from where the blue container, that initially held the doll was located, and second, the container was labelled "hats" which signalled a doll was unlikely to be stored in this container. Children may have sensed some surprise that the adult in the video placed the doll in the purple container labelled "hats" and not the yellow container labelled "toys," or they may have reasonably considered this a random event. Under conditions where the outcome is clearly implausible and unexpected, children effectively put aside this information to consider the uninformed perspective of the protagonist who held a false belief. Notably, ranks assigned to the purple container by children with knowledge of an implausible but "true" situation (at least in children's minds) were the same as children who had no knowledge of the outcome.

Further ranks assigned to the blue container, which children could reasonably assume the protagonist would falsely believe were where the doll was located, were not attenuated by a bias due to knowledge of the outcome. These results align, in general, with a fluency misattribution hypothesis, as the ease with which children's knowledge of the outcome came to mind could reasonably be interrupted by a sense of surprise or the processing of an unfamiliar, random event. The results are also consistent with findings in studies of adults that show having privileged knowledge of an outcome that is surprising (Mazursky & Ofir, 1990; Ofir & Mazursky, 1997; Müller & Stahlberg, 2007 for a review) or possibly a random event (Wasserman et al., 1991) did not curse or bias their reasoning about the perspectives of naïve others.

On the other hand, when the plausibility of children’s (or other’s) knowledge is not explicit but ambiguous and inferred from considering the relative plausibility of all outcomes, children appear to be susceptible to a cognitive bias to focus on what they believe to be the "true" situation when reasoning about the perspectives or predicted actions of a naïve person. In the Knowledge-Implausible-Location condition, the implausibility of children's knowledge of the outcome was not inferred directly from information about the purple container; rather, it was inferred from considering the relative plausibility of all containers. That is, in the absence of information about the purple container to reason otherwise, the blue container (where the doll was last seen) and the yellow container (that, after rearrangement, was in the original location of the blue container) were viewed as more plausible locations for the protagonist to look for the doll than the purple container. Under these conditions, the results show that children considered what they believed to be the "real" situation to reason about the beliefs and predicted actions of the uninformed protagonist. Specifically, ranks assigned to the purple container by knowledgeable children were inflated relative to ranks assigned by children who had no knowledge of the outcome. Although children were susceptible to a bias to consider that an uninformed person could share their knowledge of this implausible outcome, the magnitude of cognitive bias was not sufficient to attenuate reasoning that the protagonist was more likely to act in accordance with a false belief and look for the doll in the blue container, where it was last seen. Differences in the ranks assigned to the blue container by children with or without knowledge of the outcome were not statistically detectable.

Previous research (Lagattuta, Sayfan, et al., 2014) has also shown that under conditions where the information available to predict an outcome is ambiguous, older children and even adults are susceptible to a bias to attribute their own knowledge of the "true" situation to less informed others; however, susceptibility to these bias decreases over time, as children age. Lagattuta, Sayfan, et al.'s study examining children's emerging understanding illustrates that some thoughts held by people are more likely than others. In this research, 4- to 10-year-olds and adults were shown a picture that was subsequently occluded to show only a small, ambiguous portion of the picture. After viewing the actual picture that had been occluded, questions were asked about how a naïve person would likely interpret the hidden picture and about the probability that a naïve person would think of pictures that varied in probability from the actual picture (e.g., a cloud), a basic shape associated with the small, visible portion of the occluded picture (e.g., a circle for a visible arc), pictures that represented objects within the same semantic category (e.g. weather-related), and a picture that was impossible, given the visual information available to them (e.g., a bolt of lightning). The results showed that all age groups who had previously viewed the actual picture overestimated the probability that a naïve person would guess this picture; however, the trend to do so decreased with age: estimates that a naïve person would think of the actual picture occurred on 37%, 17%, and less than 3% of trials for knowledgeable children aged 4- to 5-years, 6- to 7-years, and both 8- to 10-years and adults, respectively. In comparison, children who were not shown the actual picture before predicting how an uninformed person would interpret the occluded picture rated the probability that a naïve person would guess the actual picture the same as they would guess novel, less probable interpretations of the picture. Notably, the age-related decline in misattributing privileged knowledge to a naïve person was inversely associated with a prediction that a naïve person would associate the small part of the occluded picture left visible with a basic shape. The authors suggest that children aged 6 years and older appear to draw upon their own knowledge and experience to predict how a naïve person will interpret ambiguous information; however, as they grow older, children are also more likely to imagine that a naïve person will also assign novel meanings associated with the ambiguous or under-specified information. This interpretation may also explain, in part, the result that showed when information about the specific plausibility of a known outcome is ambiguous and inferred from the relative plausibility of all outcomes (i.e., in the Knowledge-Implausible/Location condition), 7-year-old knowledgeable children were susceptible to a bias to consider what they believed to be the "true" situation to predict how a naïve person (the protagonist) would act; however, at the same time, they were also open to considering that the uninformed protagonist would reasonably act first upon a false belief that the doll was in the blue container. Under conditions where children's knowledge of an implausible outcome is inferred from several information sources in combination (i.e., the relative plausibility that the doll was in all containers), it seems reasonable to posit that age-related constraints in either working memory capacity or processing efficiency within an executive system explain the finding that children did not inhibit attention to their own knowledge when considering the perspective of the uninformed protagonist. An assumption that under the same conditions, children sensed that the plausibility of their knowledge of the outcome came readily to mind (as in a fluency misattribution hypothesis) is debatable, as the information available to estimate the plausibility of the purple container was relatively ambiguous.

5.4. Fluency Misattribution or Executive Control

The discussion in the chapter has primarily relied upon the fluency misattribution hypothesis in combination with attentional control and/or processing efficiency within an executive cognitive system to explain the results. Teasing apart the ease with which children sense their own knowledge comes to mind from their efficiency in processing this and other relevant information in an age-defined, limited capacity executive system is not possible on a dynamic, false-belief displacement task such as used in the present research. At first glance, the results observed in this study suggest that at 7 years of age, children had adequate working memory capacity to efficiently track multiple sources of information about the plausibility of their own knowledge of the outcome and to update these interpretations of plausibility as new information became available; they also successfully controlled attention to selected information necessary to interpret the uninformed protagonist’s knowledge (perspective) and to put aside any cognitive bias attributable to knowledge of what they believed was the true situation to predict the protagonist would act on a false belief. However, since there is an overall consensus among theorists and researchers that processing within a general executive system is highly inter-connected and not modular (see Cowan, 2017 for a review), it seems reasonable to assume that any effect of a sense of fluency experienced from having knowledge of an outcome is separable only in part, from the contribution of the role that the efficiency of processing knowledge plausibility plays in this association. Further, in a dynamic social context, the plausibility of children's (own and others) knowledge will likely ebb, and flow as new information becomes available. This suggests that age-related variation in working memory capacity may also contribute to this prediction when demands on an executive system increase.

5.5. Implications of the Research for Education

The findings of this research have practical implications in education. ToM may have an impact on two school domains, social and academic. Children's ability to set aside their own knowledge to understand others' perspectives influences how 7- to 8-year-olds interact on a daily basis with peers and teachers. ToM may also impact children's academic performance in the school context.

Concerning the social domain, middle childhood differs from preschool years as children spend more time with classmates or friends in formal or informal school and after-school activities. Children will have multiple opportunities to improve their mindreading skills in these contexts. Routine school interactions can lead to peer acceptance or rejection. Research findings have shown that better performance in ToM tasks is associated with peer acceptance (Banerjee et al., 2011), teacher's perception of children's social competence (Devine et al., 2016), and the ability to sustain reciprocated friendships (Fink et al., 2015). Other researchers have also documented evidence to support this claim. In a meta-analysis, Slaughter et al. (2015) examined research about ToM and peer acceptance. Their findings showed that ToM reliably predicted peer acceptance. In a follow-up study conducted with typical and deaf children from hearing and non-hearing parents, Peterson et al. (2016) found that although typical children score higher on a social maturity scale, for both groups, ToM alone predicted social maturity, even when controlling for language skills and age. Explicitly, children's abilities to infer and reason about others' mental states facilitated positive teacher-student relationships and increased peer acceptance. In this regard, Lagattuta, Hjortsvang, et al. (2014) demonstrated that positive teacher and peer relationships foster academic achievement. A child who can set aside their privileged knowledge to take others' perspectives will successfully interact with peers and instructors, avoiding confrontations and conflicts arising from misunderstandings. Research has also documented that peer conflict and rejection are risk factors for school outcomes (Campbell et al., 2006).

Children's ability to infer others' beliefs diverges across school-age children. Thus, individual differences in children's ToM may underpin children's social outcomes in school settings (Devine & Hughes, 2016; Ratcliffe, n.d.). In middle childhood, children have acquired sufficient understanding of mental state concepts such as belief and knowledge. Therefore, the critical part rests on their ability to *use* these concepts appropriately to succeed in social interactions (Devine et al., 2016). A longitudinal study with children ages 6 to 10 yielded moderated associations between ToM and later social behaviour at school as measured by teachers' ratings of social competence. The researchers contended that their findings support the hypothesis that individual differences in ToM influence later success in school social interactions.

Concerning the impact of children's ToM on their academic performance, Wellman (2016) argues that children's ability to respond appropriately to social demands in school also fosters academic achievement. Explicitly, academic achievement is not only about knowledge and skills but also hinges on children's ability to persist and understand teachers' intentions and expectations of their students. Studies have yielded evidence supporting the social competence hypothesis as playing a role in school success. For example, Denham et al. (2012) reported that preschoolers' social-emotional skills mediated the relationship between emotional awareness and later success in school. Therefore, it is possible that social understanding is critical at assisting children to build positive relationships with peers and teachers that, in turn, help children to benefit from learning experiences that reflect in their academic achievement.

Nevertheless, researchers have contended that individual differences in ToM have a specific impact on children's academic content. For example, ToM may explicitly influence children's reading comprehension. The association between ToM and reading comprehension was initially proposed by Kintsch and Rawson (2005) using the situation model theory. Following this model, beyond the text's vocabulary and propositions, readers must create a mental model of the situation described in the text. Readers prepare this model by recruiting information, not in the text. This allows them to grasp the story and predict evolving events. Kim, 2015 and Pelletier & Beatty, 2015) found that children recruited their perspective-taking abilities to infer the authors' intentions and to provide multiple interpretations of the text (Kim, 2017). In a series of investigations with children from Korea and the United States attending kindergarten to grade 2, researchers documented significant associations between ToM and measures of reading comprehension. This association remained significant even after controlling for EF skills (Kim, 2015; Kim, 2016, 2017; Kim & Phillips, 2014).

Further, Lecce et al. (2021) used longitudinal data to investigate, in 9- and 10-year-olds, relationships between ToM and reading comprehension. Critically, in older children, variables such as decoding, phonological awareness, and vocabulary do not explain differences in reading comprehension. Therefore, the researchers contended that ToM could be the missing factor that accounted for these differences. Their findings provided evidence in favour of their hypothesis. Explicitly, employing 2 ToM tasks and measures of reading comprehension, the experimenters documented a bi-directional association between ToM and reading comprehension in older children even after controlling for SES, verbal ability and working memory. ToM performance predicted reading comprehension, and, on the other hand, reading comprehension supported gains in ToM. Other studies have confirmed the association between ToM performance and reading comprehension in middle childhood. This association persisted even when accounting for variables such as prior topic knowledge, word reading fluency, and language ability, with single texts and multiple texts respectively (Boerma et al., 2017; Florit et al., 2020).

Additional support for this hypothesis comes from research with children on the autism spectrum who are known for their difficulties with perspective taking tasks and lower scores than typical peers in reading comprehension (Lindgren et al., 2009). Also, Jones et al. (2009) found that the differences in reading scores in this population could not be explained by their differences in general intelligence.

Adding to the evidence of Boerma et al. (2017), 2 studies conducted with 9- to 10-year-old-children (Lecce et al., 2021) yielded confirmatory evidence of the impact of ToM in reading comprehension. The first study included 157 participants, 9- to 10-year-olds. The researchers employed a standardized reading comprehension test and two tests of ToM. They also controlled for verbal ability, working memory and SES. Their findings demonstrated that both ToM tasks were significantly associated with reading comprehension scores. The second study added measures of mathematical ability to confirm the specificity of the relationship between ToM and reading comprehension. Based on former literature (Cantin et al., 2016) the researchers predicted that mathematical skills and ToM would be unrelated. Thus, the second study, recruited 60 9- to 10-year-old children. The experimenters gave children standardized academic achievement tests for reading comprehension and mathematical ability. Children also responded to 4 stories from the Strange Stories ToM tasks (White et al., 2009). The experiment included measures of executive functions, language skills and the SES index. The study's findings confirmed the results of the first one, that is, ToM performance and reading comprehension had a positive relationship and this relationship was also bidirectional. However, ToM and mathematical scores did not yield a significant association. Cantin et al. (2016) previously documented non-statistically detectible associations between ToM tasks and 7- to 10-year-olds children's performance on the mathematical tests of the Wechsler scale. A former study with preschool students (Blair & Razza, 2007) initially found a positive association between false belief performance and mathematical abilities (e.g., number recognition, shapes, quantity, and addition); however, this relationship faded when the researchers integrated into the equation measures of executive function (i.e., inhibitory control and attention shifting).

To sum up, children’s ability in middle childhood to reason about others' perspectives and knowledge to understand or predict their actions may extend not only to children's social lives in or out of school but also to academic achievement. This impact is particularly important on reading comprehension skills, but not necessarily on mathematical skills. However, as Wellman (2016) pointed out, children’s mindreading capacities may assist in their general academic pursuits.

Lastly, the present study raised the intriguing possibility that ambiguity of information may be a source of cognitive bias in 7- to 8-year-old children. This bias may prevent children's successful grasp of others' knowledge when uncertainty is present. However, this study cannot provide further information on educational implications, mainly because a caution is warranted in interpreting this study's findings due to its limitations. Thus, further research with larger and different age groups samples is required to confirm these findings.

5.6. Summary and Future Research

Taken together, these findings clearly show that children's understanding and appreciation of their own and others' minds continue to develop past the age of 5 years, when most children pass a classic false belief task (Dumontheil et al., 2010; Lagattuta, Nucci, et al., 2010; Miller, 2009; Osterhaus & Koerber, 2021a, 2021b). At 7 years of age, children in the present study appear to have moved from a phase of strict egocentrism to a phase in which they not only reliably consider a perspective that differs from their own, but also effectively estimate variability in the plausibility of their own and other's knowledge (perspective) to predict the actions of a naïve person. However, in contrast to previous research that has shown that adults are susceptible to a bias to extend their own knowledge to uninformed others when they have a plausible reason to do so, this bias was not found among 7-year-old children in the present research. This finding can be interpreted as child-adult differences in the sense of knowledge fluency that is attributable to age-related variation in the understanding of the concept of plausibility and its relation to knowledge familiarity and/or common knowledge; age-related change in processing efficiency of knowledge plausibility in an executive system; or age-related variation in working memory capacity necessary to infer plausibility of the outcome from the plausibility of different potential outcomes on a complex, false belief displacement task. Future research using modelling methodologies may differentiate the relative contribution of these theoretical accounts to explaining the impact of knowledge plausibility on false belief reasoning specifically, or theory of mind reasoning in general, across the lifespan.

Although the false belief displacement task in the current research was sensitive to variation in 7-year-old children's basic understanding of plausibility, it may not have reliably tapped subtle variations in children's feeling about the ease with which this information came to mind. Further modifications to the current false belief displacement task may be necessary to tap these subtle differences. Further, the psychometric properties of each condition on the false belief displacement task could be established to support future studies of the role of plausibility of knowledge on individual- and age-related differences in false-belief reasoning.

5.7. Limitations of the Study

The main limitation of the current study is the lack of power due to the sample size. The sample size suggested to detect a medium-size effect (*d* = .25; Cohen, 1988), as computed by “G Power” (Faul et al., 2009), was 270 participants; the data in this study was collected from only 88 children. Insufficient power in the research makes the analysis prone to type 2 error, defined as a failure to reject the null hypothesis. Specifically, the lack of detectible statistical differences between the experimental and control conditions may lie in the lack of power and not in a true difference between adults and children. In general, decreased power directly impacts researchers' ability to claim that their results reflect a true effect observed.

A second limitation of this study relates to using an ordinal scale to measure children's reasoning in a false belief displacement task. The data collected were sorted from first to fourth in rank order. Also, these data allowed for between groups comparison. However, ordinal data do not quantify the difference in magnitude between each ranking. Explicitly, the lack of equal distances prevented analyses requiring interval or ratio data.

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Appendix A. Scripted Events by Condition

Figure A.1

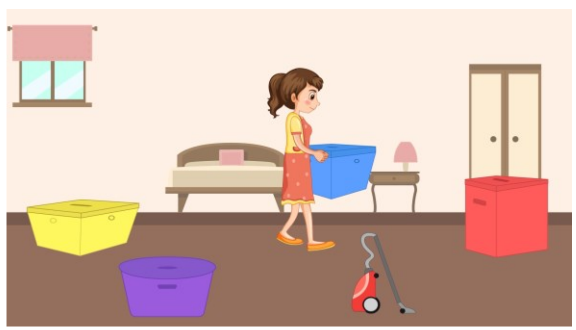
Ignorance Location Condition


Scene 1. Child puts doll in blue container


Scene 2. Child goes out of the room


Scene 3. Adult takes the doll out of the blue container


Scene 4. Ignorance Condition, No knowledge of the doll's displacement


Scene 5. Adult rearranges the containers

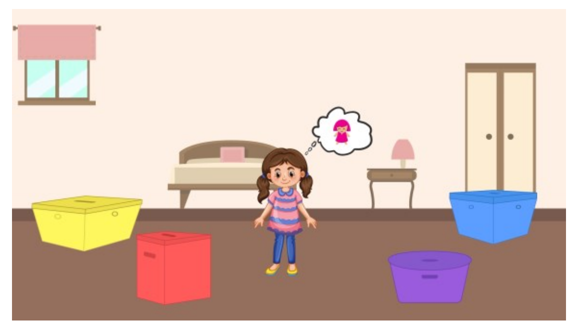

Scene 6. Child returns to the room

Figure A.2

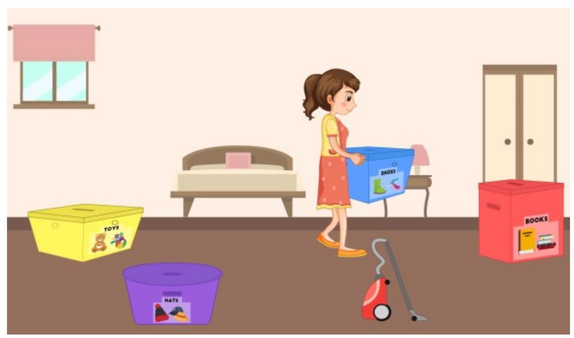
Ignorance Location/Labels Condition

Scene 1. Child puts doll in blue container

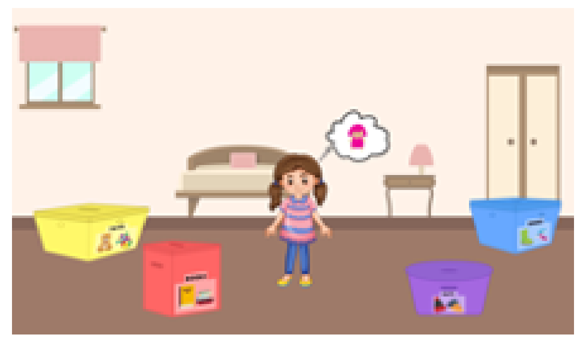
Scene 2. Child goes out of the room

Scene 3. Adult takes the doll out of the blue container

Scene 4. Ignorance Condition, No knowledge of the doll’s displacement



Scene 5. Adult rearranges the containers



Scene 6. Child returns to the room

Figure A.3.

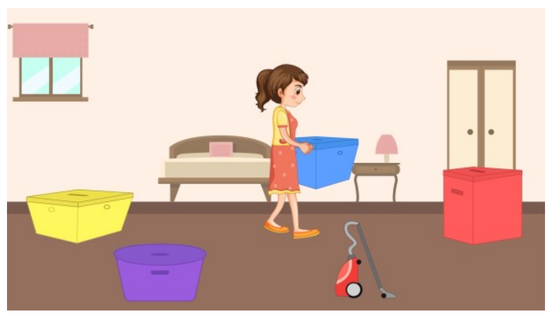
Knowledge-Plausible-Location Condition

Scene 1. Child puts doll in blue container

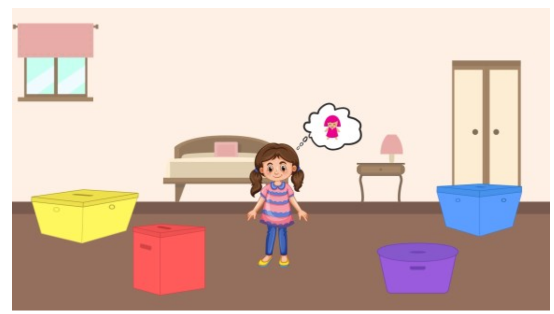
Scene 2. Child goes out of the room

Scene 3. Adult takes the doll out of the blue container

Scene 4. Knowledge-Plausible Condition, Adult places the doll in the yellow container



Scene 5. Adult rearranges the containers



Scene 6. Child returns to the room

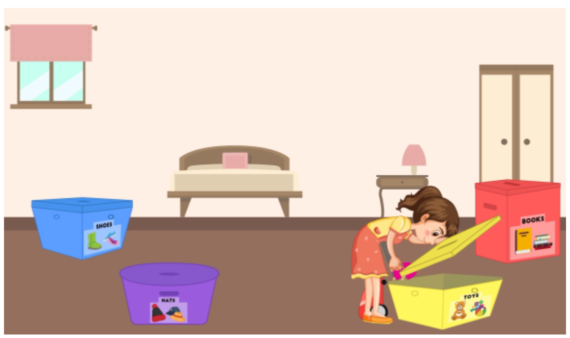
Figure A.4

Knowledge-Plausible-Location/Labels Condition

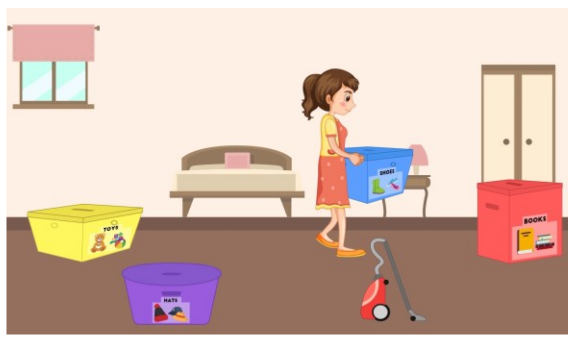
Scene 1. Child puts doll in blue container

Scene 2. Child goes out of the room

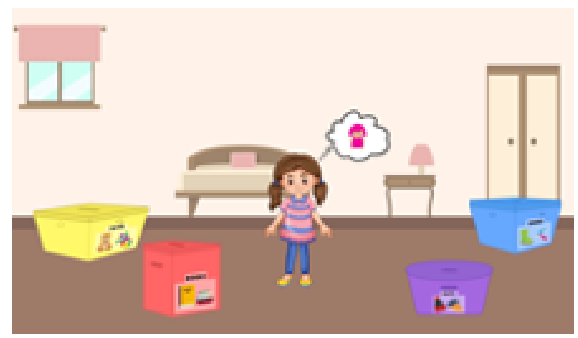
Scene 3. Adult takes the doll out of the blue container



Scene 4. Knowledge-Plausible Condition, Adult places the doll in the yellow container



Scene 5. Adult rearranges the containers



Scene 6. Child returns to the room

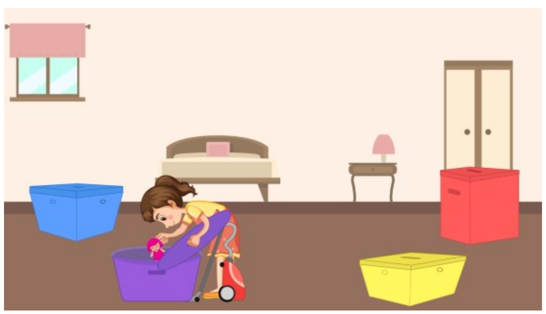
Figure A.5

Knowledge-Implausible-Location Condition

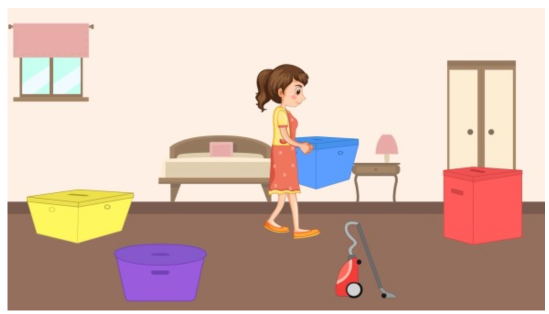
Scene 1. Child puts doll in blue container

Scene 2. Child goes out of the room

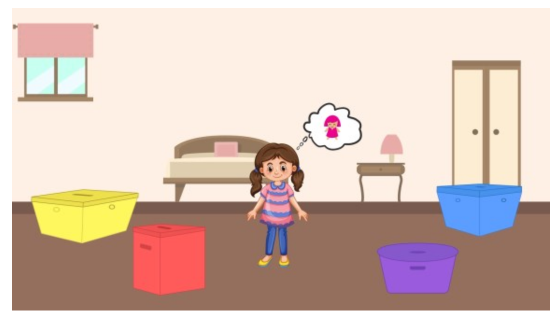
Scene 3. Adult takes the doll out of the blue container



Scene 4. Knowledge-Implausible Condition, Adult places the doll in the purple container



Scene 5. Adult rearranges the containers



Scene 6. Child returns to the room

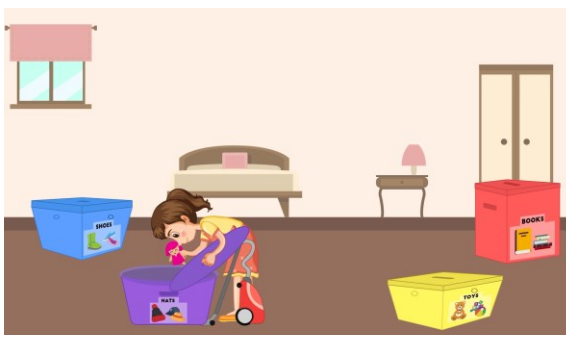
Figure A.6

Knowledge-Implausible-Location/Labels Condition

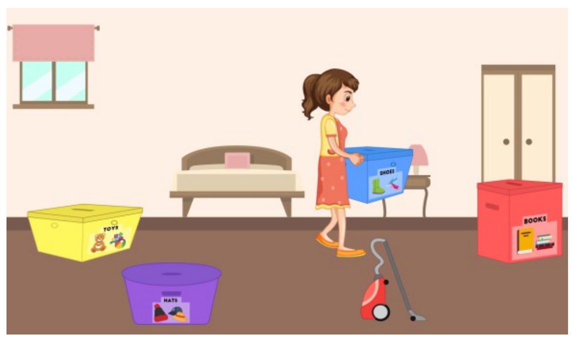
Scene 1. Child puts doll in blue container

Scene 2. Child goes out of the room

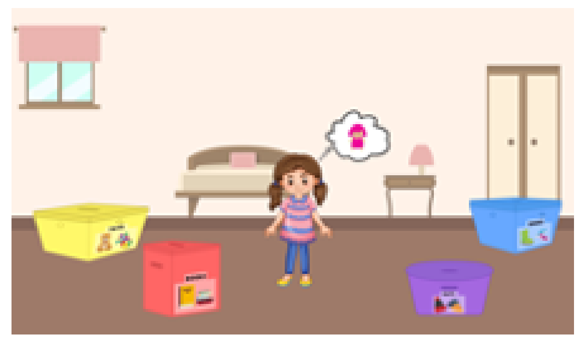
Scene 3. Adult takes the doll out of the blue container



Scene 4. Knowledge-Implausible Condition, Adult places the doll in the purple container



Scene 5. Adult rearranges the containers



Scene 6. Child returns to the room

Appendix B. Distribution of Ranks by Conditions

Table B.1

Distribution of Ranks by Ignorance Conditions

	Ignorance-Location (n=15)				Ignorance-Location/Labels (n=14)			
Rank	Blue (%)	Yellow (%)	Purple (%)	Red (%)	Blue (%)	Yellow (%)	Purple (%)	Red (%)
1	10	4	0	1	6	8	0	0
	(67)	(27)	(0)	(6.7)	(42.9)	(57.1)	(0)	(0)
2	1	7	1	6	5	4	3	2
	(6.7)	(47)	(6.7)	(40)	(35.7)	(28.6)	(21.4)	(14.3)
3	0	1	9	5	0	1	7	6
	(0)	(7)	(60)	(33)	(0)	(7.1)	(50)	(42.9)
4	4	3	5	3	3	1	4	6
	(27)	(20)	(33)	(20)	(21.4)	(7.1)	(28.6)	(42.9)

Note: Ranks are ordered so that a rank of 1 to 4 indicates a range from the most to the least likely place that the agent would look for the doll

Table B.2

Distribution of Ranks by Plausible Conditions

	Plausible-Location				Plausible-Location/Labels			
Rank	Blue (%)	Yellow (%)	Purple (%)	Red (%)	Blue (%)	Yellow (%)	Purple (%)	Red (%)
1	12	1	1	1	6	8	0	0
	(80.0)	(6.7)	(6.7)	(6.7)	(42.9)	(57.1)	(0.0)	(0.0)
2	2	8	5	0	6	2	3	3
	(13.3)	(53.3)	(33.3)	(0.0)	(42.9)	(14.3)	(21.4)	(21.4)
3	1	0	2	12	1	3	3	7
	(6.7)	(0.0)	(13.3)	(80.0)	(7.1)	(21.4)	(21.4)	(50.0)
4	0	6	7	2	1	1	8	4
	(0.0)	(40.0)	(46.7)	(13.3)	(7.1)	(7.1)	(57.1)	(28.6)

Note: Ranks are ordered so that a rank of 1 to 4 indicates a range from the most to the least likely place that the agent would look for the doll

Table B.3

Distribution of Ranks by Implausible Conditions

	Implausible-Location				Implausible-Location/Labels			
Rank	Blue (%)	Yellow (%)	Purple (%)	Red (%)	Blue (%)	Yellow (%)	Purple (%)	Red (%)
1	7	4	2	2	7	5	3	0
	(46.7)	(26.7)	(13.3)	(13.3)	(42.9)	(33.3)	(20.0)	(0.0)
2	3	2	8	2	2	8	2	3
	(20.0)	(13.3)	(53.3)	(13.3)	(13.3)	(53.3)	(13.3)	(20.0)
3	2	3	3	7	2	2	4	7
	(13.3)	(20.0)	(20.0)	(46.7)	(13.3)	(13.3)	(26.7)	(46.7)
4	3	6	2	4	4	0	6	5
	(20.0)	(40.0)	(13.3)	(26.7)	(26.7)	(0.0)	(40.0)	(33.3)

Note: Ranks are ordered so that a rank of 1 to 4 indicates a range from the most to the least likely place that the agent would look for the doll.