The Role of Language in the Development of Epistemic Concepts

by

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Human Development and Applied Psychology
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Abstract

This thesis examines the effects of linguistic input on the development of children’s epistemic concepts. It draws upon two fundamental questions in the field of cognitive development: (a) whether distinctions between automatic and controlled forms of cognitive processing are indicative of underlying conceptual differences, and (b) whether language is critical to the process of concept development. To establish the background of the current research, a summary of how these theoretical questions have been addressed in other fields of cognitive psychology is first provided (Chapter 1). These questions are then re-examined within the specific domain of epistemic concept development (Chapter 2). Changes in false-belief processing that occur between infancy and the early preschool years are discussed in relation to two competing theories of false-belief development. A framework to explain how language promotes children’s transition between automatic and controlled forms of processing is then provided. It is suggested that language facilitates change by both reducing the cognitive demands associated with controlled response tasks as well as assisting with the formation of robust epistemic representations. An empirical study that was designed to examine the effects of epistemic language (i.e., verbs and syntax) on children’s automatic and controlled processing of belief is then described (Chapters 3 to 5). Eighty-four children ($M_{age} = 3;5$ years), who initially failed elicited measures of false-belief, were trained with visual contexts of true- and false-belief.
The critical manipulation across three conditions was the linguistic input presented in conjunction with these contexts. Children heard narrations that contained either (a) the description of an agent’s actions without an epistemic verb, (b) a familiar epistemic verb (*thinks*) across both contexts, or (c) the familiar epistemic verb in contexts of true-belief and a novel epistemic verb (*gorps*) in contexts of false-belief. Results demonstrated a significant advantage for children who were trained with epistemic verbs on spontaneous measures of false-belief (i.e., anticipatory gaze). Significant effects of epistemic verb exposure were also demonstrated in novel contexts of belief induction. Implications of these findings are discussed in relation to theories that make distinct predictions about the role of language in epistemic concept development (Chapter 6).
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Chapter 1
Language and the Development of Epistemic Concepts

“You can think about red. You can think about pink. You can think up a horse.
Oh the THINKS you can think!” (“Oh, the THINKS You Can Think!” by Dr. Seuss, 1975).

One of the most intriguing social skills that children develop in the early years of life is the ability to flexibly perceive and reason about the epistemic states – i.e., states of knowledge and belief – of others. By virtue of being internal and personal, epistemic states are, after all, not as readily perceptible as more visual event features (e.g., overt actions, objects, spatial locations, etc.). Unlike characters in a comic strip, people also do not walk around with thought bubbles hanging over their head that would provide children with a visual representation of these internal states. Despite these challenges, however, children do eventually develop the sophisticated ability to both represent and infer the mental states of others in a variety of social situations – also referred to as the development of theory of mind. By the age of 5, most children not only can identify that a person can hold a belief that is distinct from their own, but also that this belief can be false (i.e., contradicts the true state of reality) and may be used to infer the subsequent actions and/or emotions of that other person (Wellman & Liu, 2004).

What has remained a highly contentious issue in this area of research, however, is the question of when the conceptual understanding of belief first develops. Traditionally, children’s ability to impute epistemic states has been assessed using elicited measures of false-belief understanding (e.g., Wimmer & Perner, 1983). In these tasks, children are typically required to infer how a protagonist will behave (e.g., where s/he will look for a target object) when acting upon a belief that is inconsistent with reality (e.g., the protagonist fails to see the displacement of a target object and therefore believes it to be in its original location). Because younger children consistently fail to respond to direct questions about their own and others’ beliefs, it has been largely accepted that a conceptual shift in children’s ability to internally represent epistemic states must occur between the ages of 4- and 5-years (Gopnik & Wellman, 1992). Alternatively, other researchers have argued that children may be aware of internal states from a far earlier point in development (Onishi & Baillargeon, 2005; Scholl & Leslie; 1999) and that children’s
performance on false-belief tasks may instead be reflective of factors that are peripheral to their understanding of belief (e.g., task demands, domain-general cognitive abilities, etc.). This latter perspective has largely been supported by recent findings that infants and young toddlers are capable of tracking the belief states of others when assessed with measures that rely on involuntary, as opposed to controlled, responses (Clements & Perner, 1994; Kovács, Téglás, & Endress, 2010; Luo & Baillargeon, 2007; Song & Baillargeon, 2008; Southgate, Senju, & Csibra, 2007). As such, it is currently unclear whether children younger than 4 are also capable of forming robust representations of belief or whether qualitative differences in response type (i.e., involuntary vs. controlled) are indicative of qualitative differences in conceptual understanding (Perner, 2010; Perner & Ruffman, 2005). Related to this debate is the equally important question of what factors are necessary for the development of epistemic concepts to occur. Specifically, there has been much research over the years examining how the development of language may directly assist children with formation of epistemic concepts (see Astington & Baird, 2005). Most of the theories and research supporting a strong link between language and epistemic concept development, however, were established between children’s emerging linguistic abilities and their performance on controlled measures of false-belief. At present, it is therefore less certain how children’s linguistic abilities interact, if at all, with the involuntary processing of epistemic states. Similarly, if language is critical for the controlled expression of epistemic understanding, it is still an open question if language can also assist children with the transition from strictly involuntary to more controlled levels of processing.

In the current thesis, these issues will be examined in more detail and will provide the basis for an empirical study examining the effects of epistemic verb exposure on preschool children’s formation of epistemic representations. Before delving into the details of this study, however, it is first imperative to outline the broader context from where these critical issues emerge. That is, it is important to demonstrate that this research is founded upon two theoretical questions that have long been central to the field of cognitive development: (1) whether differences in response processing can be interpreted as differences in conceptual understanding, and (2) how language assists with the process of concept formation. A review of how these two questions have been previously examined in other domains of cognitive psychology will therefore be provided in the following sections. This review will thereby set the stage for a more comprehensive discussion
of how these issues pertain to the topic of epistemic concept development, which will be addressed in Chapter 2.

1.1 Interpreting Differences in Response Processing

In the field of infant cognition, automatic response measures typically assess differences in involuntary behavioural responses (e.g., head turns, eye gaze) to either familiar or novel stimuli. They include paradigms that assess infants’ response to novel stimuli following a period of familiarization, or habituation, to a set of related items or events (e.g., violation of expectation and habituation paradigms). They also include paradigms that compare infants’ preferential response to different sets of stimuli in a forced-choice display (e.g., preferential looking and anticipatory eye gaze paradigms). Critically, these measures are all designed to detect subtle changes in behavioural responses as a means of demonstrating infants’ ability to discriminate between different sets of stimuli. Sometimes, however, these measures are also used to infer underlying cognitive structures that support infants’ responses on these tasks. It is this matter of interpretation that has subsequently caused much recent controversy in the field of social cognition. Importantly, this issue has also been at the forefront of other areas of developmental research for several years (e.g., physical reasoning, Bogartz, Shinskey, & Speaker, 1997; causality, Oakes & Cohen, 1990; memory development, Rovee-Collier, 1997).

With regards to interpretation, much of the debate has centred on the question of whether or not automatic responses require the same level of cognitive understandings as tasks that rely on more controlled or direct responses. In this debate, researchers typically fall into one of two camps: those that adhere to a “rich” interpretation of involuntary behavioural responses and those who adhere to more “lean” interpretations (Haith, 1998). Rich interpretations assume that children’s performance on automatic response measures is indicative of higher-order cognitive processes. For example, in a violation-of-expectation paradigm, children must form and retrieve mental representations – or internal symbols – of events they witnessed on preceding familiarization trials in order to compare and respond to test stimuli. Moreover, proponents of rich interpretations argue that the extent to which children’s automatic responses are indicative of underlying conceptual knowledge can be tested using paradigms that selectively control for the effects of extraneous features and biases (Munakata, 2000). For example, extraneous factors that are known to affect perceptual processing (e.g., perceptual similarity, novelty bias, recency
effects, etc.) are often held constant across both experimental and control test stimuli. Only experimental stimuli, however, are designed to be contingent on the conceptual knowledge being tested (e.g., children may be shown two novel exemplars of animals but only one is categorically related to a familiarized set). If children respond differentially to experimental and control stimuli (i.e., they respond to the novelty of the control but not the experimental stimuli) then this should suggest that their processing of experimental stimuli is dependent on more than just extraneous perceptual factors.

In contrast, researchers who take on more lean interpretations of automatic response data tend to attribute children’s accuracy on these tasks to lower level perceptual processes (Haith, 1998, Munakata, 2000). For some researchers, distinguishing between automatic and controlled response processes is necessary because qualitatively distinct levels of cognitive processing are thought to be associated with each. That is, automatic responses are thought to occur at an implicit level - i.e., function at a level that is inaccessible to other cognitive processes – and therefore qualitatively different from the explicit processing needed to pass direct verbal measures (Deines & Perner, 1999). For others, the reasons for avoiding rich interpretations are more practically based. Higher-order cognition cannot be gleaned from automatic response tasks because these measures were not designed to assess this (Haith, 1998). Moreover, these researchers argue that the list of extraneous factors that could potentially influence automatic responses (above and beyond conceptual knowledge) could be infinite. To claim that children’s responses are therefore the result of non-perceptible conceptual knowledge creates the near impossible task of ruling out the effects of all other possible influences. Indeed, it seems as if much of the research supporting lean interpretations of infants’ response patterns has been conducted in an effort to disprove claims made by the opposite camp.

Unfortunately, the consequence of having such polarized viewpoints is that the broader developmental story of how infants progress between different levels of cognitive understanding inevitably gets lost. Beyond addressing the factors that influence infant’s responses on specific tasks, neither rich nor lean interpretations offer clear explanations for how children might continue to develop their conceptual knowledge beyond a single testing context (or in the case of a rich interpretation, how they developed it before). In response to this dichotomy, some researchers have subsequently acknowledged the need for more graded interpretations of conceptual understanding during infancy (Haith, 1998, Munakata, 2000). These interpretations
would allow for an interaction of both perceptual and conceptual factors, recognizing that conceptual development is by no means complete before the second year of life. Importantly, this compromise of interpretations would shift the focus of infant research back to explaining the developmental trajectory of early emerging cognitive abilities. It is with this same developmental perspective that the topic of false-belief development will thus be examined in the following chapters of this thesis.

1.2 Language and Concept Development

The idea that language can influence the development of cognitive structure is also not a new issue in cognitive development, nor has it been discussed without controversy over the years (Bowerman & Levinson, 2001; Gentner & Goldin-Meadow, 2003). For example, the Sapir-Whorf hypothesis – i.e., the hypothesis that our perception of external information is dependent on the organizational structure of our native language – was well accepted in psychology up until the latter half of the 20th century. This hypothesis, however, was quickly refuted by research demonstrating that both perception and cognition could develop separately from linguistic input (Gentner & Goldin-Meadow, 2003). For several years, this view was also largely superseded by cognitive theories that viewed the development of thought as separate (e.g., modular theories) or preceding the development of language (e.g., Piagetian theory). Today, while it is generally accepted that language can interact with cognitive processing throughout development it is also well documented that the development of certain concepts precedes the acquisition of language (Arunachalam & Waxman, 2010; Carey, 2009). Despite the decline in support for Whorfian accounts of cognition and language, however, many researchers still support the idea that language may play a critical role in the development of certain concepts (Astington, 2000; Baldwin & Saylor, 2005; Gentner, 2003; Nelson, 2007). This constructivist view is largely founded upon Vygotskian principles of cognitive development and asserts that the development of conceptual knowledge is dependent on a dynamic interaction between external social input and internal cognitive structures.

Generally speaking, there are two modes by which language can be said to directly influence the cognitive structure of children’s understanding, although neither mode is strictly exclusive of the other. First, by virtue of being a social device, language helps to engage children in meaningful social interactions that serve to highlight information that is relevant within a shared social environment (Nelson, 2007). Thus, language may assist concept formation through the provision
of meaningful social constraints. Second, language provides children with a symbolic system that can assist them with the representation and reasoning of abstract information (Huttenlocher & Higgins, 1978). The grammatical structure of language not only helps to constrain the type of information that children can attend to within their environment but also serves to highlight similarities and differences between different contexts (Arunachalam & Waxman, 2010). Thus, language may assist with the formation of higher-order concepts through cognitive constraints and the promotion of comparative processes (Carey, 2009; Gentner, 2010).

The focus of the current thesis is on the cognitive constraints that language provides in the development of abstract concepts (i.e., states of knowledge and belief). To date, however, the bulk of research looking at the cognitive effects of language on concept development has focused almost exclusively on children’s reasoning about concrete concepts. For example, there is substantial evidence to demonstrate that language can uniquely assist in the promotion of object categorization during infancy (Fulkerson & Haaf, 2006; Waxman & Markow, 1995; Xu, 2002). That is, when novel objects are presented with shared category labels, infants are more likely to group objects together than when they are presented with salient non-linguistic markers (e.g., tones) or phrases that do not denote category membership (e.g., “Look at this one”).

Although less is known about the role of language in the development of more abstract concepts, research has also indicated that language can facilitate the representation and transfer of non-obvious relational patterns, even when those relations conflict with more salient perceptual similarities. For example, category labels have been shown to facilitate young children’s inductive inferences about non-obvious object properties even when those labels conflict with salient object features such as shape (Keates & Graham, 2008). Similarly, relational labels have been shown to assist children with the mapping of complex spatial relations across object displays even when those spatial relations conflict with more obvious perceptual mappings (Loewenstein & Gentner, 2005; Ratterman and Gentner, 1998). In all these studies, language critically assists children with the detection of relational patterns that would otherwise be difficult to detect via visual information alone. Importantly, by encouraging children to attend to relations that underlie more obvious surface similarities, language may also promote the representation and transfer of more abstract relational patterns, such as the relations between an agent and his/her internal states of belief.
In summary, research from diverse fields has demonstrated that linguistic input can significantly influence how children conceptually organize information that is both perceptually concrete and/or non-obvious. In the following chapter, this idea will be further extended to an area that has yet to be extensively researched: how language may assist with the representation and mapping of epistemic relations.
Chapter 2
How Language Facilitates the Processing and Development of Epistemic Representations¹

In recent years, an abundance of research examining infants’ perception of false-belief has reignited the debate of when the cognitive ability to impute and reason about others’ beliefs develops during childhood. Traditionally, it has been accepted that children do not develop this ability until the late preschool years, based on the robust finding that children do not typically pass standard false-belief tasks (Wimmer & Perner, 1983; Perner, Leekam, & Wimmer, 1987) until approximately 4 years of age (Wellman, Cross, & Watson, 2001). In a typical false-belief task, children must infer the impending actions of a protagonist who, through a series of interactions, acquires a false-belief about the location or identity of a target object. For example, in a change-of-location task, children must infer where a protagonist, who has not seen the displacement of a target object from its original location, will search for this object upon his/her return (Wimmer & Perner, 1983). Other typical tasks require children to infer what a protagonist will say is in a familiar box with unexpected contents that have been seen by the child but not the protagonist (Perner et al., 1987). Critically, most tasks require that children make elicited, verbal responses to questions about how the protagonist will act (e.g., “Where will Maxi look for the chocolate”), thereby restricting the window of assessment to an age when children can meet these linguistic demands. Recently, advancements in technology and methodology have produced false-belief paradigms that eliminate the need for verbal response and instead rely on involuntary behavioural measures. Over the past five years or so, these paradigms have been used successfully with both infants and toddlers and have produced substantial evidence of early understanding (Baillargeon, Scott, & He, 2010; Kovács et al., 2010; Southgate et al., 2007; Surian, Caldi, & Sperber, 2007). Changes in assessment methods, however, have also brought forth questions regarding the role that language development plays in false-belief reasoning and whether the cognitive structure underlying infant processing is the same as that exhibited in the preschool years. Some researchers argue that the accuracy exhibited by preverbal infants on

¹ The majority of this chapter was originally published as “Bridging the gap between implicit and explicit understanding: How language development promotes the processing and representation of false belief” by V. San Juan and J.W. Astington, British Journal of Developmental Psychology, 30(1), 105-122. Copyright © 2012 by The British Psychological Society. Adapted with permission.
involuntary measures is indicative of fully formed representations of belief (Baillargeon et al., 2010), thereby limiting the role that subsequent language development can play on the understanding of false-belief. Conversely, other researchers have argued that the structure of infants’ false-belief representations is qualitatively different from that of older children (Perner, 2010; Perner & Ruffman, 2005; Ruffman & Perner, 2005) and that language development plays a critical role in the development of explicit false-belief understanding (Astington & Jenkins, 1999; de Villiers, 2007).

Despite the ongoing disagreement about when and how children acquire a representational understanding of belief, one factor that remains consistent across both camps is the acknowledgement that children’s performance on early measures of false-belief understanding is not directly comparable to their performance on later measures. Importantly, the paradigms used to assess false-belief understanding in younger children are qualitatively different from those used to assess older children. Paradigms designed for use with infants and toddlers have been referred to as implicit or spontaneous because they exclusively measure children’s automatic responses (e.g., violation-of-expectation looking times, anticipatory-looking patterns) while traditional measures of false-belief understanding have been referred to as explicit or elicited because children are required to respond to direct questions about the belief states of themselves and/or others (Baillargeon et al., 2010). As mentioned previously, these latter measures are typically verbal, although they need not always be so (e.g., Call & Tomasello, 1999). The important contrast is that in elicited tasks, children must make controlled, as opposed to automatic, responses regarding false-belief. Further, elicited tasks have been designed to assess understanding across a wide range of false-belief contexts (e.g., change of location, unexpected contents, appearance/reality) and sources of belief induction (e.g., belief by appearance, belief by inference, belief by misinformation). Due to their relatively recent implementation, however, spontaneous paradigms are still limited to a far narrower range of tasks (e.g., contexts that lend

2 The terms spontaneous and elicited are terms that were introduced by Renée Baillargeon and colleagues (2010) to describe the distinct types of responses exhibited by younger and older children on false-belief measures. They are also used to denote the different levels of cognitive processing (i.e., automatic vs. controlled) that are associated with each response type. Importantly, these terms are sometimes used in place of the more traditional labels implicit and explicit because, unlike these terms, ‘spontaneous’ and ‘elicited’ do not imply underlying differences in conscious awareness or representational understanding (Deines & Perner, 2002).
themselves to a forced-choice looking paradigm). Studies with younger children are also rarely conducted using a repeated measures design, further limiting the extent to which knowledge generalization can be assessed.

Given the number of discrepancies that exist between early and later false-belief measures, it does not seem reasonable to use children’s responses on these disparate tasks as evidence for, or against, similarities in their representational understanding. Indeed, the fact that a large gap exists between the time when children can pass spontaneous and elicited measures of false-belief understanding suggests that a certain amount of development must occur between the two periods of assessment. What this development primarily consists of is still a matter for debate, but what is evident is that children’s performance on early and later measures of assessment are not equivalent and continuing to acquire evidence using disparate paradigms is unlikely to further elucidate the problem. What will perhaps be more beneficial to the current field is the construction of a cohesive developmental theory that explains how children progress from passing spontaneous to elicited measures of understanding and the factors that are necessary for this change to occur. This, in essence, is the purpose of the current thesis.

In the following sections I will review how current developmental accounts of false-belief understanding explain the discrepancies that exist between spontaneous and elicited false-belief task performance. Second, I will briefly review the evidence for a relationship between language and the development of explicit false-belief understanding. Third, I will propose an account that gives language a primary role in bridging the gap between spontaneous and elicited false-belief understanding. Specifically, the acquisition of epistemic verbs and their related syntax – i.e., verbs like think and know that denote states of belief – will be discussed as a mechanism for producing change both in children’s processing and representation of false-belief.

2.1 Differing Accounts of the Development of False-Belief Understanding

Theories that explain the shift in children’s performance on traditional measures of false-belief understanding typically fall into one of two camps: (a) constructivist conceptual shift accounts, and (b) nativist modular accounts. Across both accounts, change is assumed to occur between children’s earlier and later abilities to reason about false-belief. Where these accounts critically differ, however, is in defining what develops across childhood and what factors contribute to
children’s successful performance on explicit measures of false-belief understanding. How each account would explain the differences in children’s spontaneous and elicited false-belief task performance is reviewed in this section.

2.1.1 Conceptual Shift Accounts

Over the years, a number of theories have proposed that a conceptual shift in children’s epistemic reasoning occurs between 3 and 5 years of age (e.g., theory theory, Gopnik & Wellman, 1992; simulation theory, Harris, 1992; metarepresentational theory, Perner, 1991). Although these theories vary in details of how mental-state reasoning develops and functions, all share the underlying assumption that children’s mental-state representations undergo structural change between early and later childhood. For the purpose of thesis, I will focus on theories that propose changes in metarepresentational understanding (Perner, 1991) because they offer the most detailed description of how children’s concepts of belief change over time.

The assumption of conceptual change is largely supported by the pronounced shift observed in children’s elicited responses on traditional measures of false-belief understanding. Proponents of this view argue that the point at which children are able to successfully pass direct measures of false-belief understanding is the point at which they are able to metarepresent and reason explicitly about belief. By the same logic, it is questioned whether infants’ accuracy on spontaneous-response measures is indicative of the same level of understanding or whether they are derived exclusively from associative representations (i.e., situation-based) that are retrieved at an implicit level of understanding (Perner, 2010).

Explicit reasoning is typically assessed via elicited, often verbal responses, because it is assumed that conscious awareness is necessary in order to accurately communicate one’s knowledge (Dienes & Perner, 1999). Because spontaneous false-belief tasks require only automatic, non-verbal responses as indicators of understanding, it is unclear how much, if any, of children’s reasoning on these tasks occurs at a conscious level. In fact, for children who fail elicited measures of false-belief reasoning, a clear dissociation appears to exist between their elicited verbal and spontaneous non-verbal responses. Children may show correct anticipatory eye patterns upon presentation of an implicit cue (e.g., correctly anticipate that a protagonist who has not seen a target object displaced will search for it in its original location) while still failing to provide a correct response to the elicited measure of understanding (Clements & Perner, 1994).
Further, there is evidence that children are completely unaware of the knowledge conveyed through their eye gaze (Ruffman, Garnham, Import, & Connolly, 2001). These findings suggest that children can maintain implicit representations of belief that exist in complete dissociation from their explicit state of understanding.

Second, proponents of a conceptual shift account have questioned whether infants’ responses on spontaneous false-belief assessments are indicative of a true metarepresentation of belief. Metarepresentational understanding requires that children not only represent and distinguish the content of a belief from the true state of reality (e.g., believing that an object is in one location when it is really in another), but also embed this understanding within a higher-order representation of belief. That is, the child must represent the agent’s belief representation—hence, meta-representation—which allows the child to reason about the content of the agent’s belief, independent of the current state of reality (Dienes & Perner, 1999). Although it is possible that young children’s responses on spontaneous measures are driven by metarepresentational understanding, some researchers have argued that children’s spontaneous responses may be more parsimoniously explained by lower level behavioural associations, or rules (Perner, 2010; Perner & Ruffman, 2005; Ruffman & Perner, 2005). For example, in a typical change-of-location task, children must predict where a protagonist will search for a target object after it has been displaced. A prediction based on metarepresentational understanding would require children to (a) represent their own belief (i.e., knowledge) of the object’s location based on their experience with the object (i.e., witnessing the displacement) and (b) represent the false-belief of the protagonist based on his/her experience with the object (i.e., not witnessing the displacement) and, most critically (c) recognize that both beliefs, although their content is different, make reference to the same situation (Perner, 1991). Alternatively, a prediction could also be made if children form a representation that associates a specific situation (e.g., the protagonist last witnesses the object placed in location A) with a particular action (e.g., the protagonist searches for the object in location A). Either process or reasoning would lead children to accurately predict the protagonist’s behaviour on this task, but critically, the latter process does not require them to metarepresent the protagonist’s state of belief. Because young children can only show accurate patterns of prediction in measures where they are not directly asked to reason about the epistemic states of others, some researchers have concluded that their level of understanding is strictly limited to the representation of behavioural associations. The practice of examining
infant false-belief understanding using primarily between-subjects designs has also led to speculation that young children are incapable of the flexible reasoning inherent in the development of metarepresentational understanding (Perner, 2010). The ability to generalize knowledge across multiple contexts, after all, is considered by many to be the hallmark of higher-order reasoning (Gelman & Kalish, 2006). Although violation-of-expectation paradigms have successfully been adapted to measure infant false-belief reasoning across different contexts of belief induction (Baillargeon et al., 2010), the bulk of the research demonstrating accurate response patterns has been conducted between different children and different age groups. No study to date has demonstrated that within the same infant, patterns of response are coherent across different contexts of belief induction. If accuracy on spontaneous measures is truly indicative of infants’ ability to impute and reason about the belief states of others, then generalization of reasoning should be evident within the same individual.

In summary, proponents of a conceptual shift account argue that the level of understanding necessary to succeed on spontaneous measures of false-belief understanding is qualitatively different from that needed to pass explicit measures. Before they are able to explicitly reason about epistemic states, children are said to rely on automatic, situation-based representations of behavioural patterns. Once children are able to respond to elicited measures of assessment, it is assumed that they are able to consciously represent the content of another’s belief and embed this content within a higher-order representation of belief (i.e., metarepresentation). Beyond distinguishing the developmental differences in children’s processing, however, most conceptual shift accounts offer little explanation of how children transition from implicit to explicit reasoning and whether implicit representations of mental states directly influence children’s later understanding. While it is possible to assume that implicit patterns of processing may develop into higher-order representations of belief, evidence from analogous fields of cognition suggest that both implicit and explicit representations can co-exist in complete dissociation from each other (e.g., memory, Schacter, Chiu, & Ochsner, 1993; grammar learning, Gomez, 1997). Recently, evidence has begun to suggest that implicit knowledge measures in infancy may be predictive of children’s performance on later, explicit measures of false-belief understanding (Clements, Rustin, & McCallum, 2000; Low, 2010) but it is yet unclear how direct this effect is.
2.1.2 Innate Modular Accounts

In contrast to theories that propose a conceptual shift in children’s ability to represent mental states, innate modular accounts propose that concepts of belief and desire are present at birth (Baillargeon et al., 2010; Gergely, & Csibra, 2003; Leslie, German, & Polizzi, 2005). As evidenced by children’s remarkable aptitude for early social interactions, proponents of these accounts argue that from an early age, children are not only able to perceive and represent the internal mental states of others but can also make multiple inferences regarding social behaviour. What is said to develop between infancy and early childhood is not the ability to represent epistemic states themselves but, rather, the cognitive abilities necessary to process these representations. Proponents of this view argue that children are late to succeed on more traditional measures of false-belief understanding because these measures require children to make controlled, elicited responses regarding the epistemic states of others (Baillargeon et al., 2010). Moreover, elicited-response tasks are especially taxing on the cognitive abilities needed to engage in the process of response selection. For example, in a false-belief task, children must not only retrieve and consider alternate perspectives within a given context (e.g., where a target object is actually hidden and where a protagonist thinks it is), but they must also actively inhibit the more salient response of selecting a perspective that is congruent with their own (i.e., selecting the current location of a target object) (Leslie et al., 2005). Conversely, when false-belief paradigms are adjusted so that children’s understanding is indirectly accessed via their spontaneous responses, it is possible to reduce the inhibitory demands associated with response selection to a level that allows for accurate predictions to be made. Because children do not need to actively consider alternate responses before making a spontaneous response, it is argued that these measures are more pure assessments of a child’s representational abilities (Baillargeon et al., 2010). Children’s ability to succeed in these paradigms is evidenced by the growing body of research using both violation-of-expectation and anticipatory-looking eye patterns as measures of spontaneous responses. To date, spontaneous measures have been used to demonstrate that children younger than 3 years of age are able to accurately infer the behaviour of a protagonist acting on a false-belief about an object’s location (Onishi & Baillargeon, 2005; Southgate et al., 2007), an object’s appearance (Song & Baillargeon, 2008), and an object’s identity (Scott & Baillargeon, 2009).
Beyond describing the cognitive abilities that underlie discrepancies between children’s spontaneous and elicited task performance, however, innate modular theories are not as clear in explaining how social factors contribute to shifts in performance between the ages of 3 and 5 years. The ability to reason about the belief states of others is, after all, an inherently social form of cognition and, as research has indicated, it is heavily influenced by individual differences in social and linguistic experiences (de Rosnay & Hughes, 2006). According to modular accounts, however, concepts of belief develop early in life, if they are not present at birth, and changes in false-belief reasoning are primarily influenced by developments in decision making and inhibitory processes. Such accounts therefore leave little room for social factors to play a direct role in developing children’s performance accuracy on explicit measures of false-belief understanding. To date, modular accounts have not clearly outlined how these various social factors interact with the development of response-selection processes to influence children’s performance on elicited false-belief measures.

In the end, it is clear that current accounts do not offer a sufficiently comprehensive story of how children progress from spontaneous to elicited forms of false-belief processing. As it currently stands, children’s success on early measures of false-belief understanding is either considered in isolation of their performance on more traditional measures or it is taken as an indication of children’s fully formed representation of belief. For an account to be truly developmental in nature, however, there needs to be a more detailed explanation of how change occurs between different periods of development. A comprehensive account must also address how both social-linguistic and cognitive factors work together to produce changes in children’s false-belief reasoning.

2.2 Relationship between Language and False-Belief Understanding

Although children typically succeed on direct, elicited-response false-belief tasks at approximately 4 years of age (Wellman et al., 2001), the precise age of success varies among children from 3 to 5 years. Thus, considerable research effort has been expended on investigating the basis of individual differences in performance. It is now well established that language is a significantly important correlate of explicit false-belief reasoning (Astington, 2006). The term “language” is used here in a broad sense to refer to semantic, syntactic, and pragmatic abilities, internal to the child, and also to the external social-linguistic environment in which development
occurs (Astington & Baird, 2005). Many studies have shown strong correlations between explicit false-belief understanding and language when the latter is assessed using various measures of general, semantic, and syntactic linguistic ability. In a meta-analysis, Milligan, Astington, and Dack (2007) showed that general language ability (which includes semantics and syntax) explained 27% of the variability in explicit false-belief task performance. They also showed that semantics alone, assessed by receptive vocabulary measures (PPVT, BPVS) and by discourse-level semantic measures, accounted for 12% and 23%, respectively, of the variance in explicit false-belief task scores. Measures of syntactic ability accounted for 29% of the variance.

For both semantics and syntax, a particular focus has fallen on epistemic verbs. Children typically start to use these terms before the age at which they typically pass explicit false-belief tasks (Bartsch & Wellman, 1995), although full comprehension of the terms may not be evident until later (Nelson, 2005). Indeed, children’s comprehension of terms such as think and know in experimental tasks is related to explicit false-belief understanding (Moore, Pure, & Furrow, 1990) and even production of such terms in naturalistic play is associated with explicit false-belief task performance (Hughes & Dunn, 1998). Epistemic verbs are frequently used in complex sentences that allow for reference to false-beliefs, for example, “Bert thinks [that] the earth is flat.” The sentential complement “the earth is flat” (the “that” complementizer is optional) expresses a false proposition even though the whole sentence may be true. Jill de Villiers (2005, 2007) argues that mastery of such syntactic complementation is the critical aspect of language that underlies the development of explicit false-belief understanding. And indeed, in the meta-analysis cited earlier (Milligan et al., 2007) complement syntax ability accounted for 44% of the variance in false-belief task scores. This effect was not significantly different from that of the other language measures, however, perhaps because only 4 of the 104 studies included in the meta-analysis had used a complement syntax measure. Moreover, some researchers (e.g., Ruffman, Slade, Rowlandson, Rumsey, & Garnham, 2003) argue that the high correlations are not surprising, given that de Villiers’s complement syntax task (e.g., de Villiers & Pyers, 2002) assesses children’s memory for false propositions embedded under epistemic (think) or communication (say, tell) verbs (e.g., “He said he found a ring but it was really a bottle cap. What did he say he found?”). In consequence, therefore, children’s understanding of falsity is confounded with their understanding of complementation. Relevantly, a recent study that included a measure in which memory for complement syntax was independent of falsity, showed
no significant correlation between complement syntax and explicit false-belief understanding (De Mulder, 2011).

In addition, children’s pragmatic abilities to use and interpret language appropriately in communication are also related to explicit false-belief reasoning. For example, Dunn and Cutting (1999) showed that false-belief task scores were related to connected and successful communication between friends in a naturalistic play situation. Explicit false-belief understanding is also related to performance on pragmatic tasks, such as referential communication tasks that require children to take account of the knowledge states of others (Astington, 2003).

The studies cited so far show significant correlations between semantic, syntactic, and pragmatic aspects of language and explicit false-belief task performance, but this of course does not establish that language plays any causal role in the development of explicit false-belief understanding. However, findings from longitudinal studies provide more support for a causal argument (Astington & Jenkins, 1999; de Villiers & Pyers, 2002). Moreover, although other longitudinal studies have shown that the relation between language and false-belief is bidirectional (Slade & Ruffman, 2005), the Milligan et al. (2007) meta-analysis, showed that the effect size of the relation from language to false-belief is significantly greater than in the reverse direction. Moreover, evidence from training studies adds to this causal argument. For example, Lohmann and Tomasello (2003) showed that false-belief understanding was promoted by conversation about deceptive objects (i.e., objects with an appearance that is false given their true nature, such as a sponge painted to look like a rock) even though no epistemic terms and no syntactic complements were used in the discourse. In addition, specific training on the syntax of complementation in the absence of any deceptive objects also promoted false-belief understanding. However, the largest training effect occurred in a third condition that combined these two (i.e., conversation about deceptive objects using complement constructions).

So far, I have focused on the contribution of children’s own linguistic abilities to the development of explicit false-belief understanding. Although it is obvious that these internal abilities will be related to their social-linguistic environment, it is important to note that environmental-social aspects of language may also contribute to the development of explicit false-belief understanding. Even though it may be difficult to separate the roles these two factors
play, it is possible to control for the child’s own language abilities when considering the effects of the social-linguistic environment. For example, in a longitudinal study (Ruffman, Slade, & Crowe, 2002) mothers’ use of mental-state terms (which included epistemic verbs) predicted children’s later explicit false-belief understanding even when controlling for the children’s earlier explicit false-belief task performance, as well as their own earlier language ability, including use of mental terms. Ensor and Hughes (2008) report similar findings but, importantly, it was mothers’ use of cognitive terms in connected conversation that was significantly related to false-belief understanding. These findings suggest a causal link between the social discourse environment and the development of explicit false-belief understanding. Further, it is not just exposure to mental-state terms that matters but a “meeting of minds” in conversation. It should be noted that the studies did not have a separate measure of complement-understanding and so it is still possible that discourse scaffolds children’s linguistic representation of complementation, which is the proximal cause of the development of explicit false-belief understanding. Or discourse and complementation may have additive effects, as in the Lohmann and Tomasello (2003) training study mentioned earlier.

Evidence from children with atypical development also supports causal arguments for the influence of language on the development of explicit false-belief reasoning. Deaf children of deaf parents who acquire language (i.e., sign language) from birth show no deficit or delay in the development of explicit false-belief understanding, whereas deaf children of hearing parents who do not have access to language (sign language or spoken English) until later in development show a related delay in explicit false-belief understanding (Schick, de Villiers, de Villiers, & Hoffmeister, 2007). Children with autism, whose language skills do not develop typically, also do not develop explicit false-belief understanding within the typical timeframe. Moreover, the verbal ability of children with autism who do eventually pass false-belief tasks is higher than that of typical children when they first succeed on the same tasks (Happé, 1995).

Thus, it is obvious that many aspects of language are related, most likely causally, to the development of explicit false-belief understanding. It should be noted that the studies included in the Milligan et al. (2007) meta-analysis, as well as other studies cited above, used explicit false-belief tasks that were verbal tasks, which may account for at least part of the correlation found between false-belief understanding and language. Nonetheless, the evidence from longitudinal and training studies, and from studies with atypical children, all suggest that the relationship
between language and explicit false-belief is not simply an artifact of task factors. Moreover, Low (2010) has shown that language ability (semantic ability measured by PPVT scores and syntactic ability measured by the complements task) is related to children’s performance on non-verbal versions of explicit (i.e., elicited-response) false-belief tasks.

In contrast to the multitude of studies referred to above, there is little information regarding the relation of language to indirect, spontaneous-response false-belief measures. However, accurate false-belief processing is evident in infants as young as 7 months of age (Kovács et al., 2010), when language, at least individual linguistic ability, can play no contributing role. Revealingly, Low’s (2010) study showed that language ability (PPVT semantic ability, and complements-task syntactic ability) was not correlated with spontaneous-response false-belief task performance. Importantly, these language measures showed typical correlations with explicit false-belief task performance in the same sample of children aged 3 to 5 years. Although this is not a longitudinal study, Low’s data also show that complement syntax ability and spontaneous false-belief processing make unique, independent contributions to the variability in elicited false-belief task performance. This suggests that despite the dissociation referred to above (Ruffman et al., 2001), there is some continuity between implicit and explicit understanding. Thus— and this is the overarching issue addressed in this thesis— does language play a role in the evolution of explicit from implicit false-belief understanding and, most important, if it does, by what mechanism(s) does it play this role?

### 2.3 How Language May Influence the Development of Explicit False-Belief Understanding

As the previous section makes clear, many aspects of language ability are significantly related to children’s performance on elicited false-belief measures. Because most of these elicited tasks are verbal tasks, researchers who hold the innate, modular view of false-belief understanding, argue that the relation with language simply shows that it is a limiting factor in elicited-response false-belief task performance and the only role it plays is in enabling existing understanding to be revealed. On the other hand, researchers who hold the conceptual shift view of the development of false-belief understanding maintain that language provides children with resources that promote or permit explicit false-belief understanding, which is qualitatively different from implicit understanding. How language promotes development from implicit to explicit forms of knowledge, however, requires further clarification. Some researchers focus on the
environmental-social aspect of language, arguing that children become aware of beliefs and false-beliefs through conversations and stories. Other researchers focus on individual, child-cognitive aspects of language, arguing that acquisition of the semantics and syntax of epistemic verbs is key to the development of false-belief understanding. For the purpose of the current thesis, both aspects are important. Language acquired and used in social interaction then can operate as an internal representational device underlying the development of metarepresentational ability (Astington, 2006). However, what is needed is a more detailed and precise account of the mechanism whereby this is achieved.

In this section, language that is used to describe contexts of false-belief will be discussed as a mechanism for developmental change between early and later false-belief understanding. In particular, I will focus on how the acquisition of epistemic language may play a unique role in bridging the gap between early and late false-belief task performance by assisting with both the process of controlled response selection and the formation of higher-order epistemic state representations.

2.3.1 Response Selection

Proponents of accounts that primarily attribute shifts in children’s task performance to development in response selection processes have inevitably relegated language to having an indirect influence on this change. The necessity of a certain threshold of language development is acknowledged for the comprehension of explicit, and mostly verbal, tasks but it is less clear if language is necessary for the processing of explicit false-belief. In this section I argue that language does play a direct role in explicit reasoning about false-belief because it reduces the cognitive demands associated with making a controlled, elicited response. Specifically, language may assist with the process of response selection by assisting children with the internal representation of the alternate perspectives in a false-belief scenario.

The process of elicited response selection entails the ability to simultaneously consider distinct representations for the same context and then inhibit selecting an incorrect prepotent response (Baillargeon et al., 2010; Leslie et al., 2005). In a standard false-belief task, this would require children to maintain a separate representation of their own perspective (e.g., knowing where the target object has been displaced) and the perspective of a protagonist with a false-belief (i.e., believes the target object is in its original location). When inferring the protagonist’s subsequent
actions, children must then inhibit the prepotent response of aligning the protagonist’s perspective with their own (i.e., assuming that the protagonist also knows where the object has been displaced). Language may directly reduce the cognitive demands associated with this process by providing concrete, external representations of the conflicting perspectives inherent in a false-belief task. Moreover, language can be used to explicate different perspectives in two ways: through direct labelling of alternate perspectives and through the acquisition of complement syntax.

First, labelling different perspectives in a false-belief task may assist with elicited response selection by providing children with the cognitive distance necessary to flexibly switch attention between alternate perspectives and inhibit selecting a prepotent response (Deak, 2004; Jacques & Zelazo, 2005). Because labels are concrete symbols that are arbitrarily associated with the concepts that they denote, they naturally provide a separation between the information that is being represented (e.g., an object in the immediate environment) and the representation itself (e.g., the label used to describe this object). Importantly, labels also tend to be static, thereby allowing them to act effectively as salient, external markers for information that may otherwise be difficult to perceive or mentally represent. Labelling has been shown to successfully improve children’s flexible switching on tasks that require children to alternatively sort different objects along conflicting perceptual dimensions (Kirkham, Cruess & Diamond, 2003). In a false-belief task, labels can be similarly applied to denote the alternate responses that correspond to the content of a false-belief (e.g., explicitly labelling where the target object was originally placed) and the true state of reality (e.g., explicitly labelling its new location). By making these alternate responses more salient, labels may thus significantly decrease the cognitive demands associated with simultaneous consideration and switching between conflicting representations. In a study conducted by Low and Simpson (in press), 4-year-olds did in fact show an advantage in explicit false-belief reasoning when labels were used to denote both the content of a false-belief (i.e., protagonist’s perspective) and the true state of reality (i.e., child’s perspective). Similar improvements in false-belief task performance were also demonstrated when only the protagonist’s perspective was labelled, suggesting that the use of labels may induce children to override pre-existing biases and consider candidate responses that directly conflict with the salient state of reality. Interestingly, in the same study, these results were not replicated with 3-year-old children. This difference suggests that labels used to denote alternate perspectives may
only have an effect on the processing of explicit false-belief reasoning when children have begun to develop the underlying representational structure needed to support this level of reasoning.

Beyond labelling the alternate responses in an elicited false-belief measure, language that is associated with the representation of epistemic states may further provide the most direct means of representing dual perspectives. Specifically, the acquisition of syntactic frames typically associated with epistemic verbs may provide children with a unique external structure for representing both the content of a protagonist’s belief and the true state of reality. As previously mentioned, complement syntax, which is typically used in conjunction with epistemic verbs such as think, allows for the embedding of a proposition that can be false (e.g., “the chocolate is in the cupboard” after the chocolate has been displaced) within a sentence that is otherwise true (“Fred thinks [that] the chocolate is in the cupboard”). While researchers have demonstrated that comprehension of complement syntax may be more predictive of children’s elicited false-belief task performance than other components of language (de Villiers & Pyers, 2002; Hale & Tager-Flusberg, 2003; Lohmann & Tomasello, 2003), less is known about the mechanism by which this syntactic structure assists with the cognitive processing of false-belief. However, assuming that language can be used to explicate and consider distinct perspectives during the process of response selection, the acquisition of complement syntax may similarly be construed as a tool for making controlled, elicited response decisions. Within a false-belief task, the perspective of a protagonist who has acquired a false-belief can be described using a complement syntax construction (e.g., “Fred thinks the chocolate is in the cupboard.”). Alternatively, the formation of these constructions can also be cued through elicited response questions that are posed to the child (e.g., “Where does Fred think the chocolate is?”). If children understand that the proposition embedded under the verb think can be false, and can potentially generate these constructions themselves, then the use of this structure should assist them with the representation of perspectives that conflict with the true state of reality. Specifically, the structure relates the content of belief described by the proposition (i.e., “the chocolate is in the cupboard”) directly to the agent and thereby makes this association more salient during the process of response selection. Although there is no direct evidence that complement syntax works in this way to assist with the process of response selection, evidence from training studies cited above has demonstrated that improvements in explicit false-belief task performance are most pronounced when children are exposed to false-belief scenarios that are paired with complement syntax.
constructions (Lohmann & Tomasello, 2003). This suggests that the use of complement syntax constructions may promote the processing of explicit false-belief information at a procedural level.

In summary, children’s comprehension of language used to describe and elicit responses on explicit false-belief tasks may lead to improvements in task performance by directly influencing the process of controlled response selection. By explicating and distinguishing the alternate perspectives in a false-belief scenario, language may significantly decrease the cognitive demands associated with dual representation, flexible switching, and inhibition of prepotent responses. Moreover, the syntax associated with verbs that denote epistemic states may provide children with a uniquely suited structure for explicitly representing perspectives that conflict with the true state of reality (i.e., false-beliefs).

2.3.2 Formation of metarepresentational understanding

The acquisition of epistemic verbs may also play a direct role in the formation of metarepresentational understanding by promoting the generalization of knowledge across different contexts of belief. Specifically, by encouraging children to attend to and compare information across different instances of false-belief, epistemic verbs may play a direct role in the development of higher-order representations of belief (Baldwin & Saylor, 2005). According to the theory of structure mapping, proposed by Gentner and colleagues (e.g., Gentner, 2003; Gentner & Medina, 1998; Loewenstein & Gentner, 2005), processes of comparison are essential to the formation of higher-order representations because they support the abstraction of relational patterns across related contexts or events. Importantly, the process of structural alignment favours the mapping of higher-order relational patterns over situation-based surface similarities. In this way, structure mapping promotes change from knowledge that is based on context-specific patterns, or rules, to knowledge that is flexible and transferrable across different contexts. In this theory, language is also posited to play a critical role in the formation of higher-order representations by assisting with the abstraction, retention and comparison of relational patterns. Because structure-mapping theory offers a detailed description of the processes by which language may assist with the formation of higher-order cognitive structures, I will use this theory as a basis for explaining the potential role of epistemic verb acquisition in the development of metarepresentational false-belief understanding.
Gentner and colleagues (Gentner, 2003; Loewenstein & Gentner, 2005) propose that the acquisition of language that denotes relational knowledge (e.g., verbs and prepositions) can assist with the explication of patterns that may otherwise be non-obvious to perceive. Specifically, language may assist with the process of structure mapping through five key mechanisms: (1) abstracting relational patterns from their initial contexts, (2) retaining initial representations of relational patterns, (3) promoting uniform encoding of relational patterns through habitual use, (4) explicating non-obvious and complex patterns of relation, and (5) selectively focusing attention on similar patterns in novel contexts. To date, this role of language in assisting structural alignment has successfully been demonstrated in the domains of spatial mapping (Lowenstein & Gentner, 2005; Ratterman & Gentner, 1998) and object categorization (Baldwin, Markman, & Melartin, 1993; Graham, Namy, Gentner, & Meagher, 2010). In these studies, children are able to use relational labels to infer underlying relational similarities between objects (e.g., corresponding spatial positions or non-obvious object functions) in contexts where these relations are in direct conflict with more obvious surface similarities (e.g., similarity of appearance).

With respect to the explicit representation of false-belief understanding, epistemic verbs seem well suited to act as appropriate relational terms that would promote the abstraction of relational similarities across different contexts of false-belief. Unfortunately, this possibility has yet to be examined because the acquisition of epistemic concepts and, by relation, epistemic verbs has traditionally been considered too complex to test with the same paradigms that are used to examine other relational terms (Gleitman, Cassidy, Nappa, Papafragou, & Trueswell, 2005; Papafragou, Cassidy, & Gleitman, 2007). Specifically, one of the main problems associated with the study of epistemic understanding, is that, by virtue of being internal and imperceptible, epistemic states are especially difficult to identify and abstract from a given context. Evidence from two separate lines of research, however, suggests that the abstraction of relational patterns from epistemic contexts may not only be possible for young children but also facilitated by the acquisition of epistemic verbs. First, recent findings from the field of infant false-belief reasoning demonstrate that even pre-linguistic infants are capable of tracking and representing dynamic sequences of action related to states of true- and false-belief. Thus, even if this knowledge exists strictly at an implicit, situation-based level, there is strong evidence to suggest that accurate patterns of inference regarding epistemic states can be gleaned from the external
environment. Second, cross-linguistic research has shown that children’s ability to process and reason about epistemic states is significantly affected by the kinds of relational terms that are available to them through their native language (Lee, Olson, & Torrance, 1999; Liu, Wellman, Tardiff, & Sabbagh, 2008; Shatz, Diesendruck, Martinez-Beck, & Akar, 2003). That is, for children’s whose native language includes verbs that explicitly denote states of false-belief (e.g., Turkish, Puerto Rican Spanish, Mandarin, and Cantonese), performance on elicited measures of false-belief has been shown to significantly improve when test questions include these explicit markers of false-belief as opposed to verbs that denote more neutral epistemic states (e.g., like the English verb *thinks* which can denote either true- or false-beliefs). Although this research has only demonstrated that the effects of epistemic verb exposure are primarily local (i.e., that children’s performance *only* improves in the presence of these verbs but acquiring these verbs does not necessarily affect the timeline of epistemic concept development), it also suggests that children’s processing of epistemic information may be facilitated by their exposure to relational terms that denote specific states of belief.

Using the mechanisms outlined by Gentner (2003), I therefore propose that the acquisition of epistemic verbs may assist with the formation of higher-order false-belief representations in the following stages.

1. **Abstraction of relational patterns.** Assuming young children can implicitly track relational patterns of false-belief before they can pass explicit measures of understanding, the use of epistemic language in conjunction with contexts of false-belief may assist them with the initial perception of these patterns. Specifically, the use of epistemic verbs to describe the false-belief of a protagonist (e.g., “Fred thinks the toy is in the box”) may help children identify not only the content of the protagonist’s belief (e.g., falsely believes the toy is in the box), but also the patterns that relate this belief to subsequent actions (e.g., searches for the toy in the box). Moreover, epistemic verbs and complement syntax constructions may be unique in their ability to abstract relational patterns of false-belief because they allow children to represent the content of a false-belief in relation to the agent.

2. **Retention of initial representations.** Pairing non-obvious relational patterns with salient relational markers, such as epistemic verbs, should also increase the likelihood that these patterns will be represented and retained in memory. Information that is retained can then
be used to form relational patterns, or rules, of inference. For example, children may represent the inferential rule that protagonists will search for an object in its original location if s/he did not witness the object being displaced. When children later encounter similar contexts of false-belief, these patterns can be retrieved to make appropriate inferences. Before children have formed higher-order representations of false-belief, however, these rules would remain context-specific.

3. **Uniform encoding.** Habitual use of the same epistemic terms with the same relational patterns will strengthen their association over time. Perception of the epistemic verb in a similar context may therefore increase the likelihood that the same relational pattern will be perceived and represented in a uniform manner.

4. **Explication of relational patterns.** Through repeated pairing of epistemic verbs with specific inferential rules, children may begin to gain conscious awareness of these patterns. Moreover, children may begin to ascribe meanings to epistemic verbs, and accompanying complement syntax constructions, by associating these terms with specific contexts of belief. This suggestion is in keeping with social-pragmatic accounts of word learning that propose that the meanings of words are derived from the social contexts in which they are used (Nelson, 2005; 2007; Tomasello, 1999). This is also supported by evidence suggesting that children’s comprehension of epistemic verbs is still developing throughout the preschool years (see Astington & Peskin, 2004, for a review). Initially, it is possible that children may not directly associate relational patterns with specific epistemic verbs but, rather, with the complement syntax constructions in which these terms occur. This is based on theories that propose that the acquisition of syntactic structure bootstraps the acquisition of semantic understanding of associated verbs (de Villiers 2005; Gleitman et al., 2005). Specifically, Gleitman and her colleagues suggest that children use both their knowledge of the grammatical role that a verb has within a syntactic construction and information from the immediate environment to constrain their understanding of a verb’s meaning. Over time, meaning that is initially associated with specific syntactic constructions may thus be transferred to associated verbs themselves. Currently, there is some evidence to suggest that the use of complement syntax constructions in contexts of false-belief assist both children and adults in the identification of epistemic states (Papafragou et al., 2007).
5. **Selective attention and comparison in novel contexts.** Once children have associated relational patterns to epistemic verbs and/or their complement syntax constructions, then subsequent use of these terms in novel contexts would invite children to compare and contrast similar relational patterns. Critically, it is this process of comparison that should lead to the formation of higher-order representations because children may be forced to restructure their knowledge if relations do not match across different contexts. In the case of false-belief, these differences may include sources of belief induction, the content of the belief, and/or the subsequent actions that result from the false-belief. Because the same epistemic term (e.g., *think*) can be used to describe related contexts of belief, children would thus be encouraged to form explicit representations that can be used to generalize inferences across varying contexts.

In summary, the acquisition of epistemic language may promote the development of higher-order representations of belief by assisting with the abstraction and generalization of inferential patterns of processing. Based on the above proposal, children’s ability to succeed on explicit measures of false-belief would thus be dependent on their implicit ability to track relational patterns of false-belief as well as their individual experience with both epistemic contexts and epistemic language.

### 2.4 Conclusion

In this chapter, I have proposed mechanisms by which language development may directly influence both the process of elicited-response selection and the formation of metarepresentational understanding. This framework is not intended to imply that the relationship between language and epistemic concept development is not dynamic or bidirectional at different points throughout the lifespan. Instead, it is offered as a suggestion for how concrete external input (i.e., labels) may scaffold the development of explicit false-belief reasoning within a specific window of time (i.e., between the toddler and early preschool years). The obvious question that remains to be answered is how to test these proposals. Thankfully, advancements in the field of false-belief reasoning have only opened up the possibility to further examine the mechanisms of developmental change. The following are some possible methods by which paradigms could be adapted to examine the role of language in bridging the gap between implicit and explicit understanding.
First, it seems critical that more paradigms be developed that allow for the measurement of both spontaneous and elicited responses across varying contexts of belief induction. This would allow for direct comparison of representational understanding across different age groups. Such manipulations may also inform us about the structure of infants’ early understanding of false-belief and the factors that contribute to subsequent performance on elicited measures of understanding. For example, it is still an empirical question how well infants’ reasoning about false-belief transfers across different epistemic contexts. Examining young children’s ability to reason both implicitly and explicitly across different scenarios would thus inform us whether children’s early representations of false-belief are indeed situation-based or flexible in nature.

Second, the manipulation of language in both spontaneous and elicited measures of false-belief may also inform our understanding of the role of language in response selection processes. Specifically, it would be possible to determine if language that denotes alternate perspectives in a false-belief scenario would influence processing on both spontaneous and elicited response tasks.

Third, introducing relational language to paradigms that have been designed to primarily measure implicit knowledge (i.e., visual forced-choice paradigms that allow for the measure of spontaneous responses) may address whether language has any effects on the abstraction of relational patterns across different contexts of epistemic reasoning. Manipulating the type of language used (i.e., epistemic vs. non-epistemic) would then further clarify what aspects of language are unique in their ability to assist with the representation of conflicting perspectives. In the following chapters of this thesis, an empirical study will be outlined that which applied and tested the above methods.
Chapter 3
The Effects of Epistemic Verb Exposure on Preschoolers’ Representations of Belief

Until recently, research into the development of false-belief understanding has yielded two robust findings: (a) that children younger than 4.5 years of age do not typically succeed on standard measures of false-belief understanding that require them to make elicited responses (see Wellman et al., 2001 for meta-analysis), and (b) that there is a significant relation between children’s individual language abilities and their success on standard false-belief tasks (Astington & Jenkins, 1999; see Milligan et al., 2007 for meta-analysis). A growing body of research from the field of infant social cognition, however, has recently brought into question these assertions. Specifically, evidence suggesting that pre-linguistic infants may be capable of both tracking and processing the epistemic states of others has raised doubt about when false-belief understanding first emerges and the role that language may play in its development. To address this issue, an empirical study will be outlined in this chapter. This research was conducted to examine the extent to which the acquisition of epistemic verbs may assist children with the transition from early to later forms of false-belief processing.

3.1 Early False-Belief Processing

False-belief understanding has traditionally been assessed using controlled or elicited response measures that require children to make explicit, and often verbal, predictions about the epistemic states of others. For example, children may be asked to directly predict the behaviour of an agent who holds a false-belief about either the location (e.g., Change-of-Location task, Wimmer & Perner, 1983) or identity of a target object (e.g., Unexpected-Identity, Perner et al., 1987). In contrast, research examining false-belief understanding in infants and toddlers has relied almost exclusively on involuntary or spontaneous response measures – i.e., measures that capture children’s automatic behavioural responses to visual sequences of action or indirect prompts. Because young children cannot often meet the cognitive and linguistic demands associated with traditional forms of false-belief assessment, it has been argued that involuntary response measures are better suited to capture earlier forms of epistemic processing (Baillargeon et al., 2010). For consistency with previous research in this area, the terms spontaneous and elicited will be used to further describe these two types of measures. The terms automatic and controlled
will, subsequently, be used to describe the level of cognitive processing associated with each type of measure respectively.

To date, two spontaneous response paradigms have been used to assess false-belief understanding: violation-of-expectation (VOE) and anticipatory fixations. In VOE paradigms, children’s looking times are measured to see if they will attend longer to scenarios where an agent’s actions are inconsistent with his/her belief (e.g., if an agents’ searching behaviour does not match his/her belief about an object’s location). In anticipatory fixation paradigms, children’s anticipatory looks to target locations on a display are measured following a critical prompt that can be either verbal (e.g., an indirect prompt such as “I wonder where he will look for the toy”) or nonverbal (e.g., a chime) in nature. Critical prompts typically occur at a point after the agent has acquired a belief about a target object (e.g., a belief about which location the object is hidden in) but before the agent has acted upon this belief, thus allowing for measurement of children’s anticipation for the agent’s subsequent action.

The number of studies implementing these paradigms seems to have grown exponentially in recent years and their findings have yielded substantial evidence to suggest that children as young as 7-months of age (Kovács et al., 2010) can monitor the false-belief states of others. Specifically, this research has shown that before their second year of life, infants can accurately detect inconsistencies between agents’ behaviour and their beliefs about an object’s location (Luo & Baillargeon, 2007; Onishi & Baillargeon, 2005; Song & Baillargeon, 2008; Surian et al., 2007; Träuble, Marinović, & Pauen, 2010). Infants can also detect similar inconsistencies in contexts where an agent holds a false-belief about the identity of a target object (Scott & Baillargeon, 2009; Scott, Baillargeon, Song, & Leslie, 2010). This suggests that by an early age, children’s ability to track epistemic states is not restricted to a single context of belief induction, however few studies to date have demonstrated the ability to generalize false-belief representations within the same individual (Träuble et al., 2010). Studies utilizing anticipatory fixation paradigms have additionally shown that children as young as 18-months can use information about an agent’s epistemic state (e.g., whether or not the agent witnessed the transfer of a hidden object) to accurately anticipate his/her subsequent behaviour (i.e., where the agent will search for the hidden object) (He, Bolz, & Baillargeon, 2012; Senju, Southgate, Snape, Leonard, & Csibra, 2011; Southgate et al., 2007). Specifically, these studies have shown that children will show correct anticipatory fixations (i.e., they fixate on locations that correspond to
the agent’s belief) even when their verbal responses to elicited measures are incorrect (Clements & Perner, 1994; Garnham & Perner, 2001; Ruffman et al., 2001). The bulk of evidence in support of infant epistemic processing has consequently led some researchers to conclude that (a) there may be little room for further development of epistemic representations after infancy, and (b) subsequent language development may not play a primary role in the development of epistemic representations.

Closer examination of children’s response patterns across different measures, however, indicates that developmental changes in false-belief understanding may still occur between infancy and the preschool years. Distinct response measures, after all, are needed to assess children’s false-belief understanding in different age groups. This distinction is not only evident between elicited and spontaneous methods of assessment but also within different types of spontaneous response measures. Violation-of-expectation paradigms, for example, are most commonly used to assess false-belief in infancy (e.g., Onishi & Baillargeon, 2005) while anticipatory fixation paradigms have only been used with children 18-months (Senju et al., 2011) and older (e.g., Clements & Perner, 1994). Given that each measure requires children to engage in different levels of processing (e.g., detection of behavioural inconsistencies vs. anticipation of behaviours), it is difficult to rule out the possibility that children’s response patterns at different ages are indicative of distinct underlying representations. In fact, recent studies examining the flexibility of infant’s false-belief processing have indicated that younger children may hold more rigid representations of belief than older children (Poulin-Dubois, Polonia, & Yott, 2011; Sodian & Thoermer, 2008). For example, Poulin-Dubois and colleagues (2011) found that both 14- and 18-month-olds will use salient cues about an agent’s visual access to an object (e.g., if the agent is wearing a blindfold) to infer whether or not the agent is knowledgeable about the object’s location. However, children over-extended their inferences about an agent’s knowledge in contexts where visual access was less predictive of the agent’s subsequent behaviour (e.g., when an agent had previous experience successfully retrieving the object from a specific location).

These findings demonstrate that while infants have formed associations between certain contextual cues (e.g., visual access to location) and knowledge formation, their early representations of belief may not be flexible enough to adapt to varying cues of belief induction. Importantly, these findings support the notion that the development of epistemic representations may still be necessary past infancy. How children transition between early and later forms of
false-belief representation, therefore, remains an open question and it is possible that concurrent language development may still play a central role in this transition.

3.2 Theories of Language and False-Belief Understanding

It is currently well established that individual differences on elicited false-belief assessment tasks are significantly predicted by variance in children’s linguistic abilities (Astington, 2006; Astington & Baird, 2005; Milligan et al., 2007). Specifically, studies have shown that children’s performance on elicited response tasks are significantly predicted by linguistic factors that are both internal (e.g., semantic, Bartsch & Wellman, 1995; syntactic, de Villiers & Pyers, 2002; and pragmatic development, de Rosnay & Hughes, 2006) and external to the child (i.e., socio-linguistic environment, Ruffman et al., 2002). Because the current study focuses on the acquisition of epistemic verbs, only theories that describe how the development of internal language abilities contributes to the development of epistemic representations will be reviewed here.

3.2.1 Complement Syntax and False-Belief

According to Jill de Villiers and colleagues, children’s acquisition of complement syntax provides the representational structure needed to explicitly reason about false-beliefs (de Villiers, 2005; 2007). Complement syntax is the syntactic structure that is typically associated with verbs of communication (e.g., *says* and *tells*) and belief (e.g., *thinks*). In this structure, sentential complements (e.g., “the ball is in the red bin”) are embedded under the verb (e.g., “John thinks the ball is in the red bin”) and allow for the expression of the subject’s perspective (i.e., John) rather than that of the speaker. Critically, the content of a sentential complement can be false (e.g., in a context where the ball is not actually in a red bin) while the entire sentence remains true. Because complement syntax allows for the explicit representation of false-perspectives, de Villiers and colleagues have argued that children’s acquisition of these structures precedes their successful performance on elicited false-belief assessments. The *Memory for Complement Syntax* test was consequently devised by these researchers to test this hypothesis. In this task, children are asked to recall the sentential complements embedded in sentences containing communication verbs (e.g., “She said she found a monster under her chair”). Longitudinal research has demonstrated that children show improvements in their interpretation of these syntactic constructions between the ages of 3 and 5 and this ability is significantly predictive of successful performance on elicited false-belief tasks (de Villiers & Pyers, 2002). Training
studies have additionally shown that children’s exposure to sentential complement constructions, in the absence of epistemic verbs or context, can lead to significant improvements on elicited false-belief tasks (Hale & Tager-Flusberg, 2003; Lohmann & Tomasello, 2003). Importantly, because children can interpret sentential complements that are associated with communication verbs before they can explicitly reason about epistemic states, de Villiers has suggested that it is through the use of communication verbs that children first develop the representational structure needed to process false-beliefs (de Villiers, 2007).

To date, this account has not directly acknowledged how children’s acquisition of complement syntax interacts with early forms of epistemic processing. It is, however, possible that children’s automatic processing of false-belief may also be influenced by their ability to interpret sentential complement constructions. A recent study by Low (2010) addressed this issue by examining the effects of complement syntax mastery on both automatic and controlled processing of false-belief. It was found that while spontaneous response accuracy and complement syntax understanding independently contributed to children’s performance on elicited response measures, complement syntax mastery was not significantly related to children’s performance on spontaneous response tasks. This suggests that the acquisition of complement syntax may not be necessary for the early processing of false-belief but may play a role in the development of later epistemic representations.

3.2.2 Linguistic Labels and Response Selection

The process of response selection entails the simultaneous consideration of, at least, two representations (i.e., the set of potential responses to a direct question) and, potentially, the inhibition of an incorrect prepotent response. In an elicited false-belief task, this would translate into children’s ability to both (a) represent their own knowledge about an object and the conflicting belief of an agent and (b) inhibit the prepotent response to align an agent’s perspective with their own (i.e., the true state of reality). Some researchers have argued that children’s success on elicited response measures of false-belief is primarily contingent on their ability to effectively engage in response selection (Baillargeon et al., 2010; Leslie et al., 2005). Indeed, several studies have shown that cognitive abilities associated with response selection (i.e., working memory, inhibition, and cognitive flexibility) undergo significant improvements throughout early childhood and are significant predictors of children’s success on elicited response measures (Carlson, Mandell, & Williams, 2004; Henning, Spinath, & Aschersleben,
2011; Rakoczy, 2010). Within this framework, concurrent language development is important for false-belief processing in so far as it assists with reducing the cognitive demands associated with response selection. Moreover, these effects should be evident on elicited but not spontaneous response measures of false-belief because the latter tasks assess automatic processes that do not require response selection.

One way in which language has been examined in relation to response selection is through the use and interpretation of linguistic labels. Linguistic labels may reduce the cognitive load associated with response selection by acting as concrete representations, or symbols, for the competing perspectives in a false-belief task. As symbols, linguistic labels create indirect links between contextual cues (e.g., location associated with an agent’s belief) and their related mental representations (i.e., the epistemic state of an agent) (Deak, 2004, Huttenlocher & Higgins, 1978). These links not only assist children with the retrieval of epistemic information but also provide the requisite cognitive distance needed to flexibly switch attention between conflicting representations (Jacques & Zelazo, 2005). Previous research has shown that labels can assist children as young as 2 years of age on tasks that require cognitive switching (e.g., perceptual search task, Miller & Marcovitch, 2011; categorical sorting task; Kirkham et al., 2003). Only one study to date, however, has examined the effects of linguistic labels on preschoolers’ elicited false-belief processing (Low & Simpson, in press). In this study, labels were used to uniquely identify locations in a change of location task that were associated with either the agent’s perspective (i.e., the original location of an object), the child’s perspective (i.e., the new transferred location of the object), or both. Children in a control condition were provided with non-specific labels (e.g., “here”) for both locations. The researchers found that 4-year-old children showed greater response accuracy in conditions where the agent’s perspective was uniquely identified by a label but 3-year-olds did not show similar patterns of improvement.

Overall, these findings suggest that while labels associated with an agent’s perspective may reduce the cognitive demands associated with false-belief response selection, this effect may not be sufficient to support the controlled processing of younger children. Instead, children’s ability to use linguistic labels as symbolic representations of belief may be contingent on their development of additional factors, such as the development of higher-order representations of belief. Differences between children’s earlier and later forms of epistemic processing may also
be indicative of more than just developmental changes in response selection, although language may only have effects on later forms of processing.

3.2.3 Structure Mapping and False-Belief

One theory that does posit a primary role for language in the formation of both earlier and later forms of representation is structure mapping. According to this framework, proposed by Dedre Gentner and colleagues (e.g., Gentner, 2003, 2010; Gentner & Medina, 1998; Loewenstein & Gentner, 2005), concepts are formed through analogical processes that work to align relational patterns across representations of distinct but structurally similar events. For example, relational patterns that are predictive of an agent’s behavior in a change of location task (e.g., the agent will always search for an object in the location where s/he last witnessed it) could be aligned across multiple contexts of false-belief to form a higher-order representation of belief induction (i.e., seeing leads to knowing). Importantly, because this framework posits that analogical processes favor the alignment of higher-order over situation-based relational patterns, structure mapping may be essential in the formation of higher-order representations. Critically, Gentner and colleagues have argued that language that denotes relations, such as verbs and prepositions, plays a central role in structure mapping (Gentner, 2003; Loewenstein & Gentner, 2005). They also propose that relational language assists with the representation and structural alignment of relational patterns through five key mechanisms: (1) abstraction of relational patterns from their initial contexts, (2) retention of relational pattern representations, (3) the explication of non-obvious relational patterns, (4) uniform encoding of relational patterns through static and habitual use, and (5) selectively biasing attention towards similar patterns in novel contexts.

To date, studies in the domain of spatial mapping (Lowenstein & Gentner, 2005; Ratterman & Gentner, 1998) and object categorization (Baldwin et al., 1993; Graham et al., 2010) have demonstrated that children can use relational language to detect complex relations between objects. No study to date, however, has examined the effects of structure mapping and language in relation to the processing of epistemic representations. Despite this lack of evidence, it has been suggested that the principles of structure mapping theory may still be applicable to the study of epistemic concepts (Baldwin & Saylor, 2005). Specifically, the mechanisms proposed by Gentner (2003) can be used to theorize how language associated with epistemic states (e.g., epistemic verbs like think) may assist with the formation of higher-order epistemic representations. The following is one proposal of how this process may occur.
First, epistemic verbs may assist with the abstraction of relational patterns associated with epistemic states. This is because epistemic verbs denote relations that may otherwise be difficult to perceive in a visual scene\(^3\) (i.e., relations between an agent and his/her epistemic state). Through the pairing of language with contexts of false-belief, epistemic verbs may thus highlight behavioural patterns that relate an agent’s belief to his/her subsequent actions (e.g., an agent’s searching behaviour in a change of location task). Second, epistemic verbs may help children with the retention and explication of behavioural patterns through repeated exposure and association. Over time, associations between verbs and behavioural patterns would strengthen children’s representations of these patterns. These situation-based representations could then be retrieved to form predictions about an agent’s behaviour in similar linguistic and visual contexts. Finally, the presentation of familiar epistemic verbs may invite children to engage in analogical processing between different contexts. For example, if children hear a familiar verb (e.g., *thinks*) in a novel context of false-belief (e.g., an agent is misinformed about the location of an object), then the verb may encourage children to selectively attend to relational patterns that are structurally similar to their pre-existing representations. In this way, language may promote the uniform encoding of epistemic representations across similar contexts. If, however, new relational patterns do not align with pre-existing representations, then children may be forced to adapt their understanding and/or seek out higher-level structural alignments between representations. In this way, exposure to epistemic language may help with the formation of higher-order representational structures of belief.

### 3.3 Summary of Theoretical Predictions

All the above theories of language and false-belief development predict that exposure to epistemic language will produce improvements in epistemic processing. Where these theories may critically differ is in describing: (a) the levels of processing that are affected by language (i.e., automatic vs. controlled), (b) the degree to which language is important in the formation of epistemic concepts, and (c) the type of language that is important for the successful processing of epistemic states. The following is a summary of the predictions that each theory would make in relation to these factors. These predictions are further outlined in Table 1.

\(^3\) Although as noted in the previous review of children’s spontaneous false-belief processing, there is evidence to suggest that children can track epistemic information in the absence of language.
First, with regards to levels of processing, complement syntax theory predicts that children’s performance on elicited response measures should be contingent on their comprehension of sentential complements. This theory does not, however, explicitly posit whether children’s performance on spontaneous measures of false-belief is equally dependent on complement syntax mastery. In contrast, the response selection account predicts that language is exclusively related to children’s performance on elicited response measures. This is because language serves to reduce the cognitive demands associated with response selection on these measures. Moreover, this account hypothesizes that language should not predict children’s responses on spontaneous measures of false-belief because these measures do not entail the process of response selection. Finally, the structure mapping account predicts that relational language may influence the processing of both immature (i.e., context-specific associations) and robust (i.e., higher-order) representations of belief. As such, this account might predict that language will affect performance on measures that assess understanding at both early (i.e. spontaneous measures) and later stages of development (i.e., elicited measures).

In terms of how important language is to the development of epistemic representations, complement syntax theory asserts that the acquisition of syntactic structures that support false-belief representation (i.e., sentential complement constructions) is necessary in order for children to form a metarepresentational understanding of belief. The response selection account, however, only assigns language an indirect role in the processing of epistemic representations (i.e., by reducing response selection demands). This framework might therefore predict that children are capable of forming flexible representations of epistemic states in the absence of language. Structure mapping theory might similarly predict that epistemic representations may be formed in the absence of language, perhaps through the use of alternate mechanisms of learning (Gentner, 2010). Importantly, this theory would qualify this prediction by asserting that the process of structural alignment operates most efficiently when supported by relational language.

Finally, with regards to what types of language are most relevant to the processing of false-belief, complement syntax theory focuses on the acquisition of the complement syntax and, specifically, the ability to represent embedded propositions. Although this theory would also
predict that the semantics of epistemic verbs are also important to the processing of false-belief\textsuperscript{4}, this theory does not make predictions about the specific verbs that would assist children with the representation of false-belief. Instead, this theory suggests that children may first acquire an understanding of sentential complement constructions through their use with communication rather than mental state verbs. In contrast, the response selection account places greater value on language that can uniquely distinguish between alternate perspectives in an elicited false-belief task. To date, this has entailed using linguistic labels that are associated with event features (e.g., object locations) to distinguish between competing perspectives in a false-belief scene (i.e., the agent’s vs. the child’s perspective). In structure mapping theory, it is more critical that language denotes the relation between an agent and his/her epistemic states, not just the content of the belief. As such, this framework would similarly predict that the comprehension of complement syntax constructions would be important in the formation of epistemic representations. What is less clear is whether unique associations between epistemic verbs and contexts would further facilitate the abstraction of epistemic representations.

\textsuperscript{4} As both Jill de Villiers and several others have noted (e.g., Gleitman et al., 2005; Fisher & Song, 2006), the meaning of a verb is inherently constrained by the sentential frame in which it appears and thus cannot be disassociated from its syntax.
Table 1

Summary of Predictions Made by Three Theories of Language and Epistemic Processing

<table>
<thead>
<tr>
<th>Theories</th>
<th>Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Level of Processing</strong></td>
</tr>
<tr>
<td>CS Theory</td>
<td>Knowledge of CS should predict performance on elicited measures of false-belief but the theory does not currently make predictions about how CS would interact with automatic levels of false-belief processing.</td>
</tr>
<tr>
<td>Response Selection</td>
<td>Language should only predict performance on measures that require controlled processing (i.e., elicited measures) but should not be necessary for accurate performance on spontaneous response measures.</td>
</tr>
<tr>
<td>Structure Mapping</td>
<td>Relational language will affect performance on measures that assess understanding at both early (i.e. spontaneous measures) and later stages of development (i.e., elicited measures).</td>
</tr>
<tr>
<td></td>
<td><strong>Role of Language in Epistemic Concept Development</strong></td>
</tr>
<tr>
<td>CS Theory</td>
<td>The acquisition of CS is necessary for the development of epistemic concepts.</td>
</tr>
<tr>
<td>Response Selection</td>
<td>Language facilitates the controlled processing of false-belief but is not critical for the development of epistemic concepts.</td>
</tr>
<tr>
<td>Structure Mapping</td>
<td>Relational language may not be necessary for the development of epistemic concepts but may strongly facilitate the formation of higher-order representations.</td>
</tr>
</tbody>
</table>
### Type of Language that is Important for Epistemic Processing

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS Theory</td>
<td>The acquisition of syntactic structures that allow for the embedding of a false proposition (i.e., complement syntax).</td>
</tr>
<tr>
<td>Response</td>
<td>Language that can highlight and distinguish between alternate perspectives in a false-belief context (e.g., associative feature labels)</td>
</tr>
<tr>
<td>Selection</td>
<td>Language that denotes the relation between an agent and his/her perspective (i.e., epistemic verbs and related syntax).</td>
</tr>
</tbody>
</table>

*Note. CS refers to Complement Syntax*

### 3.4 Current study

The current research was designed to assess the above predictions about language and the development of epistemic representations. Specifically, this study addresses three research questions that may potentially distinguish between alternate accounts of false-belief development: (1) whether exposure to epistemic language (i.e., verbs and complement syntax) will lead to improvements in both children’s automatic and controlled processing of false-belief, (2) whether exposure to epistemic language is necessary for the formation of flexible belief representations, and (3) whether certain aspects of epistemic language (i.e., syntactic vs. semantic understanding) are more important in the of processing false-belief.

To examine these questions, a novel training paradigm was devised whereby children, who initially failed elicited response measures of false-belief, were briefly trained with visual scenes depicting both true- and false-belief scenarios. Importantly, children were randomly assigned to one of three training conditions where the critical manipulation was the verbal input that children were exposed to in conjunction with the training stimuli. In the Control condition, children were always presented with narrations that described both the actions of the agent and the alternate locations in a scene but, importantly, did not contain epistemic verbs (e.g., “Sam is going to put it with the apples but it is really a toy”). In an experimental condition, children were always presented with narrations that contained a familiar epistemic verb with an embedded sentential complement (e.g., “Sam thinks that it is an apple but it is really a toy.”). In one experimental condition the same familiar verb was always used. This condition was labeled the *No Contrast*
condition because there was no lexical contrast between the verbal stimuli that were presented in both true- and false-belief contexts. Alternatively, in a second experimental condition, children were presented with narrations that contained either a familiar epistemic verb (i.e., thinks) in contexts of true-belief or a novel epistemic verb in contexts of false-belief (e.g., “Sam *thinks* that it is an apple but it is really a toy.”). This condition was consequently labeled the *Contrast* condition because there was lexical contrast between the verbal stimuli that children heard in either true- or false-belief contexts. This latter manipulation was included to assess whether unique associations between epistemic contexts and verb semantics are necessary in order for epistemic representations to be formed\(^5\). Following training, both spontaneous (i.e., anticipatory gaze) and elicited responses were assessed across different contexts of belief in order to examine the flexibility of children’s processing. Pre-training measures of receptive language ability and comprehension of sentential complements were additionally included in the analysis to further examine the effects of language on the development of epistemic representations.

\(^5\) This hypothesis is based upon cross-linguistic research demonstrating a processing advantage for children whose native language uniquely denotes epistemic states of false-belief (e.g., Liu et al., 2008; Shatz et al., 2003).
Chapter 4  
Methods

4.1 Participants

A total of 84 children with a mean age of 3 years; 5 months (Range: 2 years; 6 months to 4 years; 5 months) participated in the study. Boys and girls were equally distributed across the three training conditions (16 boys and 12 girls in each group). An additional 30 children were also recruited but eventually dropped from the final sample\(^6\). Children were recruited from eleven daycares within a large, multi-culturally diverse Canadian city. Although information about socio-economic status or ethnicity was not formally collected, all participants were recruited from childcare facilities that were centrally located in urban settings and offered services to primarily middle and upper-middle class families of varied ethnic backgrounds. Via parental response, it was determined that 48 children in the final sample were monolingual speakers of English (i.e., did not understand or communicate in another language). Of the remaining children who were identified as having exposure to more than one language in the home, 25 children were identified as having English as their primary language while 11 children used English as their secondary language. All children attended daycares where English was exclusively spoken and all participants were able to effectively communicate with the experimenter in English.

4.2 Materials

All tasks, excluding the PPVT-4, were administered on a computer and presented on a 22” widescreen LCD monitor. A small, high definition video camera was used to record both children’s audio and visual responses.

\(^6\) This group was comprised of (a) 13 children who attained ceiling scores on the explicit false-belief pre-test measure, (b) 5 children who had incomplete data due to technical and/or experimenter error, (c) 3 children who could not complete the study due to distraction, (d) 3 children who moved before completing the study, (e) 3 children who had difficulty understanding the training task, and (f) 3 children who exceeded the age cut-off (i.e., 4;5 years) for inclusion in the study.
4.2.1 Language Measures

Two measures were used to assess participants’ language abilities. The Peabody Picture Vocabulary Test, Fourth Edition (PPVT™ - 4) (Dunn & Dunn, 2007), a standardized test that is frequently used as a control measure in studies of false-belief understanding (Milligan et. al, 2007) was used to assess for receptive vocabulary. In keeping with these previous studies, raw scores were used for analysis of this measure. The Memory for Complement Syntax Test (MCS), adapted from the original measure devised by de Villiers and colleagues (de Villiers & de Villiers, 2003) was used to assess for children’s comprehension of sentential complements (see Appendix A for images and scripts used in this task). In this task, children were presented with 12 narrated scenarios that were each split into two sections. In one section, children heard a critical sentence that contained a communication verb (saying or telling) and its sentential complement (e.g., “Kim said the ball had rolled under the dresser”) and were shown an image that depicted the content of the sentential complement (e.g., an image showing the ball underneath a dresser). In the other section, children heard a statement that contradicted the sentential complement carried by the communication verb (e.g., “…[but] the ball was underneath the chair”) and were presented with an image that depicted this information (e.g., an image of the ball underneath the chair). The order in which each section was presented was counterbalanced across scenarios so that children heard the critical sentence first followed by the conflicting information in half of the scenarios and vice versa for the other six scenarios. The two sections were always conjoined with “but”. At the end of each scenario, children were asked to indicate, either verbally or by pointing to the corresponding image, the content of the sentential complement that was presented in the critical sentence (i.e., “What did Kim say?”). Correct responses were given a score of 1 and were tallied across all items for a total score of 12.

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7 It should be noted that the version of the Memory for Complement Syntax Test used in the current study is a modification of the original task created by de Villiers and de Villiers (2003). In the current version, the number of scenarios was increased from 6 to 12 to increase variability in participants’ scores. Unlike the original test, the order in which information was presented in each scenario was also counterbalanced to control for possible order effects (Brown, Brown, & Caci, 1981; Harris, 1975). The contexts of each scenario were also adapted to ensure that no scenario included objects with deceptive appearance.
4.2.2 Training and Test Stimuli.
All training and test videos, including the change of location false-belief tasks, were comprised of animated sequences that were created using Adobe Flash Professional CS5.5. Audio stimuli were recorded separately and edited to reduce variability of length and volume using Wavepad Sound Editor software.

4.3 Procedures
Children were tested individually in a quiet room at their preschool or daycare. Children were seated directly in front of the monitor, approximately 20” away from the screen, with the camera positioned at the base of the monitor. The experimenter was seated directly next to the child and controlled the presentation of stimuli using a laptop that was connected to the monitor. Each child participated in a total of four separate sessions that were conducted within a 1-week period ($M = 6.58$ days between the first and last session).

4.3.1 Session One
Children were administered the Memory for Complement Syntax Test followed by two Change of Location test videos (see Appendix B for sample displays and script). The Change of Location task used in the current study was modeled after previous anticipatory gaze measures of false-belief understanding (Clements & Perner, 1994; Clements et al., 2000; Ruffman et al., 2001; Surian et al., 2007) and was used to assess both anticipatory gaze and elicited responses for both true and false-belief scenarios. The general display was identical for both videos and was comprised of an upper section, with a single hole or doorway in the centre, and a lower section that was split into two rooms. Each room had a separate entrance that was located on either the far right or far left corner of the screen (the distance between both entrances was 11”). In front of each entrance was also an opaque container (e.g., a box or a dresser) that varied in colour between the two rooms. At the beginning of each video, a target object (e.g., a piece of cake or a box of crayons) was shown on top of one of the containers. The original location of the target object (i.e., left or right side of the display) was counterbalanced across the two videos. Before beginning each video, the experimenter briefly introduced the characters (e.g., a mouse and bunny or a little boy and little girl) in the movie and described the scene to the child. Specifically, the experimenter showed the child that in order for the characters to access one of the containers on the lower part of the screen, they would have to first go through the central exit located on the upper half of the screen and then reappear in the entrance directly behind the
container. The experimenter provided the same demonstration for both locations before beginning the video.

For each video, children were presented with a similar sequence of events and narration. Each video was also split into two segments that allowed for the assessment of both true and false-belief understanding. In the first segment, used to assess for true-belief understanding, children observed (a) two characters going to retrieve the target object ("Look! The mouse and bunny are going to get the cake."), (b) one character hiding the target object in an opaque container while the other character looked on ("Look! The brown mouse is putting the cake inside the green box."), and (c) both characters exiting the scene. Following a brief delay, one of the characters returned to the scene, appearing in the upper section of the display and moving towards the centre of the display. The character paused behind the central exit and children heard an indirect verbal prompt that was meant to elicit an anticipatory gaze response in children (e.g., "I wonder where she will look first for the cake?"). A three second window was provided to allow for the recording of children’s anticipatory looks to either location (i.e., the lower left- or right-hand side of the screen). Following this pause, children were asked an explicit true-belief question by the experimenter (e.g., "Where is the brown mouse going to look first for the cake?").

After children’s responses to the explicit question were recorded, the video progressed to the second segment, which was used to assess for false-belief understanding. In this segment, children observed the same character remove the target object from the container in which it was originally hidden, move it to the alternate container ("Look! The mouse is putting the cake inside the purple box") and exit the scene. Following a brief delay, the second character, who did not witness the transfer of the target object, returned to the scene and moved towards the centre of the display. Again, children heard an indirect verbal prompt meant to elicit anticipatory eye gaze responses ("I wonder where he will look first for the cake?"). After three seconds, children were asked an explicit false-belief question by the experimenter (e.g., "Where is the white bunny going to look first for the cake?"). In addition to the explicit false-belief question, children were also asked a reality control (e.g., "Where is the cake right now?") and a memory control question (e.g., "Where was the cake at the beginning of the movie?"). For each type of question, correct responses were given a score of 1 and added across both test videos for a total possible score of 2. Children were ineligible to continue the study, and thus excluded from the final sample, if they responded correctly to both explicit false-belief test questions.
4.3.2 Sessions Two and Three

Children who were eligible to continue participation following the first session were randomly assigned to one of the three training conditions prior to the second session. The PPVT-4 was administered at the beginning of the second session, followed by six training videos. The remaining six videos were administered on the third session for a total of 12 training videos.

The general display for all training videos consisted of a table with two bins that were separated by a barrier in the middle (See Appendix C). Each bin contained a set of objects that were grouped together by function and type (e.g., one bin contained a set of apples while the other bin contained a set of toys). At the start of each video, one bin additionally contained a target object that was deceptive in appearance (i.e., was identical in appearance to objects in the alternate bin) but critically shared the same function as the objects it was initially grouped with. Training videos depicted both true- and false-belief scenarios and were equally distributed across the two testing sessions. All participants observed identical sequences of events for each type of scenario. The critical manipulation across conditions was the verbal stimuli that children heard in conjunction with the videos. A summary of the critical linguistic cues that children across the three conditions heard for both true- and false-belief videos is presented in Figure 1.

In false-belief training videos, children first observed a single character in the centre of the display. The character proceeded to select a non-target object from each of the bins (“Look! This is an apple.” or “Look! This is a toy”) and demonstrated the function of each object in sequential order (e.g., took a bite from the apple and squeezed the toy to produce a squeaking sound). Finally, the character selected the target object (“Look! This is a toy.”) and demonstrated its function (e.g. squeezing to produce the same sound as the other toys) before leaving the object in the centre of the table and exiting the scene. Following a 3-second delay, a second character entered the scene, looked at the target object, and moved to the centre of the display. Children heard the following narrative: “This is [Character’s name]. [Character] sees that something has been left on the table. S/he is going to put it away”. At this point, children heard a critical verbal prompt that varied by condition. In the Control condition, children heard a sentence describing what the character was about to do but did not include information about his/her epistemic state (e.g., “Sam is going to put it with the apples but it is really a toy.”). In the No Contrast condition (i.e., no lexical contrast), children heard a sentence that included a familiar epistemic verb and a sentential complement describing the content of the character’s belief (e.g.,
“Sam thinks that it is an apple but it is really a toy.”). Similarly, in the Contrast condition (i.e., lexical contrast) children heard a sentence with complement syntax that described the content of the character’s belief but, critically, the verb carrying the sentential complement was novel (e.g., “Sam gorsps that it is an apple but it is really a toy.”). Following a brief 3-second pause, the character proceeded to pick up the target object and incorrectly place it in the bin with objects that shared its appearance (e.g., would place the toy that looks like an apple with the apples). To verify that all children understood the error in the character’s actions, the experimenter then asked: “Did s/he put it in the right spot?”. If a child incorrectly responded “yes” to this question then the experimenter explicitly corrected the child by indicating where the object should have been placed (“No, he did not put it in the right spot. It was supposed to go here because it was really a toy.”).

The sequence of events in true-belief training videos was identical to that in the false-belief training videos except that two characters, rather than one, were present to observe the function of all the objects in the display, including the deceptive-looking target object (e.g., a pen that looked like a flower). Upon demonstrating the function of the target object, the character in the centre of the display placed the object in the centre of the table and exited the scene. The second character then moved to the centre of the display and children were again informed that the character was going to sort the target object into its appropriate bin (e.g., “S/he is going to put it away.”). A critical verbal prompt was then presented that varied by condition. In the Control and No Contrast conditions, children heard the same type of prompt that was used in the false-belief training videos. That is, children in the Control condition heard a narrative that did not contain an epistemic verb (e.g., “Mark is going to put it with the pens and it is really a pen.”) while children in the No Contrast condition heard a narrative containing a familiar epistemic verb (e.g., “Mark thinks that it is a pen and it is really a pen.”). Conversely, children in the Contrast condition were presented with a different prompt than what they received in the false-belief training videos. Instead of hearing a narrative that included a nonce verb (i.e., gorsps), children heard a sentence containing a familiar epistemic verb (e.g., “Mark thinks that it is a pen and it is really a pen.”). Following the presentation of the verbal prompts, the character was shown correctly placing the target object inside the bin with other objects that shared its function (i.e., placing the pen that looked like a flower inside the bin with other pens). As in the false-belief videos, the experimenter then verified that children understood this to be a correct action
by asking: “Did s/he put it in the right spot?” If children responded incorrectly by saying “no”, the experimenter would correct their response by justifying the character’s actions (e.g. “Yes, he did put it in the right spot. It was supposed to go here because it was really a pen.”).

![Figure 1. Summary of critical linguistic prompts that were presented during training.](image)

Videos for each session were presented in a set random order (see Table 2 for a summary of all scenarios). The starting location of the target object (i.e., left or right bin) was counterbalanced across videos as was the gender of the characters that demonstrated the functions of each object or sorted the target object at the end.
Table 2

Summary of Scenarios for Training Videos Presented during Sessions Two and Three

<table>
<thead>
<tr>
<th>Order (S2)</th>
<th>Context</th>
<th>Agent 1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Agent 2&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Appearance</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>True-Belief</td>
<td>Girl</td>
<td>Boy</td>
<td>Egg</td>
<td>Container</td>
</tr>
<tr>
<td>2</td>
<td>True-Belief</td>
<td>Girl</td>
<td>Boy</td>
<td>Flower</td>
<td>Pen</td>
</tr>
<tr>
<td>3</td>
<td>False-Belief</td>
<td>Boy</td>
<td>Girl</td>
<td>Coin</td>
<td>Chocolate</td>
</tr>
<tr>
<td>4</td>
<td>True-Belief</td>
<td>Boy</td>
<td>Girl</td>
<td>Present</td>
<td>Cake</td>
</tr>
<tr>
<td>5</td>
<td>False-Belief</td>
<td>Boy</td>
<td>Girl</td>
<td>Seashell</td>
<td>Soap</td>
</tr>
<tr>
<td>6</td>
<td>False-Belief</td>
<td>Girl</td>
<td>Boy</td>
<td>Apple</td>
<td>Toy</td>
</tr>
</tbody>
</table>

Order (S3)

<table>
<thead>
<tr>
<th>Order (S3)</th>
<th>Context</th>
<th>Agent 1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Agent 2&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Appearance</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>False-Belief</td>
<td>Girl</td>
<td>Boy</td>
<td>Cookie</td>
<td>Playdough</td>
</tr>
<tr>
<td>2</td>
<td>True-Belief</td>
<td>Boy</td>
<td>Girl</td>
<td>Crayon</td>
<td>Candle</td>
</tr>
<tr>
<td>3</td>
<td>False-Belief</td>
<td>Girl</td>
<td>Boy</td>
<td>Camera</td>
<td>Squirt Toy</td>
</tr>
<tr>
<td>4</td>
<td>False-Belief</td>
<td>Boy</td>
<td>Girl</td>
<td>Teddy Bear</td>
<td>Backpack</td>
</tr>
<tr>
<td>5</td>
<td>True-Belief</td>
<td>Girl</td>
<td>Boy</td>
<td>Ring</td>
<td>Candy</td>
</tr>
<tr>
<td>6</td>
<td>True-Belief</td>
<td>Boy</td>
<td>Girl</td>
<td>Doll</td>
<td>Jar</td>
</tr>
</tbody>
</table>

Note. S2 and S3 refer to the testing session in which the stimuli were presented (i.e., sessions 2 and 3 respectively).

<sup>a</sup>Agent 1 is the agent who demonstrated the function of all the objects on the display.

<sup>b</sup>Agent 2 is the agent who sorted the target object at the end of the video.
4.3.3 Session Four

In the final session, children were administered a series of transfer test videos followed by two new versions of the Change of Location test videos that were identical in structure to those presented in Session 1. Two types of transfer tests were administered to assess both direct learning and transfer of learning post-training (see Figure 2 for a comparison of these tests). True- and false-belief versions of each test were also administered (two sets for each version) for a total of 8 test videos (see Table 3).

Table 3

Summary of Scenarios for Transfer Test Videos Presented during Session Four

<table>
<thead>
<tr>
<th>Order</th>
<th>Test</th>
<th>Agent 1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Agent 2&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Appearance</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FB-DA</td>
<td>Girl</td>
<td>Boy</td>
<td>Book</td>
<td>Safe</td>
</tr>
<tr>
<td>2</td>
<td>TB-M</td>
<td>Girl</td>
<td>Boy</td>
<td>Cup/Hat</td>
<td>Cup</td>
</tr>
<tr>
<td>3</td>
<td>FB-M</td>
<td>Boy</td>
<td>Girl</td>
<td>Vase/Glass</td>
<td>Vase</td>
</tr>
<tr>
<td>4</td>
<td>FB-DA</td>
<td>Girl</td>
<td>Boy</td>
<td>Shoe</td>
<td>Phone</td>
</tr>
<tr>
<td>5</td>
<td>TB-DA</td>
<td>Boy</td>
<td>Girl</td>
<td>Toy Block</td>
<td>Eraser</td>
</tr>
<tr>
<td>6</td>
<td>FB-M</td>
<td>Boy</td>
<td>Girl</td>
<td>Cymbal/Pot Lid</td>
<td>Cymbal</td>
</tr>
<tr>
<td>7</td>
<td>TB-DA</td>
<td>Boy</td>
<td>Girl</td>
<td>Robot</td>
<td>Clock</td>
</tr>
<tr>
<td>8</td>
<td>TB-M</td>
<td>Girl</td>
<td>Boy</td>
<td>Drumstick/Chopstick</td>
<td>Drumstick</td>
</tr>
</tbody>
</table>

<sup>Note.</sup> FB-DA and TB-DA refer to the false- and true-belief versions of the Deceptive Appearance tests respectively. FB-M and TB-M refer to false- and true-belief versions of the Misinformation tests respectively.

<sup>a</sup>Agent 1 is the agent who demonstrated the function of all the objects on the display.

<sup>b</sup>Agent 2 is the agent who must sort the target object at the end of the video.

The test videos that assessed direct learning from the training stimuli were the True-Belief Deceptive Appearance (TB-DA) and the False-Belief Deceptive Appearance (FB-DA) tests. In
these videos, children observed sequences of events that were identical in structure to the true-belief and false-belief videos they had observed in training. That is, children watched one character demonstrate the function of a deceptive-looking target object, either in the presence or absence of a second character, before placing the object in the centre of the display and exiting the scene. A second character then appeared and/or moved to the centre of the display and upon hearing that this character was going to sort the target object, children were presented with a critical prompt that, again, varied by condition. For example, children in the Control condition heard a statement that questioned what the character would do next but did not include an epistemic verb (e.g., “I wonder where [Character] is going to put it?”). This prompt was heard on both true- and false-belief test videos. Similarly, for both types of test videos, children in the No Contrast condition heard a statement that alluded to the content of the character’s belief and included a familiar epistemic verb (e.g., “I wonder what [Character] thinks that it is?”). For children in the Contrast condition, the prompt varied between true- and false-belief test videos so that on false-belief tests children heard a prompt that included a nonce verb (“I wonder what [Character] gorks that it is?”) while on true-belief tests children heard a prompt that included a familiar epistemic verb (“I wonder what [Character] thinks that it is?”). The prompts were designed to elicit anticipatory responses by providing the same verbal cues used in training (i.e., verbs) without providing explicit information about location or the content of a character’s belief. Thus, prompts used in the test videos were not identical to those used in training. A 3-second window was provided to record anticipatory eye gazes, after which children were asked an explicit test question by the experimenter: “Where is s/he going to put it?”. Responses to the explicit question were scored as correct (score of 1) or incorrect (score of 0) for a total possible score of 2 for each test type.

The other two types of transfer test videos were the True-Belief Misinformation (TB-M) and the False-Belief Misinformation (FB-M) tests. These test videos were designed to measure children’s ability to transfer predictive patterns about epistemic states, which they may or may not have learned from the training stimuli, to a novel context of belief induction. In these tests, the target object was purposely made to look like it could belong to either bin of objects within the display, thus making it ambiguous, rather than deceptive, in appearance. Moreover, this manipulation ensured that the characters’ beliefs about the target object’s identity could not be acquired based on physical appearance alone and would therefore be reliant on additional
information (e.g., verbal testimony). As in the other test videos, one character was shown demonstrating the function of the target object (e.g., showing that the object functions as a vase), either in the absence (FB-M) or presence (TB-M) of a second character. The second character then either entered the scene (FB-M) and/or moved closer to the first character. The first character, who had just demonstrated the true function of the target object, pointed to the object and misinformed the other character about its identity ("The boy is telling the girl that it is a glass."). This character then exited the scene and the other character was left having to sort the target object into its appropriate bin ("S/he is going to put it away."). After this point, the Misinformation test videos were identical to the Deceptive Appearance test videos in that children were given the same critical prompts, which varied across conditions, followed by an explicit test question (i.e., "Where is s/he going to put it?"). Results were scored the same as in the Deceptive Appearance tests.
Figure 2. Comparison of Deceptive Appearance and Misinformation tests. Misinformation tests critically differed from Deceptive Appearance tests in two ways: (1) the target object was ambiguous rather than deceptive in appearance, (2) after the first agent finished demonstrating the function of the target object, s/he misinformed a second agent about the true identity of that object.
4.4 Scoring of Anticipatory Eye Fixations

For all tests where anticipatory eye fixations were measured (i.e., pre- and post-training belief tests), coding of eye fixations began at the onset of the indirect verbal prompt (e.g., “I wonder where…”) and continued for 3-seconds following the offset of this prompt. This window of time was selected because most children began making anticipatory fixations upon hearing the start of the indirect verbal prompt. Given that verbal prompts were always preceded by statements about a character’s intentions (e.g., “Look! The mouse is back and she wants to get the cake.” or “…s/he is going to put it away.”), it is possible that children learned to use these preceding statements as additional anticipatory cues.

Children’s fixations were coded frame-by-frame (with an accuracy of 0.03 seconds per frame) for three critical locations on the screen: (a) the bottom right-corner, (b) the bottom left-corner, (c) and the centre of the screen (see Figure 3). All other fixations, including looks off-screen, were coded as unrelated. Looks to the right- and left-corners, which corresponded to potential locations for the target object on each display, were later re-coded as either looks to the correct or incorrect location but this information was not evident in the videos that were used to initially code the data. For each location, fixation times (in seconds) were averaged across both trials of each measure. Proportion scores were then calculated by taking the time that participants spent fixating on a target location and dividing it by the time they spent fixating on the entire screen.
(i.e., including the centre). Proportion scores were used to control for any individual variations in attention to the display.

It should be noted that in the current paradigm, the terms ‘correct’ and ‘incorrect’ refer to the accuracy of identifying the agent’s perspective in a scene. Correct fixations therefore correspond to locations that were aligned with agent’s perspective (i.e., the location where the agent believed the target object should be sorted). Incorrect fixations correspond to locations that were not aligned with the agent’s perspective. Whether or not the agent’s perspective aligned with the child’s perspective, however, varied across true- and false-belief tests (as illustrated in Figure 4).

In contexts of false-belief, correct and incorrect fixations corresponded to locations that were uniquely associated with the perspective of the agent or the child respectively. On these tests, a greater proportion of fixations to the correct location could therefore be interpreted as children’s increased consideration of the agent’s perspective. Conversely, a greater proportion of fixations to the incorrect location could be interpreted as children’s increased consideration of their own perspective. In contexts of true-belief, however, correct fixations corresponded to locations that were associated with both the agent’s and the child’s perspective. Thus, on these tests, a greater proportion of fixations to the correct location could be interpreted as children’s increased consideration for either the agent’s or their own perspective.

![Figure 4. Definition of 'correct' and 'incorrect' fixations for both true- and false-belief contexts.](image)

All video files were coded by the primary investigator but 20% were also coded for reliability by a second independent researcher. Analysis of inter-rater reliability yielded significant intraclass correlations for all pre- and post-training belief measures ($p < .01$) with coefficients that ranged between strong (.80) to very strong (.98). Means and intraclass correlations coefficients for each anticipatory measure are presented in Table 4.
<table>
<thead>
<tr>
<th>Test</th>
<th>Primary Coder Mean</th>
<th>Secondary Coder Mean</th>
<th>Intraclass Correlation Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-training TB-C (Correct)</td>
<td>1.43</td>
<td>1.40</td>
<td>.94</td>
</tr>
<tr>
<td>Pre-training TB-C (Incorrect)</td>
<td>.59</td>
<td>.63</td>
<td>.84</td>
</tr>
<tr>
<td>Pre-training FB-C (Correct)</td>
<td>.24</td>
<td>.21</td>
<td>.84</td>
</tr>
<tr>
<td>Pre-training FB-C (Incorrect)</td>
<td>.84</td>
<td>.83</td>
<td>.92</td>
</tr>
<tr>
<td>FB-DA (Correct)</td>
<td>.66</td>
<td>.62</td>
<td>.93</td>
</tr>
<tr>
<td>FB-DA (Incorrect)</td>
<td>.82</td>
<td>.79</td>
<td>.84</td>
</tr>
<tr>
<td>TB-DA (Correct)</td>
<td>.41</td>
<td>.41</td>
<td>.97</td>
</tr>
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<td>TB-DA (Incorrect)</td>
<td>.60</td>
<td>.66</td>
<td>.91</td>
</tr>
<tr>
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<td>.91</td>
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<td>.77</td>
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<td>.97</td>
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</tr>
<tr>
<td>Post-training FB-C (Incorrect)</td>
<td>1.19</td>
<td>1.14</td>
<td>.93</td>
</tr>
</tbody>
</table>

*Note.* TB- and FB-C refer to Change of Location tests. TB- and FB- DA refer to true- and false-belief versions of Deceptive Appearance tests. TB- and FB-M refers to true- and false-belief versions of Misinformation tests.
5.1 Preliminary Group Analyses

A series of 1-way ANOVAs were initially conducted to examine whether the training groups were homogenous across four control variables: age, time between pre- and post-training sessions, PPVT-4, and MCS. For each analysis, the independent variable was training condition (i.e., Control, No Contrast, or Contrast). A summary of group means for each of the control variables is presented in Table 5. Results indicated no significant group differences ($p > .05$) on any of the control variables, suggesting that the training groups were relatively homogenous across all four factors.

Table 5

<table>
<thead>
<tr>
<th>Control Measure</th>
<th>Control</th>
<th>No Contrast</th>
<th>Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (in years)</td>
<td>3.48 (.50)</td>
<td>3.48 (.47)</td>
<td>3.50 (.44)</td>
</tr>
<tr>
<td>Time between S1 and S4</td>
<td>6.79 (4.60)</td>
<td>6.61 (5.75)</td>
<td>7.04 (4.93)</td>
</tr>
<tr>
<td>PPVT-4</td>
<td>64.25 (18.17)</td>
<td>67.61 (18.82)</td>
<td>67.61 (18.25)</td>
</tr>
<tr>
<td>Memory for Complement Syntax</td>
<td>5.07 (2.09)</td>
<td>5.14 (2.49)</td>
<td>6.07 (2.39)</td>
</tr>
</tbody>
</table>

*Note.* Standard deviations are shown in brackets.

5.2 Gender, Age and Language Effects

Regression analyses were then conducted to see if gender, age, and children’s scores on language measures (PPVT-4 and MCS) were independently predictive of their elicited and anticipatory gaze responses for all epistemic tests (i.e., Pre-training Change of Location, Deceptive Appearance, Misinformation, and Post-training Change of Location). For all three variables,
ordinal regression analyses were conducted for elicited response data\(^8\) while linear regressions were used to examine the effects of each variable on anticipatory gaze response data\(^9\). Correlations between these three variables are shown in Table 6. Both language measures (i.e., raw PPVT-4 and MCS scores) were found to be significantly correlated with each other. Significant positive correlations were also found between age and raw PPVT-4 scores as well as between gender and MCS scores.

Table 6

*Correlations Between Gender, Age, and Language Measures*

<table>
<thead>
<tr>
<th></th>
<th>Age (years)</th>
<th>Raw PPVT Score</th>
<th>MCS Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>-.02</td>
<td>.07</td>
<td>.23*</td>
</tr>
<tr>
<td>Age (years)</td>
<td>-</td>
<td>.61**</td>
<td>.18</td>
</tr>
<tr>
<td>Raw PPVT Score</td>
<td>-</td>
<td>-</td>
<td>.32**</td>
</tr>
</tbody>
</table>

\(^{*} p < .05 \)
\(^{**} p < .01\)

5.2.1 Gender

For elicited response data, a series of ordinal regression analyses were first conducted to see if gender significantly predicted children’s accuracy scores (ranging from 0 – 2) on each elicited response measure (i.e. pre- and post-training belief measures). Results indicated that gender was only significantly predictive of children’s elicited responses on the FB-M Misinformation test, \(\chi^2 = 9.54, df = 1, N = 84, p = .002\), but not significantly related to any other belief measure. Further examination of the odds ratio suggested that girls were 3.78 times more likely than boys to respond accurately on the FB-M test, \(B = 1.23, SE = .43, p = .003\).

\(^8\) All scores on elicited response measures ranged in value from 0 – 2 with higher values indicating greater response accuracy.

\(^9\) Spontaneous response data indicated the proportion of time that children fixated on either the correct or incorrect location for each test display.
For anticipatory gaze data, linear regressions were then conducted to see if gender significantly predicted the proportion of time that children fixated to either the correct or incorrect location on each anticipatory gaze measure. It was found that gender significantly predicted children’s anticipatory fixations to the correct location on TB-Misinformation tests, \( \beta = -.25, t(83) = -2.32, p = .02, r = .25 \). That is, boys were more likely than girls to show anticipatory fixations to the correct location on these tests. Gender was, however, not predictive of children’s fixation times for any other anticipatory measure.

5.2.2 Age

Ordinal and linear regression analyses were also conducted to see if age significantly predicted children’s accuracy on elicited and anticipatory response measures respectively. For each belief measure, results yielded no significant age affects for either elicited or anticipatory response data \( (p > .05) \). Thus, it is unlikely that variations in response patterns within both types of measures can be attributed to differences in age.

5.2.3 Language Scores

For elicited response data, ordinal regression analyses were conducted to see if children’s PPVT-4 and MCS scores separately predicted their accuracy (ranging from 0 – 2) on elicited response measures (i.e., pre- and post-training belief measures). PPVT-4 scores were found to significantly predict children’s accuracy on post-training TB-Change of Location tests, \( \chi^2 = 4.58, df = 1, N = 84, p = .03 \). Further examination of the odds ratio suggested that for every unit increase in PPVT-4 scores, children were 1.03 times more likely to respond accurately on this belief measure, \( B = .03, SE = .01, p = .04 \). Children’s receptive vocabulary, however, was not significantly related to any other elicited response measure. Similarly, MCS scores significantly predicted elicited responses on the TB-Change of Location task (post-training), \( \chi^2 = 7.42, df = 1, N = 84, p = .01 \), but were not significantly related to any other elicited response measures. Further examination of the odds ratio for this test suggested that for every unit increase in MCS scores, children were 1.31 times more likely to respond accurately on the TB-Change of Location task (post-training), \( B = .27, SE = .11, p = .01 \).

For anticipatory gaze data, a series of linear regressions were then conducted to see if children’s scores on PPVT-4 and MCS measures separately predicted their anticipatory fixations (correct and incorrect) on pre- and post-training belief measures. It was found that PPVT-4 scores
significantly predicted children’s correct anticipatory fixations on TB-M tests, \((\beta = -.25), t(80) = -2.33, p = .02, r = .25\). That is, higher PPVT-4 scores predicted a lower proportion of correct anticipatory fixations on these tests. PPVT-4 scores were, however, not predictive of anticipatory fixations on any other belief measure. In contrast, MCS scores were significantly predictive of incorrect anticipatory fixations on the post-training TB-Change of Location test, \((\beta = -.35), t(82) = -3.36, p = .001, r = .35\). That is, following training, children who performed better on the MCS test showed a lower proportion of incorrect anticipatory fixations on TB versions of the Change of Location task. Aside from these tests, MCS scores were not significantly related to any other anticipatory response measure.

To further examine if significant gender effects on the FB-Misinformation and TB-Misinformation tests could be attributed to gender differences in language ability, two linear regression analyses were additionally conducted with gender as the predictor variable and language scores (i.e., PPVT and MCS scores) as dependent variables\(^{10}\). Results indicated that gender significantly predicted children’s MCS scores \((\beta = .23), t(83) = 2.17, p = .03, r = .23\). That is, girls were more likely than boys to score higher on the MCS test. Gender, however, did not significantly predict raw scores on the PPVT-4. Because PPVT scores were not significantly related to gender and MCS scores did not significantly predict children’s responses on either the TB- or FB-Misinformation tests, it is unlikely that gender differences observed on these tests can be attributed to differences in language ability.

### 5.3 Training Effects

To examine the effects of training on children’s epistemic processing, separate analyses were again conducted for both elicited and anticipatory gaze response data. Specifically, ordinal regression analyses were conducted for elicited response data while repeated measures ANOVAs were used to assess anticipatory fixation data. Based on the above regression analyses, gender was only included as a covariate on tests where it significantly predicted children’s responses on belief measures (i.e., elicited FB-M and anticipatory gaze TB-M). For theoretical reasons,
language scores were included as covariates on all analyses, regardless of whether they were independently predictive of belief measures.

5.4 Elicited Response Data

Separate ordinal regression analyses were conducted for true- or false-belief versions of each belief measure (for a total of eight analyses). On each analysis, training condition (i.e. Control, No Contrast, or Contrast) was the predictor variable while response accuracy score (ranging from 0 to 2) was the dependent variable. Scores for PPVT-4 and MCS were included as covariates for all analysis and, based on the previous analyses of gender effects, gender was also included as a covariate for analysis of FB-Misinformation tests.

Results indicated that the combination of condition and language scores significantly predicted children’s elicited responses on the TB-Change of Location test (post-training), \( \chi^2 = 144.03, df = 4, N = 84, p = .04 \), but did not predict responses on any other elicited response measure. Odds ratios for the post-training TB-Change of Location task, however, indicated that only MCS scores accounted for a significant amount of variance in elicited response accuracy, \( B = .25, SE = .12, p = .04 \). That is, for every unit increase in their MCS scores, children were 1.28 times more likely to respond correctly on the post-training TB-Change of Location test. Training condition did not, therefore, independently predict children’s responses on any of the elicited belief tests. Correlations between all elicited response measures are shown in Table 7. The only elicited response measures that were significantly correlated were responses on pre-training TB- and FB-Change of Location tests (negative correlation) and TB- and FB-Deceptive Appearance tests (also a negative correlation).
Table 7

<table>
<thead>
<tr>
<th></th>
<th>FB-C (pre)</th>
<th>FB-DA</th>
<th>TB-DA</th>
<th>FB-M</th>
<th>TB-M (post)</th>
<th>FB-C (post)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB-C (pre)</td>
<td>-.52**</td>
<td>-.08</td>
<td>.03</td>
<td>-.34</td>
<td>.02</td>
<td>.33</td>
</tr>
<tr>
<td>FB-C (pre)</td>
<td>-</td>
<td>-.02</td>
<td>-.24</td>
<td>.24</td>
<td>.12</td>
<td>-.42*</td>
</tr>
<tr>
<td>FB-DA</td>
<td>-</td>
<td>-</td>
<td>-.43*</td>
<td>.14</td>
<td>-.12</td>
<td>-.23</td>
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<td>-</td>
<td>-</td>
<td>-.05</td>
<td>-.02</td>
<td>.33</td>
</tr>
<tr>
<td>FB-M</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-.32</td>
<td>-.18</td>
</tr>
<tr>
<td>TB-M</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-.08</td>
</tr>
<tr>
<td>TB-C (post)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-.19</td>
</tr>
</tbody>
</table>

Note. TB- and FB-C refer to Change of Location tests. TB- and FB- DA refer to true- and false-belief versions of Deceptive Appearance tests. TB- and FB-M refers to true- and false-belief versions of Misinformation tests.

*p < .05
**p < .01

### 5.5 Anticipatory Gaze Data

Anticipatory fixation scores for true- and false-belief versions of each belief measure were analyzed using eight separate repeated measures ANCOVAs. For each analysis, the between-subjects factor was training condition (Control, No Contrast, or Contrast) while the within-subjects factor was location of fixation (i.e., Correct vs. Incorrect). The dependent variable was the proportion of time that children spent fixating on either location. Results for all eight repeated measures ANCOVAs yielded no significant interactions between condition and location of fixation for any of the belief measures (p > .05). Despite the lack of significant interactions, analyses of both between (i.e., 1-Way ANCOVAs) and within group differences (i.e., paired-
sample t-tests) were still conducted for each epistemic measure\(^\text{11}\). Between group analyses examined whether, for each location of fixation, training groups differed in their anticipatory fixations. Within group analyses examined whether, within each condition, children differed in their fixations to either the correct or incorrect location.

### 5.5.1 Change of Location (Pre-training)

Anticipatory fixations for both pre-training TB- and FB-Change of Location measures are illustrated in Figure 5. Four 1-Way ANCOVAs were first conducted to examine between-group differences for each measure. For each ANCOVA, the independent variable was condition while the dependent variable was the proportion of time that children fixated to either the correct or incorrect location. PPVT-4 and MCS scores were also included as covariates for each analysis. On pre-training measures of true- and false-belief understanding (i.e., pre-training Change of Location tests), results yielded no significant group differences in anticipatory fixations for either the correct or incorrect location \((p > .05)\).

Paired-sample t-tests were then conducted to assess for within group differences in anticipatory fixations. Results indicated that for the true-belief tests, there was a significant bias to fixate on the correct vs. the incorrect location for all three conditions: Control \((M_{\text{correct}} = .31 \text{ vs. } M_{\text{incorrect}} = .18), t(26) = 2.48, p = .02, d = .48\), No Contrast \((M_{\text{correct}} = .36 \text{ vs. } M_{\text{incorrect}} = .14), t(27) = 4.54, p < .001, d = .86\), Contrast \((M_{\text{correct}} = .30 \text{ vs. } M_{\text{incorrect}} = .15), t(27) = 4.00, p < .001, d = .75\). For false-belief tests there was a significant bias to fixate on the incorrect vs. correct location for all three conditions: Control \((M_{\text{correct}} = .11 \text{ vs. } M_{\text{incorrect}} = .38), t(26) = -5.47, p < .001, d = .57\), No Contrast \((M_{\text{correct}} = .11 \text{ vs. } M_{\text{incorrect}} = .39), t(26) = -7.26, p < .001, d = 1.40\), Contrast \((M_{\text{correct}} = .12 \text{ vs. } M_{\text{incorrect}} = .35), t(27) = -5.12, p < .001, d = .97\).

---

\(^{11}\) One-way ANOVAs were also conducted for each measure to see if groups significantly differed in the total time they spent fixating on the screen. Results yielded no significant group differences in total looking time for any anticipatory gaze measure \((p > .05)\).
Correlations between anticipatory gaze responses for all pre-training measures are shown in Table 8. Significant positive correlations were found between correct anticipatory gaze responses on TB tests and incorrect anticipatory gaze responses on FB tests. Similarly, significant positive correlations were found between incorrect anticipatory gaze responses on TB tests and correct anticipatory gaze responses on FB tests. Correct and incorrect fixations were, however, not significantly correlated within each type of anticipatory response measure. This suggests that on both TB and FB displays, children’s consideration for the correct location (i.e.,
location associated with the agent’s perspective) was not directly contingent on their consideration of alternate locations (i.e., locations not associated with the agent’s perspective).

Table 8

Correlations Between Anticipatory Gaze Responses on Pre-training Change of Location Tests

<table>
<thead>
<tr>
<th></th>
<th>TB-Incorrect</th>
<th>FB-Correct</th>
<th>FB-Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB-Correct</td>
<td>-.16</td>
<td>.06</td>
<td>.42**</td>
</tr>
<tr>
<td>TB-Incorrect</td>
<td>-</td>
<td>.23*</td>
<td>.14</td>
</tr>
<tr>
<td>FB-Correct</td>
<td>-</td>
<td>-</td>
<td>-.05</td>
</tr>
</tbody>
</table>

*Note.* TB- and FB- refer to true and false-belief versions of the Change of Location task. Correct and Incorrect refer to the location of fixation.

*p < .05

**p < .01

5.5.2 Deceptive Appearance

Anticipatory fixations for TB- and FB-Deceptive Appearance measures are illustrated in Figure 6. Again, four 1-Way ANCOVAs were conducted to assess for between group differences in anticipatory fixations. For each analysis, the independent variable was training condition and the dependent variable was the proportion of time that children fixated to either the correct or incorrect location. Covariates were PPVT-4 and MCS scores. For TB-Deceptive Appearance tests, results yielded no significant group differences in anticipatory fixations to either the correct or incorrect location (*p > .05*). 1-Way ANCOVAs for FB-Deceptive Appearance tests, however, yielded significant group differences in incorrect anticipatory fixations, *F*(2,79) = 5.58, *p* = .01, η² = .12, but not in correct anticipatory fixations. Post hoc Tukey HSD tests indicated that this was due to children in the Control condition making a greater proportion of incorrect anticipatory fixations (M = .24, SD = .12) than children in the No Contrast (M = .14, SD = .12) or Contrast condition (M = .15, SD = .11). Children in the No Contrast and Contrast conditions, however, did not significantly differ from each other in their fixations to incorrect locations.

Paired-sample t-tests were then conducted to assess for within group differences in anticipatory fixations. For both TB-DA and FB-DA tests, results indicated that, within each training group,
there was no significant bias to fixate on either the correct or incorrect location (i.e., proportion of fixations did not significantly differ between locations) \((p > .05)\).

Correlations between anticipatory gaze responses for all Deceptive Appearance measures are shown in Table 9. A significant negative correlation was found between correct and incorrect anticipatory fixations on TB-DA tests. Correct fixations on TB-DA tests were also significantly correlated (positive relationship) with correct and incorrect fixations on the FB-DA tests. Correct and incorrect fixations were however not significantly correlated within FB-DA measures. This suggests that on FB displays, children’s consideration for the correct location
(i.e., location associated with the agent’s perspective) was not directly contingent on the amount of time they considered their own perspective (i.e., incorrect location).

Table 9  
*Correlations Between Anticipatory Gaze Responses on Deceptive Appearance Tests*

<table>
<thead>
<tr>
<th></th>
<th>TB-Incorrect</th>
<th>FB-Correct</th>
<th>FB-Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB-Correct</td>
<td>-.24*</td>
<td>.23*</td>
<td>.25*</td>
</tr>
<tr>
<td>TB-Incorrect</td>
<td>-</td>
<td>.10</td>
<td>-.05</td>
</tr>
<tr>
<td>FB-Correct</td>
<td>-</td>
<td>-</td>
<td>.13</td>
</tr>
</tbody>
</table>

*Note. TB- and FB refer to true and false-belief versions of the Deceptive Appearance task. Correct and Incorrect refer to the location of fixation.*  
*p < .05  
**p < .01  

5.5.3 Misinformation Tests

Anticipatory fixations for both TB- and FB-Misinformation measures are illustrated in Figure 7. Four 1-Way ANCOVAs were conducted to assess for between group differences in anticipatory fixations. For each analysis, the independent variable was training condition and the proportion of time that children fixated to either the correct or incorrect location were the dependent variables. Covariates for each analysis were PPVT-4 and MCS scores. Gender was additionally included as a covariate on analysis of children’s correct fixations on TB-Misinformation tests. Results indicated that for TB-Misinformation tests, there were significant group differences in anticipatory fixations to the correct location, $F(2,77) = 4.25, p = .02, \eta^2 = .10$, but not in fixations to the incorrect location. Post hoc Tukey HSD tests indicated that children in the Control condition spent a greater proportion of time fixating on the correct location ($M = .29, SD = .22$) than children in the No Contrast ($M = .15, SD = .16$) or Contrast condition ($M = .15, SD = .20$). There were, however, no significant differences in correct anticipatory fixations between children in the No Contrast and Contrast conditions. In contrast to the true-belief tests, 1-Way ANCOVAs for FB-Misinformation tests yielded significant group differences for incorrect anticipatory fixations, $F(2,79) = 5.22, p = .01, \eta^2 = .12$, but not for correct fixations. Post hoc
Tukey HSD tests indicated that this was due to children in the Control condition spending a greater proportion of time fixating on the incorrect location ($M = .27, SD = .18$) than children in the No Contrast ($M = .16, SD = .15$) or Contrast condition ($M = .15, SD = .12$). Fixations to the incorrect location, however, did not significantly differ between children in the No Contrast and Contrast conditions.

Paired-sample t-tests were then conducted to assess for within group differences in anticipatory fixations. For both TB-DA and FB-DA tests results indicated that, within each training group, anticipatory fixations did not significantly differ between locations ($p > .05$). This suggests that for each condition, there was no significant bias to fixate on either the correct or incorrect location.

Correlations between anticipatory gaze responses for all Misinformation measures are shown in Table 10. A significant negative correlation was found between correct and incorrect anticipatory responses on TB-Misinformation tests. No significant correlations were found, however, between correct and incorrect anticipatory responses on FB-Misinformation tests. This suggests that on TB, but not FB displays, children’s consideration for the correct location (i.e., location associated with the agent’s perspective) was directly contingent on their consideration of alternate locations (i.e., locations not associated with the agent’s perspective).
Figure 7. Proportion of anticipatory fixations on TB- and FB- Misinformation tests.
Table 10
*Correlations Between Anticipatory Gaze Responses on Misinformation Tests*

<table>
<thead>
<tr>
<th></th>
<th>TB-Incorrect</th>
<th>FB-Correct</th>
<th>FB-Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB-Correct</td>
<td>-.23*</td>
<td>-.01</td>
<td>.16</td>
</tr>
<tr>
<td>TB-Incorrect</td>
<td>-</td>
<td>.10</td>
<td>.01</td>
</tr>
<tr>
<td>FB-Correct</td>
<td>-</td>
<td>-</td>
<td>-.04</td>
</tr>
</tbody>
</table>

*Note. TB- and FB refer to true and false-belief versions of the Misinformation task. Correct and Incorrect refer to the location of fixation.*

*p < .05
**p < .01

5.5.4 Change of Location (Post-training)

Anticipatory fixations for both post-training TB- and FB-Change of Location measures are illustrated in Figure 8. Four 1-Way ANCOVAs were conducted to assess for between group differences in anticipatory fixations. For each analysis, the independent variable was training condition and the proportion of time that children fixated to either the correct or incorrect location were the dependent variables. Covariates for each analysis were PPVT-4 and MCS scores. Results indicated that, following training, there were no significant group differences in anticipatory fixations for either the true- or false-belief versions of the Change of Location task (*p > .05*).

Paired-sample t-tests were then conducted to assess for within group differences in anticipatory fixations. Results for the TB-Change of Location task indicated that, within each training group, there was no significant bias to fixate on either the correct or incorrect location. For the FB-Change of Location task, however, there was a significant bias to fixate on the incorrect vs. correct location for both the Control (*M*<sub>correct</sub> = .17 vs. *M*<sub>incorrect</sub> = .41), *t*(27) = -3.93, *p* = .001, *d* = .74, and the Contrast condition (*M*<sub>correct</sub> = .21 vs. *M*<sub>incorrect</sub> = .37), *t*(27) = -2.04, *p* = .05, *d* = .39. Children in the No Contrast condition, however, did not show a significant bias to fixate on either the correct or incorrect location.
Figure 8. Proportion of anticipatory fixations on TB- and FB- Change of Location tests (post-training).
Correlations between anticipatory gaze responses for all post-training Change of Location measures are shown in Table 11. A significant positive correlation was found between correct fixations on TB tests and incorrect fixations on FB tests. Significant negative correlations were also found between correct and incorrect anticipatory fixations on both TB and FB tests. This suggests that on both TB and FB displays, children’s consideration for the correct location (i.e., location associated with the agent’s perspective) was directly contingent on their consideration of alternate locations (i.e., locations not associated with the agent’s perspective).

Table 11

<table>
<thead>
<tr>
<th></th>
<th>TB-Incorrect</th>
<th>FB-Correct</th>
<th>FB-Incorrect</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB-Correct</td>
<td>-.30**</td>
<td>.19</td>
<td>.25*</td>
</tr>
<tr>
<td>TB-Incorrect</td>
<td>-</td>
<td>.05</td>
<td>.19</td>
</tr>
<tr>
<td>FB-Correct</td>
<td>-</td>
<td>-</td>
<td>-.30**</td>
</tr>
</tbody>
</table>

*Note. TB- and FB refer to true and false-belief versions of the Change of Location task. Correct and Incorrect refer to the location of fixation.  
* $p < .05$  
** $p < .01$  

To further examine changes in anticipatory fixations between pre- and post-training Change of Location measures, separate paired-sample t-tests were conducted within each condition and for each location of fixation (i.e., for a total of 12 separate analyses). For each paired sample t-test, the within-subjects variable was the time at which anticipatory looks were assessed (i.e., pre- vs. post-training). The dependent variable was proportion of time that children fixated to either the correct or the incorrect location. Looking first at the results for TB-Change of Location tasks, results indicated that, within each condition, there was no significant change in the proportion of time that children spent fixating on the correct location between pre- and post-training periods of assessment ($p > .05$). Within all conditions, however, there was a significant increase in the proportion of time that children fixated on the incorrect location between pre-and post-training periods of assessment: Control ($M_{pre} = .19$ vs. $M_{post} = .28$), $t(26) = -2.07$, $p = .05$, $d = .40$, No
Contrast ($M_{pre} = .14$ vs. $M_{post} = .29$), $t(27) = -4.08, p < .001, d = .77$, Contrast ($M_{pre} = .15$ vs. $M_{post} = .32$), $t(27) = -3.55, p = .001, d = .67$. This suggests that for all conditions, post-training changes in anticipatory fixations for TB-Change of Location tasks were primarily driven by increases in incorrect fixations (see Figure 9).

**Figure 9. Proportion of anticipatory fixations on pre- and post-training TB-Change of Location Tasks**
For FB-Change of Location tasks, results indicated that within all training conditions, there was no significant change in the proportion of time that children spent fixating on the incorrect location between pre- and post-training periods of assessment ($p > .05$). For children in the No Contrast and Contrast conditions, however, significant increases were found between pre- and post-training fixations to the correct location: No Contrast ($M_{pre} = .11$ vs. $M_{post} = .25$), $t(26) = -2.08$, $p = .05$, $d = .40$, Contrast ($M_{pre} = .12$ vs. $M_{post} = .21$), $t(27) = -2.18$, $p = .04$, $d = .41$. Children in the Control condition did not show significant change in correct anticipatory fixations between pre- and post-training assessment. This suggests that for children in the No Contrast and Contrast conditions, post-training changes in anticipatory fixations for FB-Change of Location tasks were primarily driven by increases in correct anticipatory fixations (see Figure 10).
Figure 10. Proportion of anticipatory fixations on pre- and post-training FB-Change of Location Tasks
Chapter 6
Discussion

To summarize, the current study was designed to address three questions related to language and the development of epistemic representations: (1) whether exposure to epistemic language will lead to improvements in both children’s automatic and controlled processing of false-belief, (2) whether exposure to epistemic language is necessary for the formation of flexible belief representations, and (3) whether certain aspects of epistemic language are more important in the processing of epistemic states. Importantly, these three questions address factors that may distinguish between competing accounts of language and false-belief development. The results and theoretical implications of this study will therefore be discussed in relation to each of these questions. Potential limitations of the current study will also be addressed along with suggestions for future research.

6.1 Does Language Affect both Automatic and Controlled Processing?

The current data seem to suggest that language may indeed influence both automatic and controlled forms of epistemic processing. This was first demonstrated via analyses that examined how individual differences in linguistic ability (i.e., scores on PPVT-4 and MCS tests) influenced children’s performance on post-training assessments of epistemic understanding. For example, children’s linguistic abilities (PPVT and MCS scores) were shown to significantly predict their performance on certain measures of both controlled (i.e., elicited data) and automatic (i.e., anticipatory gaze data) processing. For elicited response data, this relationship was shown between children’s accuracy on a post-training measure of true-belief (Change of Location) and their scores on both linguistic measures.12 Similarly, children’s anticipatory gaze responses to post-training measures of true-belief understanding (Change of Location) were

12 Significant correlations between linguistic ability and elicited false-belief processing were not found in the current study but this is likely due to low variance in response scores at both pre- and post-training periods of assessment. The absence of training effects on elicited response measures may also be attributed to the length of the training period used in the current study (1 week), which was substantially shorter and than the training phases implemented in previous research (e.g., Lohmann & Tomasello, 2003; Peskin & Astington, 2004).
significantly related to their comprehension of complement syntax. In this case, the correlation between language and anticipatory gaze was negative (i.e., as language ability went up, proportion of incorrect anticipatory fixations went down) but this can still be interpreted as advantageous because increases in sentential complement comprehension predicted significant decreases in incorrect fixation patterns. Interestingly, this latter result contradicts the findings of Low (2010), who failed to find a link between sentential complement understanding and automatic false-belief processing. In the current study, however, associations between language and anticipatory gaze patterns were only found following a brief period of epistemic and language training. Children’s exposure to epistemic contexts (both visual and linguistic) prior to assessment may therefore explain the discrepancy observed between the current and previous research.

The strongest evidence that epistemic language may be related to children’s automatic processing, however, was demonstrated through training effects which demonstrated the impact of epistemic language exposure on groups of children. Specifically, children exposed to epistemic verbs during training (i.e., No Contrast and Contrast conditions) showed a significantly lower proportion of incorrect fixations than children who were not exposed to epistemic verbs (i.e., Control) across both measures of false-belief (FB-DA and FB-M). This indicates that manipulating children’s exposure to epistemic verbs can directly influence their subsequent processing of false-belief. Importantly, significant reductions in incorrect fixations can still be interpreted as an improvement in epistemic processing despite the fact that no significant differences in correct fixations were found. This is because in a false-belief scene, ‘correct’ and ‘incorrect’ locations uniquely correspond to the perspective of the agent and the child respectively. Thus, a greater proportion of incorrect fixations can be interpreted as children’s increased consideration of their own perspective in a scene (e.g., knowledge of an object’s true identity or location). Inversely, a lower proportion of incorrect fixations can be interpreted as children’s decreased consideration of their own perspective.

In terms of theoretical implications, these findings fail to support accounts which posit that language should exclusively influence controlled processing of belief (i.e., response selection accounts). Instead, the current findings suggest that manipulations of epistemic verb exposure can directly influence response accuracy on spontaneous measures of false-belief understanding. Moreover, positive correlations between epistemic processing and the comprehension of
sentential complements in the current study lend further support to theoretical accounts which place the development of complement syntax at the core of false-belief development (i.e., de Villiers’ theory of complement syntax acquisition).

6.2 Is Language Necessary for Flexible Epistemic Processing?

According to Perner (2010), higher-order representations of belief may be demonstrated through accurate transfer of knowledge across different contexts of belief induction. In the current study, there was evidence of such transfer on anticipatory gaze measures but, critically, it was contingent on the linguistic input that children received during training. That is, across different anticipatory measures of false-belief, children who were exposed to epistemic verbs during training (No Contrast and Contrast conditions) showed significantly fewer response errors than children in the Control condition. Importantly, this pattern was replicated across visual scenes that depicted both familiar (i.e., FB-Deceptive Appearance) and novel (i.e., FB-Misinformation) contexts of belief induction. Thus, exposure to epistemic verbs may have differentially affected children’s ability to abstract meaningful relational patterns from visual contexts that they were exposed to during training (i.e., patterns that helped them reduce consideration of their own perspective). The significance of this learning effect is even more pronounced when one considers the various competing cues that children had to process during training (e.g., the presence or absence of a second agent, the deceptive nature of the target object, the varying outcome of an agent’s actions, the varying function of the target object, etc.). Despite these numerous sources of variability, children were still able to form representations that were robust to further changes in contextual input post-training. Exposure to epistemic verbs may have, therefore, been necessary in helping children transfer knowledge across different contexts of false-belief.

Evidence from FB-Change of Location tests further suggests that linguistic input may have promoted the formation of epistemic representations that were less susceptible to response error. For example, between pre- and post-training assessments of the FB-Change in Location task, only children in the No Contrast and Contrast condition showed significant increases in their anticipatory fixations to the correct location. This suggests that children who received epistemic verb exposure during training were more likely to consider the agent’s perspective in a false-belief context, even when this context was structurally distinct from the scenarios they were
trained with. Moreover, for children in the No Contrast condition, increases in correct anticipatory fixation following training were enough to eliminate a pre-training bias to fixate on the incorrect vs. correct location. That is, on pre-training versions of the FB-Change of Location test, children in all conditions showed a significant bias to fixate on the incorrect vs. correct location. Following training, however, only children in the Control and Contrast conditions maintained this bias to fixate on the incorrect location. Thus, the unique verbal input that children in the No Contrast condition received during training (i.e., a familiar verb that did not vary across contexts of true- and false-belief) reduced a pre-existing bias to consider their own perspective in favour of the agent’s. These findings provide the strongest evidence of learning transfer because Change of Location tests were even more structurally dissimilar to the training stimuli than Misinformation tests.

Taken together, these results suggest that language may indeed be important, if not necessary, for the formation of robust epistemic representations. Although these findings do not rule out the possibility that children can form flexible representations in the absence of language, they do indicate that epistemic language can assist with the formation of representations that are less susceptible to response error across different contexts of belief induction. As such, these results fall best in line with theoretical accounts that posit a significant role for language in the formation of flexible epistemic representations (i.e., complement syntax and structure mapping theories).

6.3 What Aspects of Language are Important for Epistemic Processing?

The training advantages demonstrated by children in the No Contrast and Contrast conditions appear to suggest that relational language (i.e., epistemic verbs) is more beneficial to the processing of false-belief than language that merely denotes distinctions in perspective (i.e., labels for alternate locations). That is, children in the Control condition did not appear to benefit from training with narrations that described the alternate perspectives in a scene (e.g., “Sam is going to put it with the apples but it is really a toy.”) but did not relate the agent to his/her perspective via an epistemic verb. Moreover, these findings build upon previous research suggesting that labels denoting perspective can assist with the processing of false-belief (Simpson & Low, in press) but only for children older than 4. In the current study, age was not found to be predictive of children’s response accuracy on any measure of belief. Children
ranging in age from 2;6 to 4;5 years, however, were able to use linguistic cues to assist them with the automatic processing of false-belief, provided these cues denoted relations between agents and their perspectives. Thus, it is the relational nature of epistemic verbs that makes them important for both the formation and processing of epistemic representations.

Findings from the current study also offer some important insight into which aspects of epistemic verbs (i.e., semantics or syntax) contribute most to improvements in epistemic processing. First, significant correlations between children’s complement syntax comprehension and their performance on post-training measures of belief (anticipatory Change of Location tests) suggest that the ability to represent embedded sentential complements may be important for the formation of new epistemic representations. Second, the fact that reductions in error bias for the FB-Change of Location task were observed for children in the No Contrast condition, but not the Contrast condition, suggests that complement syntax may be more important than one-to-one mappings between verbs and epistemic contexts for the transfer of epistemic representations. This latter conclusion is based on differences in linguistic input that children in the No Contrast and Contrast conditions received during training. That is, for children in the No Contrast condition, both syntax and verb were held constant across different training contexts of belief (i.e., true- and false-belief). This means that while children could use complement syntax to assist with the representation of relational patterns, the semantics of the individual verb (thinks) was not uniquely predictive of the agent’s subsequent actions. Conversely, for children in the Contrast condition, epistemic verbs varied with contexts of belief while syntactic structure was held constant. Thus, for children in this condition, verb semantics were uniquely associated with distinct patterns of behavior across different contexts of belief. Given that such direct associations have been shown to benefit children’s elicited processing of false-belief in cross-linguistic research (e.g., Liu et al., 2008; Shatz et al., 2003), it is possible that similar advantages would have also been seen on anticipatory measures. In the current study, however, advantages in epistemic transfer were seen for children in the No Contrast as opposed to Contrast condition. This suggests that during the formation of epistemic representations, one-to-one mappings between individual verbs and contexts may be less beneficial than the syntactic structure used to represent relational patterns.

Overall, findings from this study offer strong support for theoretical accounts which posit that exposure to relational language, as opposed to associative labels, are critical for the processing
and development of epistemic representations. Importantly, these findings also provide evidence to suggest that during the early stages of epistemic processing, syntactic structure may be more beneficial than verb semantics in the abstraction of predictive relational patterns. This finding not only complies with Jill de Villiers’ theory of false-belief development (de Villiers, 2005) but also with bootstrapping theories of verb acquisition which assert that the acquisition of syntactic structure may precede the acquisition of epistemic verb semantics (Gleitman et al., 2005).

6.4 Potential Limitations

A potential problem in the current study lies in the finding that children in the Control condition exhibited a significant processing advantage over children in the No Contrast and Contrast conditions on anticipatory true-belief transfer measures (i.e. TB-Misinformation tests). That is, on this task children in the Control condition showed a significantly greater proportion of fixations to the correct location than children in the other two conditions. While this result seems initially inconsistent with the other findings supporting an epistemic verb advantage, it is possible to explain this finding by examining the competing patterns of learning that may have occurred over the course of training. Specifically, across all conditions, children were trained to learn an explicit sorting rule about the target object – i.e., that the target object should always be sorted with items that share its function. This rule was further strengthened over the course of both sessions via explicit feedback and reinforcement from the experimenter (e.g., “Did s/he put it in the right spot?”). Following training, all children should have therefore held a strong bias to consider the appropriate sorting location of the target object. Critically, children in the No Contrast and Contrast conditions were provided with an additional cue (i.e., epistemic verb) that could potentially help them override this sorting rule in contexts where it conflicted with the agent’s perspective (i.e., contexts of false-belief). Indeed, on false-belief measures of assessment, findings indicated that children in these conditions were able to significantly reduce their consideration for the true state of reality (i.e., the location where the object should be sorted as opposed to where it would be sorted). Alternatively, children in the Control condition did not have strong supporting cues during training that would assist them in overriding the sorting rule. Indeed, as demonstrated on TB-Misinformation tests, these children may have actually formed a stronger representation of the sorting rule, perhaps in the absence of additional input during training. Moreover, while the sorting rule may have helped children in the Control condition make accurate responses on true-belief measures (i.e., when the agent’s perspective aligned with
the rule), it would not have helped children form accurate predictions on post-training measures of false-belief.

Beyond the design structure of the current study, another potential limitation of this research may be the fact that observed patterns of anticipatory response did not match those typically seen on related measures of automatic processing (e.g., Clements & Perner, 1994; Low, 2010). That is, across all false-belief measures, children did not exhibit a greater proportion of correct fixations over incorrect ones. Most notably, children did not demonstrate a pattern of correct anticipatory responses on pre-training measures of false-belief; a pattern that has been previously demonstrated in children as young as 18-month-olds (Senju et al., 2011). Instead, children’s anticipatory fixations on these tasks appeared to mirror traditional patterns of response on elicited false-belief measures. As such, it may be possible to argue that the measures used in the current study were not ‘true’ assessments of automatic processing. There are several reasons, however, for why the response patterns in the current study should not be discredited for being unlike previous findings. First, the paradigm employed in the current study is novel and, arguably, more difficult than paradigms that have previously been used to assess anticipatory processing of false-belief or training effects of language. For example, training paradigms that are designed to promote the understanding of false-belief do not typically include contexts of both true- and false-belief in their training (e.g., Lohmann & Tomasello, 2003; Peskin & Astington, 2004). While this manipulation was necessary to examine the process of abstraction in the current study, it may have also produced a paradigm that is qualitatively more difficult than methods used in previous research. Second, although it is not often cited in the literature, researchers have noted that spontaneous responses are highly sensitive to variations in task features (de Villiers & de Villiers, 2003; Poulin-Dubois et al., 2011). For example, in an anticipatory gaze Change of Location paradigm, it has been found that children’s anticipatory fixations are not actually directed towards locations where an object has been placed but rather to locations where the agent is expected to re-appear (de Villiers & de Villiers, 2003). Although this distinction may seem trivial, the fact that children’s responses can be highly influenced by seemingly inconsequential information about an agent’s motion trajectory suggests that perhaps the response patterns observed in previous research are not as robust as they first appear. Finally, the anticipatory measure used in the current study could not be otherwise classified as elicited because responses were captured before children were asked a direct question (indeed
even before they had finished hearing the implicit prompt). What is perhaps a more valid question to ask is whether different measures of spontaneous response capture the same underlying level of processing. It is possible that even at the ‘automatic’ level, there may be a gradient to how controlled children’s responses can be, particularly given the differences in cognitive demand associated with different tasks (e.g., He et al., 2012). Future research would benefit from further examination of this issue, particularly given the current finding that linguistic input may support the execution of seemingly automatic processes.

6.5 Summary and Implications

The findings from the current study invite a critical re-examination of the role that language plays in the development of epistemic representations. Importantly, they address two questions that are fundamental to the current field of social cognition: (1) How do early forms of epistemic processing interact with contextual and linguistic input to promote the further development of epistemic representations?, and (2) How important is language in the development of epistemic representations?

Overall, the results from this research seem to support theoretical accounts that propose a primary role for language in both the processing and formation of epistemic representations. Specifically, three key findings from the current study suggest that epistemic language (i.e., verbs and complement syntax constructions) may be critical for the development of belief representations: (a) epistemic language was found to positively influence both children’s automatic and controlled processing of belief (b) exposure to epistemic language assisted children with the formation and transfer of robust epistemic representations, and (c) relational epistemic language was more beneficial to the processing of belief than non-relational language.

A pending question that warrants future research is whether certain aspects of epistemic language (i.e., semantic vs. syntactic associations) are differentially advantageous in the processing of belief. Results from the current study provide important insights into this issue by suggesting that the acquisition of complement syntax may be more important than the formation of one-to-one mappings between verbs and epistemic contexts. Future research would also benefit from a closer examination of individual differences in epistemic language training effects. Such research would inform our understanding of how language interacts with children’s individual
abilities to produce changes in epistemic processing. It may also provide insight into the optimal circumstances for language to influence children’s development of epistemic concepts.
References


Seuss, Dr. (1975). *Oh the thinks you can think!* New York: Random House Inc.


Appendices

Appendix A – Displays and Scripts for Memory for Complement Syntax Test\(^\text{13}\)

<table>
<thead>
<tr>
<th>Scene 1:</th>
</tr>
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<tbody>
<tr>
<td>1) Sally’s book was in the bag…</td>
</tr>
<tr>
<td>2) …but Sally said her book was on the shelf.</td>
</tr>
<tr>
<td><strong>Test Question:</strong> What did Sally say?</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Scene 2:</th>
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<tbody>
<tr>
<td>1) Ben told Jim there were cookies inside the jar…</td>
</tr>
<tr>
<td>2) …but the jar was full of candy.</td>
</tr>
<tr>
<td><strong>Test Question:</strong> What did Ben tell Jim?</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Scene 3:</th>
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<tbody>
<tr>
<td>1) Ryan told Taryn the chocolate was inside the cupboard…</td>
</tr>
<tr>
<td>2) …but the chocolate was inside the fridge.</td>
</tr>
<tr>
<td><strong>Test Question:</strong> What did Ryan tell Taryn?</td>
</tr>
</tbody>
</table>

\(^\text{13}\) Each story narrative was split into two parts. The first part of the narrative was presented in conjunction with the picture on the left. The second part was presented in conjunction with the picture on the right.
<table>
<thead>
<tr>
<th>Scene 4:</th>
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<tbody>
<tr>
<td>1) There was soup inside the thermos…</td>
</tr>
<tr>
<td>2) …but Jeremy said there was hot chocolate inside the thermos.</td>
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</table>

**Test Question:** What did Jeremy say?

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<th>Scene 5:</th>
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<tbody>
<tr>
<td>1) Connie’s jacket was behind the door…</td>
</tr>
<tr>
<td>2) …but Ivy told Connie her jacket was inside the closet.</td>
</tr>
</tbody>
</table>

**Test Question:** What did Ivy tell Connie?

<table>
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<tr>
<th>Scene 6:</th>
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<tbody>
<tr>
<td>1) Kim said the ball had rolled under the dresser…</td>
</tr>
<tr>
<td>2) …but the ball was underneath the chair.</td>
</tr>
</tbody>
</table>

**Test Question:** What did Kim say?

<table>
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<tr>
<th>Scene 7:</th>
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<tbody>
<tr>
<td>1) There was a teddy bear inside the box…</td>
</tr>
<tr>
<td>2) …but Katie said there was a doll inside the box.</td>
</tr>
</tbody>
</table>

**Test Question:** What did Katie say?
Scene 8:
1) Freida told Carly the squirrel had run up the tree…
2) …but the squirrel was behind the bush.

Test Question: What did Freida tell Carly?

Scene 9:
1) Josh said a cell phone was inside the bag…
2) but there was a camera inside the bag.

Test Question: What did Josh say?

Scene 10:
1) The carton had milk inside…
2) but Steven told Vicky there was juice inside the carton.

Test Question: What did Steven tell Vicky?

Scene 11:
1) The cat was behind the chair…
2) but John told Maria the cat was under the bed.

Test Question: What did John tell Maria?
Scene 12:
1) Jen said there was a sandwich inside the lunch bag…
2) but there was a muffin.

Test Question: What did Jen say?
Appendix B – Scenes and Script for Change of Location Tests

<table>
<thead>
<tr>
<th>Scene</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>a)</strong></td>
<td>Two characters appeared on the top of the screen and moved towards the centre. In the video, children heard: “Look! The mouse and bunny are going to get the cake.” Each character then disappeared down the hole and reappeared in the doorway of the room with the target object (i.e., the cake).</td>
</tr>
<tr>
<td><strong>b)</strong></td>
<td>One character placed the target object inside an opaque container while the other character observed. In the video, children heard: “Look! The brown mouse is putting the cake inside the green box.” Both characters then exited the scene the same way they had come in.</td>
</tr>
<tr>
<td><strong>c)</strong></td>
<td>After 2-seconds, one character returned and stopped in the centre of the screen. In the video, children heard: “Look! The brown mouse is back and she wants to get the cake. I wonder where she will look first for the cake?” The video paused for 2-seconds (during which children’s anticipatory responses were measured). Children were then asked by the experimenter: <strong>True-Belief Question:</strong> “Where is the brown mouse going to look first for the cake?”</td>
</tr>
</tbody>
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14 The general scene for all change of location tasks is comprised of an upper half (above ground) and a lower half (below ground) that has two separate rooms. Each room contains a doorway and an opaque container (i.e., box) that varies in colour between both rooms. The target object (i.e. cake) is initially shown in one of the rooms on top of one of the containers.
d) The character proceeded down the hole and reappeared in the room containing the target object. S/he then removed the target object from its original location (i.e., the green box) and exited the room.

e) The character then re-appeared in the other room and placed the target object inside the other opaque container. In the video, children heard:

“Look! The mouse is putting the cake inside the purple box.”

Once the target object was hidden in the new location, the character exited the scene.

After 2-seconds, the other character entered the scene and moved to the centre of the display. In the video, children heard:

“Look! The white bunny came back and he wants to get the cake. I wonder where he will look first for the cake?”

The video paused for 2-seconds (during which children’s anticipatory responses were measured). Children were then asked the following questions by the experimenter:

**False-Belief Test Question:** “Where is the white bunny going to look first for the cake?”

**Reality Control Question:** “Where is the cake right now?”

**Memory Control Question:** “Where was the cake at the beginning of the movie?”
False-Belief Training

<table>
<thead>
<tr>
<th>a)</th>
<th>A character demonstrated the function of a non-target object from each bin. With each demonstration, children heard the labels for each object.</th>
</tr>
</thead>
</table>
|    | “Look! This is an apple.”  
|    | “Look! This is a toy.”  |
| b) | The character then demonstrated the function of the deceptive-looking target object (e.g., a toy that looks like an apple). Children also heard the label for this object: |
|    | “Look! This is a toy.”  
|    | Following the demonstration, the character left the target object in the centre of the display and exited the scene.  |
| c) | After 2-seconds, a second character entered the scene. In the video, children heard: |
|    | “This is Sam. Sam sees that something has been left on the table. He is going to put it away.”  |
|    | Children also heard the following prompts, that varied by condition: |
|    | **Control**: “Sam is going to put it with the apples but it is really a toy.”  
|    | **No Contrast**: “Sam thinks that it is an apple but it is really a toy.”  
|    | **Contrast**: “[Character] genre that it is an apple but it is really a toy.”  |
| d) | After a 3-second pause, the character incorrectly placed the target object in the bin with objects that share its function (e.g., with the apples). The experimenter then asked the child: |
|    | “Did s/he put it in the right spot?”  
|    | If a child said “yes”, the experimenter corrected the child: |
|    | “No, he did not put it in the right spot. It was supposed to go here [pointed to correct location] because it was really a toy.”  |
True-belief Training

a) Two characters initially appeared in the centre of the display. One character proceeded to demonstrate the function of a non-target object from each bin. With each demonstration, children heard the labels for each object.

“Look! This is a pen.”
“Look! This is a flower.”

b) The character then demonstrated the function of the deceptive-looking target object (e.g., a pen that looks like a flower). Children also heard the label for this object:

“Look! This is a pen.”

Following the demonstration, the character left the target object in the centre of the display and exited the scene.

c) The second character then moved to the centre of the display. In the video, children heard:

“This is Mark. Mark sees that something has been left on the table. He is going to put it away.”

By condition, children also heard:

Control: “Mark is going to put it with the pens and it is really a pen.”

No Contrast: “Mark thinks that it is a pen and it is really a pen.”

Contrast: “Mark thinks that it is a pen and it is really a pen.”

d) After a 3-second pause, the character correctly placed the target object in the bin with objects that share its function (e.g., with the pens). The experimenter then asked the child:

“Did s/he put it in the right spot?”

If a child said “no”, the experimenter corrected the child:

“Yes, he did put it in the right spot. It was supposed to go here [pointed to correct location] because it was really a pen.”
Deceptive Appearance Transfer Test

a) A character demonstrated the function of a non-target object from each bin. In true-belief tests, a second character was present on the side of the screen and witnessed all demonstrations. With each demonstration, children heard the labels for each object.

“Look! This is a jewelry box.”

“Look! This is a book.”

b) The same character then demonstrated the function of the target object (e.g., box that looks like a book). Children also heard the label for this object:

“Look! This is a jewelry box.”

Following the demonstration, this character left the target object in the centre of the display and exited the scene.

c) A second character then entered the scene (FB tests) or moved to the centre of the display (TB tests). In the video, children heard:

“This is [characters’s name]. [Character] sees that something has been left on the table. S/he is going to put it away.”

d) By condition, children then heard one of the following prompts:

Control: “I wonder where [Character] is going to put it?”

No Contrast: “I wonder what [Character] thinks that it is?”

Contrast: “I wonder what [Character] gorsps (FB)/thinks (TB) that it is?”

After a 3-second pause, children in all conditions were asked by the experimenter:

“Where is [Character] going to put it?”
Misinformation Transfer Test

a) A character demonstrated the function of a non-target object from each bin (e.g., “Look! This is glass” or “Look! This is a vase”) in either the absence (FB) or presence (TB) of a second character. The same character then demonstrated the function of an ambiguous-looking target object:

“Look! This is a vase.”

b) This character then pointed to the target object and looked towards the second character who had either just entered the scene (FB) or had moved closer to the table (TB). Children heard:

“The boy is telling the girl that it is a glass.”

The first character then left the target object on the table and exited the scene.

c) The second character moved to the centre of the display. In the video, children heard:

“This is [characters’s name]. [Character] sees that something has been left on the table. S/he is going to put it away.”

e) By condition, children then heard one of the following prompts:

Control: “I wonder where [Character] is going to put it?”

No Contrast: “I wonder what [Character] thinks that it is?”

Contrast: “I wonder what [Character] guesses (FB)/thinks (TB) that it is?”

After a 3-second pause, children in all conditions were asked by the experimenter:

“Where is [Character] going to put it?”