Theory of Mind Development and Behavioural Inhibition: Are They Related?

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Abstract

This thesis investigated the relation between behavioural inhibition and false belief, inhibitory control, working memory, and language. It was hypothesized that behavioural inhibition would be positively related to false belief understanding. This relation was expected to hold when working memory, inhibitory control, and syntax of complementation abilities were controlled. Behavioural inhibition was expected to be positively related to inhibitory control. No relation was expected between behavioural inhibition and either of syntax of complementation or working memory. Preschool children ($N = 45$) were tested on 11 tasks. No relation between behavioural inhibition and false belief understanding, syntax of complementation, or working memory was found. Children low in behavioural inhibition were found to have significantly greater inhibitory control than children in the mid range of behavioural inhibition. Predictors of false belief (working memory, inhibitory control and language) were examined in relation to the current literature.

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Introduction

Theory of mind development, the emergence of the ability to understand that people hold beliefs, desires and intentions (i.e., an understanding of mental states), emerges in children between the ages of 3 to 5 years (Wellman, Cross, & Watson, 2001).

Theory of mind is a concept that was introduced by Premack and Woodruff (1978):

In saying that an individual has a theory of mind, we mean that the individual imputes mental states to himself and to others A system of inferences of this kind is properly viewed as a theory, first, because such states are not directly observable, and second, because the system can be used to make predictions, specifically about the behaviour of other organisms. (p. 515)

Mental states include beliefs, desires and intentions and are indicated by terms such as *thinks*, *wants*, and *believes* (Premack & Woodruff, 1978). The main aspect of theory of mind that has been studied is children's ability to understand *beliefs*. This understanding has been measured with a construct called the 'false belief task' (see below) and children who pass this task are considered to have 'false belief understanding'.

Once children are able to impute mental states (the ability to represent in their own mind the representations of another person, or their own representations) they change the way they reason about what their peers may be thinking and are able to predict behaviour based on what they know another child believes. Furthermore, children interact differently with others once they have developed an understanding of others' beliefs (e.g., Dunn & Cutting, 1999). Thus, false belief understanding is an important cognitive development, emerging between the ages of 3 and 5, that impacts on social understanding.

The specific purpose of this thesis is to examine the relation between false belief development and behavioural inhibition in children. Behaviourally inhibited children exhibit shy, fearful, withdrawing, reticent behaviour in new or novel situations (Buss & Plomin, 1984; Kagan, 1997). Researchers have examined individual differences in acquiring false belief understanding in the area of autism, psychosis, and schizophrenia (see Repacholi & Slaughter, 2003 for a review). However, little has been done examining the development of false belief understanding in relation to behavioural inhibition. Given that children with this temperament style often become socially anxious (e.g., Kagan, Snidman, Zentner, & Peterson, 1999) it is important to investigate the relation between mental state understanding (sometimes called ‘social cognition’) and behavioural inhibition.

There are three critical cognitive development achievements that predict false belief understanding. The first is working memory, the ability to hold and manipulate information in short-term memory (Baddeley, as cited in Carlson, Moses & Breton, 2002). The second is inhibitory control, the ability to suppress a desired response and choose a secondary response (Zelazo & Müller, 2002). Working memory and inhibitory control are considered executive functioning abilities. Executive function is the construct that refers to the process of control and monitoring of thought, manipulating information, planning and decision-making, (Moses & Carlson, 2004; Zelazo & Müller, 2002). The third cognitive predictor of false belief understanding is an ability to understand sentences with complex clauses (sentential complements), in the area of syntactic development (de Villiers & Pyers, 2002).

Research in false belief development has focused on predictors as discussed above, as well as the social correlates and implications of developing mentalizing skills (Wellman et. al. 2001). Researchers have reported that false belief understanding is positively related to mental state talk with friends, length and frequency of friendships, smoothness of communication with friends, co-operative pretend play, and likeability as measured by peers (Brown, McCall, & Dunn, 1996; Cassidy, Werner, Rourke, Zubernis, & Balaraman, 2003; Dunn & Cutting, 1999; Slomkowski & Dunn, 1996), and is negatively related to rejection by peers (Peterson & Seigal, 2002).

Given the findings reported above, we can begin to see that a link can be drawn between the cognitive predictors of false belief understanding and the cognitive predictors of behavioural inhibition. For example, both the temperament of behavioural inhibition and the ability to understand false beliefs have been found to be positively related to inhibitory control in 5- to 7-year-olds (Thorell, Bohlin, & Rydell, 2004; Moses & Carlson, 2004). Secondly, behaviour similarities between early false belief development and children with behavioural inhibition support a link. Children who developed mentalizing skills earlier than their peers were found to be more sensitive to teacher criticism in kindergarten (Dunn, 1995). In addition they were likely to experience negative perceptions of the early school experience. These descriptions are similar to descriptions of socially anxious children, which include self-consciousness, self-deprecation, anxiety, and heightened sensitivity to social threat cues, resulting in extreme stress for the individual (Crozier & Alden, 2001). Put together, we can see that behavioural inhibition predicts social anxiety and increased inhibitory control, and early false belief development predicts increased sensitivity in social situations and is also

positively related to inhibitory control. Therefore, a positive relation between false belief and behavioural inhibition is proposed.

Arguments against a positive relation between false belief development and behavioural inhibition are not supported. Peterson and Seigal (2002) found that children who are rejected by their peers performed significantly worse than popular children in their false belief development. They suggested that social interaction is necessary for mentalizing skill development. It may be suggested, then, that children who are behaviourally inhibited will be similar to rejected children in their mentalizing skills, because they initially withdraw from social situations due to an overactive fear response (Buss & Plomin, 1984; Kagan, 1997). However, these children are not similar to rejected children in that they often play well in familiar situations (Asendorpf & Meier, 1993). So while they may be limited in some social situations, they have sufficient experience in positive social interactions to develop false belief understanding. Therefore I would not expect behaviourally inhibited children to have a deficit in their mental state understanding based on Peterson and Seigal's research.

In addition, as discussed above, language and working memory are important in mental state understanding; delays in these skills may impact on mental state development. There is some research that has found that socially anxious middle school children have working memory deficits (Kusché, Cook, & Greenberg, 1993) but there is no research concerning working memory and behavioural inhibition for preschool children. Although behavioural inhibition predicts later social anxiety (Kagan et al. 1999) it does not necessarily mean that working memory is developing differently during the preschool years for these children. In addition, the results from the Kusché et al. study

may be due to performance apprehension and not due to an underlying competence deficit. Therefore working memory would not be expected to mediate a relation between behaviourally inhibited children and their false belief development for children who are high in behavioural inhibition.

Research in the area of language and behavioural inhibition has been divided. Some researchers find no difference between behaviourally inhibited children and their same age peers for receptive and expressive language skills (Spere, Schmidt, Theall-Honey, & Martin-Chang, 2004) while others report deficits in complex sentences used (Van Kleeck & Street, 1982). If these skills are delayed then we may expect a later development of theory of mind understanding. However, this work is considered controversial, with some researchers (Crozier & Perkins, 2002; Crozier & Hostettler, 2003) contending that the skill deficits are one of *performance* rather than one of *competence*. Crozier and Hostettler (2003) found that by varying test situations, shy children showed greater differences in test scores than did non-shy children. They suggested that test performance was affected by the amount of stress the child was experiencing due to the test method, especially for the shy child. Asendorf and Meier (1993) reported that in a more familiar environment (at home with siblings) shy children became more talkative. These studies highlight the importance of ensuring that behaviourally inhibited children are at ease during a testing situation in order to get a true picture of their language competence. Therefore, based on the Spere et al. findings, language ability is also not expected to impact the relation between behavioural inhibition and theory of mind development for children high in behavioural inhibition.

An examination of the relation between mental state understanding and behavioural inhibition that considers these factors (working memory, language, and inhibitory control) within the same sample of children is indicated.

Therefore, this thesis has a dual purpose; first, to test the hypothesis that behavioural inhibition will be positively related to false belief and secondly, to examine the cognitive correlates of false belief (working memory, inhibitory control and language) in a group of children who are rated as high, mid, and low on a scale of behavioural inhibition.

I propose that children who are high on a scale of behavioural inhibition will have a greater degree of inhibitory control than mid and low behaviourally inhibited children. However, I do not expect that children high on behavioural inhibition will differ from others in their working memory or language ability. The possible mediating or moderating effects of working memory, inhibitory control and language on false belief understanding for the behavioural inhibited child will be analyzed.

I will begin with a review of the literature concerning false belief, its predictors, correlates and outcomes. Next, the temperament literature concerning behavioural inhibition will be discussed. The corresponding cognitive precursors of false belief understanding (inhibitory control, working memory, and language) in relation to behavioural inhibition will also be reviewed. Hypotheses (and justifications), as well as the results, will be presented.

Theory of Mind

‘Theory of mind’ is a term used in the psychological literature to identify a child’s ability to attribute mental states such as beliefs, desires, and intentions, to themselves and

to others (e.g., Wellman, Cross, & Watson, 2001; Wimmer & Perner, 1983). In order to develop a theory of mind, children must understand that people do not have direct access to reality, but construct and construe the world through mental representations (Astington, 1993). Astington suggested that young children first understand that there is a real world 'out there' with real things, but these young children do not realize that they are representing the world in their minds. Once children develop an understanding that their mind represents the world, they are then able to begin to understand that other people are experiencing the world through mental representations. With this understanding comes the ability to predict that others will act on their representations even though these representations may not reflect reality. Mentalizing skills include an understanding of belief, desire and intention (Astington, 2001). This thesis will focus on the development of belief understanding as measured by the false belief task. This task is a simple yet robust test of mentalizing skills (Wellman, Cross, & Watson, 2001) and is by far the most widely used task within theory of mind research.

False Belief

The idea that children may not be born with an ability to represent their own beliefs and the beliefs of another individual (metarepresentational ability) was initially researched by Wimmer and Perner (1983). This research was based on the work of Premack and Woodruff (1978), in which they investigated whether chimpanzees were able to impute mental states to other chimpanzees, through the use of a deception training task. Although Premack and Woodruff tested chimp's ability to deceive, Wimmer and Perner noted that a simpler, language based task might be constructed to determine whether young children have metarepresentational ability.

To examine whether children could represent another child's belief it was necessary to create a situation where children could have a belief based on their own representation of reality, but would be asked to comment on another person's belief which may be a *mis*representation of reality (false belief). It was important that the other person's belief be false so as to be able to assess whether the child was responding based on reality or on the (false) belief held by another. Therefore, Wimmer and Perner developed the false belief task.

In their false belief (FB) task (a change of location task), a child is told a story concerning a boy named Maxi who places a chocolate in a drawer (location X) and goes out to play. His mother subsequently moves this chocolate to another visually different drawer (location Y) and she leaves. At this point the participant is asked a memory question "Do you remember where Maxi left the chocolate before he went to play?" (correct answer = location X) as well as a reality question, "Where is the chocolate now?" (correct answer = location Y). Then Maxi returns to look for his chocolate and the participant is asked, "Where will Maxi look for his chocolate?" (correct answer = location X). The results were that young children (between 4 and 5 years of age) would give incorrect answers and respond that Maxi would look for the chocolate where it currently was, rather than where he left it. These same children were able to correctly answer the memory and reality questions, so their errors weren't caused by failing to recall important story facts. There was a developmental trend reported for the belief question with a significant increase found from the 4- to 5-year-old group to the 6- to 9-year-old group. Wimmer and Perner concluded that a novel cognitive skill developed between the ages of 4 to 6 years which was not simply attributable to an increase in memory and information

processing skills. This skill was an ability to represent the relationship between the mental states of two (or more) people. Put another way, the developing skill was metarepresentational in nature in that a child had to be able to represent another child's representation of the situation to succeed.

To further this understanding, Gopnik and Astington (1988) examined children's understanding of representational change. Representational change is the idea that individuals can understand the difference between a real change in the *world* and changes in their *beliefs* about the real things in the world. Gopnik and Astington investigated how an understanding of representational change was related to two mentalizing tasks (false belief and appearance-reality). The study was designed to determine if the ability to correctly pass these tasks developed at the same time, or if one ability came earlier than the other two. To examine representational change they used a variation of Perner et al.'s Smarties® task (unexpected contents task), as cited in Gopnik and Astington (1988). In this task, children were shown a Smarties® box and asked what they thought was in the box. The box was then opened to reveal pencils, the box was closed again and children were asked what was in the box and what they thought was in the box before it was opened. It was expected that children would answer that they first thought Smarties® were in the box, and that they now know that pencils were in the box. Answers of this type would confirm that the child could represent current reality, as well as his/her own former belief concerning reality (representational change). Answers stating that they first thought pencils were in the box would indicate an inability to hold a representation of past (erroneous) beliefs (note: as long as the answer to the final question matched the answer to the first question, children's answers are considered correct on this task).

The appearance-reality task was a variation of a task developed by Flavell, Flavell and Green (as cited in Gopnik & Astington, 1988). In this task children were shown an object that looks like a rock. They were then allowed to touch it only to discover it was not a rock but rather a sponge. Children were then asked to report what they thought the object was before they touched it (correct answer = rock), what it looked like (correct answer = rock), and what it was (correct answer = sponge).

The results indicated that children's performance on the standard false belief task was significantly better than performance on the representational change question. The performance scores on the appearance-reality question fell in-between the other tasks' scores, although it did not vary significantly from performance on either of them. A significant effect of age was found for all questions, with performance increasing across three age groups of 3-, 4-, and 5-year-olds.

The authors concluded that 3-year-olds do not understand that their earlier representation may be different from their present understanding of reality. Therefore they behave as if their present representation of the situation was always their representation of it. As well, it was concluded that representational change is a concept that is developed between 3 and 5 years of age. It was also determined that performance on the three tasks—false belief, appearance-reality and representational change (unexpected contents)—are correlated when age is controlled, indicating that there is a similar underlying concept which is undergoing development.

After hundreds of false belief studies had been conducted, Wellman et al. (2001) conducted a much needed meta-analysis in order to clarify some of these findings. They reviewed 77 reports of 178 studies with 591 different conditions. This analysis looked at

the effects of asking the question of ‘where will Maxi look for the chocolate?’ with three different verbs; ‘think’, ‘say’ and ‘look’. They also studied the effect of varying the type of protagonist, whether it was a doll, a puppet or a story character. The meta-analysis found that performance on the false belief task showed a developmental trend with 3-year-olds performing the task below chance, and 5-year-olds performing correctly above chance. The 3-year-olds often erred on the side of the present reality, presumably because reality is salient and therefore is difficult to suppress. However Wellman et al. found that varying the salience of reality did not increase the likelihood of three-year-olds' ability to perform above chance.

Secondly, Wellman et al. (2001) reported that there was no effect of task, nature of protagonist, or type of question on performance. They concluded that because task variations were not found to be significant, the child's response was based on their underlying conceptual understanding of human action rather than on task-specific responses brought about by special features. They did find three things that made the task easier: (1) using deception in the task; (2) getting the child to make the transformation him/herself; or (3) changing the salience of the protagonists' experience by reducing the salience of the real world state of affairs. However, these variations helped older children, but did not sufficiently raise the 3-year-olds' performance to above-chance level (it did however, reduce their errors in that they were less likely to choose reality). Even when the authors analyzed all of the most helpful task conditions together, the youngest children still did not perform above chance. As well, task variations did not change the basic shape of the developmental pattern.

Wellman et al. (2001) found that conversational language ability was related to the development of theory of mind. The analysis found that competence in mental state language aided older children but did not help younger children. As well, executive functioning was found to correlate with false belief competence even when age and verbal intelligence were partialled out (see Moses & Carlson, 2004). However, Wellman et al. reported that above average development of inhibitory control ability in 3-year-old children did not contribute to above chance performance on false belief tasks. They concluded that the development of inhibitory control might aid a transitional child in their understanding of false belief (see sections on 'executive function' and 'inhibitory control' later in this paper). The authors suggest that inhibitory control facilitates the child's ability to reduce the salience of reality in order to focus on the mind. This enables children to think about the mind and therefore may aid in their conceptual development.

Wellman et al. (2001) concluded that the meta-analysis supported the hypothesis that false belief understanding is a robust, orderly and consistent test of mentalizing skills. It is testing an underlying development of the conceptual ability to represent beliefs occurring from age 3 to 5 years.

From this meta-analysis it can be concluded that the false belief task can be used as a marker for mentalistic understanding in the area of beliefs. In summary, passing a false belief task indicates that a child is able to represent beliefs in another person's mind, their own mind, and that the child is be able to predict a person's behaviour. As discussed in Wellman et al. (2001), there are two abilities that a child needs to acquire which are linked to representational development. The first is language and the second is inhibitory control. I will now examine the literature concerning the nature of the relation between

language and false belief understanding. Following this, a review of the executive functioning precursors will be discussed. Finally a review of the social correlates of theory of mind will be discussed.

Language and false belief. General language ability has been shown to be a necessary ability, but not the only ability required, in order to be successful on false belief tasks (Jenkins & Astington, 1996). Jenkins and Astington examined individual differences in the false belief task in relation to language and memory. Their sample consisted of 69 children ranging in age from approximately 3 to 5 years of age. These children were tested on four false belief tasks, a language measure, and a working memory measure. The false belief tasks consisted of two change of location tasks (based on Wimmer & Perner's 1983 false belief task) and two unexpected contents task (e.g., Smarties box task). Language was measured using the Test of Early Language Development (TELD; Hresko, Reid, & Hammill, as cited in Jenkins & Astington, 1996), which includes both productive and receptive items, as well as semantic and syntactic ones. Verbal working memory was tested by using the sentence memory measure from the Stanford-Binet whereas non-verbal working memory was measured using the bead memory sub-test from the Stanford-Binet. Family size and birth order information was also gathered. Jenkins and Astington (1996) reported that language ability and verbal working memory were significantly correlated with false belief understanding even when age was controlled. Interestingly, when verbal working memory and age were controlled, language remained significantly correlated to false belief understanding. The authors found that a threshold in language proficiency would predict passing the false belief task.

Children above a score of 14 on the TELD were more likely to pass the false belief tasks than those scoring lower.

In addition, there was a positive correlation between number of siblings and false belief understanding, supporting Perner, Ruffman, and Leekam's results (as cited in Jenkins & Astington, 1996). Further analysis revealed that having more siblings was related to successful performance on false belief tasks, especially for children with lower language ability scores. The authors concluded that false belief understanding is strongly associated with linguistic ability. However having more siblings mediates the effect of better language ability on the task. Therefore theory of mind development involves more than just a linguistic skill. This would support the hypothesis that theory of mind acquisition is based on development of the conceptual understanding of the nature of beliefs and representations of beliefs.

De Villiers and Pyers (2002) examined the relation between false belief and language development in a longitudinal study of the development of the syntax of complementation. De Villiers and Pyers pointed out that mental representation not only involves understanding mental verbs such as 'think' and 'know', but also requires an understanding of the specific syntax of complementation. Mental state verbs usually have a proposition embedded under them: for example, 'Sarah thought that *the earth was flat*'. The proposition 'the earth was flat' is embedded under the mental state verb 'thought'. The semantics of the complement allow the child to consider the distinction between things in the world (reality) and the way things are represented in the mind (which may be true or false of the world). Note that this is the very distinction that the false belief task taps into. The statement the '*earth was flat*' may be untrue but the sentence 'Sarah

thought that *the earth was flat*’ is dependent upon Sarah’s mental state and so therefore may be true even if the embedded proposition itself is false. This syntax also occurs in communication verbs such as ‘say’ or ‘told’. (e.g., ‘Sarah told the girl there was a bug in her hair’ may be true regardless of whether or not there was a bug in the girl’s hair). De Villiers and Pyers hypothesized that children must be able to master the structure of complementation in order for false belief understanding to emerge. The task developed in this study involved the use of complements with communication verbs and mental state verbs. Using drawn pictures, brief stories were told. For example, participants would hear a statement such as “He thought he found his ring, but it was really a bottle cap. What did he think?” while corresponding pictures were pointed out. The measure also included items using communication verbs instead of mental verbs. This task variation had the advantage of testing for the general syntactic structure without confounding the ability to deal with mental verbs.

General language ability was measured by analyzing the spontaneous speech of children during test sessions and play sessions. Utterances were audiotaped and were broken down into Mean Length of Utterance scores (MLU), total sentence score, total complex sentences, total score for complements and total complex minus complements score. The important finding from this study was that language measures pertaining to complementation predicted the score on false belief, and that this held up even when performance on *all* of the other language measures were controlled. Thus, De Villiers and Pyers suggested that once children begin to master the syntax of complementation, they begin to recognize that mental verbs indicate something different than communication verbs. For example if a person says ‘Mary said that ...’ this can be verified by the reality

of what was said, but in the sentence ‘Mary thought that...’ the truth is more difficult to determine. Therefore, the syntax of complementation a very specific language ability can be seen as a keystone in developing a false belief understanding. The results also indicate that in terms of examining the nature of the relation between language and false belief development, what is important is the specific ability to deal with the structure of complementation, and *not* general language ability.

These two studies illuminate the role that language plays in the development of theory of mind. I will review the relation between language development and behavioural inhibition following a review of the temperament literature. An examination of executive functioning—specifically, working memory and inhibitory control—in relation to the false belief task will now follow.

Executive functioning and false belief. Executive functioning is also related to the false belief task (Carlson & Moses, 2001; Perner, Lang & Kloo, 2002). Executive functioning involves the ability to plan and make decisions, and it is implicated in judgment and self-perception (Zelazo & Müller, 2002). Moses and Carlson (2004) discussed their recent findings on the relation between executive functioning and false belief development. They propose that a key component of executive functioning, which is related to theory of mind, is self-regulation. They pointed out that self-regulation is lacking in preschoolers as evidenced by a lack of self-control. As well, preschoolers are also poor perspective takers. Furthermore, frontal lobe development is implicated in both self-control regulatory process and in mental state development. Damage to the frontal lobes has been shown to affect self-regulation. (Luria; Rothbart & Posner, as cited in Moses & Carlson, 2004). Frith and Frith (as cited in Moses & Carlson, 2004) found

through imaging techniques that the frontal lobes were implicated in mental state understanding. Since both mental state understanding and self-regulation were found to be linked to frontal lobe development, Moses and Carlson conducted a number of studies to examine the relation between executive functioning and mental state understanding.

Moses and Carlson (2004) conducted a review of their previous research on executive functioning and false belief. In this review two possibilities were examined. The first was that a child needs executive control to *perform* the false belief task in order to inhibit reality and comment on another person's representation (i.e., executive function is a performance factor). Alternatively, the development of executive control may be required to be able to *understand* the mere existence of abstract mental representation (i.e., executive function is a competence factor).

Based on the results of their past work (e.g., Carlson & Moses, 2001, Carlson et al., 2002), Moses and Carlson's (2004) article explored four hypotheses. Three of these are relevant to this thesis. The first was that there was a common developmental timetable for inhibitory control and false belief performance; in other words, a correlation would be found between mental state understanding and executive control. To determine if false belief understanding and executive control were linked, Moses and Carlson reviewed their 2001 study. In this study (Carlson & Moses, 2001) eight false belief tasks were used to measure theory of mind (two change of location tasks, two appearance-reality tasks, two unexpected contents and two descriptive pointing tasks). In addition, ten inhibitory control tasks were used, which were divided into types: conflict inhibition and delay inhibition. Conflict inhibitory control tasks involve inhibiting an inappropriate prepotent response while activating a novel response (hence the conflict). An example of

a conflict inhibitory control task was the Bear/Dragon task. Children were asked to perform the bear's instructions but inhibit the dragon's instructions (this game is much like 'Simon Says'). The prepotent response (the predominant or more powerful response option) that would need to be inhibited in the bear/dragon example is the child's impulse to comply with all requests (like 'touch your nose').

Delay inhibition tasks require the child to delay responding with the prepotent response, but do not require the child to substitute something else in its place (no conflict). In these tasks, children have to suppress their desire to immediately see or do something. An example of the delay task was the gift delay task in which children had to remain turned away from an experimenter while she noisily wrapped a gift for the child. The children had to suppress their urge to peek at the gift while it was being wrapped and the amount of time that they could do this was measured. Children's summed score across the inhibitory control battery was found to be strongly correlated with performance on the false belief battery. This remained significant when age, sex, and verbal memory were controlled. Separating the inhibitory control battery into conflict and delay tasks resulted in only the conflict battery still predicting false belief performance. The authors proposed that the conflict tasks must share some central theoretical core with the false belief tasks due to the fact that the correlation held even when other developmental constructs were controlled.

The second hypothesis that Moses and Carlson (2004) proposed was that two aspects of executive control, working memory and inhibitory control, were involved in mental state understanding. Working memory involves the ability to simultaneously hold and manipulate information while inhibitory control involves suppressing thoughts or

actions that are not important to the goal. They suggested that both working memory and inhibitory control are important in mental state understanding since mental state performance requires an ability to hold relevant perspectives in mind and inhibit irrelevant information.

To analyze whether working memory was also implicated in theory of mind development Carlson et al. (2002) ran a study, using the same inhibitory control battery described above. They included two working memory measures. One working memory measure was the backward digit span task (Davis & Pratt, as cited in Carlson et al., 2002) in which children were asked to listen to a list of numbers and to repeat this list of numbers back in reverse order. The second working memory measure was the dual counting and labeling task (Gordon & Olson, as cited in Carlson et al., 2002). In this task the children must count and name a set of objects (e.g., “one is a shoe, two is a spoon and three is a car.”). The results of this study concluded that working memory was correlated to the inhibitory control, but it was not correlated to false belief once inhibitory control was partialled out. This confirmed that working memory is a necessary component for the conflict inhibitory control tasks, but was not related directly to false belief understanding on its own. Moses and Carlson (2004) commented that the conflict inhibitory control tasks involve a working memory component in that children have to hold competing information in mind and make a choice of when to respond. Therefore the conflict inhibitory control task involves more than the delay inhibitory control (which only requires inhibiting a response): it also includes a working memory component.

Finally, Moses and Carlson (2004) suggested that advances in self-regulation (inhibitory control) were critical for the *emergence* of theory of mind development and

not just the *expression* of false belief understanding. As noted in the false belief literature (Wellman et al., 2001) there is some suggestion that the problem performing the false belief task is the problem of the salience of reality as discussed above. Children need to suppress reality in order to correctly answer what the protagonist is thinking. In this case then the point can be made that inhibitory control development enables the child to suppress the urge to answer the question with the true state of affairs (prepotent response) and thereby allows the child to achieve competent performance on the task.

Alternatively, the point can be made that children may need self regulation (inhibitory control) to be able to reflect on thoughts and action and distance themselves from the immediate situation in order to construct complex concepts of mental life. In order to assess which view is supported, Carlson and Moses (2001) examined false belief tasks, which required the suppression of a prepotent response, and those false belief tasks, which did not. The findings of this paper concluded that inhibitory control was related just as strongly to tasks that showed prepotency as to those that did not. The authors therefore concluded that inhibitory control aided the emergence of belief understanding as well as on the performance of the task.

In summary, Moses and Carlson (2004) illustrated that inhibitory control and false belief understanding are tightly linked, and that working memory is a factor that is jointly implicated with inhibitory control in relation to false belief understanding. Finally, they provide support to the theory that inhibitory control is important in the emergence of false belief understanding.

Perner et al. (2002) also found support for this last finding in another study examining executive control and false belief development. In two experiments, two

executive control tasks were used to assess the children's inhibitory control ability in relation to false belief development. The first executive control task was the dimensional change card-sorting task (DCCS; Frye et al., as cited in Perner et al., 2002). In this task the children had to sort two decks of cards, the first deck had small and large, yellow and red items, the children were told to sort the cards first by color placing all the red ones in one slot and all the yellow ones in a separate slot. After 5 trials they were instructed to switch and sort by size, all the big ones in one slot and all the little ones in a separate slot. The second deck of cards required the children to sort by shape (cats and snakes) for the first 5 trials and color (red and yellow) for the second 5. The children were scored on the number of correct sortings after the rule was switched. A second inhibitory control task, the 'Go No-Go' task, was administered. In this task the children were required to press a button on a computer whenever a red item appeared but not to press it when a yellow item appeared.

These inhibitory control tasks require different levels of ability. The DCCS task requires the child to construct a representation of a problem space, choose a plan, and keep the plan in mind to guide their behaviour, and finally carry out the behaviour. After the rule change, problems in performing correctly may be due to three possibilities (Zelazo & Müller, 2002): perseveration errors (problems inhibiting the task they were just doing); an inability to form a new plan (representational inflexibility); or problems in carrying out the new plan (lack of response control). Just as in the conflict battery described in Moses and Carlson (2004), this task requires both inhibition and working memory. The Go No-Go task merely requires the child to inhibit a response. In addition

Perner et al., tested the children's verbal intelligence using the Kaufman-ABC intelligence test.

The false belief tasks used in this study were a variation of the traditional tasks described earlier. In the first experiment the children were told that two identical twins were playing with a ball. One left the room leaving the ball in one location. The second twin played with the ball and then he left the ball in a different location and he left the room. Then both twins were brought back into the room and they looked for the ball in the two locations. The children were asked about the mistaken twin: "why does this one look in this box?" Children's answers were noted and were then scored as to whether they attribute the 'mistaken looking' to a mental state or to some other explanation.

In the second experiment, they modified this task by using only one story character. Also the children were given two versions of the story: a prediction version where they were asked where the protagonist would first go to get the object and an explanation version where they were told where the protagonist would look for the object and asked why they thought that the protagonist would look for the object in that location.

Perner et al. (2002) hypothesized that if inhibitory control was related to assisting the child to suppress the salience of reality it should not be related to the explanation version of the story. Results of these experiments supported the work of Carlson and Moses (2001) and Carlson et al. (2002) in that the inhibitory control task was related to both the explanation question and the prediction question in both experiments. Furthermore the results concluded that verbal intelligence did not remain a factor once executive functioning and age were partialled out. The dimensional change card sort task

was correlated with false belief understanding after age and verbal intelligence were controlled, however the Go No-Go task was not. The fact that the Go No-Go task did not relate to performance gives further support to the idea that it is not merely the inhibition of a prepotent response that is necessary to perform well on the false belief task. Instead, an underlying conceptual component may be necessary in order to acquire mentalizing skills. As discussed in Moses and Carlson (2004), this may be the ability to hold a representation in mind and be able to access this representation in order to make a decision.

In summary, false belief tasks are a measure of a child's development of the ability to understand mental representations and act or predict action based on those representations. Although language development (complementation) is one prerequisite, executive control is also necessary, specifically a conflict inhibitory control ability. The executive functioning component is necessary for the development of false belief understanding; however it is not sufficient on its own as there is support for the idea that it enables the child to think about the nature of beliefs and therefore enables them to develop this concept.

Up to this point we have been describing the cognitive requirements necessary to succeed in mental state understanding. However, to verify that performance on the false belief tasks is an important step in understanding another person's mind, an examination of the social implications observed in behaviour between children who succeed on the task and children who are delayed is necessary.

Social implications of false belief understanding. Many researchers have examined the relation between false belief performance and social understanding. This

research is motivated by the fact that being able to predict and understand others' mental states is a critical skill for successful social interaction. Generally, it has been found that false belief does predict social understanding in a number of different ways. As well, earlier social experience such as having a long term friend (Brown, McCall & Dunn, 1996; Peterson & Seigal, 1995) can facilitate theory of mind development. These findings increase the validity of the false belief task as a measure of something that is applicable outside the testing situation. A review of some of this research follows.

Brown, McCall and Dunn (1996) reported a positive relation between mental state talk with friends and children's false belief performance for children of 47 months. The amount of mental state talk with friends was measured by observations of one hour play episodes between friendship dyads. Brown et al. also reported that mental state talk which was used to direct interaction or to talk about a shared mental experience was positively related to the explanation question of the false belief task (e.g., why will she look there). In addition mental state talk was positively associated with co-operative interactions between friends. Brown et al. also reported that length of friendship and how frequently the friends saw each other (e.g., less than once a week to every day) was positively related to false belief performance.

Dunn and Cutting (1999) reported that social understanding (a combined measure of emotional understanding and theory of mind) was related to low frequency of conflict between friends, shared pretend play, and a smoothness of communication between friends in a sample of 3.5 to 4.8 year olds.

Slomkowski and Dunn's (1996) results supported and added to this finding. They also measured false belief understanding and affective perspective taking (the ability to

identify emotions which are acted out) in relation to connected communication.

Connected communication was measured by behavioural observations of a dyadic shared play episodes in 38 children (40 and 47 months of age). During this period, the amount of turn taking in conversation, number of play turns, and number of pretend turns were measured. They reported that false belief understanding was associated with all 3 measures of connected communication separately from affective perspective taking. They concluded that the experimental measure of false belief was related to behavioural observation of social functioning. The authors suggested that this research supports the idea that an underlying similar social-cognitive skill is being measured by the experimental and observational measures.

Another study by Cassidy et al. (2003) of 67 children between the ages of 37 to 65 months of age, found that social competence was related to false belief performance. Social competence was measured by peer ratings of likeability and teacher ratings from the Social Skill rating system questionnaire (Gresham & Elliott, as cited in Cassidy et al., 2003). False belief understanding was measured by a deception task and the change of location task (the task in which an object is moved and the participant has to predict where the protagonist will search for it). Furthermore, Peterson and Siegal (2002) reported that preschoolers who were rejected by their peers and who had no mutual friendships scored lowest on theory of mind tasks, whereas having a mutual friend or scoring as 'most liked' on a sociometric measure both predicted false belief scores independently (positive correlation).

However, results from a longitudinal study reported that developing an early theory of mind understanding (as evidenced by explanation of a false belief behaviour at

40 months) was found to be related to negative perception of school experience at the start of kindergarten. Those children who could successfully perform the false belief tasks at an early age were more sensitive to teacher criticism and tended to judge the reactions of others towards themselves at school in a guarded or negative way (Dunn, 1995). Therefore, an early understanding of others' minds is related to sensitivity and awareness of the judgments of others. It is difficult to know which comes first, however. An early understanding of theory of mind (false belief understanding) may lead to a higher sensitivity to criticism and some social withdrawal. Alternatively, an already sensitive child may develop theory of mind earlier (possible mechanism for this will be explained in the temperament section). The resulting sensitivity in kindergarten may be a result of an early temperament of behavioural inhibition compounded with an earlier understanding of mental states.

Dunn (1996) suggested that it is important to explore affect in relation to theory of mind development. Quoting Hoffman, she suggests that affect may start, stop, accelerate or disrupt information processing. Affect is responsible for focusing attention on specific aspects of the environment. Dunn goes on to discuss that negative affect affected children's management of disputes in that they were less likely to use reasoning and perspective taking when they were experiencing negative affect than when they were experiencing positive affect. Also, joint pretend play was less likely to occur when a child was distressed, and pretend play is a predictor of false belief development (Dunn & Cutting, 1999). This aspect of theory of mind development links up with temperament as temperament differences impact on the degree to which children experience negative and positive affect (Buss & Plomin, 1984). As well, these differences impact on the degree to

which individual children engage in social activity (Buss & Plomin, 1984). This research begins to make more explicit the interplay between false belief understanding (theory of mind) and temperament (behavioural inhibition) as it relates to social development.

The next section will outline temperament theory and how a temperament of behavioural inhibition may be implicated in the development of a child's developing ability to consider others' mental states.

Temperament

Temperament can be defined as a combination of personality traits that are biological in origin, which interact with the environment during development, resulting in individual differences in behaviour throughout the life span (Buss & Plomin, 1984; Plomin & Rowe, 1977; Thomas & Chess, 1975).

This thesis is concerned with a temperamental construct of 'behavioural inhibition'. This construct is described as behavioural reactions to unfamiliarity, which result in fearful or subdued behaviour and withdrawal. Initially these behavioural reactions are measured by increased motor action and distress in infants but later the reactions to novelty are manifested as wariness and withdrawing behaviour in preschool children (Kagan, 1997; Biederman et al., 2001).

Kagan (1997) based this construct on animal behaviour research which has found that all mammals have a readiness to react to situations that are different from those experienced in the past (discrepant events). These reactions to unfamiliar events produce an increase in attention and an orienting response in infants and may result in a fear response if the event cannot be easily assimilated. Kagan hypothesized that there would be individual variability in the degree to which humans would respond to discrepant

events because the response is biologically based. The hippocampus plays a role in the detection of novel events and provokes activity in the amygdala and changes in the autonomic function (Kagan, 1997).

Kagan (1997) began a longitudinal study with 462 healthy middle-class Caucasian 16-week-old infants. He presented each infant with brightly coloured toys moved back and forth in front of their faces, tape recordings of voices, and cotton swabs dipped with an unfamiliar scent. He then measured their motoric and distress reactions. He found that 20% became motorically active and distressed during these presentations while 40% remained relaxed and did not cry or fret. Of the reactive infants 33% went on to have high levels of fears at 14 and 21 months with only 3% showing minimal fear. The reverse was found for the non-reactive infants. Fear was assessed based on the child's reaction to the presentation of a series of unfamiliar objects, adults and robots, by crying or fretting or refusing to approach. At 4½ years of age the high reactive children were found to display less spontaneous smiles and comments when interacting with an unfamiliar adult and 40% were shy and timid when observed in a play session with two unfamiliar peers (Kagan, Snidman, McManis & Woodward, 2001). Of these high reactive infants less than 10% were found to be outgoing; in contrast, two thirds of the low reactive children were found to be outgoing and sociable. The high reactive children therefore exhibited 'behavioural inhibition' (Kagan, 1997; Kagan, Snidman, Zentner, & Peterson, 1999; Kagan et al., 2001).

A number of physiological correlates have been associated with behavioural inhibition. As compared to their uninhibited counterparts, inhibited children were reported to have a lower threshold for physiological arousal, greater EEG right frontal

asymmetry, high morning salivary cortisol, and greater reactivity in the cardiovascular system (Kagan & Snidman, 1999; Kagan, Reznick & Snidman, 1987). These findings support the hypothesis that these factors relate to the amygdala, which is implicated in reactivity to environmental threat with a fear response (Kagan & Snidman, 1999).

There have been some research findings linking inhibition in infancy and toddlerhood with the later development of social anxiety. For example, results from research have indicated that the high reactive infants (as measured by frequency of motor activity, fretting and crying) were more likely to develop anxious symptoms at age 7 years based on a battery of 12 lab procedures (Kagan et al., 1999).

In a separate series of studies of these same children, 61% were found to exhibit social anxiety in adolescence whereas only 27% of the non-inhibited children displayed social anxiety. Moreover, 44% of females and 22% of males displaying this temperament at 21 months old were classified as impaired in the area of general social anxiety in adolescence, with 61% displaying social anxiety (Kagan, 1997; Schwartz, Snidman, & Kagan, 1999). In a separate study behavioural inhibition in children 2, 4, and 6 years of age was associated with avoidant disorder and social phobia, but was not significantly associated with other mood disorders in childhood (Biederman et al., 2001).

Kagan (1997) discusses the possibility of researching behavioural inhibition as a continuous variable or as a categorical variable. He proposes that there is support to see it as a categorical variable since behaviourally inhibited children have physiological characteristics that are unique. Also within the two extremes (high reactive vs. low reactive infants) high motor arousal seemed to be on a continuum, but high distress or crying was not. The variation within the two groups did not predict later fearfulness, but

rather between the two groups there were distinct differences. He suggested then that the top and bottom 20% were uniquely different in their reactivity as infants and these differences predicted unique differences in their future behaviours.

Behavioural inhibition describes the child's reaction to unfamiliar events, objects and people. A behaviourally inhibited child's reaction to unfamiliar people closely matches descriptions of shy children who are described in the research literature as displaying fearful, anxious and withdrawing behaviour resulting in lack of speech and communication during social interactions (Buss & Plomin, 1984; Coplan, Prakash, O'Neill, & Armer, 2004; Evans, 1996; Rubin & Mills, 1988; Spere et al., 2004; Van Kleeck & Street, 1982).

Bishop, Spence and McDonald (2003) created a questionnaire, which was designed to measure behavioural inhibition in a quick and economical way. The questionnaire was administered to mothers, fathers and teachers. The final version of the behavioural inhibition questionnaire (BIQ) consisted of 6 contexts, which covered three domains. These were situations involving unfamiliar peers, adults, performing in front of others, separation and preschool, novel situations in general, and physical activities involving risk. These six subscales each loaded significantly on a single higher order factor supporting the use of the scale to measure overall behavioural inhibition. The BIQ was correlated with behavioural observations of the children in a laboratory environment resulting in moderate correlations. However when the sample was divided into high and low BIQ scores based on 20%, the correlations were stronger especially when mothers were the raters. Correlations between observations of behaviour and the BIQ scale for the group in the midrange were much weaker. The authors suggest that parents and teachers

may be more sensitive to behaviours at the extreme end of the scale. Stability of the measure over a 12-month period ranged from coefficients of .49 to .78 depending on the rater. Highest for mother reports of behavioural inhibition, indicating moderate stability. This questionnaire is a robust measure of behavioural inhibition with good psychometric properties especially when used to measure children at the extreme ends of the scale.

Since it has been shown that anxiety disorders have a genetic basis and a precursor of anxiety disorder is a temperament of behavioural inhibition, which involves high arousal, it is reasonable to expect that there may be a neurological difference in behaviourally inhibited children. This underlying neurological difference may impact on the child's cognitive development in two ways. It may be that the same systems that are responsible for regulating the anxiety response are also implicated in cognition (see Hooper & March, 1995). Secondly, it may be that the anxiety response causes the person to respond to their environment in a specific way resulting in a different development path of specific cognitive processes. For example, language may be affected by problems with neurological differences, but it may also be affected by the amount of social interaction in which the individual child engages.

As reported, behavioural inhibition is a precursor to anxiety disorder. This type of behaviour is the result of an overactive fear response to stimuli. Gray's Model (Gray, 1982) suggested that two systems are responsible for behavioural reactions. This first system is a behavioural inhibition system (BIS), which is sensitive to punishment, non-reward and novel situations. This system, when activated, will result in hypervigilance, increased arousal and behavioural inhibition. Therefore when the individual's BIS is activated they will have a heightened response to scan the environment for danger, in

doing so their focus will be distracted from their current activity. They will pull back from their current activity to evaluate the potential threat and their autonomic nervous system will be prepared to activate the second system described as the 'fight or flight' system. This system will mobilize the individual to take action (Gray, 1982). Gray's model was based on animal behaviour experiments to specific neurological systems, research on patients with lesions to specific brain regions, and the effects that anxiety medicines have on patients (see Gray, 1982 for a review). Gray postulated that individuals may have an overactive BIS causing them to be more susceptible to anxiety.

Based on this model the hypervigilance response could have implications for the behaviourally inhibited individual. These children would more likely be distracted from their normal activities during novel situations. This may create problems in attentional focus. Unlike children with attention deficit disorder these children may be *more* alert to the environment in certain situations (see Hanoch & Vitouch, 2004).

Secondly the autonomic nervous system response has implications for the behaviourally inhibited child. Overarousal may cause the child to have difficulty in cognitive performance. This is evidenced by the findings of Yerkes and Dodson (as cited in Hooper and March, 1995). The Yerkes-Dodson law stated that easy cognitive tasks were facilitated by arousal or anxiety, since the arousal may improve motivational effort. However, increased task difficulty required lower levels of anxiety and arousal. They found that the best performance was obtained with medium levels of anxiety/arousal. Eysenck (as cited in Hooper and March) reported that worry, which overloads the working memory capacity, may be responsible for this effect. Therefore too much anxiety may make difficult tasks harder due to limited working memory capacity.

However Hanoch and Vitouch (2004) argue that while overarousal may reduce performance on a task, it actually is refocusing attention onto the perceived threat. In this way a better performance in relation to the threat is achieved. For example, if a rabbit is confronted with a snake, the rabbit's performance for exploring cues in the environment will be reduced but his performance on observing the behaviour of the snake may be increased. In this way when behaviourally inhibited children are confronted with a novel situation such as meeting a new person they may be hyperfocused on the actions and behaviour of the new person. Often these children are seen standing on the sidelines watching other children at play (Coplan et al., 2004). This would support a positive link between theory of mind understanding and behavioural inhibition, because the behaviourally inhibited child may be more focused on the behaviour of others and will therefore be more aware of the differences between their own mental states and the mental states of others. They would then try to reconcile people's behaviour with the underlying mental state that caused it.

It is important then to examine the relation between behavioural inhibition and the development of cognitive processes in young children. In the following sections, a number of studies examining working memory, inhibitory control tasks, and language will be reviewed in relation to this temperament. These are the same developmental processes that are implicated in false belief understanding.

Behavioural inhibition and working memory. Little research has been done on behavioural inhibition and working memory. However, in a study of anxiety disordered children Toren et al. (2000) compared anxious children with normal controls on measures of working memory as well as intelligence. The anxious group consisted of 19 children

ranging in age from 6 to 18 years with a mean age of 11.5 years. Separation anxiety disorder was found in 47% of the group and overanxious disorder made up 77% of the group. Co-morbid disorders such as ADD or depression were not included in this group. The control group consisted of 14 children also ranging in age from 6 to 18 years with a mean age of 11.5, exhibiting no history of anxiety disorder. No children were included with an overall I.Q. of less than 85 or a neurological disorder. They were also not taking medication for anxiety.

Executive functioning was assessed using the Wisconsin card sort task (WCST; this is much like the dimensional card sort task described earlier as an executive function task). This requires the child to sort cards into four categories and change the sorting behaviour based on the examiner's feedback as to whether the card is sorted correctly or not. This task measures an ability to relinquish an old category for a new one. As well, number of correct responses after positive feedback versus number correct for negative feedback can be observed.

The results of this study reported significantly higher scores for the anxiety group on the WCST total errors. As well, the anxiety group made more mistakes after negative feedback than after positive feedback. The authors concluded that anxiety and worry impairs performance on tasks that have high demands on working memory and cognitive flexibility. Working memory was impacted in this situation due to a perceived threat by the anxiety-disordered group. The constant feedback, both negative and positive, may have impacted the anxiety disordered group more than the control group. This test then does not differentiate between performance versus competence. The participants knew they were being watched and corrected if they made a mistake, which may have caused

excessive worry. Without this type of scrutiny they may not have performed worse than the control group. Therefore we can not conclude from this study that working memory is impaired during everyday situations.

Kusché, Cook, and Greenberg (1993) conducted a comprehensive study of anxiety-disordered children. This study included 305 children with a mean age of 8 years and a range from 6 to 11 years. These children were gathered from a normal school environment and included children referred for special education. There was no minimum I.Q. cutoff score required in order to participate. The children were categorized into one of four groups: a control group of nonpathological children; an anxiety group with children exhibiting anxiety, somatization, and withdrawn behaviours; a conduct disordered group; and a combination anxiety and externalizing group. For the purpose of this paper, only the results of the anxiety group compared with controls in the area of working memory will be reported.

Working memory was measured by the trails A and B task. In trails A children connected a series of circles in order of numbers, and in trails B they connected by number then letter (e.g., 1, A, 2, B etc.). The Stroop Color and Word test were also administered to test for executive functioning.

Results from these tests revealed the following for the anxiety-disordered group: the Stroop test revealed a dyslexic pattern. In the area of working memory, deficits were found for the anxiety-disordered sample in performance of trails B but not trails A. The authors suggested that the anxiety disordered children were experiencing problems with cognitive functioning.

These two studies point to problems with working memory for anxiety disordered youth. Research into the relation between behavioural inhibited children and working memory is an important step in furthering an understanding of this relation. As discussed above, working memory is linked with inhibitory control as a precursor to competency on the false belief task. Therefore, if a link is found between behavioural inhibition and working memory there may be implications for false belief understanding. However, if working memory is only impacted during high stress interactions and is not impaired during everyday situations then behaviourally inhibited children will not be expected to be impaired on the false belief task. Therefore assessing preschool children's performance on working memory tasks that do not involve negative feedback and have reduced threat is indicated.

Inhibitory control and behavioural inhibition. Literature examining the relation between inhibitory control and the behaviourally inhibited temperament has also been limited. A recent study by Thorell et al. (2004) examined the relation between the behaviourally inhibited temperament and inhibitory control. This study was the first to examine the relation between these two constructs. One hundred fifty-one, 5-year-olds participated in this study. Using a parental rating scale based on the Colorado Child Temperament Inventory (CCTI) shyness dimension (with new questions added by the authors) as well as laboratory measures similar to Kagan's (1997) including both unfamiliar toy interactions and adult interactions, they identified children high in behavioural inhibition and compared them to children at the low end of this scale. They found that children who were high on behavioural inhibition had higher scores in measures of inhibitory control as measured by the Go No-Go task.

The Go No-Go task was a computerized task involving four stimuli, a blue square, a blue triangle, a red square, and a red triangle. The children were told to press a key every time a blue square was shown but to not press when a red square was presented. Then the rule was switched and the children were told to press a key when a square was shown but not to press a key when a triangle was shown. Their results confirmed a relation between inhibitory control and behavioural inhibition. This Go No-Go task is similar to the dimensional card sort task discussed in Perner et al. (2002)'s paper, which was related to FB performance (Perner et al., 2002). Both of these tasks involve the inhibition of a prepotent response but also to a lesser degree a working memory component is involved as the rule must be attended to. Therefore the dimensional card sort task and Thorell et al.'s Go No-Go task involve both working memory and inhibitory control and these task are positively related to behavioural inhibition and theory of mind. This supports the proposal that false belief performance may be positively related to behavioural inhibition.

It should be noted that Perner et al. (2002) reported that the Go No-Go task did not relate to false belief. However the description of Perner et al.'s task (see above) was different from the Go No-Go task described by Thorell et al. (2004). The Go-No Go task in Perner et al's study did not involve the rule switch. Therefore, though the tasks have the same name, they tap into different abilities so their findings only seem contradictory in nature.

Behavioural Inhibition and language. Another recent article examined the relation between behaviourally inhibited children and language development (Spere et al., 2004). This study, examined 44 children (22 shy and 22 non-shy as measured by the CCTI).

Expressive and Receptive language was assessed using the Picture Peabody Vocabulary Test-Revised (PPVT-R; Dunn & Dunn, as cited in Spere et al., 2004) and the Test of Auditory Analysis Skills (TAAS: Rosner, as cited in Spere et al., 2004). The shy children scored significantly lower than their non-shy counterparts on receptive and expressive language skills. However, when examining the results in relation to the standardized scores the shy children did not differ from their age group, but the non-shy children performed significantly above the standardized sample. They out-performed the sample by almost a year. The authors concluded that shyness did not impair language performance, however being outgoing certainly improved it.

Of interest to false belief development is the ability of the child to understand complex sentences, specifically the syntax of complementation (de Villiers & Pyers, 2002). One study has examined shy children's use of complex sentences when speaking with adults (Van Kleeck & Street, 1982). This study compared two shy children with two non-shy children. Children were determined as shy by asking their teachers to select two quiet children. These children interacted with 6 to 8 adults for a half hour. These sessions were taped and analyzed on a number of dimensions. Of interest to this paper was the finding that quiet children used complex sentences significantly less than their non-shy peers. However this study is limited in the sample size as well as their assessment of what constitutes a shy child. Also the quiet children may understand complex sentences but are less likely to speak as often as their non-shy counterparts. It is important therefore to examine behaviourally inhibited children's *receptive* performance on complex sentences further in order to assess whether this may be a factor in false belief performance for these children.

A problem in getting a true picture of the nature of language ability of shy children is the fact that language develops through interaction. Although shy children may speak more in familiar environments their amount of speech is reduced depending on the familiarity of the environment (Asendorpf & Meier, 1993). In a study examining the amount of speech of shy children in relation to non-shy children across social situations Asendorpf and Meier found that shy children spoke as frequently as non-shy children in familiar situations (at home, with no unfamiliar person present). However in situations of medium familiarity (outside with two familiar persons present) and unfamiliarity (outside with many children or with unfamiliar persons present) the shy children spoke less than non-shy children. Therefore because behaviourally inhibited children are found to experience language through familiar situations it is not expected that they would be delayed in their language development. The results of Spere et al. (2004) support the conclusion that they are not delayed (although they are not at an advantage either).

A second issue concerning the results of behaviourally inhibited children's cognitive ability is the question of whether the outcomes are due to one of competence or performance. It may be the nature of the testing experience that interferes in the ability of a high reactive individual to perform well. To examine the effect of different testing environments on shy children Crozier and Hostettler (2003) varied the test context between high socially demanding to low socially demanding test situations. Shy children were compared to non-shy children across three types of test situations. In the first condition, the children were tested individually, in a one on one interview, with the test presented orally by an examiner. In the second situation the test was presented orally but

the examinees were instructed to respond in writing. In the third condition the children were tested as a group.

The results of this study confirmed that the testing situation resulted in differences in test score for the shy children to a much greater degree than for the non-shy children. Shy children performed better in group testing (where they were not singled out). They also performed worse in the condition where they were to write their responses. The authors suggested that this may be due to the increased anxiety of answering correctly and the problem of maintaining a good presentation. The authors concluded that the sense of being the focus of attention is the important factor interfering with the test performance. When the shy children were able to answer in a group they exhibited their best results. This indicates that the true picture of shy children's cognitive ability is difficult to determine with performance and competence being confounded by the assessment situation.

In summary, a positive correlation was found between a task involving inhibitory control and behaviourally inhibited children. However, no research has been done examining working memory and behavioural inhibition. Based on the studies reported above on anxious older children it may be expected that behaviourally inhibited children may also have working memory difficulties. However this can be disputed because behaviourally inhibited children performed well on a task involving both inhibitory control and working memory recall (Thorell et al., 2004). Therefore an examination of the working memory capacity of behaviourally inhibited preschool children is necessary. Finally, it would appear that language may not necessarily be a problem for shy/anxious children, but an examination of their understanding of complex sentences is indicated.

Specifically, an examination of their ability to deal with the specific syntactic skill of complementation is warranted.

The importance of behavioural inhibition in the development of cognitive skills, especially in the area of mentalizing skills, has been under-investigated. This thesis is a first step in examining a link between a behavioural inhibition with early preschool cognitive development.

Based on this literature review, it was expected that behavioural inhibition would be positively related to inhibitory control, which would mediate a positive relation with mentalizing skills as measured by the false belief tasks.

Primarily, I hypothesize that behavioural inhibition will be positively related to theory of mind development as measured by the false belief task. Dunn's (1995) results indicated that early mentalizing skill development resulted in anxiety behaviours in the early school experience. This may be due to the fact that these children had a behaviourally inhibited temperament and therefore they developed false belief understanding earlier. This hypothesis is supported by the fact that inhibitory control is positively related to behavioural inhibition, and therefore it was predicted that this would aid children in developing false belief understanding. Furthermore, because children who are behaviourally inhibited may be more focused on behaviour during interaction with unfamiliar peers and adults, I propose that they would be better able to focus on differences between mental states of others and representations of the state of affairs, resulting in a positive link between the behaviourally inhibited child and understanding mental states.

Secondly, I hypothesize that behavioural inhibition will be positively related to false belief understanding after working memory, inhibitory control, and the syntax of complementation is controlled. Factors of age, gender, and friendship will also be examined and controlled for if they are found to be significant.

Thirdly, I hypothesize that behavioural inhibition will be positively associated with inhibitory control, replicating Thorell et al's (2004) findings. I do not expect to find that children who are high in behavioural inhibition will have differences in working memory ability from low or mid behaviourally inhibited children for two reasons: (a) there is no previous research with this population that would suggest deficits in working memory; and (b) although older children with anxiety disorder have working memory deficits this may be because of heightened performance anxiety due to the testing environment. It is possible that younger children with behavioural inhibition would not experience performance anxiety to the same extent.

I also do not expect to find performance on complex syntactic language skills to be different between children who are high behaviourally inhibited with those who are low or mid behaviourally inhibited, as the task is limited in performance difficulty, and it is expected that behaviourally inhibited children would have ample opportunity to practice their language skills in familiar environments so as to not be delayed on this measure.

Methods

Participants

Seven hundred consent forms were distributed to daycare centres throughout the Ottawa area and one hundred of these were returned (consent rate of 14.3%). Those

consenting ranged in age from 40 to 62 months of age. This sample was observed by the experimenters to be a diverse group both economically and culturally matching the Ottawa area population. A subset of 45 children ranging in age from 41 to 62 months ($M_{age} = 52$ months) were administered a series of tasks based on results from the BIQ parental questionnaire (Bishop et al., 2003; see below for details). The low BIQ group consisted of 5 boys and 10 girls ($M_{age} 53.1$), mid BIQ group consisted of 11 boys and 4 girls, ($M_{age} 52.7$ months), and the high BIQ group consisted of 6 boys and 9 girls ($M_{age} 50.6$ months).

Procedure

Parents of the children were asked to complete the Behavioural Inhibition Questionnaire (BIQ; Bishop et al., 2003). One hundred questionnaires were received and scored. Results of the questionnaire were analyzed and children measuring in the top, middle, and bottom 15% of the scale were interviewed individually by an examiner, during play time at their respective daycare centres. Each child was administered a series of tasks (listed below) in the same order for each.

Measures

Behavioural Inhibition

The BIQ (Bishop et al., 2003) was designed to measure behavioural inhibition across situations. Six subscales of behavioural inhibition can be established in the following areas; situations with unfamiliar adults, unfamiliar peers, performing, separation and preschool, novel situations and physical activities posing a small risk. All of these subscales have been shown to load significantly on the higher overall scale of behavioural inhibition. The BIQ correlates well with observational methods of

determining behavioural inhibition. Parents were asked to rate their child from 1 (hardly ever) to 7 (almost always) on a series of 30 questions concerning their child's behaviour (e.g., will happily approach a group of unfamiliar children to join in their play [reverse scored]). High scores represented children who were high in behavioural inhibition (see Appendix A).

Mental State Understanding

False belief was assessed through the use of one change of location task and two unexpected contents tasks. These tasks assessed the children's ability to recognize false belief both for self and for others. Overall, children earned a score out of 5 (based on two items measuring an understanding of false belief in themselves and three items measuring that understanding in others, see Appendix B for complete stories). The types of tasks are as follows:

Change of location. A variation of the Wimmer and Perner (1983) change of location task was given. Children were told a story concerning a protagonist who is playing with a ball and leaves it in one toy box. It is then moved by a playmate to another toy box. The protagonist then re-enters the scene and the children were questioned as to where the protagonist would look for the ball and why they would look there. Memory and reality questions were also used (control questions). This task tested the children's ability to understand another child's mistaken (false) belief (score 1 point other for correct answer).

Unexpected contents. A variation of Perner, Leekam, and Wimmer's (as cited in Astington, 1993) unexpected contents task was given. A Crayola® box filled with stickers was shown to the children. The children were asked what they thought was in the

box. They were then shown that stickers were in the box. They were then asked what they first thought was in the box and what was in the box now. Finally they were asked what their friend would think was in the box before it was opened. This task tested the children's ability to understand a mistaken belief for others and also in themselves. (score 1 point for other and 1 point for self, for a total of 2 points).

An unexpected contents task using a Band-Aids® box filled with pencils was also given. The protocol was the same as above.

A possible total score of 5 for false belief was determined by adding the total scores from the three tasks.

Executive Control

Children were assessed for their ability to inhibit a prepotent response through the use of four inhibitory control tasks (Moses & Carlson, 2004; Perner et al. 2002).

The dimensional change card sort task. This task (DCCS, Frye et al.; as cited in Zelazo & Muller, 2002) requires the child to sort cards first by one dimension and then by another. Children were given two sorting boxes and were asked to sort a series of cards showing either a blue boat or a red rabbit. The children were first told to sort the cards by colour and then were given a new rule to sort by shape. This task tested the child's inhibitory control and working memory. (To score, total number of correct responses performed after switching to the second sorting dimension was recorded. Higher scores indicate greater inhibitory control.)

The whisper task. was administered. This task (Kochanska et al.; as cited in Carlson & Moses, 2001) required the child to remember to whisper answers to questions concerning what cartoon character is pictured on a card. It was expected that children

with a difficulty in inhibitory control would find it difficult to continue whispering when seeing a card that they recognize after viewing a few that they do not recognize. This task tested the child's inhibitory control ability. (Scored with, 0 = shout, 1 = normal or mixed voice, and 2 = whisper, where higher scores indicate greater inhibitory control; see Appendix C.)

The day/night task. In this task (Gerstadt, Hong, & Diamond; as cited in Zelazo & Müller, 2002) children were shown a picture of a moon and were instructed to say 'day'. Then they were shown the picture of a sun and were instructed to say 'night'. They were shown a series of these pictures and the number of correct responses was scored (see Appendix D).

Monkey/Tiger task. This task (based on Bear/Dragon task, Read et al.; as cited in Carlson et al., 2002) is a simplified version of Simon Says. The children were introduced to two puppets, a tiger and a monkey. They were instructed to do what the monkey asks them to do but not do what the tiger asks them to do. The children were first asked if they could do a series of commanded actions, for example, 'touch your ears' or 'clap your hands'. A total of 10 trials were administered (5 for each puppet) and the instructions were repeated after the first 5 trials regardless of the performance of the child. (Scores were 0 = full movement, 1 = partial movement, 2 = wrong movement, and 3 = no movement, reverse scored for monkey trials. Total possible score = 30; see Appendix E).

Working Memory

Three working memory measures designed to be used with preschool children were chosen for this study.

Backward digit span. Working memory was assessed through the use of a backward digit span task (Carlson et al., 2002). The children were told that a puppet was being silly and whatever the experimenter says the puppet says backwards, so if the experimenter says “1, 2” the puppet would say “2, 1”. Then the children were asked to do what the puppet did. The list size increased with each successful trial and the highest level scored was recorded. This was designed to assess verbal working memory (see Appendix F). We were concerned that this task may be too difficult for 4-year-old children resulting in floor effects, therefore the backward word span task and the counting and labeling task were added.

Backward word span task. A backward word span task was modified for this thesis (Slade & Ruffman, 2005). This task is similar to the backward digit span task. The words we used were carefully chosen to be single syllable words that did not relate to each other. For example upon hearing “Girl, Four” children were instructed to say “Four, Girl” (see Appendix G). Of the 4-year-olds tested in the Carlson et al. (2002) study, the mean score for the backward word task was 2.21 ($SD = .86$) out of a possible score of 4. This was considerably higher than the mean score for the backward digit span task ($M = 1.44$). Therefore it was expected that there would be a good range of scores without floor effects for this task.

Counting and labeling task. The third working memory task that was administered was the counting and labeling task based on Gordon and Olson’s task (as cited in Carlson & Moses, 2002). Children were asked to first name three objects (Fish, Train, Pig) and then count them (one, two, three) and then name and count them (one is a Fish, two is a Train, and 3 is a Pig). Children were shown one set by the examiner and

were then given two trials. A possible score out of 2 was given (see Appendix H). Of 4 year olds tested in Carlson et al. (2002) the mean score for counting and labeling was 1.44 ($SD = .81$) of a possible score of 2. Therefore floor effects were not expected for this measure either.

Language

A complement comprehension task was administered. Eight sets of photographs with two photographs in each set were shown to the child while a statement was read for each set. For example, children heard, "She thought the girl was reading a book, but she was really playing cards" while the appropriate photos were being indicated. The child was asked, "What did the girl think?". Half of the items used mental verbs (e.g., 'think') while the other half used communication verbs (e.g., 'say'). Children received a score out of 4 for each type of verb (see de Villiers & Pyers, 2002). The exact measure that was used was from Jill deVilliers (personal communication with Deepthi Kamawar; see Appendix I). This language measure was chosen as it was found to be a prerequisite to mental state understanding (de Villiers & Pyers, 2002).

Social Correlates

Parents were asked to report how many siblings the child had and if the child had a particular friend or friends with whom they enjoy playing.

Results

Preliminary Analysis

Descriptive statistics for the tasks and questionnaire for this study are listed in Table 1.

Table 1 *Means, Standard Deviations, and Ranges for All Variables.*

	Total Mean (SD)	Range	Low BIQ Mean (SD)	Mid BIQ Mean (SD)	High BIQ Mean (SD)
N	45		15	15	15
BIQ (N 100) (total score 210)	85 (31.85)	34-166	41.8 (6.1)	82 (5.4)	139.6 (14.8)
FB (total score 5)	2 (1.9)	0-5	2.2 (1.9)	1.7 (1.8)	2.3 (2)
Backward digit span	1.16 (.52)	0-2	1.3 (.6)	1.2 (.4)	.9 (.5)
Backward word span	1.33 (.56)	0-3	1.5 (.7)	1.3 (.5)	1.2 (.4)
Counting and labeling	1.42 (.78)	0-2	1.4 (.8)	1.4 (.7)	1.5 (.8)
Dimensional card sort	3.31 (2.3)	0-5	4.1 (1.8)	2.7 (2.6)	3.2 (2.4)
Day/Night	11 (4)	0-16	12.7 (2.3)	9.2 (5)	11.7 (4)
Monkey/Tiger	27 (7.8)	0-30	25.9 (10.5)	26.7 (8.3)	28.5 (3.3)
Whisper	11 (1.8)	3-12	11.7 (.9)	11.3 (1.6)	11 (2.5)
Complement-Comp Mental verbs	2.68 (1.4)	0-4	2.9 (1.3)	2.7 (1.5)	2.5 (1.6)
Complement-Comp Communication verbs	2.7 (1.5)	0-4	2.7 (1.5)	2.8 (1.6)	2.7 (1.6)
Complement-Comp Total	5.4 (2.8)	0-8	5.5 (2.6)	5.5 (2.9)	5.2 (3.1)

Raw summary scores on all of the measures were used for all analyses, except for BIQ groups (low, middle, and high) which were used for between-subjects factors in both the ANOVAs and the MANOVAs.

Performance on the Monkey/Tiger and Whisper tasks were very near ceiling for this sample, so they were dropped from any further analysis (see Table 1).

To ensure that there were no differences among the three BIQ groups for gender, a Chi Square analysis was performed. A marginal effect for gender was found $\chi^2(2, N = 45) = 5.51, p = .06$. Recall that the low BIQ group consisted of 5 boys and 10 girls, mid BIQ group consisted of 11 boys and 4 girls, and the high BIQ group consisted of 6 boys and 9 girls.

To ensure that this marginal effect would not impact on the outcome variables, series of independent samples *t*-tests were performed with gender entered as the grouping variable and the outcome variables of backward digit span, backward word span, counting and labeling, dimensional card sort, day/night, complement comprehension, and false belief, entered as the test variables. No significant effect of gender was found for any of the outcome variables.

Behavioural inhibition and false belief. To test the hypothesis that behavioural inhibition is positively related to false belief, an ANCOVA was performed with false belief scores entered as the dependent variable, BIQ groups (low, mid and high) were entered as the between-subjects variable and age in months was entered as a covariate. No significant difference was found among the BIQ groups, $F(2, 41) = .99, p < .38$.

Behavioural inhibition and inhibitory control. To test the hypothesis that children high in behavioural inhibition would have greater inhibitory control, a MANOVA was

performed with the dimensional card sort score and the day/night scores entered as dependent variables and BIQ groups (low, mid, and high) entered as a between-subjects factor with age (in months) entered as a covariate in order to control for any possible age effects. A significant effect was found for the day/night task, $F(2, 41) = 3.2, p < .05$. Tukey post hoc tests revealed a significant difference between the low BIQ and the mid BIQ group on performance on the day/night task with the low BIQ group performing significantly better than mid BIQ group ($HSD = 3.5, p < .05$). No significant difference was found between high BIQ and the other groups. No significant difference was found between BIQ groups on the dimensional card sort task $F(2, 41) = 1.67, p < .20$.

Behavioural inhibition and working memory. To test whether there were differences between BIQ groups in their performance on working memory tasks another MANOVA was performed with backward digit span, backward word span, and counting and labeling scores entered as dependent variables, BIQ groups entered as the between-subjects factors, and age in months was entered as a covariate in order to control for any possible age effects. No significant differences were found among the BIQ groups and the working memory measures.

Behavioural inhibition and syntax of complementation. In order to test whether there were differences between groups on the language measure of syntax of complementation, one total for the complement comprehension task was calculated as well as scores for the two subscales of mental state verbs (CCthink) and communication verbs (CCtell). An ANOVA was performed with complement comprehension total raw score entered as the dependant variable and again BIQ was entered as a between-subjects factor with age in months controlled as a covariate. No statistically significant difference

between groups was found. A MANOVA was then performed with the two subscales of complement comprehension (mental state verbs and communication verbs) entered as dependent variables, with BIQ groups entered as the between-subjects variable and age controlled as a covariate. Once again no significant difference was found between groups on the separate subscales.

In order to assess the relation between variables, correlations for all measures in the study were performed (See Table 2). At this step no variables were partialled out.

Table 2 Inter correlations Between All Variables

Subscale	1	2	3	4	5	6	7	8	9	10	11
1 Behavioural inhibition	--	-.00	-.36**	-.18	-.01	-.07	-.15	.01	-.16	-.08	-.26*
2 False belief		--	.25*	.54**	.36**	.55**	.54**	.50**	.46**	.10	.41**
3 Backward digit span			--	.59**	.28*	.25*	.28*	.20	.34*	.22	.13
4 Backward word span				--	.50**	.45**	.49**	.37**	.45**	.21	.29*
5 Counting and labeling					--	.32*	.34*	.27*	.31*	.17	.33*
6 Complement comprehension						--	.95**	.96**	.49**	.40**	.34*
7 Complement comprehension (think)							--	.81**	.56**	.43**	.38**
8 Complement comprehension (tell)								--	.37**	.33*	.27*
9 Dimensional card sort									--	.16	.45**
10 Day/night										--	.02
11 Age											--

* $p < .05$, ** $p < .01$

Mediator and moderator effects. No relation was found between BIQ and any of the outcome variables except backward digit span (see table 2). Since backward digit span was only one of the working memory measures, and no between group differences were found on any the working memory measures, analyses of mediator effects were not required.

In order to ensure that the outcome variables (working memory, inhibitory control, and complement comprehension) did not moderate the relation between behavioural inhibition and false belief, regression analyses were performed. False belief was entered as the dependent variable and a two-way interaction terms represented by multiplicative products (e.g., working memory x BIQ raw score) entered as independent variables after the outcome variables (working memory, inhibitory control, and complement comprehension) were controlled for in the model. No significant interactions were present. Therefore working memory, inhibitory control and complement comprehension did not moderate the relation between false belief and behavioural inhibition.

In addition a hierarchical regression analysis was performed to assess whether the present sample would perform similarly to what is expected in the false belief literature in terms of the predictive power of working memory, inhibitory control, and complement comprehension for false belief performance. From the literature reviewed above it was expected that complement comprehension would be key in predicting false belief understanding based on de Villiers and Pyers (2002). Inhibitory control was expected to uniquely predict false belief once working memory was controlled based on Carlson et al. (2002) results. Therefore false belief was entered as the dependent variable, age (in

months) was entered at Step 1 (in order to control for age effects), the working memory measures were entered at Step 2, the dimensional card sort was entered at Step 3 (recall that there was ceiling effect for the monkey/tiger and whisper tasks), and complement comprehension was entered at Step 4. The day/ night task was not included as no correlation was present between day/night and false belief or day/night and dimensional card sort (see Table 2). Results of this analysis are reported in Table 3. The results indicate that both working memory and complement comprehension were predictors of false belief, however, dimensional card sort was not predictive once working memory was controlled.

Table 3 *Summary of Regression Analysis of Working Memory, Inhibitory Control, and Language on False Belief.*

Dependant variable false belief

		<i>B</i>	<i>SE B</i>	β	ΔR^2
Step 1	Age	.15	.05	.40**	--
Step 2	Working memory	.30	.11	.39**	.14**
Step 3	Dimensional card sort	.18	.12	.22	.03
Step 4	Complement comprehension	.22	.10	.34*	.08*

* $p < .05$, ** $p < .01$

Discussion

The present thesis is one of the first empirical studies to research potential cognitive differences in behaviourally inhibited preschool children. As previously discussed, research has investigated the relation between shyness and language development, only one study has investigated behavioural inhibition and inhibitory control and no research could be found investigating behavioural inhibition and working memory during preschool development. Behaviourally inhibited children hold back in novel social situations (Kagan, 1997) and it has been shown that these children have heightened physiological reactivity in novel situations (Kagan & Snidman, 1999; Kagan, Reznick & Snidman, 1987). Therefore further research investigating behaviourally inhibited children and cognitive development in the preschool age was needed, especially in relation to their developing social cognition (as the field of Theory of Mind is sometimes called).

The main hypothesis that behavioural inhibition would be positively related to false belief understanding was based on: (a) Dunn's (1995) results indicating that early mentalizing skill development resulted in anxiety behaviours in the early school experience; (b) the fact that research has demonstrated that inhibitory control is positively related to behavioural inhibition, which has been shown to predict children's false belief understanding; and (c) the expectation that children who are behaviourally inhibited may be more focused on behaviour during interaction with unfamiliar peers and adults, and therefore they would be better able to focus on differences between mental states of others and representations of the state of affairs, aiding false belief understanding. Based on the data collected in this thesis, however, this hypothesis was not supported.

The hypothesis that behaviourally inhibited children would have a greater ability to inhibit a response (inhibitory control) was also not supported. There were no differences among the groups on the dimensional card sort task, nor was there a difference between the high BIQ group with the other two BIQ groups on the day/night task.

I did not expect to find differences in working memory or syntax of complementation between children high in behavioural inhibition and those in the low or mid group and no differences were found between the groups in this sample. Furthermore, contrary to hypothesis 3, working memory, syntax of complementation and inhibitory control were not found to either mediate or moderate the relation between behavioural inhibition and false belief.

The null results could be due to: (a) the possibility that children who are high in behavioural inhibition do not develop differently than the other groups in their false belief understanding, inhibitory control, working memory or syntax of complementation; or (b) the possibility that children who are high in behavioural inhibition are developing differently, but that because of the sample or the measures used, I was unable to detect such differences.

To address the first possibility, that children who are high in behavioural inhibition do not develop differently, I have considered each of the reasons in support of the main hypothesis separately. First, although High behaviourally inhibited children may watch and wait before joining in play this may not aid in their false belief understanding. It may be that although false belief understanding requires interaction with other children, the additional watching from the sidelines does not aid in false belief development.

Secondly, although early false belief understanding leads to social anxiety symptoms in the early school experience, this early belief understanding may not be related to behavioural inhibition. It may be that the early false belief understanding in itself creates this type of social anxiety. Children who are advanced in their belief understanding may expect their peers to share this understanding. Incongruence in belief understanding between themselves and their peers may create anxiety because they are unable to communicate effectively with their peers on that level. This inability to relate effectively may create fear in social situations and may lead to social anxiety. It is most likely the case that social anxiety has multiple causes and predictors and that behavioural inhibition may be only one of them.

Thirdly, behavioural inhibition may not be related to inhibitory control. There was only one reported study concerning behavioural inhibition and inhibitory control for this age group. The results of the present study which indicated a lack of differences between groups on inhibitory control contradicts the Thorell et al. (2004) finding that the high BIQ group had greater inhibitory control as measured by the GO No-Go Task.

One possible explanation for not finding the same result is the differences in the measure of inhibitory control between the two studies. The Go-No Go task measured the ability of the child to press a key when seeing a 'go' stimuli (e.g. blue item) and inhibit pressing for a 'no-go' stimuli (e.g. red item). Only the correct number of times the child was able to inhibit pressing a computer key when the 'no-go' stimulus was presented was scored. However, Thorell et al. did not measure the correct number of keys pressed for the 'go' stimulus. The behaviourally inhibited child may have taken longer to press the key in both situations ('go' or 'no-go') and may not have pressed the correct key when

the ‘go’ stimulus was presented. In the present research the child had to make a decision with every card presented with no time pressure. The participants in the present study were scored on the total number of correct sortings. This tests a measure of inhibitory control, with a rule switch component. The Go No-Go task was similar to the dimensional card sort task in that the participants were first instructed to sort (our task) or inhibit (Thorell et al. task) based on one dimension (colour) and then sort or inhibit based on a different dimension (shape). This part of the task measured the participants’ ability to inhibit the instructions for the earlier rule and follow instructions for the second rule. This rule switch task may be measuring a sophisticated inhibitory control ability. Since the Thorell et al. (2004) task did not measure the preswitch trials separately from the postswitch trials nor did they measure the number of correct “go” keys pressed it is difficult to know whether the behaviourally inhibited children were merely not responding (inhibiting) or latent in their responding for *all* stimuli. The dimensional card sort task used in this thesis did not find that there were differences between levels of behavioural inhibition for inhibiting a response to a previous rule when following the present rule.

The present study also did not find a significant difference between the high BIQ group and the mid or low groups in performance of the day/night task. The day/night task requires the child to suppress the first word associated with a picture and say the opposite word. It was interesting to find a difference between the low BIQ and the mid BIQ group with the low BIQ group performing better. It may be that children high in behavioural inhibition do not have greater inhibitory control ability. Further work investigating the

relation between these measures on a different sample is required to address the differences between this study and the Thorell et al. (2004) study.

I did not expect to find a difference between BIQ groups on the syntax of complementation. This finding supports the earlier discussion about language and behavioural inhibition proposing that the differences in research results were due to problems with performance on the language task in an unfamiliar environment rather than a language competence deficit. The task in the present study did not require a great deal of speech production even though it involved expressive communication. The participants did have to express an answer to the question “what did she say?” or “what did she think?” but the response did not require a large production of speech (e.g., one or two word answers would suffice). However, this task did require a somewhat sophisticated level of language comprehension to perform well. It may be that behaviourally inhibited children are competent in their speech ability when performance demands in an unfamiliar environment are limited. However due to sample limitations addressed below further research is required to address this finding.

A number of considerations are outlined below to address the second possibility, which is that children high in behavioural inhibition may have differences in false belief understanding and inhibitory control, but these differences were not evident in the present sample. This thesis is limited in that the sample was selected from daycare centers; preschool children who are cared for in their homes or in home-based day care were not recruited for this study. This consideration may be important in that children high in behavioural inhibition who are in an environment with less opportunity to interact socially may have more difficulties in the area of language and social cognition.

Furthermore, it may be the case that children who score in the highest range for behaviour inhibition may be the very children who are not enrolled in group child care programs because they are too upset by the experience. Therefore, the group sampled may have not included children who would have scored very high on the BIQ. Further research, drawing upon children from a wider range of childcare situations, is required to investigate the impact of the different caregiver environments.

Also due to time and resource limitations and difficulty in recruitment (approx. 15% response rate) this study employed a small sample with 15 participants in each of the BIQ groups. As well, it may be that parents with children at the extreme high end of behavioural inhibition were reluctant to sign their child up for a possibly uncomfortable research project.

Another consideration is that this study used the full BIQ scale, which measures inhibition to novel situations, people and play. A different result may be found if a subset of children who are high in behavioural inhibition in the area of novel social situations is examined. In addition, one measure of Kagan's (1997) work examined the degree to which children fretted or cried in the face of novel experiences. This may be considered a display of negative affect. The BIQ scale (Bishop et al. 2003) did not mention negative affect in any of the questions other than question 18 "gets upset..." It may be that the negative affect component is a key factor for children who are high in behavioural inhibition in relation to cognitive development. If a high behaviourally inhibited child is able to positively overcome a novel situation they may have a more typical cognitive development trajectory than behaviourally inhibited children who are fretful and upset in novel situations. Dunn (1996) reported that children were less likely to use reasoning and

perspective taking when they were experiencing negative affect than when they were experiencing positive affect. Again, further research examining cognitive factors in relation to negative affect and behavioural inhibition is required. The newly developed BIQ scale (Bishop et al., 2003) would aid in this research in that the two factors, behavioural inhibition and negative affect could be examined separately.

A regression analysis was performed to determine whether the false belief predictors (working memory, inhibitory control and syntax of complementation) reported in the literature were similar for this sample. This regression replicated earlier research (Carlson et al. 2002; de Villiers & Pyers, 2002; Perner et al. 2002) in that working memory, and the syntax of complementation were predictors of false belief. However, although both working memory and syntax of complementation added unique variance in predicting false belief, the card sort task was not significant. In addition, the day/night task was not found to be related to false belief for this sample and monkey/tiger and whisper performance were at ceiling for this sample. These findings are not consistent with the finding of Carlson et al. (2002) who found that inhibitory control was predictive of false belief once working memory was controlled. Therefore in this sample, inhibitory control did not predict false belief. However, working memory and syntax of complementation were both significant predictors of competence on the false belief task.

There are two differences in this sample that would explain why the sample did not replicate the findings of Carlson et al. (2002). First, the present sample is a selected sample on the basis of degree of BIQ (although the sample was selected equally throughout the BIQ range, low, mid and high). Secondly, Carlson et al.'s sample ranged from 3 to 6 years of age whereas my sample ranged from 3.5 to 5 years of age. The

Carlson et al. sample therefore had a broader range of scores on the measures of working memory. It is interesting to note that the backward word span task was the only working memory measure that was predictive for the current sample. The backward digit span was found to be a slightly more difficult task for this sample with more children refusing to try or not succeeding beyond the practice trials than for the backward word span task. The fact that the backward word span task uniquely predicted false belief in this study but not in the Carlson et al. study, presents the need to consider differences in outcomes based on the range of ages examined. Looking at one slice of the developmental time period may present different results for predictor variables (e.g., inhibitory control vs. working memory) than when examining a larger developmental range.

The final regression model discussed above supported the work of de Villiers and Pyers (2002) with complement comprehension (total score) uniquely predicting false belief. However, the separate subscales did not replicate the findings that communication verbs predicted false belief on their own. Again, the fact that the present sample was a select sample may have impacted this finding. In addition the measure of false belief in this thesis was a total possible score from 1 to 5, however de Villiers and Pyers used a pass/fail criteria. This may account for the different findings for this sample.

This thesis is important in that it explored a number of aspects of the cognitive development of preschool children in relation to behavioural inhibition. Although no differences were found in the area of false belief understanding, complement comprehension, working memory, and inhibitory control for behaviourally inhibited children, these results contribute to the literature concerning behavioural inhibition, shyness, social anxiety and false belief development. Further research is needed

especially in the areas of working memory and inhibitory control in order to better understand this population.

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Appendix A

Behavioural Inhibition Questionnaire (Parent Form)

The following statements describe children's behaviour in different situations. Each statement asks you to judge whether that behaviour occurs for your child "*hardly ever*", "*infrequently*", "*once in a while*", "*sometimes*", "*often*", "*very often*", or "*almost always*". Please circle the number "1" if the behaviour "*hardly ever*" occurs, the number "2" if it occurs "*infrequently*", etc. Try to make this judgment to the best of your ability, based on how you think your child compares with other children about the same age.

	1	2	3	4	5	6	7
	Hardly Ever	Infrequently	Once in a While	Sometimes	Often	Very Often	Almost Always
1. Approaches new situations or activities very hesitantly					1	2	3 4 5 6 7
2. Will happily approach a group of unfamiliar children to join in their play					1	2	3 4 5 6 7
3. Is very quiet around new (adult) guests to our home					1	2	3 4 5 6 7
4. Is cautious in activities that involve physical challenge (e.g., climbing, jumping from heights)					1	2	3 4 5 6 7
5. Settles in quickly when we visit the homes of people we don't know well					1	2	3 4 5 6 7
6. Enjoys being the centre of attention					1	2	3 4 5 6 7
7. Is comfortable asking other children to play					1	2	3 4 5 6 7
8. Is shy when first meeting new children					1	2	3 4 5 6 7
9. Happily separates from parent(s) when left in new situations for the first time (e.g., kindergarten, preschool, childcare)					1	2	3 4 5 6 7
10. Is happy to perform in front of others (e.g., singing, dancing)					1	2	3 4 5 6 7
11. Quickly adjusts to new situations (e.g., kindergarten, preschool, childcare)					1	2	3 4 5 6 7
12. Is reluctant to approach a group of unfamiliar children to ask to join in					1	2	3 4 5 6 7

Continued next page

1	2	3	4	5	6	7				
Hardly Ever	Infrequently	Once in a While	Sometimes	Often	Very Often	Almost Always				
13. Is confident in activities that involve physical challenge (e.g., climbing, jumping from heights)				1	2	3	4	5	6	7
14. Is independent				1	2	3	4	5	6	7
15. Seems comfortable in new situations				1	2	3	4	5	6	7
16. Is very talkative to adult strangers				1	2	3	4	5	6	7
17. Is hesitant to explore new play equipment				1	2	3	4	5	6	7
18. Gets upset at being left in new situations for the first time (e.g., kindergarten, preschool, childcare)				1	2	3	4	5	6	7
19. Is very friendly with children he or she has just met				1	2	3	4	5	6	7
20. Tends to watch other children, rather than join in their games				1	2	3	4	5	6	7
21. Dislikes being the centre of attention				1	2	3	4	5	6	7
22. Is clingy when we visit the homes of people we don't know well				1	2	3	4	5	6	7
23. Happily approaches new situations or activities				1	2	3	4	5	6	7
24. Is outgoing				1	2	3	4	5	6	7
25. Seems nervous or uncomfortable in new situations				1	2	3	4	5	6	7
26. Happily chats to new (adult) visitors to our home				1	2	3	4	5	6	7
27. Takes many days to adjust to new situations (e.g., kindergarten, preschool, childcare)				1	2	3	4	5	6	7
28. Is reluctant to perform in front of others (e.g., singing, dancing)				1	2	3	4	5	6	7
29. Happily explores new play equipment				1	2	3	4	5	6	7
30. Is very quiet with adult strangers				1	2	3	4	5	6	7

Appendix B

False Belief: Change of Location

Materials: boy doll, girl doll, white box, polka-dot box, small ball

- This little girl's name is Jill, and she is playing with a ball. When she was done playing with it, she put it in the white toy box and then went outside to play.
 - While she was playing outside, her friend Peter found the ball and put it in the polka-dot toy box. Then he went away to do something else.
 - Where did Jill put her ball? [white box] _____
 - Where is the ball now? [polka-dot box] _____
 - A little while later, Jill came back from playing outside. She wanted to play with the ball again.
 - Where will Jill first look for the ball? [white box] _____
 - Why will she look there? _____
-

False Belief: Unexpected Contents

Materials: Band-aid box containing pencils.

Look at this, what do you think is in this box? [Band-Aids] _____

Here, why don't you open it up? What's in there? [pencils] _____

Okay, let's close it up and put it back over here.

So, what's really in the box? [pencils] _____

Before we opened the box, what did you first think was in the box?

[Band-Aids] [pencils] _____

If I showed this to [name of friend in class], what would [friend] think was in the box before I opened it? [Band-Aids] [pencils] _____

Unexpected Contents – Crayon box

Materials: Crayon box containing Stickers.

Look at this, what do you think is in this box? [Crayons/Markers/Colours]

Here, let's open it up? What's in there? [Stickers] _____

Okay, let's close it up and put it back over here.

So, what's really in the box? [Stickers] _____

Before we opened the box, what did you first think was in the box?
[Crayons/Markers/Colours] [Stickers]

If I showed this to [name of friend in class], what would [friend] think was in the box
before I opened it? [Crayons/Markers/Colours] [Stickers] _____

Appendix C

Whisper**EXPERIMENTER WHISPERS FOR ENTIRE TASK.**

Now we're going to play the Whisper game. Can you whisper your name? ...Good.

[yes] [no]

I'm going to show you some pictures. I want you to tell me who's in the picture, and I want you to whisper. If you don't know who's in the picture, that's OK. Just say "I don't know", but keep whispering. Ready?

Show pictures: Dora the explorer, Elmer Fudd, Nemo, Petunia, Sponge Bob Square Pants, Mickey Mouse, Huckle, Blue, Calimero, Caillou.

	Shout	Normal	Whisper
1)	0	1	2
2)	0	1	2
3)	0	1	2
4)	0	1	2
5)	0	1	2

Correct	Incorrect	Don't know	
			(1)
			(2)
			(3)
			(4)
			(5)

Say, "Remember to whisper."

	Shout	Normal	Whisper
6)	0	1	2
7)	0	1	2
8)	0	1	2
9)	0	1	2
10)	0	1	2

Correct	Incorrect	Don't know	
			(6)
			(7)
			(8)
			(9)
			(10)

Appendix D

Day/Night

Now we're going to play a different game.

- **SHOW MOON.** This looks like night, right? When you see this picture, I don't want you to say 'night'. No, I want you to say 'day'.
- **REMOVE MOON; SHOW SUN.** This looks like day, right? When you see this picture, I don't want you to say 'day'. No, I want you to say 'night'.

Training

- **SHOW SUN.** (IF HESITATION, What do you say for this one?)
- [D] [N] (Good.)
- **SHOW MOON.** (IF HESITATION, What do you say for this one?)
- [D] (Good.) [N]

IF WRONG OR NO RESPONSE ON EITHER ONE, REPEAT RULES AND TRAINING. MAX. OF 3 TRAINING SESSIONS.

1.	D	N
2.	D	N
3.	D	N
4.	D	N
5.	D	N
6.	D	N
7.	D	N
8.	D	N

9.	D	N
10.	D	N
11.	D	N
12.	D	N
13.	D	N
14.	D	N
15.	D	N
16.	D	N

Appendix E

Monkey/Tiger

Can you do these things with me? [**CHECK OFF THE ONES CHILD CAN DO.**]

Stick out your tongue
Touch your teeth
Clap your hands
Touch your head
Touch your nose

Touch your ears
Touch your eyes
Touch your feet
Touch your tummy
Wave your hand

RULES

This is a nice Monkey. So when he talks to us, we will do what he tells us to do.
This is a naughty Tiger. So when he talks to us, we won't listen to him. If he tells us to do something, we won't do it.

TRAINING

MOVING MONKEY'S MOUTH (HIGH-PITCHED VOICE): Touch your (nose). full (0) partial (1) wrong (2) none (3)
MOVING TIGER'S MOUTH (LOW, GRUFF VOICE): Touch your (tummy). full (0) partial (1) wrong (2) none (3)

IF MOVEMENT ON TIGER TRIAL, REPEAT RULES AND TRAINING. MAX. OF 5 TRAINING SESSIONS.

TESTING

	Full	partial	wrong	none
1 Monkey: Stick out your tongue	0	1	2	3
2 Monkey: Touch your ears	0	1	2	3
3 Tiger: Touch your teeth	0	1	2	3
4 Monkey: Touch your eyes	0	1	2	3
5 Tiger: Clap your hands	0	1	2	3

REPEAT RULES

6 Tiger: Touch your feet	0	1	2	3
7 Tiger: Touch your head	0	1	2	3
8 Monkey: Touch your tummy	0	1	2	3
9 Monkey: Touch your nose	0	1	2	3
10 Tiger: Wave your hand	0	1	2	3

Appendix F

Backward Digit Span (One digit per second)

"Monkey is being silly. Whenever I say numbers, Monkey says them backwards. Listen.

E: **5 – 8**. Monkey: **8 – 5**. I want you to do the same as Monkey and say my numbers backwards. Do you understand? Let's try one. Ready? Listen carefully. Remember to say the numbers backwards. **2 – 4**."

If incorrect: "Monkey says **4 – 2**, and you should too. Remember, I said **2 – 4**. To say **2 – 4** backwards, you would say **4 – 2**."

"Let's try another one. Ready? Listen carefully. Remember to say the numbers backwards. **7 – 1**."

If incorrect: "Monkey says **7 – 1**, and you should too. Remember, I said **7 – 1**. To say **7 – 1** backwards, you would say **1 – 7**."

	<u>Digits Forward</u>	<u>Child's Response</u>
i.	2 – 4	_____ – _____
ii.	7 – 1	_____ -- _____
<hr/>		
1.	6 – 3	_____ – _____
2.	4 – 9	_____ – _____
3.	2 – 9 – 5	_____ – _____ – _____
4.	8 – 1 – 6	_____ – _____ – _____
5.	8 – 5 – 2 – 6	_____ – _____ – _____ – _____
6.	4 – 9 – 3 – 7	_____ – _____ – _____ – _____
7.	8 – 1 – 3 – 7 – 9	_____ – _____ – _____ – _____ – _____
8.	4 – 2 – 5 – 8 – 1	_____ – _____ – _____ – _____ – _____

Appendix G

Backward Word Span (One word per second)

"Monkey is being silly. Whenever I say words, Monkey says them backwards. Listen. E: **Chair—Cake**. Monkey: **Cake—Chair**. I want you to do the same as Monkey and say my words backwards. Do you understand? Let's try one. Ready? Listen carefully. Remember to say the words backwards. **Girl—Four**."

If incorrect: "Monkey says, **Four — Girl**, and you should too. Remember, I said **Girl—Four**. To say **Girl—Four** backwards, you would say **Four—Girl**."

"Let's try another one. Ready? Listen carefully. Remember to say the words backwards. **New—Grass**."

If incorrect: "Monkey says, **Grass—New**, and you should too. Remember, I said **New —Grass**. To say **New —Grass** backwards, you would say **Grass —New**."

<u>Words Forward</u>	<u>Child's Response</u>
i. Girl — Four	_____ - _____
ii. New — Grass	_____ -- _____
<hr/>	
1. Doll — Cat	_____ - _____
2. Book — Run	_____ - _____
3. Cold — Go — Song	_____ - _____ - _____
4. Frog — Boy — Time	_____ - _____ - _____
5. Ant — Ball — Fly — Big	_____ - _____ - _____ - _____
6. Bag—Stop—Fence—Eat	_____ -- _____ -- _____ -- _____
7. Bird—Full—Shoe—Yes—Cow	_____ -- _____ -- _____ -- _____ -- _____
8. Rain—Good—Door—Jar—Leaf	_____ -- _____ -- _____ -- _____ -- _____

Appendix H

Counting and Labeling

- Point at each toy as mentioned

Set out Fish, Train and Pig.

"I'm going to name these toys:"

"Fish." "Train." "Pig."

"Now I'm going to count them."

"One." "Two." "Three."

"Now I'm going to count and name them at the same time:"

"One is a fish." "Two is a train." "Three is a pig."

Set out Bee, Car and Duck.

"It's your turn now. Can you name these toys?" (correct if needed)

"Can you count them?" (correct if needed)

"Now count and name them at the same time." (do not correct)

☐

(√ or x)

Set out Dog, Truck and Star

"It's your turn now. Can you name these toys?" (correct if needed)

"Now count them." (correct if needed)

"Now count and name these toys at the same time." (do not correct)

☐

(√ or x)

Appendix I

Complement Comprehension

Materials: Binders with pictures

Protocol: Read the story pointing to the important objects in each pictures. Point again to the first picture when asking the question.

1. What-think (other)

She thought the girl was reading a book, but she was really playing cards.

What did she think? _____

2. What-tell (other).

She told the girl there was a bug in her hair, but it was only a leaf.

What did she tell the girl. _____

3. What-tell (self)

She told her husband she saw a ghost, but it was really a blanket.

What did she tell her husband? _____

4. What-think (self).

She thought she had a hole in her pants, but it was really a piece of paper.

What did she think? _____

5. What-tell (other)

She told her dad he had a cut, but it was really ketchup

What did she tell her dad? _____

6, What-tell (self)

She told the teacher she drew a face, but it was really a scribble,

What did she tell the teacher? _____

7. What-think (other)

She thought her friend was eating an egg, but it was really a ball.

What did she think? _____

8. What-think (self)

She thought there was a spider in her cereal, but it was really a berry.

What did she think? _____