THE RELATIVE CONTRIBUTIONS OF VERBAL ABILITY AND INHIBITORY CONTROL TO THEORY OF MIND IN PHYSICAL AND AFFECTIVE DOMAINS

by

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(Under the Direction of Patricia Miller)

ABSTRACT

Theory of mind (ToM) is the ability to attribute mental states to other people that may or may not differ from reality. However, much of the literature on ToM is devoted to tasks that measure false belief understanding in regard to beliefs about objects. This study looks at the role of verbal ability and executive function in physical and affective domains. Results indicate that verbal ability, measured through Mean Length of Utterance (MLU), was predictive of affective, but not physical tasks. Executive functioning was not predictive of tasks in either domain. The role of embedded mental states and implications to theory theory are discussed.

INDEX WORDS: Theory of mind, Verbal ability, Inhibitory control, Executive functioning, Mean length of utterance, Theory theory

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DEDICATION

This thesis is dedicated to my parents, Dan and Maureen Baran, who believed in me even when I didn't. It is also dedicated to Jason, who always acted fascinated, even when he wasn't.

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CHAPTER 1

INTRODUCTION

THE CONTRIBUTION OF VERBAL ABILITY AND INHIBITORY CONTROL TO FALSE BELIEF UNDERSTANDING IN AFFECTIVE AND PHYSICAL DOMAINS

Between the ages of 3 and 5, a child's thinking is transformed by an understanding that people have representations of the world that may or may not correspond to reality. This theory of mind (ToM) permits the understanding that others have beliefs and desires different from one's own. The development of ToM has been shown to be related to later adaptability to different circumstances (Dunn, 1995), peer acceptance (Slaughter, Dennis, & Pritchard, 2002), school success (Lalonde & Chandler, 1995), and positive social skills (Watson, Nixon, Wilson, & Capage, 1999).

Multiple factors contribute to ToM, including number of siblings (Jenkins & Astington, 1996), verbal ability (Astington & Jenkins, 1995), executive functioning (Carlson & Moses, 2001; Perner & Lang, 2000), maternal language (de Rosnay, Pons, Harris, & Morrell, 2004), and parenting style (Ruffman, Perner, & Parkin, 1999). The purpose of this study was to examine the effects of two of these factors, namely verbal ability and inhibitory control, on individual differences in ToM.

ToM has been implicated in social ability, but for the most part has been tested without a social context. The false belief task, coined by Wimmer and Perner (1983), has been the benchmark for testing ToM in preschoolers. It takes various forms, all of which test the child on the ability to attribute a false belief to self or other. For example, a character has a belief (albeit

false) about an object's contents (Perner, Leekam, & Wimmer, 1987), reality (Flavell, Green, & Flavell, 1986), or location (Wimmer & Perner, 1983). However, in all cases, the target question revolves around the false mental representation of an object. Thus, the second purpose of this study is to explore the relative contributions of language and inhibitory control to understanding false beliefs about objects versus emotions.

Affective Versus Physical False Belief Tasks

To assess whether ToM is an indicator of later developing social skills, it is necessary to use a task with social content. Few studies have looked at false belief understanding in a social context (for exceptions, see Davis, 2000; Friend & Davis, 1993; Gross & Harris, 1988). "Affective False Belief Tasks", coined by Gross and Harris (1988), involve a referent of emotion, rather than an object. Following the 'appearance/reality' format, the child has to attribute a false belief to a protagonist about another character's emotion. They found that false belief understanding in the affective domain was limited prior to age 6, while tasks in the physical domain were being passed much earlier.

Friend and Davis (1993) also found that children are able to attribute a false belief about an emotion later than a false belief about an object. In their study, children between the ages of 3 and 8 were tested on affective and physical tasks using the same 'appearance-reality' format. Age predicted success on both the physical and affective false belief tasks. However, significant differences between physical and affective tasks were found only when greater inference was needed to pass the affective tasks. Thus, task factors are important.

In a follow up study, Davis (2000) noted that using an 'unexpected contents' format for both affective and physical tasks resulted in equal performance across domains. Davis noted that this format allows for less inference of the target emotion from the child, and thus increases

success. Moreover, embedding both tasks in a meaningful context increased the chances of a child passing the false belief tasks. Thus, when the contexts are closer to 'real world' situations where false belief understanding will be used, children pass tasks in a more equal manner.

Other lines of ToM research have examined emotion recognition through false beliefs (de Rosnay et al., 2004). In these experiments, the child must indicate the protagonist's feelings in regard to a falsely held belief. de Rosnay et al. (2004) confirmed earlier findings that a child's ability to attribute an emotion about a false belief emerges later than, and only after, the ability to attribute a false belief. They posited that the apparent lag between false belief understanding and emotion attribution may be due to individual differences in a child's linguistic ability. Further, a mother's input may facilitate social cognition and, therefore, emotion recognition (2004).

Verbal Ability

Passing a false belief task apparently requires the possession of an adequate level of verbal ability and inhibitory control skills to complete the task. Further, it seems logical to assume that individual differences in verbal ability and inhibitory control skills would be predictive of false belief success across domains. However, such skills may contribute much more than task performance. Much research to date has looked at the relative contributions of linguistic ability on false belief understanding *per se* (Astington & Jenkins, 1995; de Villiers & Pyers, 2002; Happe, 1995).

Astington (2001) indicates that language is not predictive merely of task performance on the standard false belief task, but of the development of theory of mind itself. This is consistent with Ruffman's (2000) indication that general language ability allows children to formalize preexisting knowledge of other's minds. Empirically, Astington and Jenkins (1995) found that children who pass standard false belief tasks use different language when assigning roles for

pretend play to those they feel possess a different knowledge of the pretense. Further, significant correlations between ToM and social abilities often disappear when language is partialed out (Cassidy, Werner, Rourke, Zubernis, 2003). Clinically, children with autism who are able to pass ToM tasks often possess higher language ability (Happe, 1995).

Specific aspects of language ability have been implicated in ToM development. Astington and Jenkins (1999) found that syntax, as measured in the TELD, was significantly related to success in false belief tasks. Semantics were not found to be related to false belief task success (1999). Within syntax, specific linguistic constructs have been shown to contribute to task performance. de Villiers and de Villiers (2000) note that sentential complements allow for embedded propositions behind a verb. Specifically, verbs of mental states give rise to a sentential structure that allows for a main clause to be true while the embedded clause may be false (e.g. Sally *thought* that candy was inside of the container). de Villiers and de Villiers (2000) have found in a longitudinal study that an early understanding of sentential complements predicts later ToM success. Later studies by de Villiers and Pyers (2002) found that a general language ability captured sentential complement understanding and theory of mind success.

A recent study by Hughes, Jaffee, and Happe highlights the strength of the relationship between verbal ability and ToM (2005). In this large twin study (n = 1,116 pairs), verbal ability and ToM success were strongly linked. Shared environmental influences accounted for much of the consistency seen in false belief understanding. Further, the genetic factors that accounted for ToM differences were those that were also responsible for verbal ability. Thus, environmental influences and level of linguistic ability lead to individual differences in false belief understanding. This study confirms other studies that point to maternal mental-state talk as a predictor of false belief understanding (de Rosnay et al., 2004) and of sibling relationships

(Jenkins & Astington, 1996). If shared environment is predictive of false belief understanding, exposure to language and mental state talk will be a good indicator of ToM success.

Inhibitory Control

Executive functioning, including goal-directed planning, inhibitory control, and flexibility, also plays a role in ToM development in the physical domain (Carlson, 1997). Lang and Perner (2002) describe the role of executive functioning in ToM as the ability to understand that evoking false action schemas can result in actions that are fruitless. The ability to think in a goal-directed manner will aid in mental state representation and thus the child's understanding of the causal link between thoughts and action (Perner, 1991). Further, the ability to inhibit one's own knowledge in favor of that of a less-knowledgeable person is necessary for realizing that others have a false belief (Pillow & Weed, 1997). Later developing positive correlates of ToM, such as adaptability to different situations, may be due to executive functions of cognitive flexibility.

Executive functions have been implicated in ToM development, because correlations remain significant when the contributions of age and verbal ability are removed (Carlson, Moses, & Claxton, 2004; Hughes, 1998). The robust effects of executive functioning tasks on ToM success are not simply indicative of the task demands. Moses and Carlson (2004) propose that children's development of self-regulation in the preschool period aids their attention to features that are not salient in the context. They explain the robust effects of executive functioning on ToM success as an enabling, rather than a 'performance,' factor.

Two executive functions given much attention in the ToM literature are inhibitory control and planning. Carlson et al. (2004) looked at ToM success as related to these two functions. Using standard physical false belief tasks, they found that inhibitory control was more predictive

of ToM scores, even when age and vocabulary were taken into account. Further, they found that conflict inhibition measures, whereby a child has to hold in mind the rules while inhibiting a prepotent response, were significantly related to false belief understanding more than delay inhibition tasks. Keeping this in mind, the present study only uses control inhibition measures.

The literature on executive functioning in ToM has used only tasks in the physical domain. Perhaps because of the emphasis on cognitive means to explain ToM development, none have looked at executive functions when tasks are embedded in a social context, but rather use an object-oriented task. It is apt to apply executive functions to affective false belief understanding, because in real world applications of ToM, one must understand the goal-oriented actions of others and be able to inhibit one's own knowledge of the situation.

The present study investigates the relative contributions of language ability and inhibitory control to false belief understanding in the physical and affective domains in 4-year-olds. Based on Davis (2000), children at this age have a fledgling understanding of mind and have also learned to mask their emotions. They can call upon such knowledge when answering ToM questions across domains. Additionally, by 4 years, many children are performing ToM tasks consistently at or above chance levels in the physical domain.

The examination of the affective domain is particularly important because few studies have looked at false beliefs about emotions. It is predicted that physical and affective false belief tasks will require the same level of executive control, but that affective tasks will require a higher language ability. The latter prediction is based on the proposal that affective false belief understanding requires one mental state embedded in another. de Villiers and Pyers (2002) have shown that more advanced verbal ability is necessary for the increased difficulty of embedded mental states.

CHAPTER 2

METHOD

Participants

Forty preschoolers (*M* age = 4.25) participated in this study as part of a larger longitudinal study at a large Southeastern university. The sample consisted of 23 boys and 17 girls. Ninety percent were white and the rest were minorities. Parents received $30 and a copy of the videotaped session for participation in the study.

Procedure

Children were tested individually in a laboratory setting for affective and physical ToM tasks and inhibition measures as part of a single 3 hour session that was videotaped. Due to the longitudinal nature of the study, measures were presented in a fixed order, with affective false belief procedures coming first, executive control following, and physical false belief procedures last. Three parts of the session were transcribed later for verbal assessment. They are described in detail in the following section.

Measures and Materials

Verbal Ability. Verbal ability was assessed using Mean Length of Utterance (MLU), a standard way of assessing verbal complexity in young children (Brown, 1972). MLU has been shown to be a reliable method of capturing differences in general verbal ability in preschoolers (de Villiers & Pyers, 2002). de Villiers and Pyers (2002) note that MLU, although assessing quantity, captures differences that are correlated with syntactically and semantically focused tests. Three separate parts of the session were transcribed by two independent raters for a total of

45 minutes of a child's speech. Two parts were opportunities for spontaneous speech (an unstructured free play and a snack time) and the last part was story completion of the MacArthur Story Stem Battery (Bretherton, Oppenheim, Buchsbaum, Emde, & the MacArthur Narrative Group, 1990). Utterances were determined by the natural breaks in the child's language. A mean length score was established.

False Belief Tasks. Four different affective and two different physical false belief tasks were administered. All tasks followed an 'unexpected contents' format (Perner, Leekam, & Wimmer, 1987), whereby a protagonist does not know that the true contents of a container (or an individual) that differs from that suggested by the container (e.g. a candy container holding a toy fish). A score of one was given for each time both control questions and ToM questions were answered correctly. A total score of four was possible for the affective tasks. Examples are provided in the appendix.

Card Sort. The card sort is a version of the Wisconsin Card Sort, which is used to test for frontal lobe damage in children, whereby a child must inhibit the first rule in favor of a new rule (Frye, Zelazo, & Palfai, 1995). Two sets of cards (2" x 2") were used. Each set of cards contained two target cards, each affixed to a small plastic container into which the test cards were placed. There were twelve test cards; three with red sailboats, three with blue sailboats, three with red teddy bears, and three with blue teddy bears. Each trial consisted of a preswitch and postswitch phase.

In the preswitch phase, children were given the rules of the game. The experimenter explained, "Now we are going to play a SHAPE game. If the card shows a blue one, put it in here. If it's a red one, then it goes here. This is a blue teddy bear, where does it go?" Children receive feedback after each trial. Then, in the postswitch phase, the children were given a new

set of rules. The experimenter explained, “Now we are going to play a COLOR game. If the card shows a teddy bear, put it in here. If it’s a sailboat, then it goes here.” Children receive no feedback in the postswitch phase.

Animal Stroop Task. The Animal Stroop Task is a developmentally-appropriate measure of inhibition in children (Wright, Waterman, Prescott, & Murdoch-Eaton, 2003). Following a standard stroop task administration, an animal’s body is matched with an incongruent head. The children are asked to name the less salient body of the animal. To explain the rules, experimenters presented four pictures and asked children to indicate the body of the animal. Next, a circle was put in place of the head of the animal and children were once again asked to name the animal’s body. For the test phase, 12 cards with incongruent heads were presented and children were asked to name the body. If a child incorrectly named the animal’s head, the rules were told to the child. Scores were based on number of items correct, rather than response time, for a total possible score of 12.

Tray of Toys. To assess inhibition of excitement, children were presented with a tray of toys and asked to simply name the desired toy (Kochanska, Murray, & Harlan, 2000). The children were asked to sit with their hands on their laps and then the experimenter explained, “I have a tray of toys here, when I lift off the cover, can you just tell me what toy you would like”. Children were given a score based on their response, with 0 = grabbing toy; 1 = touching toy; 2 = pointing to toy; 3 = hands leaving lap; 4 = following directions.

CHAPTER 3

RESULTS

Preliminary Results

Table 1 presents the means, standard deviations, and ranges of performance on the various measures. Because preliminary analyses indicated that gender was not significant, gender was not examined in subsequent analyses. Below are presented the correlational tests of the specific questions asked in the study.

Affective vs. Physical

The first question examined is: does performance differ across affective and physical false belief tasks? Children performed above chance on the physical tasks (mean of 66% of tasks correct). Children performed below chance on affective tasks (mean of 41% of tasks correct). A paired-sample t-test done on proportions revealed that children performed significantly better on physical tasks ($M = .66$, $SD = .36$) than affective tasks ($M = .41$, $SD = .32$), $t(39) = 3.95$ $p < .001$. To explore a potential fatigue effect and to equate the range of scores for affective tasks (4 tasks) with the physical tasks (2 tasks), the second and fourth affective tasks were dropped because they were less equivalent to the physical tasks than were the other two tasks. In so doing, the mean success rate for affective tasks increased to chance level, at 50%. T-tests still yielded significant results, $t(39) = 2.31$, $p < .05$. Thus, tasks differed both when the ranges were unequal, and when the ranges across domains were equated and the tasks were more similar. Nonparametric test were also performed and yielded similar results.

Follow up question: Are a greater proportion of children passing the physical tasks or passing the affective tasks? A mean split was done on tasks in each domain to create a pass/fail dichotomous variable. Fifty three percent of children passed the physical tasks, while 47 percent passed the affective tasks. These percentages were not significantly different from one another based on the Sign test of dependent proportions, $p = .12$.

The second question examined was: is there a significant relationship between affective and physical tasks? A significant correlation was found between false belief success in the affective and physical domains (Kendall's $W = .319$, $p < .05$). Again, the number of tasks was equated and correlations remained significant ($r = .313$, $p < .05$). Correlations also remained significant when age was accounted for ($r = .325$, $p < .05$). Thus, performance across tasks is related.

Verbal Ability

The third question is: was there a relationship between verbal ability and scores in affective and physical tasks? A significant correlation was found between verbal ability and the affective score (Kendall's $W = .353$, $p < .05$), but not between verbal ability and physical scores (Kendall's $W = .280$, $p = .080$). When controlling for age, the correlation between verbal ability and affective scores remained significant ($r = .380$, $p < .05$). Again, to ensure that range was not a possible reason for the correlation, the number of tasks was equated. Correlations between verbal ability and affective tasks remained significant ($r = .326$, $p < .05$). Thus, verbal ability was related to scores in the affective tasks, but not in the physical tasks.

Inhibitory Control

The fourth question asked was: is there a relationship between the individual tasks used to capture inhibitory control? Z-scores were created for all three of the inhibitory control

measures. None of the inhibitory control measures correlated with each other. The animal stroop task did not correlate with either the tray of toys (Kendall's $W = .04$, $p = .79$) or the card sort (Kendall's $W = .06$, $p = .65$). The tray of toys and card sort also did not correlate (Kendall's $W = -.01$, $p = .97$). No ceiling or floor effects were noted for any of the tasks. Thus, it appears that the three tasks chosen to capture inhibitory control were unrelated.

The fifth question asked was: is there a relationship between inhibitory control and affective or physical tasks? As all inhibition measures were based on physical inhibition, to increase the range of scores, a composite inhibitory control score was created by summing the z-scores across the three tasks ($M = .00$, $SD = 1.76$, $Range = 7.46$). Correlations between the composite inhibitory control score in both physical (Kendall's $W = .117$, $p = .36$) and affective (Kendall's $W = -.09$, $p = .45$) tasks were nonsignificant. Thus, there was no relation between inhibitory control in either the physical or affective tasks.

Interaction of Verbal Ability and Inhibitory Control.

The sixth question asked was: do verbal ability and inhibitory control interact to affect performance on false belief tasks? A hierarchical regression analysis was conducted to predict the ToM success from verbal ability, inhibitory control, and the interaction of verbal ability and inhibitory control. The criterion variable was a composite ToM score based on z-scores from affective and physical tasks. The results of this analysis indicated that verbal ability accounted for a significant amount of the ToM variability, $R^2 = .15$, $F(1, 38) = 6.80$, $p < .05$, indicated that children with higher verbal ability tended to perform better on ToM tasks.

A second step evaluated whether ToM success was based on inhibitory control. The results of this analysis indicated that inhibitory control did not account for a significant amount of ToM variability, R^2 change = .002, $F(1, 37) = .10$, $p = .75$. These results are consistent with

previous results, indicating that children with greater inhibitory control do not perform better on ToM tasks.

The third step evaluated whether the interaction of verbal ability and inhibitory control predicted ToM success over and above those of either verbal ability or inhibitory control. Results were nonsignificant, R^2 change = .002, $F(1, 36) = .09$, $p = .77$, indicating that the interaction of verbal ability and executive control had no effect on ToM scores.

An additional analysis was conducted to predict the composite ToM score from the reverse order of interaction effects, inhibitory control, and verbal ability. Once again, only verbal ability was predictive of ToM success. These findings are consistent with previous tests.

Table 1: *Means, Standard Deviations, and Ranges Across Tasks*

Task	*M*	*S.D.*	Range
Affective FB			
range of 4	1.65	1.27	0-4
range of 2	1.00	.78	0-2
Physical FB	1.33	.73	0-2
Animal Stroop Task	8.45	3.09	1-12
Card Sort	4.10	1.32	0-5
Tray of Toys	2.35	1.55	0-4
Exec Functioning	14.90	3.73	6-21
Verbal Ability (MLU)	5.71	.74	3.82-7.61

Table 2. *Correlations between Affective FB, Physical FB, Verbal Ability, and Executive Functioning.*

	1	2	3	4
1. Affective FB	--			
2. Physical FB	.319*	--		
3. Verbal Ability	.353*	.280	--	
4. Executive Fn.	-.072	.172	.139	--

* $p < .05$

CHAPTER 4

DISCUSSION

The results now will be discussed in terms of the main questions of the study. Following that, implications and limitations will be presented.

Affective Versus Physical False Belief Tasks

This study explores the contributions of verbal ability and inhibitory control on false belief understanding in physical and affective domains. Results indicate that success across the two domains is correlated, suggesting that they may be assessing the same, or related, ToM concepts. Overall, children at 4 years tend to do better on physical tasks than on affective. This finding contradicts Davis's (2000) findings, which indicate that children succeed on tasks in both domains concurrently when an 'unexpected contents' format is used. A potential reason for this may be that Davis used a large sample. Adding more participants may account for this difference. Another reason for the success on physical over affective tasks may be that the two tasks, though following the same format, are not completely equal. The affective tasks required a story format, whereas the physical tasks did not. The story in the affective tasks may have led to worse performance due to the amount of attention needed to infer the correct answer.

Verbal Ability

As hypothesized, results indicate that verbal ability predicted ToM success in affective tasks among 4-year-olds. This finding is consistent with the literature on verbal ability in ToM in physical domains. However, results indicating that verbal ability was not predictive of ToM success in the physical domain are inconsistent with previous literature. The most obvious difference between previous studies and the current study is that others have used a variety of

formats of ToM, while this study only used 'unexpected contents' in order to equate tasks across domains. It may be that the 'unexpected contents' format requires an advanced language ability in the affective domain, but not the physical domain. That is, the two tasks may have different demands on language skills.

Also, the relationship between verbal ability and affective success may be due to task demands. While both the physical and affective tasks were in an 'unexpected contents' format, the affective tasks were embedded within a story, while the physical tasks were not. Thus, advanced verbal ability may be necessary for understanding the story that surrounded the affective tasks. It should be noted that, in contrast to language comprehension, the verbal demands of production were minimal in both tasks, because children only had to produce one word answers (e.g. happy/sad or fish/candy).

Alternatively, the effect on affective versus physical tasks may not be due to task demands at all. According to Ruffman (2000), an increased verbal ability gives children the ability to formalize their understanding of mental states. Further, de Villiers and Pyers (2002) point out that understanding of sentential complements, which allow for prediction of mental states, develops sometime during the preschool period. It may be that verbal ability was predictive of affective task success because high-verbal children could better formalize their understanding of emotional states embedded within mental states. Thus, higher verbal ability would be correlated with a higher affective score, because greater understanding of embedded mental states would be necessary. This embedding of one mental state inside another mental state was not present in the physical tasks.

Inhibitory control

Inhibitory control was not predictive of task performance in either domain. Inhibitory control only approached significance in the physical domain. This is inconsistent with much of the research on executive functioning and ToM. Once again, format may account for the nonsignificance, as much of the research on inhibitory control has been done on another type of task or composite scores of various types of tasks. Perner, Lang, and Kloo (2002) used 'change of location' tasks and found robust correlations with the adapted version of the Wisconsin Card Sort. Likewise, Moses and Carlson (2000) used 'change of location' tasks to find significance with inhibitory control. However, later analyses by Carlson, Moses, and Breton (2002) used two 'unexpected contents' tasks, but lumped the score with one 'change of location' task. Significant correlations were found, suggesting that the contents tasks had some relation to inhibitory control. Independent analyses of each type of tasks were not done. Lastly, Carlson, Moses, and Claxton (2004) once again used one 'unexpected contents' task, along with 'appearance-reality' tasks and used the composite score. Thus, the contribution of inhibitory control looking at only an 'unexpected contents' format has not yet been established. The current study suggests that these task differences are worth exploring in more depth. The effect of inhibitory control on theory of mind tasks may not be as general as believed.

Another possible explanation for the apparent lack of contribution of executive function to false belief understanding in the present study is the nature of the inhibitory control tasks themselves. While all examine inhibition, whereby a rule must be kept in mind while a prepotent response is suppressed, they may be tapping different dimensions of inhibitory control. The animal stroop task, while requiring inhibition, does not require a motor response.The tray of toys task requires general motor inhibition. Similarly, the card sort requires the child to inhibit one motor response in favor of another. Indeed, children performed better on some executive

function tasks than others, specifically, 82%, 71%, and 58% correct performance for the card sort, animal stroop task, and toys on a tray, respectively. Moreover, the high performance on the card sort, and modest performance on ToM tasks suggest that cognitive flexibility on the card sort—switching from one dimension to another—is not an executive function that is sufficient for ToM tasks.

One possible contributor to the lack of effect of inhibitory control is that children may have become fatigued over time. The three tasks were embedded within a battery of tasks that were all tapping aspects of inhibition. All three tasks followed one right after another, with the card sort coming first, the animal stroop second, and the tray of toys third, with 82%, 71%, and 58% correct, respectively. Children are doing worse, the more inhibition tasks they have completed. Having completed ten inhibition tasks by the time that the tray of toys was presented perhaps stretches many 4-year-olds' limits. However, closer examination indicates that the performance on each individual task was consist with that found in other's research (Kochanska, Murray, & Harlan, 2000; Wright, Waterman, Prescott, & Murdoch-Eaton, 2003)

Implications

This study highlights the importance of examining specific aspects of false belief, in particular, whether the domain is affect or physical objects. Many times when the belief understanding is employed, it is done so in reference to emotions. With so many studies looking at positive social correlates with ToM, it is imperative to design tasks that tap into knowledge about emotions. Researchers should not assume that children use the same type of thinking in reference to objects and emotions. Simply capturing some aspect that may underlie both does not equate the tasks.

This study also highlights the importance of understanding the developmental trajectory of affective false belief. There is a paucity of research in this area, while false belief tasks tapping physical targets are numerous. By understanding the development of children's knowledge of others' minds in reference to emotions, researchers can understand how children learn to embed understanding of mental states. One developmental step is understanding facial display rules (i.e., that facial expressions may hide emotions). However, this alone is not sufficient for passing false belief tests. In addition, children must develop the understanding that there can be a discrepancy between belief and reality not only concerning location or contents, but also concerning emotions. That is, children must learn to represent another person's understanding of facial display rules. This is a representation of a representation about a surface facial display and an internal emotion.

Knowledge of other's minds concerning emotions involves understanding of belief and desires, because most often emotions arise from unmet desires. Wellman and others have suggested that possession of this type of belief-desire psychology does not exist prior to 4 years (Wellman, 1990). Affective false belief tasks tap into a child's understanding of embedded desire within a belief. Success on such tasks requires a sophisticated understanding of mind. Thus, affective ToM would emerge later than false belief understanding in reference to objects, as a child's representation of the mental world must be more sophisticated.

The "theory theory" (Wellman, 1990) explains that children possess theories of other people's minds and revise such theories with the acquisition of new experiences. Children come to realize that beliefs and desires drive behavior and that such beliefs may not reflect reality. However, theory theory does not specify how children's ability to refine theories is related to other cognitive capacities developing over the preschool period. For example, language may help

to formalize knowledge of others' minds (Ruffman, 2000). Other cognitive capacities, such as planning and inhibition, also may expand or limit a child's ability to succeed on at least certain types of false belief tasks (Moses & Carlson, 2004). Other developing capacities are likely to contribute to a developing ToM as well.

Theory theory is concerned primarily with beliefs and desires. However, this study and others have highlighted the importance of emotions in ToM. Taking a more integrative view of what constitutes a mind is necessary for interpreting children's naïve psychology. Emotions *also* drive behavior, and a truly integrative theory of mind would integrate emotion into belief-desire theories. Most studies have concurred that knowledge about other's emotions develops later than either belief or desire. Understanding of beliefs about emotions may develop later because an understanding of beliefs, emotions, and desires (unmet desires often evoke emotions) must be established and embedded within one another. Thus, belief-desire reasoning should not be considered the culmination of acquisition of a ToM. Rather, more work should be done to indicate when an emotion-belief-desire psychology emerges.

Finally, ToM tasks often show what a child is capable of doing, and not what actually happens everyday. Affective tasks tap into the potential for use of beliefs about emotions, but preschoolers may actually ignore or not attend to less salient information because of their fledgling understanding of emotions. For instance, a child may realize that a friend would be disappointed because that friend wouldn't like a particular gift, but would interpret his facial display rule of smiling as liking the gift if he himself liked it.

Limitations

While this study extends and qualifies the existing literature on false belief, it has limitations that may affect its generalizability. The first such limitation is that the study was

embedded within a larger longitudinal study exploring mother-child interactions. The length of the entire session was approximately 3 hours. All of the measures for this study were done during the second hour. Hints of fatigue appeared both within and across tasks, suggesting that later tasks may underestimate children's ability.

A potential problem in the experiment was the laboratory setting itself. While the children were completing all tasks, shelves of toys were in the room. The children had been instructed earlier in the session not to touch the toys on the shelf. Thus, many children paid attention to the toys on the shelf when they had tired of the present task. Thus, children may have divided their attention between the experimental tasks and the shelves of attractive, yet unattainable, toys.

Although considerable effort was made to equate the physical and affective tasks, some minor differences were necessary in order for the emotion story to make sense. While both tasks followed an 'unexpected contents' format, only affective tasks were embedded within a story. In the affective false belief tasks, rationale was given for the false display rule. In the physical tasks, no such rationale was provided for why the contents did not match the container marked otherwise. Overall, children succeeded in the physical tasks at a higher rate than in the affective tasks, so lack of a rationale does not appear to have hindered performance.

The necessity of incorporating emotions into the concept of mental state understanding is apparent. While this study looks at potential cognitive correlates of ToM across domains, it remains necessary to further investigate the developmental trajectory of false belief understanding in the affective domain. This study only sought to explore cognitive correlates at one point in time. However, longitudinal studies may highlight changes in the relative

contributions over time that capacities such as verbal ability and inhibitory control make to ToM across domains.

General verbal ability, measured through MLU, was explored in this study. However, more detailed tests of embedded language may increase understanding of what aspects of verbal ability are responsible for understanding embedded mental states. While sentential complements have been implicated as responsible for understanding mental states in the physical domain, other more sophisticated grammatical complexities may be at work in affective tasks, where one is asked about a belief regarding an emotion. Furthermore, researching the syntactic contributors to false beliefs in the affective domain will aid in understanding the developmental trajectory of affective tasks. If, as many have proposed, verbal ability helps children to organize and formalize their knowledge of others' minds, knowing what aspects of language are related to affective tasks will help us understanding the inner workings of the ToM development across domains.

Conclusions

This study highlights the importance of incorporating the affective domain into false belief understanding. False beliefs can occur in reference to objects, but also to emotions. A truly social domain is necessary for understanding other's minds. This study highlights that verbal ability has more of an effect in affective tasks over physical. However, neither task was related to inhibitory control. A truly developmental account of ToM is incomplete until social-cognitive capacities involved in ToM acquisition are examined.

REFERENCES

Astington, J.W. (2001). The future of theory-of-mind research: Understanding motivational states, the role of language, and real-world consequences. Commentary on "Meta-analysis of theory-of-mind development: The truth about false belief." *Child Development, 72(3)*, 685-687.

Astington, J.W., & Jenkins, J.M. (1995). Theory of mind development and social understanding. *Cognition and Emotion, 9*, 151-165.

Astington, J.W., & Jenkins, J.M. (1999). A longitudinal study of the relation between language and theory-of-mind development. *Developmental Psychology, 35(5),* 1311-1320.

Badenes, L.V., Estevan, R.A., & Bacente, F.J. (2000). Theory of mind and peer rejection at school. *Social Development, 9,* 271-283.

Bosacki, S., & Astington, J.W. (1999). Theory of mind in preadolescence: Relations between social understanding and social competence. *Social Development, 8,* 237-255.

Bretherton, I., Oppenheim, D., Buchsbaum, H., Emde, R.N., & the MacArthur Narrative Group (1990). *MacArthur story-stem battery*. Unpublished manual.

Carlson, S.M., Moses, L.J., & Breton, C. (2002). How specific is the relation between executive function and theory of mind? Contributions of inhibitory control and working memory. *Infant and Child Development, 11,* 73-92.

Carlson, S.M., Moses, L.J., & Claxton, L.J. (2004). Individual differences in executive functioning and theory of mind: An investigation of inhibitory control and planning ability. *Journal of Experimental Child Psychology, 87,* 299-319.

Cassidy, K.W., Werner, R.S., Rourke, M., & Zubernis, L.S. (2003). The relationship between psychological understanding and positive social behaviors. *Social Development, 12,* 198-221.

Davis, T.L. (2001). Children's understanding of false belief in different domains: Affective vs. physical. *British Journal of Developmental Psychology, 19,* 47-58.

de Rosnay, M., Pons, F., Harris, P.L., & Morrell, J.M. (2004). A lag between understanding false belief and emotion attribution in young children: Relationships with linguistic ability and mothers' mental-state language. *British Journal of Developmental Psychology, 22,* 197-218.

de Villiers, J.G, & de Villiers, P.A. (2000). Linguistic determinism and false belief. In P. Mitchell & K. Riggs (Eds.), *Children's Reasoning and the Mind*. Hove, England: Psychology Press.

de Villiers, J.G., & Pyers, J.E. (2002). Complements to cognition: A longitudinal study of the relationship between complex syntax and false-belief-understanding. *Cognitive Development, 17*, 1037-1060.

Dunn, J. (1995). Children as psychologists: The later correlates of individual differences in understanding of emotions and other minds. *Cognition and Emotion, 9,* 187-201.

Friend, M., & Davis, T.L. (1993). Appearance-reality distinction: Children's understanding of the physical and affective domains. *Developmental Psychology, 29(5),* 907-914.

Frye, D., Zelazo, P.D., & Palalfai, T. (1995). Theory of mind and rule-based reasoning. *Cognitive Development, 10*, 483-527.

Gopnik, A., & Astington, J.W. (1988). Children's understanding of representational change and

its relation to the understanding of false belief and the appearance-reality distinction. *Child Development, 59(1),* 26-37.

Gross, D., & Harris, P. (1988). False beliefs about emotion: Children's understanding of misleading emotional displays. *International Journal of Behavioral Development, 11*, 475-488.

Hughes, C., & Dunn, J. (1998). Understanding mind and emotion: Longitudinal associations with mental-state talk between young friends. *Developmental Psychology, 34(5)*, 1026-1037.

Hughes, C. (1998). Finding your marbles: Does preschoolers' strategic behavior predict later understand of mind? *Developmental Psychology, 34(6),* 1326-1339.

Hughes, C., Jaffee, S.R., & Happe, F. (2005). Origins of individual differences in theory of mind: From nature to nuture? *Child Development, 76(2),* 356-370.

Kochanska, G., Murray, K.T., & Harlan, E.T. (2000). Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. *Developmental Psychology, 36(2),* 220-232.

Lalonde, C.E., & Chandler, M.J. (1995). False belief understanding goes to school: On the social-emotional consequence of coming early or late to a first theory of mind. *Cognition and Emotion, 9,* 167-185.

Lang, B., & Perner, J. (2002). Understanding of intention and false belief and development of self control. *British Journal of Developmental Psychology, 20,* 67-74.

Moses, L.J., & Carlson, S.M. (2004). Self-regulation and children's theories of mind. In C. Lightfoot, C. Lalonde, & M. Chandler, (Eds.), *Changing conceptions of psychological life* (pp. 127-146). Mahwah, NJ: Lawrence Erlbaum Associates.

Nguyen, L., & Frye, D. (1999). Children's theory of mind: Understanding of desire, belief, and emotion with social referents. *Social Development, 8,* 70-92.

Perner, J., Lang, B., & Kloo, D. (2002). Theory of mind and self-control: More than a common problem of inhibiton. *Child Development, 73(3),* 752-767.

Perner, J., Leekam, S.R., & Wimmer, H. (1987). Three-year-olds' difficulty with false belief: Representational limitation, lack of knowledge, or pragmatic misunderstanding? *British Journal of Developmental Psychology, 5,* 125-137.

Pillow, B.H., & Weed, S.T. (1997). Preschool children's use of information about age and perceptual access to infer another person's knowledge. *Journal of Genetic Psychology, 158,* 356-376.

Ruffman, T. (2000). Nonverbal theory of mind: Is it important, is it implicit, is it simulation, is it relevant to autism? In J.W. Astington (Ed.), *Minds in the making: Essays in honor of David R. Olson* (pp. 456-479). New York: Blackwell.

Ruffman, T., Perner, J., & Parkin, L. (1999). How parenting style affects false belief understanding. *Social Development, 8*, 395-411.

Slaugter, V., Dennis, M.J., & Pritchard, M. (2002). Theory of mind and peer acceptance in preschool children. *British Journal of Developmental Psychology, 20*, 545-564.

Wellman, H.M. (1990). *The child's theory of mind*. Cambridge, MA: MIT Press.

Wellman, H.M., Cross, D., & Watson, J. (2001). Meta-analysis of theory-of-mind development: The truth about false belief. *Child Development, 72(3),* 655-684.

Wright, I., Waterman, M., Prescott, H., & Murdoch-Eaton, D. (2003). A new Stroop-like measure of inhibitory function: Typical developmental trends. *Journal of Clinical Psychology and Psychiatry, 44(4)*, 561-575.

APPENDIX A

AFFECTIVE THEORY OF MIND SCRIPT

Task 1. Jenny/Benny gets a birthday present from her/his aunt. Jenny/Benny opens the present and looks like this on his face [put a happy face on doll's face].

1. How do you think Jenny/Benny is feeling inside? [ask child to put a face on doll's chest]

Now I'm going to tell you how Jenny/Benny is really feeling in his/her heart. Jenny/Benny really feels sad because the present is just a baby rattle. But Jenny/Benny doesn't want her/his aunt to see how s/he feels because s/he doesn't want to hurt her/his aunt' feelings.

2. [take off the old face and ask child to put a new one on doll's chest] Now, how do you think Jenny/Benny really feels in his/her heart?

3. [turn the doll away from child] How did you think Jenny/Benny felt, before I told you how s/he really feels in his/her heart?

Susie/Tommy has never been told how Jenny/Benny feels in his/her heart. S/he comes into the room and sees Jenny/Benny for the first time.

4. [take off the old face and ask child to put a new one on doll's chest] How will Susie/Tommy think Jenny/Benny feels?

Task 2. Jenny/Benny is at a friend's house and her/his friend's mother makes a chocolate cake for her/him. Jenny/Benny takes a bit of the cake and looks like this on her/his face [put a happy face on doll's face].

1. How do you think Jenny/Benny is feeling inside? [ask child to put a face on doll's chest]

Now I'm going to tell you how Jenny/Benny is really feeling inside. The cake really tasted yucky and Jenny/Benny is really sad that the cake tastes bad. But Jenny/Benny wants to be nice and polite.

2. [take off the old face and ask child to put a new one on doll's chest] Now, how do you think Jenny/Benny really feels in his/her heart?

3. [turn the doll away from child] How did you think Jenny/Benny felt, before I told you how s/he really feels in his/her heart?

Susie/Tommy has never been told how Jenny/Benny feels in his/her heart. S/he comes into the room and sees Jenny/Benny for the first time.

4. [take off the old face and ask child to put a new one on doll's chest] How will Susie/Tommy think Jenny/Benny feels in his/her heart?

Task 3. Jenny/Benny sees a boy in her class trip and fall. S/he walks over to him and looks like this on her/his face [put a sad face on doll's face].

1. How do you think Jenny/Benny is feeling inside? [ask child to put a face on doll's chest]

Now I'm going to tell you how Jenny/Benny is feeling in his/her heart. Jenny/Benny doesn't like the mean boy and she really feels happy that he fell. But Jenny/Benny doesn't want the boy to know how s/he feels because he may get made and pick on her.

2. [take off the old face and ask child to put a new one on doll's chest] Now, how do you think Jenny/Benny really feels in his/her heart?

3. [turn the doll away from child] How did you think Jenny/Benny felt, before I told you how s/he really feels in his/her heart?

Susie/Tommy has never been told how Jenny/Benny feels in his/her heart. S/he comes into the room and sees Jenny/Benny for the first time.

4. [take off the old face and ask child to put a new one on doll's chest] How will Susie/Tommy think Jenny/Benny feels?

Task 4. Jenny/Benny class was supposed to have a swimming party but it is raining so they can't go swimming. Jenny/Benny looks out the window at the rain and looks like this on his face [put a sad face on doll].

1. How do you think Jenny/Benny is feeling inside? [ask child to put a face on doll's chest]

Now I'm going to tell you how Jenny/Benny is really feeling in his/her heart. Jenny/Benny is afraid to swim, so s/he really feels happy that it is raining. But Jenny/Benny doesn't want the other children to know how s/he feels because they might tease her/him about being afraid.

2.[take off the old face and ask child to put a new one on doll's chest] Now, how do you think Jenny/Benny really feels in his/her heart?

3. [turn the doll away from child] How did you think Jenny/Benny felt, before I told you how s/he really feels in his/her heart?

Susie/Tommy has never been told how Jenny/Benny feels in his/her heart. S/he comes into the room and sees Jenny/Benny for the first time.

4. [take off the old face and ask child to put a new one on doll's chest] How will Susie/Tommy think Jenny/Benny feels?

APPENDIX B

PHYSICAL THEORY OF MIND SCRIPT

Task 1: M&M or Fish

Place container on the table across from the child. Do you see what I have put on the table?

1.What do you think is inside the box [container]? [The child is not to touch the box.]

Okay, you think that there are xx in the box. Let's open it and see. [Together open the box. Take out the item. Show it to the child.]

2. What is really in the container? Let‘s put it back behind the line..

3. Before you looked inside, what did you think was in the box?

4. What is really inside the box?

Look, here is Charley. Charley has not seen this box before. S/he does not know what it is inside this box.

5. What does Charley think is in the box?

6. What is really inside the box?

Task 2 Band-aid box

Procedure: Place band-aids box and a plain box on the table behind the line. I have a band-aid box and I have a plain box.

1. Can you point to the box that you think has the band-aids in it.

[Open each box. Show that the prototypical box is empty but that the expected contents are in the plain box. Close boxes.] [Introduce puppet.] Look, here is Charley. Charley has a cut, see? Charley needs a band-aid.

2. Where do you think s/he will look for the band-aid?

3. Will s/he find the band-aid?

[Introduce stuffed animal.] This is Charley's friend Ling-Ling. Ling-Ling also needs to have a band-aid.

[Show Ling-Ling has a missing nose. Move Ling-Ling towards the band-aid box. Mimic that s/he wants to open it.]

4. Why do you think Ling-Ling is looking in that box?

5. Where is the band-aid really?