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INDIVIDUAL DIFFERENCES IN INHIBITORY CONTROL: RELATIONS Across Domains and Predictions to Theory of Mind

A Thesis in
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by
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ABSTRACT

The preschool years are a period of child development during which many abilities show considerable maturation. Children’s ability to inhibit their internal and external reactions to environmental stimuli, inhibitory control, is an important skill that shows growth during this age and is related to healthy development across varied contexts. The present study sought to explain relations among emotional, behavioral, and cognitive measures of inhibitory control in 4.5 year old children. Using parent reports and laboratory tasks, we found that measures of emotion regulation and executive function both provided a meaningful, independent contribution to understanding children’s behavioral control. However, children’s overall executive function performance could mainly be attributed to their behavioral control ability, not their control over emotional expressions. When measures of children’s inhibitory control abilities were related to their performance on theory of mind tasks one year later, it was revealed that both behavioral control and executive function were related to theory of mind performance. However, it appeared that executive function was the primary predictor of theory of mind ability, as this aspect of inhibitory control was related to theory of mind after controlling for the effect of all other indices of inhibitory control. These findings offer an important contribution to our understanding of how regulation in various developmental domains may work together to contribute to children’s social outcomes.
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The preschool years represent a period of child development during which many abilities show considerable maturation. During this time, children’s abilities to inhibit their internal and external reactions to environmental stimuli show substantial growth, and these skills are necessary for healthy development across varied contexts. Inhibitory control is broadly defined as the active suppression of interfering or competing information for the purposes of pursuing a goal (Rothbart & Posner, 1985). This ability is best conceptualized as a general control or organization over one’s responses, or the suppression of an immediate reaction in order to allow for the execution of a more appropriate or beneficial one.

Inhibitory control is one constituent of children’s competent behaviors across a number of developmental domains, including emotional, cognitive, and motor/behavioral development. Within the field of emotional development, inhibitory control is involved in the development of emotion regulation, the extrinsic and intrinsic process that is responsible for monitoring, evaluating, and modifying emotional reactions (Thompson, 1994). Specifically, inhibitory control aids the processes involved with the modification or suppression of emotional reactions or expressions (Rothbart & Ahadi, 1994).

Within the cognitive domain, inhibitory control has been identified as an important element of children’s development of executive function, the set of processes that underlie flexible, goal-directed behavior (Luria, 1966). The field of executive
function identifies inhibitory control as one of a variety of mechanisms underlying children’s performance on tasks that require restraint of a prepotent response such that inhibitory abilities are responsible for controlling or actively suppressing mental content (Nigg, 2000). There is agreement within the cognitive community that any complete account of cognitive ability should incorporate inhibitory control to fully explain individual performance (Harnishfeger & Bjorklund, 1993).

Finally, with respect to motor or behavioral control, inhibitory control is implicated in tasks requiring children to suppress, slow down, or delay motor activity and engage in appropriate behavioral responses. Greater inhibitory control may facilitate children’s ability to automatically or intentionally delay an overt motor response (Harnishfeger, 1995), or suppress a dominant motor response in order to perform a more acceptable subdominant response (Kochanska, Murray, and Harlan, 2000).

Although inhibition plays a key role in children’s activities within each of these areas, very little attention has been drawn to the study of inhibitory control as a global construct. Nigg (2000) proposes the need for a workable taxonomy of types of inhibition that will help us understand how the various inhibitory constructs are related to one another. Such an integrative approach would not only illustrate theoretical similarities and distinctions among developmental constructs, but also may guide the explanation of outcomes associated with children’s development in each of these domains. Given the relatedness among the fields of emotional, cognitive, and motor/behavioral development in outcomes associated with social competence and psychological disorders, it may be useful for researchers to address multiple types of inhibition in their attempts to predict
individual differences in children’s outcomes, rather than resorting to the current domain-specific approach to explaining outcomes (Nigg, 2000).

Given the importance of inhibitory control across these developmental domains, the need to explore individual differences in a variety of children’s inhibitory abilities is evident. A limited amount of research has only begun to touch upon this issue, leaving many unanswered questions regarding the relatedness of specific indices of inhibitory control. Furthermore, no study to date has examined a broad range of inhibitory tasks in preschool aged children for the purpose of investigating a unified account of this ability. The first aim of the present investigation, therefore, was to examine preschool children’s inhibitory control abilities across tasks demanding emotional, cognitive, and behavioral control. In line with this goal, individual differences in a broad range of inhibitory abilities were explored in an effort to understand the relatedness of these abilities across domains.

The next step in the pursuit of a comprehensive assessment of global inhibitory ability was to explore the underlying structure of this concept. Developmental researchers have traditionally explored inhibitory competence in a somewhat domain-specific approach (e.g., Luria, 1966; Rothbart & Ahadi, 1994). Various domains of research have incorporated distinct measures of inhibitory control and commonly defined it as the active suppression of a prepotent response for the purposes of pursuing a goal. According to this domain-specific approach, inhibitory ability may be thought to be a three-dimensional construct, separated by the type of response that is inhibited (e.g., emotional, mental, or motor). While this approach is meaningful on face value, one
might speculate that there exists an alternative underlying factor structure which may more succinctly explain the covariation among indices of inhibitory control. For example, one possibility is that inhibitory abilities may be better represented by a model that separates them not by the type of response that is suppressed, but by the *type of goal* that is pursued. As such, socially-motivated inhibitory abilities may cohere into a separate factor from non-social indices. The present investigation offered an opportunity to empirically address this question. Specifically, the second goal of this study, which was exploratory in nature, was to examine the factor structure of a broad range of inhibitory control measures in order to better understand the covariation among specific abilities.

Finally, an important implication for an understanding of children’s developing inhibitory skills is the explanation of social outcomes that are thought to develop via these abilities. Different types of inhibition have been shown to be related to a variety of social, educational, and psychological outcomes. One approach to understanding this relation between inhibition and developmental outcomes has been to explore the associations between inhibitory skills and theory of mind development (e.g., Carlson & Moses, 2001; Hughes, 1998). Theory of mind refers to children’s ability to attribute mental states to themselves and others, and is most often studied using a false belief paradigm which requires children to make behavioral predictions based on a character’s false knowledge of a situation rather than the actual reality of the situation (Wellman, 1990). Traditional accounts of the development of false belief understanding have emphasized the emergence of children’s conceptual understanding of others’ mental
states and their understanding that mental states can be modified by external events (e.g., Wellman, 1990). Recent research has also highlighted the importance of children’s ability to consider situations from multiple perspectives as an important precursor to false belief understanding (Carlson & Moses, 2001; Hughes, 1998). This line of work argues that in order for children to be able to attribute false beliefs, they must overcome, or inhibit, a prepotent tendency to base beliefs on their own perspective, rather than that of others (Carlson, Moses, & Hix, 1998). Thus, the possible association between false belief understanding and inhibitory ability is evident.

Furthermore, theory of mind ability has been implicated in children’s development of social skills and social competence. The rationale for this connection is that if children can see beyond the reality of a situation to attribute others’ behaviors according to multiple perspectives, they will have greater competence in social interactions (Astington, 2003). This relation between theory of mind development and social competence points to the importance of better understanding the relations between inhibitory control and theory of mind development. However, although some indices of inhibitory control have been empirically linked to false belief understanding (e.g., Carlson & Moses, 2001; Frye, Zelazo, & Palfai, 1995; Hughes, 1998; Perner & Lang, 1999), other indices, including emotion regulation, have yet to be explored. Moreover, as no study to date offers a comprehensive approach to understanding the prediction of theory of mind ability by specific inhibitory abilities, little is known about the specific contribution of different indices of inhibitory to theory of mind ability. The third goal of this investigation, therefore, was to investigate whether individual differences in
emotional, cognitive, and behavioral inhibitory competence predicted later differences in theory of mind ability.

In sum, the present investigation sought to examine a variety of inhibitory control abilities in preschool-aged children, to explore the underlying factor structure of these abilities, and to assess the associations between these abilities and children’s theory of mind. Although the focus of the present study was at the individual level, it was recognized that many other factors may influence these developmental skills, including parents, siblings, peers and the larger social environment of the child. Consideration of such extrinsic factors is certainly a next step in this line of research once the field fully understands these developmental abilities at the individual level. This investigation was only a first step toward a complete understanding of children’s development of inhibitory control abilities.
Chapter 2

LITERATURE REVIEW

This review of literature is structured according to the three aims of the present investigation. The first goal was to explore individual differences in inhibitory control abilities within the constructs of emotion regulation, behavioral control, and executive function. The first section of this review will begin with a discussion of the broad, overarching definition of inhibitory control that has been applied across different developmental domains. Next, the constructs of emotion regulation, behavioral control, and executive function will be discussed, in terms of the role of inhibition within these constructs, and the development of this ability through the preschool years. Finally, associations between indices of inhibitory control across these developmental domains will be discussed, beginning with theoretical explanations of such linkages, followed by a review of the current empirical evidence concerning such associations.

The next section will discuss the possibility that an alternative underlying factor structure of a general construct of inhibitory control may offer a more coherent picture of this concept rather than the domain-specific approach. Although very little work has been done to this end, the theory behind examining inhibitory control from a different perspective than the current one will be discussed.

The third section discusses social outcomes and consequences of inhibitory control competence across varied contexts. Next, the relevance of theory of mind ability as a proxy measure of social competence is illustrated, and the relation between theory of
mind and inhibitory control ability is explained. In the final section of this review, broad conclusions regarding the literature are drawn, and research goals and hypotheses motivating the present investigation are set forth.

**Inhibitory Control**

The ability to have control over actions and responses is essential for healthy development across varied contexts. This ability, known as inhibitory control, is broadly defined as the active suppression process engaged for the purposes of pursuing a goal (Harnishfeger & Bjorklund, 1993; Rothbart & Posner, 1985). This ability often goes hand in hand with the notion of interference, which is the susceptibility to performance decrements under conditions of multiple distracting stimuli (Lane & Pearson, 1982). Inhibition includes the ability to control interference from both internal and external sources, and to suppress stimuli that are not relevant, or appropriate to, the individual’s present goal (Dempster, 1992).

There is a very limited body of work that approaches inhibitory control as a global construct (Nigg, 2000). Nevertheless, there is consensus in the field of child development that this ability is an important aspect of children’s competent behaviors across a number of developmental domains, including emotional, cognitive, and motor/behavioral development. Moreover, a great deal of research within each of these fields points to the brain’s frontal lobe as the driving mechanism for a variety of inhibitory abilities, and these findings will be reviewed in the forthcoming section on the relatedness of these processes. Overall, the commonness of inhibitory competence across a variety of developmental domains points to the need for an integrative approach to this
concept in order to empirically link the conceptual similarities between constructs, to suggest points of discrepancy between constructs, and to guide the explanation of outcomes associated with children’s inhibitory development within each of these domains.

Inhibitory Control of Emotional Expressions

In the field of emotional development, inhibitory control is thought to play a role in facilitating children’s ability to suppress or regulate the spontaneous expression of extreme emotions. Emotion regulation is an extrinsic and intrinsic process that is responsible for monitoring, evaluating, and modifying emotional reactions (Thompson, 1994). As children’s emotion regulation develops, they demonstrate an increased ability to respond flexibly to the ongoing demands of their environment in a socially appropriate way (Cole, Michel, & O’Donnell Teti, 1994). The ability to inhibit and subdue emotional arousal is only one component of emotion regulation, as this process may also involve maintaining or enhancing emotional arousal (Masters, 1991). Inhibitory control guides emotion regulation by enabling the general organization of emotional responses.

There exist a number of theoretical approaches to the construct of emotion regulation. Within the temperament perspective on this construct, such as that of Rothbart and colleagues, the emphasis is place on the interaction between emotion and self-regulatory processes. Emotion regulation is a major constituent of these authors’ definition of temperament (i.e., individual differences in reactivity and regulation), and in line with this definition, emotion regulation ability is thought to reflect a behavioral style, have a constitutional basis, and remain relatively stable over time (Rothbart, Ziaie, &
O’Boyle, 1992). On the other hand, researchers from the emotion perspective on emotion regulation emphasize the emotional experience, consider emotion regulation to be the voluntary expression of this experience (Izard, 1990), and conceptualize regulatory processes to be components of the emotions rather than responses to the emotions (e.g., Campos, Mumme, Kermoian, & Campos, 1994; Dawson, Panagiotides, Klinger, and Hill, 1992). Most recently, many emotion researchers have taken the functionalist approach, which acknowledges the significance of person-event transaction in the conceptualization of emotion (Campos, et al., 1994). Finally, those researchers who represent a cognitive perspective, such as Kopp and colleagues, emphasize the role of cognitive abilities to intentionally control arousal or distress (Kopp, 1989). This approach highlights the role of cognitive mechanisms, including learned associations of cause and effect, planfulness, organization, and monitoring in aiding children to identify sources of distress, reflect on how this distress was alleviated in the past, and enlist the appropriate strategies for self-soothing.

Developmental Course. During the first year of life, infants display a range of emotional expressions, including surprise, interest, joy, sadness, and anger (Malatesta-Magai, 1991). The ability to regulate emotions is also thought to emerge in early infancy (Stifter, 2002), and gradually progresses from being a highly external process that is primarily reliant on caregiver intervention, to an internal, self-driven one (e.g., Thompson, 1994). As infants move into their second year of life, the first facial indications of emotion regulation appear. The work of Malatesta-Magai (1991) has documented the emergence of two new facial expressions during this period: biting the
lower lip, and tightly compressing the lips. These expressions are thought to be an index of the infant’s negative affect (i.e., anger and anxiety), as well as attempts to regulate this affect. During the third year of life, children’s emotional expressions are more subdued, but the frequency of these expressions remains stable (Malatesta-Magai, 1991). Studies of preschool-aged children’s expressions show that they display fewer extreme episodes of negative affect than younger children, including tantrums and intense crying (e.g., Fabes & Eisenberg, 1991). Overall, across the developmental period from early infancy through the preschool years, children become better able to express and self-regulate their emotions, as can be seen in their generation of emotion expressions in play, and modulation of emotion expressions during stressful events (Cole et al., 1994).

An elegant paradigm designed to study children’s ability to modulate their emotional expressions is the disappointment paradigm (Cole, 1986; Saarni, 1984). This task is designed to elicit negative emotions in young children after they are presented with an undesirable gift from an experimenter. Children must suppress these emotional expressions for the purpose of engaging in display rules, that is, in order to be polite when the experimenter is present. Display rules are cultural guidelines for socially appropriate behaviors (Cole, 1986), for example suppressing laughter during a funeral service or disappointment when given an unwanted gift.

Findings from the disappointment paradigm indicate that children as young as 3 years of age are able to regulate their emotional expressions by displaying more positive facial expressions when an experimenter who gave them the undesirable gift is present, and more negative expressions when the experimenter leaves the room, thereby
suppressing their expressions of disappointment when appropriate (Cole, 1986; Cole, Zahn-Waxler, & Smith, 1994). Age related changes in the ability to suppress negative emotional expressions have also been documented from first through fifth grade, such that older children have been shown to display more positive affect than younger children after receiving an undesirable toy (Saarni, 1984). In addition to the process of minimizing negative expressions, emotion regulation also consists of the ability to generate positive expressions when experiencing negative emotions, or “up regulating” (Cole, 1986; Cole, 2003).

The Role of Reactivity. Emotion regulation is a complex and multi-faceted phenomena, requiring a person-oriented approach to identify sources and outcomes of variation in its developmental course (Thompson, 1994). Across a number of studies, the consensus is that emotional reactivity, the overall intensity and threshold of emotional responding, plays a particularly important role in the development of emotion regulation (Thompson, 1990). Studies of individual differences in emotion regulation during infancy suggest that infants who are highly reactive may compromise their own ability to develop internal regulatory mechanisms, due to their extreme levels of distress (Fox & Calkins, 1993). For example, Stifter and Spinrad (2002) found that male infants who cry excessively and show high levels of negative reactivity at 6 weeks of age display fewer emotion regulatory behaviors at 5 months of age. The influence of emotional reactivity has also been demonstrated using both behavioral and biological methods, such that easily frustrated infants have been observed to use different behavioral emotion regulation strategies, display more physiological reactivity, and less ability to regulate
physiological reactivity than less easily frustrated infants (Calkins et al., 2002).

Furthermore, the influence of high reactivity may affect the caregiver’s source of regulation whereby the highly reactive infant’s caregiver cannot respond contingently to the infant’s frequent distress episodes (e.g., Crockenberg, 1981, van den Boom, 1989).

Emotional reactivity, or emotionality, is also thought to play an important role in explaining regulatory abilities in preschool aged childhood. Specifically, Eisenberg and colleagues have demonstrated that individual differences in children’s social functioning vary as a function of both emotional reactivity and emotion regulation. The results of one such study by Eisenberg et al. (1995) indicated that children who displayed high emotional reactivity but low emotion regulation showed the greatest behavioral problems. Furthermore, problem behaviors were shown to increase with increasing levels of negative emotional intensity at low and medium levels of regulation, but not at high levels of regulation indicating an interactive effect such that high levels of emotion regulation moderated the occurrence of behavior problems, even with increasing levels of negative emotional intensity (Eisenberg, et al., 1995).

In sum children’s ability to exhibit control over their emotional expressions illustrates the role of inhibitory control in emotional development. Tasks such as the disappointment paradigm (Cole, 1986) are well suited for examining children’s expressive control as they offer researchers an opportunity to consistently elicit a prepotent emotional response (i.e., internally attributed disappointment), and to present a situation requiring children to inhibit or suppress this response. Furthermore, individual differences in emotional reactivity may play an important role in children’s development
of emotion regulation, pointing to the importance of including measures of overall negativity in our investigation of emotion regulation.

Inhibitory Control of Motor and Behavioral Processes

As children develop greater motor capacities and an increasingly complex behavioral repertoire, they also develop the ability to actively control their behaviors. Motor movement and other bodily activities may be functional for the achievement of children’s goals in some contexts, but may also interfere with performance on tasks in other situations. The inhibition of some motor activity is necessary for the attainment of goals that do not call for physical activity (Maccoby, Dowley, Haga, and Degerman, 1965). This ability often involves a balancing of self-defined needs with social expectations (Kopp, 2002), and includes the capacity to actively suppress or delay approach, and to regulate the pace of one’s movement (Maccoby, 1980; Rothbart, 1989). While there exist a number of theoretical approaches to behavioral and motor control, including effortful control (e.g., Kochanksa, 1991; Rothbart & Ahadi, 1994), self-regulation (Kopp, 1982, 2002), and ego-control (Block & Block, 1980), the consensus is that inhibitory control is a central component of children’s ability to exhibit control over their motor and behavioral activities.

The term “effortful control” has been used to describe behavioral control in two significant bodies of work. First, Rothbart and colleagues (e.g., Rothbart & Ahadi, 1994) identify this concept as one dimension of children’s constitution or temperament, and propose that effortful control, sometimes also called “attentional control”, is a special class of self-regulatory mechanisms closely related to the child’s maturation of voluntary
attention. Consistent with Rothbart’s approach, the work of Kochanska also describes children’s ability to control their behaviors as “effortful control”, and suggests that this ability enables children to engage in acceptable behaviors that require them to willingly inhibit forbidden impulses (Kochanska, 1991). A number of abilities are subsumed under these authors’ concept of behavioral control, including the delay of gratification, slowing down of motor activity, ability to suppress/initiate activity, and compliance to others’ requests (Kochanska, Murray, and Harlan, 2000; Rothbart, Derryberry, & Posner, 1994).

According to Kopp (1982), behavioral control in the preschool years, referred to as “self-regulation”, is the voluntary process of changing ongoing behavior in response to events and stimuli in the environment, and the monitoring and inhibition of behavior in accord with social norms (Kopp, 1982). Her approach is consistent with both Rothbart (e.g., Rothbart & Ahadi, 1994) and Kochanska’s (e.g., Kochanska, 1991) notion of effortful control, as they all emphasize children’s ability to comply with norms and delay behaviors as appropriate.

Finally, from a psychoanalytic perspective, the notions of ego control and ego resiliency are consistent with the concept of behavioral control. Ego-control refers to the threshold reflecting one’s degree of impulse control and modulation, whereas ego-resiliency refers to the linkages of the ego structures that keep the personality system within tenable bounds (Block & Block, 1980). Control can be conceptualized as the modulation or inhibition of behavior, and resiliency as the ability to flexibly apply this control to varying contexts according to the different demands of those contexts.
It should be noted that the present investigation’s conceptualization of behavioral inhibitory control is different from the notion of behavioral inhibition set forth by Kagan (1998) which refers to a separate temperamental trait concerning differences in children’s approach-withdrawl orientation thought to be linked to the affective system of fear (Rothbart, Derryberry, & Posner, 1994). In the present study, behavioral inhibitory control refers to the ability to actively suppress behavioral responses, an ability that may conceivably be available to both the approach-oriented and withdrawal-oriented children. Indeed, in a study of 4-year olds in a Head Start program, Blair (2003) found that parental reports of behavioral activation and behavioral inhibition were not significantly related to children’s performance on executive function tasks, suggesting that behavioral inhibition and inhibitory control are separate concepts.

**Developmental Course.** Research suggests that between 6 to 12 months of age, infants demonstrate behavioral control by becoming more active stimulus-seekers, showing greater use of organized motor behaviors, and by becoming better able to redirect their visual attention (Rothbart, Derryberry, and Posner, 1994; Rothbart, Ziaie, and O’Boyle, 1992). During their second year, infants are in a phase that Kopp and colleagues refer to as “control”, which involves compliance to commands, self-initiated monitoring of behavior, and children’s active role in guiding their own behavior (Kopp, 1982). From around 24 months onward, children reach the phase of self-control and progress to what Kopp calls “self-regulation”, which differs from self-control in degree, not in kind. Self control involves limited flexibility in adapting acts to meet new situational demands, whereas self-regulation involves more mature adaptations to
changes, presumably by the use of reflection and strategies involving introspection, consciousness, and meta-cognition. Self-regulation includes compliance to others’ requests, as well as the emergent ability to delay an act on request and to behave according to caregivers’ and social expectations in the absence of external monitors (Kopp, 1982).

Children show further developments in their behavioral control abilities as they enter the preschool years. Maccoby, Dowley, Hagen, and Degerman (1965), assessed the motor control of children between the ages of 3.5 and 5 years, and found marked improvements with age in children’s ability to slow the pace of their movements in both a walking task and a drawing task, such that 3.5 year olds had a great deal of difficulty moving very slowly, but showed significant improvement each year until the age of 6 years. Additionally, in delay of gratification paradigms in which children are offered the choice between a small, immediate reward, and a later, larger reward, 4-year olds have difficulty inhibiting the impulse to go for the reward immediately, whereas by the age of 5 or 6 years, children display a greater ability to wait for the larger reward (Mischel & Mischel, 1983). Furthermore, 4 year olds have difficulty in go/no go tasks which require them to suppress a response (e.g., a key press) under specific conditions and elicit the response under different conditions. However, by the age of 5 or 6 years, children succeed at such tasks (Livesey & Morgan, 1991). Together, these findings suggest that children show considerable developmental maturation in their behavioral inhibitory abilities during the preschool period.
In sum, while a variety of terms and definitions exist for children’s emerging ability to exhibit motor and behavioral control, there is agreement in the field that inhibitory control plays an integral role in this ability, across a variety of tasks involving delay of gratification, slowing down motor activity, and suppressing and initiating activity as appropriate. Thus, these varied measures are all important for an investigation of the role of inhibition in behavioral and motor control.

**Inhibitory Control of Cognitive Processes**

Executive function broadly refers to a set of abilities that are involved in goal-directed or future oriented behavior (e.g., Luria, 1966; Welsh, 2002), the temporal organization of behavior (e.g., Fuster, 1997), and flexibility of complex and purposeful behavior (e.g., Hart, Schwartz, & Mayer, 1999). Inhibitory control is a central component of executive function performance (e.g., Diamond, Prevor, Callender, Druin, 1997), and is thought to facilitate one’s ability to resist distraction and preservation, while sustaining concentration (Diamond et al., 1997). It should be noted that other mechanisms are also thought to influence executive function performance, including attention (Barkley, 1997; Halperin, 1996; Norman & Shallice, 1985), working memory (e.g., Baddeley, 1992; Pennington, Bennetto, McAleer, & Roberts, 1996), and cognitive complexity and meta-cognition (e.g., Borkowski & Burke; Frye, Zelazo, & Burack, 1998).

**Developmental Course.** The earliest accounts of executive function ability are offered by Diamond and colleagues, who suggest that this ability emerges by the end of the first year (Diamond et al., 1997). Using the A-not-B task as a measure of executive
function (i.e., operationally defined as working memory and inhibition of prepotent response), these researchers demonstrate that between 8 to 12 months, infants who observe the displacement of an object from location A to location B continue to search for the object in its original location (location A). However, by 12 months, infants search at the correct location (location B), indicating that they have overcome their earlier preservative behavior and demonstrate the ability to inhibit this prepotent inclination (Diamond et al., 1997).

The greatest developmental growth in executive function ability is thought to occur between 3 and 6 years of age. On executive tasks requiring inhibitory control, such as the Day/Night Stroop, children show relatively continuous improvement between the ages of 3.5 and 7 years. Children younger than 4.5 years tend to have greater difficulty with this task, yet show nearly perfect performance by the age of 6 or 7 years (Gerstadt, Hong, & Diamond, 1994). A somewhat earlier improvement is seen in children’s performance on the Tapping Task, another executive task requiring inhibitory control. On this task the greatest improvements appear to occur between 3.5 and 4 years of age, with smaller increments of improvement between 4.5 and 7 years of age (Diamond & Taylor, 1996). Similarly, on hammering-board tasks (i.e., the Three Pegs Tasks) designed to assess children’s ability to inhibit preservative responses and use overt speech to monitor overt behavior, 4 year olds show considerably better performance than 3 year olds (Balamore & Wozniak, 1984).

By about 10 years of age, children’s performance on tasks that seem to tap inhibitory skills (e.g., Matching Familiar Figures Test and Wisconsin Card Sort Test) is
thought to reach adult levels. It appears that at about the age of 8, there is a marked improvement on more complex executive function tasks (e.g., Tower of London and Spatial Working Memory task), but adult level performance on these tasks is not reached until later in adolescence (Welsh, 2002).

There exist only a handful of developmental studies specifically aimed at examining the early emergence of executive function ability, its underlying mechanisms in a normative sample of young children, and the consequences of this ability. Such studies typically begin to examine this ability in children who are 3 or 4 years old (e.g., Welsh, Pennington, & Groisser, 1991; Luciana & Nelson, 1998), although there are some exceptions (e.g., Diamond, et al., 1997). Morris (1996) comments on the dearth of studies concerning young children’s executive function development, and suggests the importance of such studies for addressing developmental questions including the sequence in which various abilities unfold, their rate of change, and how such changes affect other related functions. As of yet, however, the majority of studies have been done with adults and with clinical samples.

Individual differences approaches to executive function in young children are also extremely limited. Some studies have explored the degree to which differential development of underlying mechanisms associated with executive function may drive individual variability in other mechanisms. For example, Dowssett and Livesey (2000) found that experience with executive function tasks that are thought to involve complex rule structures (i.e., a card sort and change paradigm) improved children’s inhibitory control performance, as measured by a go/no go discriminant learning task. The authors
suggest that these results indicate the potential social consequence of enhancing executive processes (Dowsett & Livesey, 2000), such that practice on rule-based reasoning may enhance inhibitory competence in other domains of development. Other studies have found a positive relationship between individual differences in executive function and ‘theory of mind’, the ability to attribute mental states to others, and this relation has been shown to stay high for both 3- and 4-year-olds, even when other variables such as age, gender, and verbal ability were controlled for (Carlson & Moses, 2001).

In sum, little is known about individual differences in executive function, particularly in early childhood, pointing to the need for studies that assess young children’s executive abilities in conjunction with other developmental abilities that may influence or be influenced by executive abilities. Additionally, the empirical literature suggests that the period between 3 and 6 years of age is an important one for studying executive function, as inhibitory abilities show dramatic maturation during this time.

*Relations among Inhibitory Control Constructs*

The first goal of this investigation was to explore the relations among children’s inhibitory control abilities across the three constructs of emotion regulation, behavioral control, and executive function. This section will begin with a theoretical conceptualization of how and why inhibitory control might be related across constructs, followed by empirical support for such relations.

The field of neuropsychology suggests that inhibitory abilities may be related across constructs because they are all guided by the same brain systems. According to
this approach, the frontal lobe region of the brain may offer a possible window on the concordance between inhibitory processes across contexts, as this region of the brain is thought to govern a broad range of inhibitory abilities (e.g., Dawson et al., 1992; Fuster, 1997). Specifically, it is thought that the system linked to lateral orbito-prefrontal cortex may be related to social and behavioral inhibition and hyperactivity (Fuster, 1997), while the anterior cingulate gyrus may be related to the ability to control interference and focus attention (e.g., Posner & Raichle, 1994).

Neuropsychological research also points to correlations between dysfunctions of the frontal lobe and inhibitory deficits in action, cognition, emotion, and personality (Dempster, 1992; Fuster, 1997; Luria, 1973). There is evidence that by 4 months, the development of the parietal cortex and/or frontal eye field connections allow for more flexible disengagement, and more self-regulation. Before this development, infants engage in “obligatory attention” due to the development of middle-level lamina of the primary visual cortex, which comes to support an inhibitory pathway to the superior colliculus (Rothbart, Ziaie, & O’Boyle, 1992). Some researchers have suggested that maturation of the frontal lobe during this time reflects the infant’s increasing ability to manage arousal and emotionally arousing situations (e.g., Diamond, 1990; Fox, 1994). Studies also suggest that the period of maximum synaptic density in the frontal region (i.e., at around 12 months for human infants) coincides with the period of emergence and improvement of delayed response and object permanence (Goldman-Rakic, 1987). Fuster (1997) argues that the most distinctive function of the frontal lobe is to initiate and carry out novel goal-directed behavior, including delayed response and complex
sequences of directed gaze behavior. Early goal-directed behavior may be linked to executive processes, while complex gaze behavior has been suggested to be an important dimension of behavioral control and higher order emotion regulatory strategies. Early frontal lobe development, therefore, seems to indicate some concordance between the early appearances of inhibitory abilities across the emotional, behavioral, and cognitive domains.

Beyond the neuropsychological approach, there are a variety of theories suggesting that observable differences or developments in specific indices of inhibitory abilities may explain individual differences in other inhibitory domains. According to Thompson (1994), a variety of outcomes are thought to be influenced by emotion regulation, including social competence, behavioral self-control, and intellectual and cognitive functioning. Consequently, emotion regulation could directly facilitate the child’s emerging abilities on tasks requiring complex executive demands (i.e., those requiring flexibility, and problem-solving) as well as tasks requiring motor control, by aiding the child to suppress the interference of negative internal arousal (i.e., frustration, and disappointment), and better allowing selection of stimuli, intensive concentration, or attention to bodily movements (Mathews & Wells, 1999; Wells & Mathews, 1996). Consistent with this line of reasoning, Blair (2002) suggests that the developmental primacy of subcognitive processes relating to emotion, for example the temperamental notion of emotionality, may have a direct effect on the automatization of behavior related to higher-order thinking and appraisals. According to Blair, the ability to regulate emotional reactivity may better enable a child to succeed at higher order processes. An
important empirical question for the present investigation was to explore the degree to which children’s negative emotional reactions and emotion regulatory abilities together explained differences in performance on executive and behavioral control tasks.

It is also possible that behavioral control (e.g., the ability to delay a desirable activity or control motor movements) has a direct influence on children’s executive function ability. It is conceivable that behavioral control may be a strong predictor of executive function even after accounting for the influence of emotion regulation. Such a model would suggest that greater ability to properly execute subdominant responses relies more heavily on children’s control over motor and behavioral processes than on their ability to control emotional arousal. Individual differences in the organization of behavior (i.e., behavioral control), therefore, may explain differences in executive function, even after accounting for emotion regulatory ability.

Finally, as emotion regulation develops, it becomes what some might consider to be a higher-order process, consisting of the ability to alter interpretations or construals of arousing events, reinterpret the circumstances eliciting emotion, enhance one’s access to coping resources, predict and control the emotional requirements of one’s environment, and to select adaptive response alternatives (Thompson, 1994). In other words, this higher-order process of emotion regulation may be set apart from the present study’s notion of emotion regulation as a temperamental tendency, as it involves more complex reasoning and emerges later in childhood. Executive inhibitory abilities may play a role in children’s ability to engage in these higher-order emotional processes by way of strategy selection and use, such that better control over cognitive resources may lead to
the selection of better emotional coping strategies and a greater aptitude for deploying such strategies. Calkins (1994) suggests that cognitive development may influence emotion regulation by increasing children’s understanding of the need for regulation and enabling a greater ability to apply regulatory strategies. As they expand their competency in regulating their emotions, children may enlist a variety of executive skills in the process (e.g., anticipation, intentionality, reference to means-ends behavior, and planfulness). Although the assessment of higher-order emotion regulation strategies is beyond the scope of the current investigation, this theoretical connection is an important aim for future studies.

**Empirical Evidence.** Although no study to date has examined all of these indices of inhibitory control in a unified investigation, recent research has begun to draw some linkages among these constructs. With respect to the association between emotion regulation and behavioral control, the work of Kochanska and colleagues (e.g., Kochanska, Murray and Coy, 1997) offers insight as to how these constructs are related. Specifically, these authors examine “effortful control” (Rothbart & Ahadi, 1994), the ability to inhibit a prepotent behavioral or emotional response. Findings from studies of 22-, 33-, 46-, and 65- month-olds suggest that effortful control may be viewed as a temperamental system because this construct shows longitudinal stability from the first through sixth year of life. Additionally, these studies indicate good internal consistency for indices of effortful control, including delay, slowing down of motor activity, and parental measures of inhibitory control (Kochanska, Murray and Coy, 1997; Kochanska, Murray, and Harlan, 2000). Finally, at 33 months, the relation between effortful control
and emotion restraint in the context of a temptation was explored. Findings indicated that children who had greater effortful control were slower to show either anger or joy, and showed less intense anger and joy (Kochanska, Murray, and Harlan, 2000).

Further evidence of this relation has been set forth by the work of Stifter and colleagues (Stifter, Spinrad, & Braungart-Rieker, 1999). Findings of a study of 5-, 10-, and 18-month-olds revealed that infants who were unable to regulate frustration were more noncompliant as toddlers. It was found that regulation interacted with high reactivity in predicting compliance and defiance, such that those children who were highly reactive but had good regulatory skills showed lower defiance than children with high reactivity and poor regulatory skills. Low levels of frustration regulation were associated with low levels of behavioral control, including the use of avoidance or defiance in response to requests to comply. Moreover, these authors also found negative reactivity to moderate this association, such that infants who were low in reactivity but high in regulation at 5 months used passive noncompliance. At 10 and 18 months, however, low regulation was associated with passive noncompliance. This study addresses the role of reactivity in the early development of regulation, and suggests that the experience of some negative reactivity in early infancy may be vital to the development of regulation. Infants who do not experience frustration early on, for example, may not have the opportunity to learn effective regulatory strategies (e.g., by way of caregiver intervention), and this setback in the development of regulatory skills may have negative consequence in later childhood when they do experience frustration.
situations such as those that require them to delay a desired activity or comply to their mother’s requests (Stifter, Spinrad, and Braugart-Rieker, 1999)

Together, the abovementioned literature offers evidence of a suggested link between emotion regulation and behavioral control such that regulation of affect facilitates children’s performance on tasks requiring behavioral control. According to this process, children experience negative emotions when expected to control their behaviors, and in order to be successful on such tasks, they must be able to modulate this negative emotion.

There also exists empirical research suggesting a link between executive function and behavioral control. Cole, Usher, and Cargo (1993) found executive function, as measured by a tapping test, a rapid-alternating-stimulus-naming test, a hand movement test, a block sort, and a visual search test, to be related to preschoolers’ attentional and behavioral self-regulation, as measured by their ability to resist temptation in a forbidden-object paradigm (Cole, Usher, and Cargo, 1993). Additionally, Carlson & Moses (2001) found children’s performance on some tasks requiring executive inhibitory abilities (e.g., Day/Night task and Card Sort task) to be related to their ability to delay gratification (i.e., to wait, without peeking, while an experimenter wrapped a gift), even after controlling for age, gender, and verbal ability (Carlson & Moses, 2001). Thus the concurrent relation between executive function and behavioral control has also been empirically demonstrated.

It is clear that the current state of the literature is limited in its exploration of relations among inhibitory control abilities. For example, no study to date has
specifically explored the possible connection between the regulation of emotional expressions and executive function. Furthermore, few studies have incorporated a wide range of inhibitory control tasks in their assessments of preschool aged children. Those studies with multiple tasks have relied primarily on one domain of inhibitory competence rather than approaching this notion from tasks reflecting all of these constructs. There exists a significant gap in the literature on preschool age children’s development of inhibitory control.

Underlying Factors Associated with Inhibitory Control

In line with the overarching goal of the present investigation to propose a comprehensive model for explaining global inhibitory ability, it is important to explore the underlying structure of this ability. Developmental researchers have traditionally explored inhibitory competence in a somewhat domain-specific way, such as that which has guided this review thus far (e.g., Luria, 1966; Rothbart & Ahadi, 1994). That is, various domains of research, including the emotional, cognitive, and motor/behavioral domains, have identified inhibitory control as a mechanism or skill necessary for the regulation of interfering content within that domain of study. Various fields have incorporated distinct measures of inhibitory control and commonly defined it as the active suppression of a prepotent response for the purposes of pursuing a goal. The present domain-specific approach would suggest that inhibitory ability may be a three-dimensional construct, separated by the type of response that is inhibited (e.g., emotional, mental, or motor). While this approach is a meaningful one, it may not offer the most succinct explanation of the relatedness between constructs involving inhibition.
An alternative model would be one that separates inhibitory abilities by the type of goal that is pursued, rather than by the type (or content) of response that is suppressed. Such an approach would emphasize the motivations or goals that guide children’s performance on a range of inhibitory tasks (Nigg, 2000). This approach would be consistent with findings from a study of normal and behaviorally disturbed boys (Kindlon, Mezzacappa, and Earls, 1995) in which the two factors of executive inhibitory control (e.g., Stroop, Trail-making B) and motivational inhibitory control (e.g., Go/No Go, Newman card-playing tasks) emerged. The degree to which inhibition involves incentives (such as in the delay paradigms) may be the distinguishing factor among these tasks. In line with this reasoning, incentives could be material (e.g., more candy) or social (e.g., considering the feelings of a person who has given you a gift). A two-factor structure may explain inhibitory abilities such that socially-motivated inhibitory abilities (e.g., emotion regulation and some tasks involving behavioral control) may cohere into a separate factor from non-social indices (e.g., executive function, and some tasks involving motor control).

This approach would be consistent with that of Borkowski and Burke (1996) who suggest that inhibitory concepts may differ in terms of generality versus specificity, cognitive versus motivational orientations, and frequency of usage in everyday learning and problem solving. That is, executive function might be considered to be a more specific concept because it is heavily task-dependent. Also, executive function might be considered to be more cognitive, as it guides the use of lower-level strategies on complex,
novel tasks, whereas emotion regulation and some aspects of behavioral control may be considered more motivationally driven.

Most recently, Zelazo (2003) has proposed a theory suggesting that executive function should be defined in terms of outcomes and accomplishments. According to this theory, tasks that have little or no affective consequences (e.g., Day/Night Stroop) reflect “cool” executive functions, whereas those that are affectively or motivationally driven (e.g., delay of gratification) reflect “hot” executive functions. Zelazo also suggests that these differences may be represented by brain structures, such that “hot” executive functions would be more influenced by the limbic region of the brain that guides emotions (Zelazo, 2003). Although Zelazo does not include examples of emotion regulation in this theory, one might suggest that it too reflects a “hot” control function.

The findings of previous research offer some insight as to the underlying factor structure of inhibitory control. For example, Carlson & Moses (2001) performed a principal components analysis using a variety of inhibitory tasks, and found two factors to emerge: delay and conflict. Items that fell on the delay scale included Pinball, Gift Delay, Tower Building and KRISP. These tasks are thought to require the child to merely inhibit their responses (e.g., wait until the experimenter gave the signal on the Pinball task). On the other hand, the items that fell on the conflict scale included the Day/Night Stroop, Grass/Snow, Spatial Conflict, Bear/Dragon, the Dimension Change Card Sort, and Whisper. The authors suggest that these tasks require the child to not only inhibit a prepotent response, but to additionally activate a conflicting, novel response (Carlson & Moses, 2001). While these findings offer some evidence of differences
underlying commonly used tasks of inhibitory control, they do not take into account emotional regulation, which would contribute to a more comprehensive account of inhibitory ability.

Is there an underlying factor structure that can explain the pattern of variation between indices of inhibitory control? The present investigation was an opportunity to empirically address this question by exploring a range of tasks requiring inhibitory control. It was proposed that inhibitory control might best be described in terms of the social relevance of the function, motivation, and the final goals associated with control.

Social Outcomes of Inhibitory Control

Individual differences in inhibitory control have been shown to be related to a variety of social outcomes, including outcomes associated with psychological disorders as well as differences in a range of normative outcomes. Deficiencies in inhibitory control have been implicated in behavioral disorders including Attention Deficit Disorder (ADD) and Attention Deficit Hyperactivity Disorder (ADHD; Barkley, 1997), Conduct Disorder (CD; Lueger and Gill, 1990), Obsessive-Compulsive Disorder (OCD; Enright and Beech, 1990), as well as a number of psychopathological tendencies referred to as “disinhibitory psychopathology”, including antisocial behavior, hysteria, impulsiveness, and alcoholism (Gorenstein and Newman, 1980).

The process by which inhibitory control influences these outcomes is thought to vary by disorder. Children with ADD are thought to have particular difficulty withholding strong, prepotent, or overlearned responses (Barkley, 1997), while ADHD children are more impulsive and behaviorally active (Hynd et al., 1991). Children with
CD, on the other hand, are characterized by poor impulse control, acting-out behaviors, disruption, and delinquency (Lueger & Gill, 1990). Children with OCD exhibit repetitive and fixed patterns of behaviors or obsessive thoughts that are difficult to disengage, leading to an inability to suppress inappropriate and disturbing thoughts (Enright and Beech, 1990). Across these disorders, therefore, inhibitory ability may be important for the control over thoughts and cognitions or behaviors.

The preschool years are a particularly important period during which to examine the consequences of inhibitory abilities. During these years, children typically begin to enter more socially demanding contexts and spend a greater amount of time with other children. This period is an opportunity for children to gain a significant amount of knowledge about inhibitory skills, and the consequences of these abilities on social acceptance. New social goals enter into the picture during this period (e.g., peer acceptance), creating a context in which the child’s self-control may have greater social consequences. As such, a greater understanding of the role of inhibitory abilities on social competence during the preschool years could have profound implications for researchers interested in identifying factors that facilitate children’s readiness for structured school settings (Blair, 2002).

In a study of children’s control of emotional expressions in the face of disappointment, Cole, Zahn-Waxler, and Smith (1994) found that boys who were at-risk for a variety of problems (e.g., conduct, oppositional, attention deficit, depression, and anxiety) displayed more negative emotion and for longer periods of time than low-risk boys while they were in a room with the experimenter who disappointed them.
Interestingly, high-risk boys did not differ from their low-risk counterparts in terms of negative emotions displayed once the experimenter left the room. These results suggest that the low-risk boys, but not the high-risk boys, demonstrated expressive control. These finding were not, however, found for high-risk girls. Interestingly, high-risk girls displayed twice as much positive as negative emotion in the experimenter-present situation, and showed no difference in emotion expression when the experimenter was absent. This pattern of emotion expressions, referred to as “minimization of negative emotion” predicted attention deficit and conduct disorder symptoms for female subjects (Cole, Zahn-Waxler, and Smith, 1994). Thus, there is a clear link between children’s ability to control emotional expressions and social outcomes, and gender may interact with this association. Cole and colleagues have also explored the link between behavioral control, cognitive intelligence, executive function, and social outcomes. Findings of this study revealed that lower intellectual functioning among preschoolers was associated with higher parent and teacher ratings of externalizing behaviors, and that high risk preschoolers were more likely than moderate-risk preschoolers to yield to temptation in a measure of behavioral control. However, the association between executive function and risk status was not found to be significant in this study (Cole, Usher, and Cargo, 1993), possibly due to the fact that the executive function battery used in this study taps the underlying executive mechanisms of planning, organization, problem-solving, shifting, and attention to a greater extent than the mechanism of inhibitory control.
Furthermore, Eisenberg and colleagues have extensively studied the relationship between emotionality and emotion regulation in predicting outcomes, and their findings suggest that the combination of good regulation and low emotionality predicts social competence concurrently and longitudinally (Eisenberg, Fabes, Nyman, Bernzweig, & Pinuelas, 1994). Measures of regulation in this study consisted of adult reports of coping styles and attentional control. In a subsequent study by Eisenberg and colleagues, similar findings were obtained when the measure of regulation was extended to include adult reports of inhibition control, and impulsivity (Eisenberg, Fabes, Murphy, Maszak, Smith & Karbon, 1995).

A link between behavioral control and social outcomes has also been empirically demonstrated. Effortful control has been shown to be negatively associated with violations of maternal prohibitions (Kochanska, Murray, and Harlan, 2000), and to be positively associated with the development of conscience in school aged children (Kochanska, Murray, and Coy, 1997). Interestingly, the relations between effortful control and conscience held for a range of aspects of conscience, including those that require initiating and sustaining mundane activity, those that require suppressing desired but prohibited behavior, moral self, and moral cognition (Kochanska, Murray, and Coy, 1997). Additionally, effortful control has been suggested to be associated with conscious regulation of conduct, specifically, behaviors requiring an active suppression of approach or initiation or maintenance of acts that are unpleasant (Rothbart, 1989). This self-regulatory ability at age 2 has been shown to predict conscience development at age 8 (Kochanska, 1991). Finally, the ability to delay gratification has also shown longitudinal
predictions to persistence, planfulness, attention, and reasoning ability (Shoda, Mischel, and Peak, 1990).

The outcomes associated with children’s development of executive function have been a topic of interest in recent studies. In a study of “hard to manage” preschoolers, Hughes, Dunn, and White (1998) found that children who were classified as “hard to manage” were significantly more likely to fail executive function tasks than children in a control group. Although this group difference nearly diminished once verbal ability and social background were accounted for, the findings offer support for the notion that executive function may lead to problems of disruptive behavior (Hughes, Dunn, and White, 1998).

In sum, there is a great deal of convergence among the fields of emotional, cognitive, and motor development in terms of outcomes associated with individual differences in these domains. Children’s developmental trajectories within these fields have consequences for the development of social competence and psychological disorders and inhibitory control is thought to be a major contributor to differential outcomes. It would be valuable, then, for researchers to utilize a comprehensive approach, addressing multiple types of inhibition in the prediction of outcomes, rather than examining these outcomes in the current domain-specific approach (Nigg, 2000). One important component of social competence outcomes is children’s understanding of theory of mind.
Theory of mind

Traditional accounts of theory of mind development suggest that the ability to understand false beliefs involves conceptual change. That is, prior to about the age of 3.5 years, children are thought to lack an understanding of mental states (Wellman, 1990). Recently there has been an influx of literature suggesting that false belief performance may also be influenced by executive ability (e.g., Carlson & Moses, 2001, Frye, Zelazo, & Palfai, 1995). There are at least two lines of reasoning which explain the association between executive function and theory of mind. The first, referred to as the “expression” account, suggests that children have theory of mind understanding prior to the age of 3.5 years, but that without executive function they cannot express this knowledge of false belief in traditionally-administered tasks. Such tasks require children to predict the actions of a character on the basis of the real situation or the character’s false representation of the situation. Thus without the executive ability to inhibit their knowledge of reality, children under 3.5 years of age fail false belief tests (Moses, 2001).

Another account of the association between executive function and theory of mind, the “emergence” account, states that some executive ability must be in place before a child can even construct a belief concept. A critical prerequisite for children to attain a concept of beliefs is the ability to reflect on thought and action, to distance themselves from the immediate situation, and to inhibit salient but misleading knowledge (Moses, 2001).

The empirical support of the association between theory of mind and executive function has recently begun to grow. Carlson and colleagues have done considerable work drawing linkages between theory of mind and inhibitory abilities. These studies
have found that at both 3- and 4-years of age, theory of mind was related to executive inhibitory control ability (e.g., day/night and card sort), as well as to measures of delay of gratification (e.g., gift delay). These associations were significant even after controlling for the effect of age, gender, and verbal ability (Carlson & Moses, 2001; Carlson, Moses, & Hix, 1998). Overall, this work offers an important contribution to the understanding of inhibitory control by bringing together executive function, behavioral control, and theory of mind.

Another study has shown a relation between children’s behavioral control and theory of mind. Specifically, Moore, Barresi, and Thompson (1998) found that 4-year olds who opted for a delayed reward that involved sharing with a partner showed greater theory of mind performance. The delay contingency in this study involved giving children the choice between immediate stickers (to self or to a play partner) or delayed sticker (that would be shared between the child and play partner). These findings propose the relatedness between the ability to inhibit responding to a perceptually salient event, the ability to imagine other’s mental states, and the ability to show future-oriented prosocial or sharing behaviors (Moore, Barresi, and Thompson, 1998). Overall, this study offers some insight regarding the process by which a variety of inhibitory skills may work together with theory of mind understanding. For example, sharing or delaying a desired prize could elicit negative emotions in many children. The ability to regulate the immediate negativity that arises from this situation may enable children to focus their mental resources on thinking about others’ mental states or feelings. On the other hand, theory of mind might facilitate children’s regulation of negative emotions such that
children with a better capacity to represent others’ mental states may be more motivated to control this negativity and behave in a socially-appropriate way because they can mentally represent the consequences of their own actions on other’s feelings.

The abovementioned research offers evidence of concurrent relations between executive function, behavioral control, and theory of mind. Hughes’ (1998) examination of the associations between executive function ability and theory of mind found similar results, even when examining theory of mind one year later. Specifically, inhibitory control was related to both deceit and false-belief explanation, after controlling for age-related effects. When age, verbal ability, and non-verbal ability were controlled, inhibitory control was significantly related to deceit. Deceit is thought to be a strong indicator of false belief understanding as this ability requires children to understand that their own mental states are independent from, and potentially inconsistent with those of others. In order to carry out deceitful activities, one must hold the assumption that others can have false beliefs about the reality of a situation. Hughes (1998) further explored the relation between inhibitory control and theory of mind by carrying out a mediational statistical model to determine whether improvements in inhibitory control mediate age-related improvements in children’s deception. The results of these analyses suggested that age-related improvements in deception could be explained by co-occurring improvements in inhibitory control.

Theory of Mind and Social Competence

What are the implications for understanding the role of individual differences in inhibitory competence on theory of mind ability? Theory of mind development may be
considered an index of social competence as recent research suggests a strong connection between children’s development of theory of mind and various socially competent behaviors. Children with theory of mind, which includes the ability to describe, explain, and predict the actions of others using mental terms and concepts (e.g., Butterworth, 1994), are thought to be more poised to exhibit prosocial behaviors. Some suggest that this is because the ability to consider multiple perspectives and even counterfactual information (as is required of false belief tasks) may be a prerequisite for the ability to make accurate attributions regarding others’ behaviors, to act prosocially, and to inhibit reactive responses. Having an understanding of the potential discrepancy between another person’s beliefs and reality, therefore, may be important to the development of social competence (Capage & Watson, 2001). For example, false belief understanding may play a role in children’s behavioral responses to normal, everyday interactions with peers and siblings in which they are required to reason regarding issues of cooperation, negotiation, and the intent behind wrongful actions (Watson, Nixon, Wilson, and Capage, 1999).

Recent research has revealed a strong association between children’s false belief understanding and their social behaviors. Capage and Watson (2001) found false belief performance to be negatively related to teacher ratings of aggression, and positively related to two scores on the preschool interpersonal problem-solving test (generation of more alternative relevant solutions and fewer forceful solutions to interpersonal problems. Similarly, Watson, Nixon, Wilson, and Capage (1999) found that false belief understanding was a significant predictor of teacher ratings of preschoolers’ and
kindergarteners’ positive social skills (as measured by a global indicator of social skills), even after controlling for age, language comprehension ability, and talkativeness.

Additionally, in an observation of peer interactions of 3- and 4-year-old’s peer play over a 7 month period, Jenkins and Astington (2000) found theory of mind to be related to socially competent peer play, including joint planning (i.e., reference to the activity of both self and other) and role assignment (i.e., explicitly assigning a pretend role to self or other). It is suggested, therefore, that theory of mind development plays a role in cooperative interactions with peers. In a study by Lalonde and Chandler (1995), “intentional” markers of social competence at 3 years of age (i.e., behaviors demonstrating the intention or motivation to act pro-socially) were related to false belief understanding in this age group. Social competence was measured by a questionnaire loosely based on the Vineland Socialization Scale (Sparrow & Cicchetti, 1984).

Finally, the consequences of impaired theory of mind ability are evident in children with autism, a developmental delay involving severe difficulties in social, language, and behavioral domains. Children with autism typically fail false belief tasks while children with other delays, including Down syndrome, do not. This has led many to hypothesize that a theory of mind deficit underlies the main elements of this developmental delay (Astington & Barriault, 2001).

In summary, there exists empirical evidence linking inhibitory control with social competence, inhibitory control with theory of mind, and theory of mind with social competence. While some relations have been identified, there are limitations that remain to be resolved. First, while a connection has been drawn between theory of mind and
both executive function and one aspect of behavioral control (i.e., delay of gratification), no study to date has considered the association between emotion regulation and theory of mind. From a theoretical standpoint, one might suggest that in situations requiring negotiation with peers, for example, emotion regulation may facilitate children’s ability to control their internal reactivity and consider others’ mental states and feelings. Also, it is conceivable that those children who display greater control over their emotional expressions may do so because they have a greater understanding of others’ thoughts and feelings and are acting in accordance with this knowledge. This ability to consider other’s perspectives may also play a role in whether children choose to, or are motivated to, control their emotional expressions. Findings from Capage and Watson’s (2001) study support this speculation. Capage and Watson found a relation between teacher’s ratings of aggression and theory of mind. The authors suggest that this might indicate that children with a well-developed theory of mind may be better able to inhibit their reactive responses, including aggressive ones, by taking into account past and future events, rather than just the current reality, when making attributions about causes of behavior (Capage & Watson, 2001). While control of aggressive activity is not a direct indicator of emotion regulation, aggressive behavior is considered a lack of behavioral control, and is often accompanied by lower levels of regulation. Thus, the connection between the theory of mind and the ability to regulate one’s emotions may be implied from these findings. However, a more direct investigation of these abilities is necessary for better understanding how inhibitory control of emotional expressions may be related to theory of mind development. Exploring relations between children’s false belief and
emotion regulation, as well as their theories of other’s feelings and emotions may be an important approach to understanding these relations.

Conclusions and Hypotheses

Aim 1. The Relations among Inhibitory Control Skills across Constructs.

The findings from previous literature provide theoretical and empirical support of relations among inhibitory abilities across contexts. In particular, these abilities appear to be governed by a common brain structure. However, to date, no study has investigated inhibitory control across the emotional, behavioral, and cognitive domains in preschool aged children. The first goal of the present investigation, therefore, was to examine inhibitory control abilities in tasks designed to measure emotion regulation, executive function, and behavioral/motor control in 4.5 year olds. In line with this goal, we examined specific predictive relations among these abilities. Hypothesis 1a. Measures of emotional, behavioral, and cognitive inhibitory control would cohere within each of these constructs such that measures within the same domain would show significant positive relations. Hypothesis 1b. The indices of emotional, behavioral, and cognitive inhibitory control would be positively related such that behavioral control would be related to emotion regulation and executive function even after controlling for verbal ability. It was also expected that emotion regulation would be related to executive function, although this hypothesis was exploratory. Hypothesis 1c. Emotional arousal and emotion regulation would show an interactive effect in predicting behavioral and cognitive control, such that children who display high levels of negative reactivity and the ability to suppress their negativity would perform better on cognitive and behavioral
tasks requiring inhibitory control, whereas children with high levels of negativity and little or no ability to modulate this reactivity would show poorer performance on cognitive and behavioral inhibitory tasks. **Hypothesis 1d.** Composite measures of emotion regulation and executive function would significantly predict a composite measure of behavioral control even after controlling for verbal ability. **Hypothesis 1e.** Behavioral control would predict executive function above and beyond the effect of emotion regulation and verbal ability.

**Aim 2. Identifying an Underlying Factor Structure for Global Inhibitory Control.** The second aim of the present investigation was to identify an underlying factor structure for explaining the pattern of variation among indices of inhibitory control. The traditional approach to studying inhibitory control has been to explain inhibition according to the type (or content) of response children must control (e.g., emotional, motor, or mental). It was proposed that an alternative, more concise, approach would be to explain inhibitory control in terms of the social versus non-social function, motivation, and final goals associated with control because such an approach would be more meaningful to developmental researchers interested in understanding the consequences of children’s inhibitory ability across contexts. Because this aim was exploratory in nature, no specific hypotheses were proposed.

**Aim 3. Predicting Theory of Mind.** Children’s theory of mind understanding has many consequences to their development of social competence. A greater understanding of the antecedents of this ability would be an important step toward identifying predictors of social competence. While several recent studies have explored
the role of individual differences in inhibitory control in predicting differences in theory of mind development, the emphasis has been on cognitive inhibitory ability (i.e., executive function). Very little is known regarding the role of behavioral control in theory of mind ability, and even less is known about the role of emotional control in the development of theory of mind. Thus, the third aim of the present investigation was to explore the degree to which children’s theory of mind understanding at 5.5-years of age was predicted by individual differences in emotional, behavioral, and cognitive control at 4.5-years. **Hypothesis 3a.** Consistent with previous research, there would be a relation between specific indices of cognitive and behavioral inhibitory control and theory of mind ability, even after partialling the effect of verbal ability. **Hypothesis 3b.** It was also expected that individual difference in the ability to regulate emotional expressions would be related to differences in theory of mind, such that children with greater emotion regulatory ability will show better theory of mind performance. This hypothesis was exploratory in nature. **Hypothesis 3c.** Executive function and behavioral control would significantly predict theory of mind, with executive function showing the strongest prediction, even after controlling for emotion regulation and verbal ability.
Chapter 3

METHOD

Participants

Participants were drawn from two samples of 150 healthy, term infants who were recruited at 2 weeks of age, and were participating in a longitudinal study of emotional development. At 4.5 years, 92 subjects (43 female, 49 male) were observed with their mothers and 90 subjects (43 female, 47 male) were observed with fathers. At 5.5 years, 86 subjects (41 female, 45 male) were observed with their mothers and fathers. At the 4.5-year observations, children had a mean age of 4 years, 6 months (range = 4 years, 5 months – 5 years, 0 months) at their first visit, and 4 years, 7 months (range = 4 years, 5 months – 4 years, 9 months) at their second visit. At the 5.5-year observation, children had a mean age of 5 years, 6 months (range = 5 years, 5 months – 5 years, 9 months) at their first visit, and 5 years, 8 months (range = 5 years, 6 months – 6 years, 1 month) at their second visit. Families were predominantly White, and were originally recruited from a local community hospital. At the time of their 4.5-year visit, mothers had a mean age of 35 years (range = 20 - 47 years) and an average of 15 years of education. Fathers had a mean age of 37 years (range = 25 - 50 years) and an average of 16 years of education. At the time of their 4.5-year visit, the combined annual income of the families were as follows: 6% reported between $10,000 and $25,000, 25% reported between $10,000 and $25,000, 32% reported between $50,000-75, 000, 26% reported between $75,000 to 100,000, 10% reported between $100,000-150,000, and 1% reported greater than $150,000.
Procedure

Children visited the laboratory separately with each of their parents at 4.5 and 5.5 years of age, for a total of four laboratory visits. These visits were conducted in a quiet observation room with a one-way mirror and two video cameras. Children were seated at a small wooden table next to the experimenter. The room also contained a computer cart, a chair for the parent, and a small table next to the parent’s chair. All the following procedures were videotaped for off-line coding purposes. With the exception of one 4.5-year-old child, children’s visit to the lab with their mother always preceded that with their father. If unusual circumstances prevented one parent from being present at the lab visit, the other parent took his or her place. This was the case for two fathers who were absent at the 5.5-year visit.

4.5-year visits. At 4.5-years, both parents completed the Parent Report of Child Reactions Questionnaire and Child Behavior Questionnaire. At the laboratory, children participated in a series of tasks. See Table 1 (p. 64) for the sequencing of laboratory tasks at each of the four visits (tasks used for the purposes of this investigation are in boldface). The disappointment task and PPV test measures were obtained at this child’s 4.5-year visit to the laboratory with his or her mother, and the Three Pegs task, Continuous Performance Task (CPT), Day/Night task, Tapping task, Walk-the-Line task, Dinky Toy task, and Delay of Gratification task measures were obtained at the child’s 4.5-year visit to the laboratory with his or her father.
5.5-year visits. At 5.5-years, both parents completed the Child Behavior Questionnaire. As with the 4.5 year laboratory visit, the children participated in a number of tasks. Only the Theory of Mind (ToM) measures which were obtained at the child’s 5.5-year visit with his or her father was used in the present study. See Table 1 for a sequencing of the tasks for the 5.5 year father laboratory visit.

Measures

Laboratory tasks are categorized as reflecting verbal ability, emotion regulation, behavioral control, executive function, or theory of mind. Parent report questionnaires are presented separately as these were used as measures of different types of inhibitory control and negative reactivity. The variables derived from each measure are also described, and these are listed in Table 1.

Laboratory tasks

Verbal Ability

Peabody Picture Vocabulary Test-Revised. The PPVT-R (Dunn & Dunn, 1981) was used as a measure of the child’s receptive vocabulary, and a proxy for children’s intelligence. The PPV variable consists of the child’s standardized PPV score at 4.5 years of age. This variable was used as an index of the child’s language development to assess the degree of variation in other study variables that may be accounted for by the child’s language development.

Emotional Regulation

Disappointment Task. Following Cole’s (1986) procedure, the disappointment paradigm was used in which children received an undesirable toy. Children were first
asked to rank six small prizes, some of which were undesirable (a broken rattle, a broken comb, a plastic lizard, play-dough, bubbles, and a piece of chalk). After the child ranked the toys, the experimenter put the toys away and continued with other laboratory tasks. After the child completed a series of tasks, the experimenter told the child that she and his or her mother would go into the other room to get a prize for the child. The experimenter returned to the observation room with the child’s gift-wrapped prize, which consisted of the toy that the child had ranked as the least favorite. This marked the beginning of the disappointment situation.

The experimenter handed the child the wrapped prize, sat next to the child, and remained in the room for 30 seconds while the child unwrapped the gift (experimenter-present/social condition). The experimenter did not engage the child during this time and only responded with a nod of the head to any of the child’s verbalizations. After 30 seconds, the experimenter left the room saying “I need to check on something in the other room”. The child was alone in the room for 60 seconds (experimenter-absent/nonsocial condition). After 60 seconds, a second experimenter entered the room and interviewed the child to determine self-report of feelings during the disappointment. Children were asked what prize they were given, and how they felt when they got that prize (question 1). If the child indicated that he or she felt a positive emotion (e.g., “happy” or “okay”) upon receiving the prize, the interviewer said, “I thought that this was the one you did not want. So, how did you feel about getting the prize that you did not want?” (question 2a). If the child continued to indicate that he or she felt a positive emotion upon receiving the prize, the interviewer said, “Some children would be happy with this [prize] and some
wouldn’t. I want to know how you feel about getting this [prize]” (question 2b). If the child indicated that he or she felt a negative emotion at question 1, the interviewer skipped questions 2a and 2b. The child’s answers to these questions were recorded. Finally, the child was offered the opportunity to trade his or her prize with another one. Whether or not the child traded in the prize was also noted.

The child’s facial expressions were coded during both the experimenter-present and experimenter-absent conditions. An independent group of coders transcribed the children’s vocalizations during both of these segments. Coding of facial expressions was derived from Elkman and Friesen’s (1978) Facial Action Coding System (FACS). Using a continuous coding method, the onset and offset of the following facial expressions were accounted for: high positive, low/moderate positive, neutral, low/moderate negative, and high negative. Positive expressions included lip corner pull and cheek raise. Negative expressions included lip corner depress, upper lip raise, chin raise, lip tighten, lip press, lip bighting, nose wrinkle, inner brow raise, and brow lower. To avoid bias due to vocal displays of emotion, coders viewed the tapes without sound. Twenty-four percent of the subjects were independently coded to assess reliability. Coders first trained to 89% duration agreement and maintained 84% duration agreement across all coding (see Appendix A for a description of the coding scheme).

The child’s vocal expressions were coded by an independent pair of coders. To ensure that coding of vocalizations would not be biased by children’s facial expressions, coders listened to recordings of the disappointment task without observing the video image of the task. Each vocalization was coded according to content and tone.
Verbalizations were coded as negative if they included words such as “angry”, “sad”, “hate”, “don’t like”, or if the child cried. Verbalizations were coded as positive if they included such words as “happy”, “like or love” or if the child laughed. Tone was coded as negative if it was hostile/loud, demanding, accusatory, disgruntled, or whiney, and as positive if it was pleasant, cheerful, or appreciative. Each vocalization that was considered to be positive or negative according to content or tone was coded as low positive or low negative, respectively. Vocalizations with evidence of positive or negative content and tone were coded as high positive and negative, respectively. All other vocalizations were coded as neutral. Neutral vocalizations typically consisted of children’s reference to, or description of, the prize itself. Twenty-eight percent of the subjects were independent coded to assess reliability. Coders maintained an average Cohen’s Kappa of .91 across all coding.

The disappointment task variables consisted of: duration of positive, negative, and neutral facial expressions for each segment (experimenter-present and experimenter-absent), number of positive, negative, and neutral verbal expressions for each segment (experimenter-present and experimenter-absent), self-reported feeling of disappointment (answers to interview questions 1, 2a, and 2b), and prize exchange (yes/no).

**Behavioral/Motor Control**

*Continuous Performance Test (CPT).* A computer based go/no go continuous performance task (CPT) was used to assess behavioral control. The task consisted of 16 trials. At each trial, the child was presented with a black and white drawing of an animal on a computer screen. Children were instructed to press the space bar on the computer
keyboard as fast as possible when a rabbit was presented. The duration of the picture presentation began at 4 seconds, and decreased by an increment of 1 second at every fourth trial. The stimuli consisted of rabbits (the target animal), and distractor animals (i.e., elephant, frog, deer, and polar bear). The order of the stimuli presented was random without replacement. The picture disappeared from the screen either in response to a key press, or when the duration of presentation time elapsed. Tones signaled the accuracy of a response such that a high-pitched beep sound indicated a correct response, whereas a low-pitched beep indicated an incorrect response (i.e., error of commission). The computer recorded the child’s performance on each trial. The \textit{CPT task variables} consisted of: total number of correct responses, number of errors of commission (pressed the key when it was not called for), number of errors of omission (did not press the key when it was called for), and average reaction time for correct key press trials.

\textit{Delay of Gratification.} The delay of gratification situation was adapted from Mischel \& Mischel (1983). In this task, children were told that the experimenter needed to leave the room with their father. Two small cups were placed on a table immediately in front of the children, and a bell was placed between the two cups. One M&M candy was placed in one cup, and two M&M candies were placed in the other cup. The experimenter confirmed that the children were aware of the two different quantities of M&M candies in the cups. Then, the experimenter informed children of the delay contingency: if they waited for the experimenter to return with their father, then they would receive two M&M candies, but if they rang the bell to summon the return of the experimenter and father, they would receive only one M&M candy. Next, the
experimenter ensured that the children understood this contingency by asking, “So what do you get if you wait for us to return? But if you can’t wait, what should you do? If you ring the bell, what do you get?” The task lasted up to 15 minutes, or until the child rang the bell. The Delay of Gratification variables consisted of: type of ending to delay (i.e., whether the child waited for experimenter, rang the bell, or ate an M&M), and the latency to delay (i.e., the total duration of time that the child waited without ringing the bell or eating an M&M).

Dinky Toy Task. In this task (Kochanska, 1997), children were presented with a large container filled with small toys. The experimenter told the child to wait to hear the rules of the game before touching anything. Next, the experimenter opened the container of toys and the children were told that they would have the opportunity to choose one toy to keep, but that the first toy that they touched would be the one that they would have to keep. The container was placed immediately in front of the child, and the experimenter waited while the child chose a toy. The Dinky Toy task variables consisted of: type of ending to dinky toy task (i.e., whether the child touched a toy that he or she did not want, or successfully chose the toy that he or she wanted), and the latency to choose a dinky toy (i.e., the total time taken to choose a toy).

Walk the Line Task. This task (Kochanska, 1997) was used to assess the degree to which the child could slow down his or her motor activity. The child was asked to walk along a line (denoted by black tape glued to the floor, 12 feet in length and 2.5 inches wide) without stepping off the line, and to ring a service bell (that sat upon a table at the end of the line) upon reaching the end of the line. The child was to begin at a waiting
strip about 1 foot from the walking line. The experimenter demonstrated this task to the child. The first trial was considered a practice trial. In the second trial, the experimenter announced that she wanted to see how slowly the child could walk down the line without stepping off the line while demonstrating the task. In the third trial, the experimenter said that she again wanted to see how slowly the child could walk down the line, and demonstrated by walking slowly down the line in a highly exaggerated manner. Finally, in the fourth trial, the experimenter announced that she wanted to see how fast the child could walk down the line. The Walk the Line variables consisted of: duration of time taken to walk the line in each of the four trials.

Executive Function

Day/Night Task. This stroop-like task (Gerstadt, Hong, & Diamond, 1994) was used to assess children’s ability to follow two card-naming rules requiring inhibition of a prepotent response. Children were shown a black card with a picture of a moon and instructed to say “day” whenever presented with this card (Rule 1). Then, children were shown a white card with a picture of a sun and instructed to say “night” whenever presented with this card (Rule 2). Next, the experimenter moved on to the practice trials, during which the child was presented with each card with no prompt. If the child gave the correct response on both practice trials, the experimenter continued on to the test trials. If the child was incorrect, the experimenter repeated both rules, beginning with the card the child got incorrect, and then presented the child with the practice trials again. If the child was correct on both of these practice trials, the experimenter continued on to the test trials. If the child was incorrect on either of the second practice trials, the
experimenter reminded the child of the rules again and then began the test trials. If the child hesitated on any trial, the experimenter said, “What do you say for this one?”, but never said the words “night” or “day” as prompts. Children received a total of 16 test trials in a fixed random order. The **Day/Night task variables** consisted of: number of practice trials required, percentage of correct responses across all test trials, and percent correct on trials 1-4, trials 5-8, trials 9-12, and trials 13-16.

**Tapping Task.** This task (Diamond & Taylor, 1996; Luria, 1966) was used to assess children’s ability to follow two stick-tapping rules requiring inhibition of a prepotent response. Children were instructed to tap a stick on a table once if the experimenter tapped the stick twice (Rule 1), but to tap the stick twice if the experimenter tapped it once (Rule 2). Once the child demonstrated his or her ability to perform each rule, the experimenter moved on to the practice trials, during which the child was presented with both tapping conditions with no prompt. If the child was correct on both of these practice trials, the experimenter continued on to the test trials. If the child was incorrect, the experimenter repeated both rules beginning with the tapping rule the child got incorrect, and then presented the child with the practice trials again. If the child was correct on both of these practice trials, the experimenter continued on to the test trials. If the child was incorrect on either of the second practice trials, the experimenter reminded the child of the rules again. For testing to continue the child had to have been correct on each rule at least once over the practice trials and first two testing trials. Children received a total of 16 test trials in a fixed random order. The **Tapping Task variables**
consisted of: number of practice trials required, percentage of correct responses across all test trials, and percent correct on trials 1-4, trials 5-8, trials 9-12, and trials 13-16.

*Three Pegs Task.* This task required the child to tap colored pegs according to the experimenter’s instructions (Balamore & Wozniak, 1984). The apparatus consisted of wooden board (12 inches in length) with three colored pegs arranged in the order: red, yellow, green. The child used a small orange stick (8 inches in length) to tap the pegs.

A pretest was conducted to insure that the child could correctly identify the three colored pegs. The experimenter asked the child to point to each colored peg in the order they appear on the wooden board (i.e., red, yellow, green). Next, the instruction condition took place, in which the experimenter instructed the child, “With this stick I want you to tap each peg one time, the red peg first, then the green peg, then the yellow peg”. This order was inconsistent with the order in which the pegs were arranged on the board. The stick was handed to the child and, if the child tapped correctly, he or she was asked to do it again with a reminder of the instructions. If the child was again correct, the task was complete. If the child was not correct on the first trial, the demonstration condition took place, in which the experimenter added a demonstration of the order in which the pegs should be tapped, saying, “Watch me. I would like you to tap the red peg, then the green peg, then the yellow peg like this...” Then the experimenter handed the stick to the child and said, “Now you do it”. If the child was correct, he or she was asked to do it again with a reminder of the instructions. If the child was again correct, the task was complete. If the child was incorrect on either the demonstration or confirmation trials, then the vocalization condition took place, in which the experimenter repeated the
demonstration, saying, “With this stick, tap the red peg first, then the green peg, then the yellow peg. But this time I want you to say the colors at the same time you tap the pegs, like this…” If the child did not correctly say the names of the pegs while tapping them, the child and remind him or her to say what color the pegs are when tapping them. If the child did not get this correct then the task ended. If the child was correct then a confirmation trial followed after the child reminded of the instructions. If the child self-corrected on any of the trials, this was considered a correct trial. The Three Pegs task variables were: outcome of the task (i.e., pass/fail), and number of trials required to pass.

**Theory of Mind**

Theory of mind: Location false belief. A modified version of Wimmer and Perner’s (1983) standard unexpected location false belief task was used. Children watched a video of two children (Molly and Bradley) acting out a scenario in which both characters witness the placement of cookies in one location. Then, while one of the characters is absent, the other character places the cookies in a new location and then leaves the room. Finally, the first character returns to the room and wants another cookie. See Appendix B for full script and questions asked of the subjects. Following the end of the videotaped scene, children were asked one location false belief test question (i.e., “Where will Molly look for the cookies?”), one justification question (i.e., “Why will she look there?”), and two location reality control questions (i.e., “Where are the cookies really? Where were the cookies put first of all?”). Children were rated as completely correct on the location false belief test question if they also responded correctly to both reality control questions.
Answers to justification questions were categorized according to whether the answer was justification of a correct or incorrect answer to the false belief test question. If the child’s answer to the false belief test question was correct, the follow-up justification answer was categorized as: 1) reference to Mary’s belief (e.g., she doesn’t know that Bradley moved the cookies); 2) a reference to the initial location (e.g., that’s where she put them); or 3) other. If the child’s answer to the false belief test question was incorrect, the follow-up justification answer was categorized as: 1) reference to Bradley’s knowledge or actions (e.g., Bradley put them there); 2) reference to the current location (e.g., that’s where the cookies are); or 3) other. All other answers to justification questions will be coded as “other”. The ToM: Location false belief variables consisted of the child’s answers to the following four questions: the location false-belief question (correct/incorrect), the two location reality control questions (correct/incorrect), and the justification question (type of justification).

Theory of mind: Belief-desire reasoning. This task (see Harris, Johnson, Hutton, Andrews, & Cooke, 1989) requires children to predict an emotion from an attributed false belief about the contents of a container. See Appendix C for full script and questions asked of the subjects. Children watched a video recording of two children (Mary and Bradley) acting out a scenario in which one character plays a mean trick on the other character by replacing the contents of the first character’s can of coke (his favorite drink) with milk (the drink that he does not like). Midway through the video, children were asked two emotion questions (i.e., “How does Bradley feel when he gets the can of coke? How would Bradley feel if he got some milk?”), each with a follow-up emotion reality
control question (i.e., “Why would he feel that way?”). At the end of the video, children were asked one emotion-contingent-on-false-belief question (i.e., “When Bradley first comes back, how does he feel?”), a justification question (i.e., “Why does he feel that way?”), a contents false belief question (i.e., “What does Bradley think is in the can?”), a contents reality control question (i.e., “What is in the can really?”), an emotion question (“How will Bradley feel after he has a drink from the can?”), and a follow-up emotion reality control question (i.e., “Why will he feel that way?”). To completely pass the false belief and emotion questions, children had to also pass the respective reality control questions.

Answers to the justification question were categorized according to whether the answer was justification of a correct or incorrect answer to the emotion-contingent-on-false-belief question. If the child’s answer to the emotion-contingent-on-false-belief question was correct, the follow-up justification answer was categorized as: 1) reference to Bradley’s belief (e.g., he doesn’t know that Mary poured milk in his coke, he thinks there is coke in his can); 2) a reference to the contents of the can (e.g., he wants his coke, he can drink his coke); or 3) other. If the child’s answer to the emotion-contingent-on-false-belief question was incorrect, the follow-up justification answer was categorized as: 1) reference to Molly’s knowledge or actions (e.g., Molly poured milk in his can, Molly played a trick on him); 2) reference to the current contents of the can (e.g., he doesn’t like milk, there is milk in his can); or 3) other. The ToM: Belief-desire reasoning variables consist of the child’s answers to the following ten questions: three emotion questions (correct/incorrect), three emotion reality control questions (correct/incorrect), contents
false belief question (correct/incorrect), contents reality control question (correct/incorrect), emotion-contingent-on-false-belief question (correct/incorrect), and the justification question (type of justification).

**Theory of Mind: Second Order False Belief.** This task requires the child to attribute second-order beliefs to characters in a story enacted by the experimenter using Lego pieces for the characters, and a rug that depicted a neighborhood. See Appendix D for full script and questions asked of the subjects. Children sat facing the experimenter on the opposite side of the rug, and watched as the experimenter enacted the story. At the conclusion of the story, children were asked one second order false belief test question (i.e., “Where does John think that Mary has gone?”), one justification question (“Why does he think she has gone there?”), and three reality control questions (“Does Mary know that the ice cream truck is at the library?”, “Does John know that Mary talked to the ice cream man?” “Where did Mary really go for her ice cream?”).

Answers to the justification question were categorized according to whether the answer was justification of a correct or incorrect answer to the second order false belief question. If the child’s answer to the second order false belief question was correct, the justification answer was categorized as: 1) a nesting of belief or knowledge states (e.g., John doesn’t know that she knows that the ice cream truck is there); 2) a nesting of information within a belief (e.g., John doesn’t know that she saw the ice cream truck); 3) reference to the initial location (e.g., that’s where she said she would go for ice cream); or 4) other. If the child’s answer to the second order false belief question was correct, the justification answer was categorized as: 1) a first order reference to either John’s or
Mary’s belief (e.g., because the ice cream man told John/Mary that he’d be there); 2) a reference to the current location (e.g., the ice cream man is there); or 3) other. The **Tom: Second order false belief variables** consist of the child’s answers the following five questions: second order false belief question (correct/incorrect), three reality control questions (correct/incorrect), and justification question (type of justification).

**Theory of Mind: Knowledge of Other’s Feelings.** This task (Muris, et al., 1999) is comprised of three drawings depicting characters involved in emotion-eliciting situations. Children were asked to interpret each situation, to identify each character’s emotion, and to provide the reasoning for each character’s emotion (See Appendix E for task pictures and the questions asked of children). This task is designed to assess both lower-order theory of mind (i.e., recognition of characters’ emotions) and higher-order theory of mind (i.e., justification of these emotions).

The first picture depicted a fire with five main characters in and around the fire. Children were asked to interpret the picture. Next, children were asked to identify the character in the picture that was afraid, happy, sad, and angry. Answers to the emotion questions were scored as correct (1) or incorrect (0), for a maximum of five points. Following each emotion question, children were asked to justify their answer (e.g., “Why is that person happy?”). Answers to these questions were scored as (0) inconsistent with the character’s status in the situation, or (1) consistent with the character’s status in the situation.

The second picture depicted two boys who are talking and pointing to a third boy. Children were asked to interpret the picture. Next the experimenter informed the child
that the picture depicts two boys who are saying mean things about the third boy who hears them. Children were asked to identify how one of the first two boys felt and how the boy who was being ridiculed felt. Answers to the emotion questions were scored as (1) correct, or (0) incorrect. Next children were asked to justify their answer (e.g., “Why is that boy sad?”). Answers to these questions were scored as (0) inconsistent with the character’s status in the situation, or (1) consistent with the character’s status in the situation.

The last picture depicted a girl who had fallen and hurt herself, yet was smiling. The children were asked to interpret the situation. Next, the experimenter informed the child that the picture depicts a girl who has fallen and hurt herself. Children were asked to identify how they feel when they hurt themselves. This answer was scored as (1) bad/negative feeling, or (0) good/positive feeling. Next, children were asked if they could see from the girl’s face how she really feels. Due to the variability in types of answers, this answer was scored as (0) happy, (1) sad, (2) yes, or (3) no. Next, children were asked if it is possible to look happy when you hurt yourself. This answer was scored as (0) no, or (1) yes. Finally, the children were asked to explain why the girl who has fallen and hurt herself might be smiling. These answers were scored as (0) no reference to control or masking of emotion, (1) reference to control or masking of emotion.

The **ToM: Knowledge of others’ feelings variables** consisted of the child’s answers to the seven lower-order emotion-identification questions (from pictures 1 and
2), the seven higher-order justification questions (from pictures 1 and 2), and the five questions from picture 3.

**Parent Reports**

*Children’s Behavior Questionnaire.* The CBQ (Ahadi, Rothbart, & Ye, 1993; Rothbart, Ahadi, Hershey, and Fisher, 2001) is a 98-item parent report of child temperament that identifies the broad dimensions of surgency/extraversion, negative affectivity, and effortful control. The scales used for the purposes of the proposed study were those which comprised the dimension of emotion regulation (i.e., falling reactivity/soothability, anger/frustration, and sadness), attentional focusing (to reflect cognitive control), inhibitory control (to reflect behavioral control), and negative affectivity (i.e., discomfort, fear, anger/frustration, and sadness). Across a number of studies the reported internal consistency of CBQ scales has ranged from .64 to .94, with a mean internal consistency of around .77 across all scales (Kochanska et al., 1994; Rothbart, Ahadi, Hershey, & Fisher, 2001). Additionally, this questionnaire has been shown agree with laboratory observations, as well as to other parent reports of socialization-relevant traits, including aggressiveness, empathy, guilt/shame, help-seeking, and negativity.

**Parent Report of Coping.** This parent report (Eisenberg, et al., 1993; Fabes, Eisenberg, Karbon, Troyer, & Switzer, 1994) was used to assess the child’s emotional reactivity and responses to emotion-eliciting situations. This assessment consisted of 44 items asking parents to report on their child’s typical reactions to specific situations that may require emotion regulation, (i.e., when the child is hurt due to peer ridicule, when the
child is hurt or angry because other children are playing without him or her, and when the child is angry because a peer has disrupted the child’s activity) and the child general response to problems. Responses reflected four overarching coping style scales: (1) denial, avoidance, distracting actions, and cognitive avoidance, (2) instrumental and reactive aggression, (3) instrumental support, instrumental intervention, and emotional support, and (4) venting and emotional interventions. The reported average alphas (across reports from mothers, teachers and aids) for each of the composite scales are: Scale 1 (.70), Scale 2 (.90), Scale 3 (.82), and Scale 4 (.82). Findings from previous studies suggest that mother’s reports of children’s coping, as measured by this questionnaire, were related to children’s social competence in the school setting (Eisenberg, et al., 1993; Fabes, Eisenberg, Karbon, Troyer, & Switzer, 1994).
Table 1  

Sequence of Laboratory Tasks and Derived Variables

<table>
<thead>
<tr>
<th>Laboratory Task</th>
<th>Derived Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5-Year Visit with Mother</td>
<td></td>
</tr>
<tr>
<td>Electrode Placement</td>
<td></td>
</tr>
<tr>
<td>Reward Punishment Task</td>
<td></td>
</tr>
<tr>
<td><strong>Disappointment Toy Rating</strong></td>
<td></td>
</tr>
<tr>
<td>Emotion Vignettes and Interview</td>
<td></td>
</tr>
<tr>
<td><strong>PPV Test</strong></td>
<td>Standardized PPV score</td>
</tr>
<tr>
<td><strong>Disappointment Task</strong></td>
<td>Duration of positive, negative and neutral facial expressions (Experimenter Present)</td>
</tr>
<tr>
<td></td>
<td>Number of positive, negative, and neutral verbal expressions (Experimenter Present)</td>
</tr>
<tr>
<td></td>
<td>Duration of positive, negative and neutral facial expressions (Experimenter Absent)</td>
</tr>
<tr>
<td></td>
<td>Number of positive, negative and neutral verbal expressions (Experimenter Absent)</td>
</tr>
<tr>
<td></td>
<td>Self-reported feeling of disappointment (answers to interview questions 1, 2a, and 2b)</td>
</tr>
<tr>
<td></td>
<td>Prize exchange (yes/no)</td>
</tr>
<tr>
<td>Electrode Removal</td>
<td></td>
</tr>
<tr>
<td>Structured Play</td>
<td></td>
</tr>
<tr>
<td>Free Play/Clean up</td>
<td></td>
</tr>
</tbody>
</table>
Table 1

*Sequence of Laboratory Tasks and Derived Variables*

<table>
<thead>
<tr>
<th>4.5-Year Visit with Father</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coping Stories</strong></td>
</tr>
<tr>
<td><strong>Three Pegs Task</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Day/Night Task</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Delay of Gratification Task</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Walk the Line Slowly Task</strong></td>
</tr>
<tr>
<td><strong>Structured Play</strong></td>
</tr>
<tr>
<td><strong>CPT Task</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Tapping Task</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Dinky Toy Task</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Free Play/Clean Up</strong></td>
</tr>
</tbody>
</table>
### Table 1  
*Sequence of Laboratory Tasks and Derived Variables*

<table>
<thead>
<tr>
<th>5.5-Year Visit with Father</th>
<th>Theory of Mind: False Belief Location</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Answer to location false belief question (correct/incorrect)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answer to two location reality control questions (correct/incorrect)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answer to justification question (type of justification)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Theory of Mind: Belief-Desire Reasoning</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Answers to three emotion questions (correct/incorrect)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answers to three emotion reality control questions (correct/incorrect)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answer to emotion-contingent-on-false-belief question (correct/incorrect)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answer to justification question (type of justification)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answer to contents false belief question (correct/incorrect)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answer to contents reality control question (correct/incorrect)</td>
<td></td>
</tr>
</tbody>
</table>

Card Sort Task

CPT Task

Puzzle Task

Competitive Game with Father

<table>
<thead>
<tr>
<th>Theory of Mind: 2nd Order False Belief</th>
<th>Answer to second order false belief question (correct/incorrect)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Answers to justification question (type of justification)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answers to three reality control questions (correct/incorrect)</td>
<td></td>
</tr>
<tr>
<td>Theory of Mind: Others’ Feelings</td>
<td>Answer to seven emotion recognition questions (correct/incorrect)</td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answer to seven justification questions (correct/incorrect)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answer to five question from picture 3 (correct/incorrect)</td>
<td></td>
</tr>
<tr>
<td>Coping Stories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frustration Task (Operation Game)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Play/Clean Up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delay</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
RESULTS

Results are organized into four sections. The first section reports preliminary statistics for each of the study tasks, and explains the steps taken to reduce the number of variables used in subsequent analyses. The last three sections address the primary study analyses. Specifically, the relations among emotional, behavioral, and cognitive measures of inhibitory control will be addressed as well as specific predictive relations among these variables. Next, the factor structure of a selection of inhibitory control variables will be investigated. Finally, the relation between inhibitory control and theory of mind will be examined.

Data Reduction and Preliminary Analyses

This investigation consisted of a large number of variables which were derived from lab tasks and questionnaires. Because variables which were measured on different scales would contribute unequally to the final analyses, all final study variables were converted to z-scores prior to including them in the final analyses. To create z-scores, the variable’s distribution mean was subtracted from each raw score, and this value was divided by the standard deviation. This standardization technique yields variables with equal means (0) and standard deviations (1), and allows for a clearer interpretation of the linear relationship between continuous variables (Neter, Kutner, Nachtsheim, & Wasserman, 1996). For clarity, the means and standard deviations for each of the study variables is presented in raw form in the following tables.
Verbal Ability

*Peabody Picture Vocabulary Test (PPV).* A single variable was derived from children’s performance on the PPV test. Children’s raw scores on the test were converted to standard score equivalents based on norms for their age (Dunn & Dunn, 1997). The mean standard score for the sample was 111.4 ($SD = 12.44$). The range of PPV scores was 70 to 139. The PPV variable was converted to $z$-scores prior to being used in subsequent analyses.

Behavioral Control

*Delay of Gratification.* Two variables were derived from the delay of gratification task: the outcome of the task (success/failure) and the latency to delay gratification. The majority of children ($n = 58$ out of 87) succeeded at the delay task by waiting for the experimenter to return. Among children who failed to delay, 25 did so by ringing the bell to summons the return of the experimenter, and 4 did so by eating an M&M (see Table 2). Children who succeeded to delay gratification waited the maximum duration of the task (900 seconds). The mean delay latency for children who ate an M&M and those who rang the bell was 110.3 seconds ($SD = 104.3$) and 239.5 seconds ($SD = 255.9$), respectively. A one-way analysis of variance (ANOVA) was conducted to determine whether these three groups of children differed with respect to their latency to delay. There was a significant difference in the delay latency of children among the three groups, $F(2, 84) = 234.41, p < .001$. Post-hoc analyses revealed that those children who succeeded at the task waited significantly longer than children who failed the task by
Table 2

*Descriptive Statistics for Delay of Gratification Task*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children who waited for the experimenter to return</td>
<td>58</td>
</tr>
<tr>
<td>Number of children who rang the bell</td>
<td>25</td>
</tr>
<tr>
<td>Number of children who ate an M&amp;M</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency of <em>all</em> children</td>
<td>673.88 seconds</td>
<td>350.39</td>
<td>11.70 – 900</td>
</tr>
<tr>
<td>Latency of children who rang the bell</td>
<td>239.5 seconds</td>
<td>255.9</td>
<td>11.70 – 836.27</td>
</tr>
<tr>
<td>Latency of children who ate an M&amp;M</td>
<td>110.3 seconds</td>
<td>104.3</td>
<td>26.2 – 244.46</td>
</tr>
</tbody>
</table>

*Transformed Variables*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency of all children (Logged)</td>
<td>6.09</td>
<td>1.29</td>
<td>2.46 – 6.80</td>
</tr>
<tr>
<td>Latency of children who rang the bell (Logged)</td>
<td>4.72</td>
<td>1.42</td>
<td>2.46 – 6.73</td>
</tr>
<tr>
<td>Latency of children who ate an M&amp;M (Logged)</td>
<td>4.27</td>
<td>1.12</td>
<td>2.46 – 6.80</td>
</tr>
</tbody>
</table>
eating an M&M ($p < .001$) or by ringing the bell ($p < .001$). However there was no significant difference in the delay latency of children who ate an M&M and those who rang the bell. Because the delay latency score provided a continuous measure of children’s performance and adequately distinguished between those who succeeded and failed at this task, this score alone was used in subsequent analyses to reflect children’s performance on the delay of gratification task. Because this variable was negatively skewed, values were reverse-scored (i.e., reflected) prior to using a logarithmic transformation (Tabachnick & Fidell, 2001). As a result, the interpretation of the scores changed such that lower values represented a greater success at delay and higher values indicated less of an ability to delay. The log-transformed scores were then converted to z-scores which were used in all subsequent analyses.

*Dinky Toy.* The dinky toy task consisted of two initial variables: the dinky toy outcome (success/failure) and the latency to touch a toy. The majority of children ($n = 78$) succeeded at the dinky toy task by refraining from touching a toy unless it was the one that they wanted. Seven children failed this task by touching a toy that they did not want (see Table 3). A one-way ANOVA was conducted to determine whether these groups differed with respect to their latency to choose a toy. This analysis revealed that there was not a significant difference between the latencies of children who first touched a toy they wanted versus those that first touched a toy they did not want, $F(1, 83) = 1.39, p = .24$. Because the dinky toy latency variable was positively skewed, a logarithmic transformation was used. A constant of 1.0 was added to all values prior to the transformation to avoid obtaining negative values (Tabachnick & Fidell, 2001). The log-
Table 3

*Descriptive Statistics for Dinky Toy Task*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequencies</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children who touched the toy they wanted</td>
<td>78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of children who touched a toy they did not want</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latency of all children</td>
<td>32.05 s</td>
<td>47.31</td>
<td>.47 – 187.57</td>
<td></td>
</tr>
<tr>
<td>Latency of children who touched the toy they wanted</td>
<td>33.85 s</td>
<td>48.78</td>
<td>.47 – 187.57</td>
<td></td>
</tr>
<tr>
<td>Latency of children who touched a toy they did not want</td>
<td>11.90 s</td>
<td>16.84</td>
<td>3.03 – 49.56</td>
<td></td>
</tr>
<tr>
<td>Transformed Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latency of all children</td>
<td>2.72</td>
<td>1.20</td>
<td>.39 – 5.24</td>
<td></td>
</tr>
<tr>
<td>Latency of children who touched the toy they wanted (Logged)</td>
<td>2.77</td>
<td>1.21</td>
<td>.39 – 5.24</td>
<td></td>
</tr>
<tr>
<td>Latency of children who touched a toy they did not want (Logged)</td>
<td>2.11</td>
<td>.89</td>
<td>1.39 – 3.92</td>
<td></td>
</tr>
</tbody>
</table>
transformed scores were then converted to z-scores which were used in all subsequent analyses.

*Walk the Line.* The walk the line task initially consisted of four variables: the child’s duration to walk the line on each of four trials (i.e., practice, slow, even slower, and fast trial). Examination of the data from each trial revealed a possible outlier in the duration scores for the second walking trial. Specifically, one subject had a duration score that was 35 seconds higher than three standard deviations from the mean. This child’s score was also 42 seconds higher than the next-highest score in the data. Rather than deleting this case, the score was replaced with a score of 3 standard deviations from the mean. This allowed the child’s score to remain in the data set and to maintain its rank order among other children’s scores while reducing the impact of the outlier. All subsequent descriptive information and analyses were conducted using the corrected data.

The mean durations of time taken to walk the line across the four walking trials are presented in Table 4. A repeated measures ANOVA was conducted to determine whether walking duration differed significantly across trials. This analysis revealed that there was a significant difference in walking time among trials, $F(3, 243) = 79.63, p < .001$. Post-hoc analyses revealed that in comparison to trial 1, children walked significantly slower on trial 2 ($p < .001$) and trial 3 ($p < .001$). Children walked significantly slower on trial 3 than trial 2 ($p < .01$). Finally, children walked significantly faster on trial 4 than on all other trials ($ps < .001$).

To assess the change in children’s walking speed across trials, an index of the difference in walking duration relative to the initial walking duration was calculated.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of walk trial 1 (Practice)</td>
<td>10.04</td>
<td>5.20</td>
<td>2.97 – 32.33</td>
</tr>
<tr>
<td>Duration of walk trial 2 (Slow)</td>
<td>12.85</td>
<td>6.86</td>
<td>3.60 – 35.87</td>
</tr>
<tr>
<td>Duration of walk trial 3 (Even slower)</td>
<td>14.09</td>
<td>7.80</td>
<td>3.87 – 43.90</td>
</tr>
<tr>
<td>Duration of walk trial 4 (Fast)</td>
<td>4.48</td>
<td>2.19</td>
<td>1.53 – 14.33</td>
</tr>
<tr>
<td>Percent change between trials 2 and 1 (slow – slow)</td>
<td>.38</td>
<td>.68</td>
<td>-.63 – 3.70</td>
</tr>
<tr>
<td>Percent change between trials 3 and 2 (even slower – slow)</td>
<td>.14</td>
<td>.33</td>
<td>-.49 – .94</td>
</tr>
<tr>
<td>Percent change between trials 4 and 1 (fast – practice)</td>
<td>.50</td>
<td>.22</td>
<td>-.35 – .81</td>
</tr>
</tbody>
</table>
That is, after calculating the difference between a pair of trials, this value was divided by the initial walking duration to reflect the “percent change” in walking for each child. Zero-order correlations revealed that children’s change in speed between trials 2 and 1 (slow versus practice) was significantly related to their change in speed between trials 3 and 1 (even slower versus practice), $r(83) = .84, p < .001$. Those children with a greater change (i.e., inhibition of speed) between the first two trials also showed a greater change between the first and third trial. Children’s change in speed between trials 1 and 4 (practice versus fast) was not significantly related to either of their changes in the trials involving slowing down. Because of the significant relation between change scores across trials 1 to 2 and 1 to 3, and the greater overall mean change in speeds across trials 1 to 2 versus trials 2 to 3, the index of change across trials 1 to 2 alone was used in all subsequent analyses to reflect children’s inhibition of speed. Because in trial 4 (fast trial) the children were instructed to walk faster and stay on the line, this trial was also considered to be a valid index of behavioral control. Thus, the index of change across trials 1 and 4 was used in all subsequent analyses to reflect children’s ability to increase their speed. Both of these variables were converted to z-scores which were used in all subsequent analyses.

**CPT.** The CPT task initially consisted of the following variables: proportion of responses correct, proportion of responses which were errors of commission, proportion of responses which were errors of omission, and reaction time for correct key presses. Descriptive information concerning these variables is presented in Table 5. A repeated measures ANOVA was conducted to examine whether there was a significant difference
Table 5

*Descriptive Statistics for CPT Task*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of trials correct</td>
<td>.49</td>
<td>.23</td>
<td>0 – .92</td>
</tr>
<tr>
<td>Proportion of trials with errors of omission</td>
<td>.38</td>
<td>.25</td>
<td>0 – 1.0</td>
</tr>
<tr>
<td>Proportion of trials with errors of commission</td>
<td>.13</td>
<td>.15</td>
<td>0 – .54</td>
</tr>
<tr>
<td>Average reaction time on first 10 correct trials</td>
<td>885.96</td>
<td>210.07</td>
<td>221 - 1300</td>
</tr>
</tbody>
</table>

among the proportion of correct, error of commission, and error of omission responses. This analysis revealed a significant difference among these response outcomes, $F (1, 81) = 4.5, p < .05$. Post-hoc analyses revealed that on average, children responded correctly on a significantly greater proportion of trials than they did with an error of commission ($p < .001$) or an error of omission ($p < .05$). Additionally, children responded with an error of omission on a significantly greater proportion of trials than they did with an error of commission ($p < .001$). Reaction time data was available for all trials to which children responded correctly. Because the number of trials presented to each child was random and varied slightly, and because we wanted to assess reaction time among a uniform set of trails, the average reaction time across the first 10 trials that the child got correct was used for this assessment. Children’s mean reaction time across the first 10 trials was 885.86 msec. ($SD = 210$). The range of average reaction times (221 to 1300 msec.) suggested that a few children had very fast responses to the stimuli. Closer examination of the data revealed that only five children had an average reaction time below 600 msec.
Zero-order correlations revealed that the average reaction time across the first 10 trials was significantly negatively related to the proportion of errors of omission, \( r (79) = -0.56, \ p < .001 \), and positively related to the proportion of errors of commission, \( r (79) = 0.42, \ p < .001 \). Thus, children’s who were faster at responding to a correct stimulus (i.e., the rabbit) were more likely to commit errors involving responding when they should not have responded, and less likely to commit errors involving omitting a response.

The proportion of correct responses and proportion of trials with errors due to commission were considered to be the indices of CPT performance most relevant to the present investigation. Correct responses reflected children’s ability to process the incoming stimulus and activate a behavioral response that was consistent with the rules of the game. Errors due to commission reflected children’s impulsivity, such that children with more errors due to commission displayed less behavioral control. These variables, as well as the average reaction time, were converted to z-scores and used in subsequent analyses.

**Parent Report of Behavioral Control.** The inhibitory control scale of the Child Behavior Checklist (CBQ) was used to reflect parents’ ratings of their children’s behavioral control due to this scale’s emphasis on children’s control over movement and bodily activities. There was a significant, positive relation between mothers’ and fathers’ ratings of their children on this scale, \( r_s (77) = 0.41, \ p < .001 \). Because both parents’ ratings were considered to be meaningful, the final score for inhibitory control was created by averaging the standardized values of mothers’ and fathers’ ratings.
Cognitive Control

Tapping Task. The tapping task consisted of the following variables: number of practice trials required, percentage of correct responses across all test trials, and percentage of correct responses on trials 1-4, trials 5-8, trials 9-12, and trials 13-16 (See Table 6 for descriptive information). As has been found in previous research with this task (Diamond & Taylor, 1996), children’s performance deteriorated across trials from an average of 84% correct on the first four trials to 66% on the last four trials. A repeated measures ANOVA revealed that there was a significant difference in children’s performance among the four quarters of this task, \( F(3, 243) = 12.59, p < .001 \). Specifically, performance across the first four trials was significantly better than that on the second \((p < .01)\), third \((p < .001)\) and fourth \((p < .001)\) set of four trials. Additionally, performance on the second four trials was significantly better than that on the third \((p < .05)\) and fourth set of four trials \((p < .01)\). There was not a significant difference between the percent correct in the third set of four trials and the last four trials. Children’s performance across tapping trials is graphically depicted in Figure 1.

In addition to percentage of total trials correct, we determined how well children performed on this task compared to chance. Because the children were given the two possible answers to all test trials (i.e., one tap or two taps) they may have answered 50% of questions correctly simply by guessing. Children were placed into three groups based on their percentage of correct responses: less than chance, at chance, and greater than chance. Frequencies revealed that the greatest number of children \((n = 65)\) performed at
Table 6

*Descriptive Statistics for Tapping Task*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of practice trials required</td>
<td>2.74</td>
<td>1.21</td>
<td>2 - 6</td>
</tr>
<tr>
<td>Percent correct across the entire task</td>
<td>.73</td>
<td>.26</td>
<td>.06 – 1.00</td>
</tr>
<tr>
<td>Percent correct across trials 1 through 4</td>
<td>.84</td>
<td>.24</td>
<td>0 – 1.00</td>
</tr>
<tr>
<td>Percent correct across trials 5 through 8</td>
<td>.75</td>
<td>.32</td>
<td>0 – 1.00</td>
</tr>
<tr>
<td>Percent correct across trials 9 through 12</td>
<td>.69</td>
<td>.32</td>
<td>0 – 1.00</td>
</tr>
<tr>
<td>Percent correct across trials 13 through 16</td>
<td>.66</td>
<td>.36</td>
<td>0 – 1.00</td>
</tr>
</tbody>
</table>

*Frequencies*

<table>
<thead>
<tr>
<th>Frequency Description</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children who performed greater than chance (&gt; 50%)</td>
<td>65</td>
</tr>
<tr>
<td>Number of children who performed at chance (= 50%)</td>
<td>3</td>
</tr>
<tr>
<td>Number of children who performed less than chance (&lt; 50%)</td>
<td>15</td>
</tr>
</tbody>
</table>
a level greater than chance, while 3 children performed at chance, and 15 children performed at a level less than chance. The percentage of trials correct was significantly negatively related to the number of practice trials required, \( r (83) = -.32, p < .01 \). Children who required more practice trials performed significantly poorer on test trials than did those who required fewer practice trials. Both percent correct and number of practice trials required were considered to be meaningful indicators of children’s ability on this task. Thus, a composite measure of children’s overall performance on the tapping task was created from these two variables. The number of practice trials was reverse coded to be consistent with the variable reflecting percent correct. To create the composite score, these variables were averaged after being converted to z-scores.
Day Night Task. The day/night task consisted of the following variables: number of practice trials required, percentage of correct responses across all test trials, and percentage of correct responses on trials 1-4, trials 5-8, trails 9-12, and trials 13-16 (see Table 7). While, similar to the tapping task, children’s performance deteriorated across trials from an average of 87% correct on the first four trials to 44% correct on the last four trials, this decline in performance was not linear (See Figure 2). This finding was consistent with previous work using this task (Diamond & Taylor, 1996; Gerstadt, Hong, & Diamond, 1994). Specifically, children performed poorer in the second set of four trials (63% correct) than they did in the third set of four trials (72% correct). A repeated measures ANOVA revealed that there was a significant difference in children’s performance among the four quarters of this task, $F(3, 255) = 34.40, p < .001$. Specifically, performance across the first four trials was significantly better than that on the second, third, and last set of four trials ($ps < .001$). Additionally, performance on the second four trials was significantly better than that on the last four trials ($p < .001$), and performance on the third set of trials was significantly better than that on the last four trials ($p < .001$). Interestingly, the children performed significantly worse on the second set of four trials than on the third set ($p < .05$). This dramatic drop in performance during the second set of four trials may have been due to the fact that there was a sudden change in the pattern of correct responses during this set of trials. The order of card presentation requires a pattern of alternating responses (“day” then “night”) across the first few trials in this task. On the seventh trial, this pattern suddenly changes as two “day” cards are presented consecutively. Thus, many children gave an incorrect response on the first
Table 7

*Descriptive Statistics for Day/Night Task*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of practice trials required</td>
<td>2.61</td>
<td>.89</td>
<td>2-5</td>
</tr>
<tr>
<td>Percent correct across the entire task</td>
<td>.66</td>
<td>.24</td>
<td>0 – 1.00</td>
</tr>
<tr>
<td>Percent correct across trials 1 through 4</td>
<td>.87</td>
<td>.25</td>
<td>0 – 1.00</td>
</tr>
<tr>
<td>Percent correct across trials 5 through 8</td>
<td>.63</td>
<td>.27</td>
<td>0 – 1.00</td>
</tr>
<tr>
<td>Percent correct across trials 9 through 12</td>
<td>.72</td>
<td>.38</td>
<td>0 – 1.00</td>
</tr>
<tr>
<td>Percent correct across trials 13 through 16</td>
<td>.44</td>
<td>.43</td>
<td>0 – 1.00</td>
</tr>
</tbody>
</table>

*Frequencies*

<table>
<thead>
<tr>
<th>Frequency</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children who performed greater than chance (&gt; 50%)</td>
<td>68</td>
</tr>
<tr>
<td>Number of children who performed at chance (= 50%)</td>
<td>3</td>
</tr>
<tr>
<td>Number of children who performed less than chance (&lt; 50%)</td>
<td>16</td>
</tr>
</tbody>
</table>
occasion that the cards fell out of this pattern, causing a drop in overall performance across the second set of four trials. This result is consistent with the findings of Diamond and Taylor (1996).

In addition to percentage of total trials correct, we assessed children’s performance on the day/night task compared to chance. There were two possible answers to all test trials (i.e., “day” or “night”), thus if children guessed at each test trial, they had a 50% chance to answer correctly. Frequencies revealed that the greatest number of children ($n = 68$) performed at a level greater than chance, while 3 children performed at chance, and 16 children performed at a level less than chance.
The percentage of trials correct was negatively related to the number of practice trials required, but this association was just below statistical significance, \( r(87) = -.20, p = .07 \). Thus, there was a non-significant trend toward children who required more practice trials performing worse on test trials than those who required fewer practice trials. Both percent correct and number of practice trials required were considered to be meaningful indicators of children’s ability on this task. Thus, a composite measure of children’s overall performance on the day night task was created from these two variables. The number of practice trials was reverse coded to be consistent with the variable reflecting percent correct. To create the composite score, these variables were converted to z-scores and then averaged.

*Three Pegs Task.* The three pegs task resulted in two variables: outcome of the task (pass/fail) and the number of conditions or trials required to pass. The majority of children (\( n = 72 \)) succeeded at this task, whereas 16 children failed (See Table 8). Among those children who passed the task, they required an average of 1.53 trials (\( SD = .71 \)) to pass the task. From these two variables, a single variable was derived which included information on whether children failed this task or the number of trials necessary to pass. Children were given a score of zero if they failed this task, 1 if they required 3 conditions, 2 if they required 2 conditions and 3 if they required only the initial instruction. This variable was standardized prior to being included in subsequent analyses.

*Parent Report of Cognitive Control.* The attentional focusing scale of the Child Behavior Checklist (CBQ) was used to reflect parents’ ratings of their children’s
Table 8

*Descriptive Statistics for Three Pegs Task*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of children who passed task after initial instruction</td>
<td>43</td>
</tr>
<tr>
<td>Number of children who passed task after demonstration</td>
<td>20</td>
</tr>
<tr>
<td>Number of children who passed task after vocalization</td>
<td>9</td>
</tr>
<tr>
<td>Number of children who failed task</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average number of conditions required to pass the task</td>
<td>1.53</td>
<td>.71</td>
<td>1-3</td>
</tr>
</tbody>
</table>
cognitive control due to this scale’s emphasis on children’s ability for mental concentration. There was a significant, positive relation between mothers’ and fathers’ ratings of their children on this scale, \( r_s (77) = .41, p < .001 \). Because both parents’ ratings were considered to be meaningful, the final score for attentional focusing was created by averaging the standardized values of mothers’ and fathers’ ratings.

**Emotional Control**

*Disappointment Task.* A number of variables were derived from the disappointment task. These included duration scores for positive, negative, and neutral emotional facial expressions in the two task situations (experimenter present and experimenter absent), the total number of positive, negative, and neutral vocalizations in the two task situations, children’s self-reported feelings of disappointment, and whether or not children exchanged the prize they were given. This section will first describe children’s self-report of disappointment and their appraisal of the disappointment situation to assess whether children were indeed disappointed by the task. Next, descriptive information concerning facial and vocal emotional expressions will be reported. Finally, the relations among the variables within this task will be examined and an explanation of the final, composite emotion regulation variable will be provided.

The first method of assessing whether children were disappointed by this task was to note whether they exchanged the prize that was originally given to them (Cole, 1986). All but three children in our sample exchanged the prize that was given to them by the experimenter, suggesting that the task was successful at disappointing most children. It was believed that the three children who did not trade in the prize failed to do
so because they did not understand the experimenter’s offer to switch prizes. To confirm that these children did not differ from the remainder of the sample with respect to any disappointment task study variables, one way ANOVAs were conducted comparing these children’s data (facial expressions, vocal expression, and final regulation score) to that of other children. No significant differences were found between these three children and the remainder of the sample, thus their data was included in all analyses.

In response to the first disappointment interview question, the majority of children (40 %) answered that they were felt happy about receiving the prize. Other answers included mad (10%), sad (23%), bad (5%), and 23% of the children had responses that were categorized as “other” (see Table 9). If children said they were happy, two follow-up questions were asked to provide them the opportunity to disclose a negative emotion. By the conclusion of the interview, more children had indicated that they felt a negative feeling ($n = 48$) than a happy feeling ($n = 24$). The remainder of the children either failed to respond to the interviewer’s questioning or had answers that were classified as “other”. Thus, consistent with information from children’s trade-in behavior, data from the disappointment interview also supported the validity of this task as a source of disappointment (or negativity) for most children.

Observations of children’s facial expressions during the experimenter present and experimenter absent situations revealed that children’s predominant emotional expression was neutral across both of these situations (see Table 10). To reduce the number of variables, high and low positive durations were combined to reflect total duration of
Table 9

Children’s Answers to Disappointment Interview Questions

<table>
<thead>
<tr>
<th>Interview Questions</th>
<th>Percentage of Children with Answers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Happy</td>
</tr>
<tr>
<td>“How did you feel when you got the [prize]?”</td>
<td>40</td>
</tr>
<tr>
<td>If child answered “Happy” to first question, the interviewer said,</td>
<td>61</td>
</tr>
<tr>
<td>“I thought that this was the one you did not want. So how did you feel about getting</td>
<td></td>
</tr>
<tr>
<td>the prize that you did not want?”</td>
<td></td>
</tr>
<tr>
<td>If child answered “Happy” to second question, the interviewer said,</td>
<td>75</td>
</tr>
<tr>
<td>said, “Some children would be happy with the [prize] and some wouldn’t. I want to</td>
<td></td>
</tr>
<tr>
<td>know how you feel about getting this prize”</td>
<td></td>
</tr>
</tbody>
</table>
Table 10

Descriptive Statistics for the Children’s Facial Expressions during Disappointment Task

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimenter Present</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Positive</td>
<td>.02</td>
<td>.05</td>
<td>0 – .30</td>
</tr>
<tr>
<td>Low Positive</td>
<td>.20</td>
<td>.21</td>
<td>0 – .77</td>
</tr>
<tr>
<td>Neutral</td>
<td>.61</td>
<td>.28</td>
<td>.01 – 1.00</td>
</tr>
<tr>
<td>Low Negative</td>
<td>.14</td>
<td>.23</td>
<td>0 – .97</td>
</tr>
<tr>
<td>High Negative</td>
<td>.01</td>
<td>.04</td>
<td>0 – .22</td>
</tr>
<tr>
<td>Unobservable</td>
<td>.03</td>
<td>.06</td>
<td>0 – .48</td>
</tr>
<tr>
<td><strong>Experimenter Absent</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Positive</td>
<td>.03</td>
<td>.02</td>
<td>0 – .17</td>
</tr>
<tr>
<td>Low Positive</td>
<td>.03</td>
<td>.06</td>
<td>0 – .25</td>
</tr>
<tr>
<td>Neutral</td>
<td>.65</td>
<td>.29</td>
<td>0 – 1.00</td>
</tr>
<tr>
<td>Low Negative</td>
<td>.07</td>
<td>.13</td>
<td>0 – .55</td>
</tr>
<tr>
<td>High Negative</td>
<td>.02</td>
<td>.06</td>
<td>0 – .40</td>
</tr>
<tr>
<td>Unobservable</td>
<td>.08</td>
<td>.16</td>
<td>0 – .84</td>
</tr>
</tbody>
</table>

*Note:* Values represent the proportion of total time spent displaying that facial expression.
positive facial expressions, as were high and low negative durations. To test whether there was an interactive effect between emotional expressions in the two experimenter situations, a multivariate analysis of variance (MANOVA) was conducted. The results revealed a significant interaction between emotional valence (positive, negative, and neutral facial expressions) and experimenter situation (experimenter present and experimenter absent), $\Lambda^* = .27$, $F(2, 87) = 120.85$, $p < .001$. Bonferroni-adjusted pairwise comparisons revealed that children displayed negative facial expressions for a significantly longer proportion of time when the experimenter was absent than when the experimenter was present ($p < .01$). Also, children displayed positive facial expressions for a significantly longer proportion of time when the experimenter was present than when the experimenter was absent ($p < .001$). Thus, the experimenter’s presence affected children’s positive and negative facial expression displays consistent with the use of socially-appropriate display rules. One-way repeated measures ANOVAs were conducted to test for differences among facial expressions within the experimenter present and absent situations. Within the experimenter present situation, there was a significant difference among the proportions of time that children expressed each facial expression, $F(2, 178) = 56.06$, $p < .001$. Neutral expressions occurred for a significantly greater proportion of time than positive ($p < .001$) and negative ($p < .001$) facial expressions. Within the experimenter absent situation, there was also a significant difference among the proportions of time that children expressed each facial expression, $F(2, 178) = 110.14$, $p < .001$. Specifically, neutral expressions occurred for a significantly greater proportion of time than positive ($p < .001$) and negative ($p < .001$) facial expressions, and
negative facial expressions occurred for a significantly greater proportion of time than positive facial expressions ($p < .001$).

Children’s vocalizations were recorded and coded for emotional valence during the experimenter present and experimenter absent situations (see Table 11 for descriptive information). To reduce the number of variables, high and low positive and high and low negative vocalization were combined to reflect the total number of vocalizations for each valence. A predominant number of children’s vocalizations were categorized as neutral across both the experimenter present and absent situations. One-way repeated measures ANOVAs revealed that children expressed a significantly greater number of neutral vocalizations than both positive and negative vocalizations within both experimenter situations ($ps < .001$). However, there were no significant differences between the number of positive and negative vocalizations within either experimenter situation. Because children vocalized very little during the experimenter absent situation (i.e., when they were alone), assessing the effect of experimenter presence on valence of emotional vocalizations was not meaningful.

In order to compare children’s facial and vocal expressions, children’s vocalizations within each of the two experimenter situations were first converted to proportions by dividing the vocalizations of each valence by the child’s total number of vocalizations. To assess the relation between children’s facial and vocal emotional expressions, zero-order correlations were conducted. These analyses revealed that during the experimenter present situation, children’s positive facial expressions were significantly related to their positive vocalizations, $r (90) = .29, p < .01$, and during the
Table 11

*Descriptive Statistics for Children’s Vocalizations during Disappointment Task*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experimenter Present</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Positive</td>
<td>.03</td>
<td>.23</td>
<td>0 – 2</td>
</tr>
<tr>
<td>Low Positive</td>
<td>.18</td>
<td>.70</td>
<td>0 – 4</td>
</tr>
<tr>
<td>Neutral</td>
<td>3.22</td>
<td>3.11</td>
<td>0 – 18</td>
</tr>
<tr>
<td>Low Negative</td>
<td>.39</td>
<td>.87</td>
<td>0 – 4</td>
</tr>
<tr>
<td>High Negative</td>
<td>.02</td>
<td>.15</td>
<td>0 – 1</td>
</tr>
<tr>
<td><strong>Experimenter Absent</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Positive</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Low Positive</td>
<td>.07</td>
<td>.39</td>
<td>0 – 3</td>
</tr>
<tr>
<td>Neutral</td>
<td>1.17</td>
<td>2.10</td>
<td>0 – 14</td>
</tr>
<tr>
<td>Low Negative</td>
<td>.17</td>
<td>.59</td>
<td>0 – 3</td>
</tr>
<tr>
<td>High Negative</td>
<td>.06</td>
<td>.54</td>
<td>0 – 5</td>
</tr>
</tbody>
</table>

*Note:* Values represent the number of vocalizations.
Experiment absent situation, children’s negative facial expressions were significantly related to their negative vocalizations, $r(89) = .27, p < .01$. No other associations were found to be significant, suggesting that children’s facial and vocal expressions may offer independently meaningful information concerning expressivity during the disappointment task. As such, these values (facial expression proportion scores and vocal expression proportion scores) were standardized and then averaged to reflect the child’s overall expression of each emotion within the experimenter present and absent situations.

Finally, to derive a composite index of emotion regulation during the disappointment task, a duration score was calculated to reflect evidence of regulation during the experimenter present situation. First, children’s overall positive expressions (facial and vocal) during the experimenter present situation were adjusted for their total proportion of positive expression (across both experimenter present and absent situations) to control for each child’s base amount of positive expressions. That is, each child’s duration of positive expressions during experimenter present situation was divided by that child’s total duration of positive expressions across the entire task. The same calculation was used to derive duration of negative expressions during the experimenter present situation adjusted for total negative expressions. Finally, the duration of negative expressions was subtracted from positive expressions to create a variable that reflected increasing emotion regulation from the disappointment task. Thus, higher scores on this emotion regulation variable reflected those children who were better regulated during the disappointment task. This variable was standardized prior to being included in subsequent analyses.
Parent Report of Emotional Control. Children’s emotion regulation was measured by aggregating the following scales of the Child Behavior Questionnaire (CBQ): falling reactivity/soothability, (minus) anger/frustration, (minus) sadness (Rotbhart et al., 2001). There was a significant, positive relation between mothers’ and fathers’ aggregate ratings of their children’s emotion regulation, \( r_s (77) = .46, p < .001 \). Because both parents’ ratings were considered to be meaningful, the final score for emotion regulation was created by averaging the standardized values of mothers’ and fathers’ ratings.

Parent Report of Children’s Coping. This questionnaire consisted of 44 items asking parents to report their child’s typical reaction (i.e. coping style) to various emotion-eliciting situations. Based on previous research using this measure (Eisenberg, Fabes, Bernzweig, Karbon, Poulin, & Hanish, 1993), the 44 items were grouped into six categories of coping styles: distraction/avoidance, aggression, venting, seeking support, cognitive restructuring, and instrumental coping. Items were standardized prior to being summed to form each of these categories. Examination of the agreement between mothers’ and fathers’ ratings revealed that parents’ agreed significantly with respect to five out of six coping style ratings at the \( p < .05 \) level (See Table 12). The exception was parents’ ratings of distraction/avoidance which showed a positive trend, \( r (84) = .18, p = .09 \).
Table 12

Agreement between Mothers and Fathers on Parent Report of Children’s Coping

<table>
<thead>
<tr>
<th>Measure</th>
<th>Spearman’s rho</th>
<th>p-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distraction/Avoidance</td>
<td>.18</td>
<td>p = .09</td>
</tr>
<tr>
<td>Aggression</td>
<td>.34</td>
<td>p &lt; .01</td>
</tr>
<tr>
<td>Venting</td>
<td>.27</td>
<td>p &lt; .05</td>
</tr>
<tr>
<td>Seeking Support</td>
<td>.27</td>
<td>p &lt; .01</td>
</tr>
<tr>
<td>Cognitive Restructuring</td>
<td>.29</td>
<td>p &lt; .01</td>
</tr>
<tr>
<td>Instrumental Coping</td>
<td>.25</td>
<td>p &lt; .05</td>
</tr>
</tbody>
</table>

Both parent’s ratings were considered to be individually meaningful, thus an aggregate of ratings for each of the coping style categories was created. The relations among the six coping styles (collapsed across parent rating) are displayed in Table 13. Distraction was significantly positively related to instrumental coping, cognitive restructuring, and seeking support, but negatively related to aggression. Aggression was positively related to venting, but negatively related to both cognitive restructuring and instrumental coping. Seeking support was significantly positively related to cognitive restructuring and instrumental coping. Finally, cognitive restructuring and instrumental coping were significantly positively related. Based on these interrelations and prior theory concerning the relations among coping strategies (Eisenberg, Fabes, Bernzweig, Karbon, Poulin, & Hanish, 1993), one variable which reflected increasing positive coping strategies and decreasing negative (i.e., “acting out”) strategies was created from the sum of
Table 13

*Intercorrelations among Parent Report of Coping Style Categories*

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Distraction/Avoidance</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Aggression</td>
<td>-.40**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Venting</td>
<td>-.18</td>
<td>.37**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Seeking Support</td>
<td>.22*</td>
<td>-.16</td>
<td>.17</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Cognitive Restructuring</td>
<td>.61**</td>
<td>-.30**</td>
<td>-.09</td>
<td>.31**</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>6. Instrumental Coping</td>
<td>.48**</td>
<td>-.30*</td>
<td>-.17</td>
<td>.44**</td>
<td>.60**</td>
<td>--</td>
</tr>
</tbody>
</table>

*Note.* Coping style group values reflect the average of mothers’ and fathers’ standardized rating.

**Correlation is significant at the .01 level (2-tailed).  *Correlation is significant at the .05 level (2-tailed).
distraction/avoidance, seeking support, cognitive restructuring, and instrumental coping, (negative) aggression and (negative) venting. This variable, which reflected parent’s ratings of regulated coping, was standardized before being used in subsequent analyses.

Negative Affectivity

To test the hypothesis that negative reactivity would interact with emotion regulation in the prediction of cognitive and behavioral control, a negative reactivity score was created by aggregating the following scales from the Child Behavior Checklist (CBQ): discomfort, anger/frustration, sadness, and fear. There was a significant, positive relation between mothers’ and fathers’ aggregate ratings of their children’s negative affectivity, $r_s(77) = .47, p < .001$. Because both parents’ ratings were considered to be meaningful, the final score for negative affectivity was created by averaging the standardized values of mothers’ and fathers’ ratings.

Theory of Mind

Children’s theory of mind ability was tested using four separate tests: location false belief (LFB), belief-desire reasoning (BDR), second-order false belief (SOFB), and knowledge of others’ feelings (KOF). Because the LFB, BDR, and SOFB tasks were standard, commonly-used measures of theory of mind, performance on these tasks was considered separately from that on the KOF task. Scores were derived from the above tests as follows: 1) Children’s performance (pass/fail) on seven LFB, BDR, and SOFB test questions were considered separately as binomial outcomes (See Table 14 for descriptive information); 2) A composite score of children’s overall performance on LFB,
### Table 14

**Percentage of Children Who Passed Theory of Mind Tasks**

<table>
<thead>
<tr>
<th>Task</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>Correct</td>
</tr>
<tr>
<td>Location False Belief (LFB)</td>
<td>69</td>
</tr>
<tr>
<td>Location False Belief and all reality control questions</td>
<td></td>
</tr>
<tr>
<td>Belief-desire Reasoning (BDR)</td>
<td>57</td>
</tr>
<tr>
<td>Emotion 1 and emotion reality control question</td>
<td></td>
</tr>
<tr>
<td>Emotion 2 and emotion reality control question</td>
<td></td>
</tr>
<tr>
<td>Emotion 3 and emotion reality control question</td>
<td></td>
</tr>
<tr>
<td>Contents False Belief and contents reality control question</td>
<td></td>
</tr>
<tr>
<td>False Emotion/Belief and false contents and contents reality control question</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td></td>
</tr>
<tr>
<td>73</td>
<td></td>
</tr>
<tr>
<td>92</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Second-order False Belief (SOFB)</td>
<td>13</td>
</tr>
<tr>
<td>Second-order False Belief Question and all reality control questions</td>
<td></td>
</tr>
</tbody>
</table>
BDR, and SOFB test questions was created by summing the total number of correct responses to these questions (range = 0 to 7). This variable was labeled the ToM total score; 3) A composite score of children’s performance on the three justification questions from the LFB, BDR, and SOFB tasks was created by summing the total number of responses with reference to false belief (range = 0 to 3). This variable was labeled the ToM justification score; 4) A composite score of children’s performance on six emotional identification questions of the KOF task was created by summing the total number of correct responses to these questions (range = 0 to 6). This variable was labeled the ToM emotional identification score; 5) A composite score of children’s performance on six emotional explanation questions of the KOF task was created by summing the total number of correct responses to these questions (range = 0 to 6). This variable was labeled the ToM emotional explanation score; and 6) A composite score of children’s performance on the emotion regulation interpretation of the KOF task (i.e., third picture interpretation) was created by summing correct responses to four questions (range = 0 to 4). This variable was labeled the ToM emotion regulation interpretation score. This component of the KOF task was considered separately from other KOF picture interpretation questions because it directly assessed children’s interpretation of a situation involving controlling the expression of a felt emotion, which was particularly relevant to the present investigation. See Table 15 for descriptive information concerning all theory of mind composite scores. Examination of interrelations among the theory of mind composite scores revealed that the overall performance score was significantly positively related to the justification score, $r (85) = .31, p < .01$, and to the emotion regulation
Table 15

*Descriptive Statistics for Theory of Mind Composite Scores*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory of mind total score&lt;sup&gt;FBL, BDR, SOFB&lt;/sup&gt;</td>
<td>4.20</td>
<td>1.70</td>
<td>0 – 7</td>
</tr>
<tr>
<td>Theory of mind justification score&lt;sup&gt;FBL, BDR, SOFB&lt;/sup&gt;</td>
<td>.42</td>
<td>.75</td>
<td>0 – 3</td>
</tr>
<tr>
<td>Theory of mind emotional identification score&lt;sup&gt;KOF&lt;/sup&gt;</td>
<td>4.09</td>
<td>1.16</td>
<td>0 – 6</td>
</tr>
<tr>
<td>Theory of mind emotional explanation score&lt;sup&gt;KOF&lt;/sup&gt;</td>
<td>1.55</td>
<td>1.01</td>
<td>0 – 4</td>
</tr>
<tr>
<td>Theory of mind emotion regulation interpretation score&lt;sup&gt;KOF&lt;/sup&gt;</td>
<td>1.18</td>
<td>.54</td>
<td>0 – 3</td>
</tr>
</tbody>
</table>

*Note:* FBL = False belief location; BDR = Belief desire reasoning; SOFB = Second order false belief; KOF = Knowledge of Others’ Feelings

interpretation score, $r (85) = .24$, $p < .05$. The justification score was also significantly positively related to the emotion regulation interpretation score, $r (85) = .27$, $p < .05$.

Finally, the emotional identification and emotional explanations scores were significantly positively related, $r (85) = .28$, $p < .01$. Given the relatedness of the emotional identification (e.g., “who is afraid”) and emotional explanation (e.g., “why is that person afraid”) scores, these two scores were combined to reflect children’s interpretations of emotional pictures. Thus, a total of 11 variables were used in subsequent analyses to reflect children’s theory of mind performance: 4 composite scores and 7 binomial outcome variables.
Primary Analyses

Relations among Measures of Inhibitory Control

The first aim of the present investigation was to assess the relatedness of various measures of inhibitory control. Table 16 presents all resulting variables after data reduction. Prior to conducting the primary analyses, one-way ANOVAs were conducted on all study variables to test for gender differences. No significant differences were found between males and females with respect to any study variables.

Relations among Measures of Emotional Control

Spearman’s correlations were conducted to test the hypothesis that indices of emotional control would be related. Measures of children’s observed regulation during the disappointment task, parent report of emotion regulation from the CBQ, and parent report of regulated coping from the Parent Report of Child Reactions questionnaire were included in these analyses. Results revealed that the two parent reports of regulation were significantly related, $r_s (83) = .27, p < .05$ (See Table 17). However, the observed measure of children’s regulation during the disappointment task was not related to either parent report measure of emotion regulation. For the purpose of incorporating both observed and parent report measures of emotional control, all three variables were averaged to create a composite measure of emotion regulation used in subsequent analyses.
### Table 16

**Table of Variables Resulting from Data Reduction**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Resulting Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emotional Control</strong></td>
<td></td>
</tr>
<tr>
<td>Disappointment Task</td>
<td>Disappointment emotion regulation</td>
</tr>
<tr>
<td>CBQ Emotion Regulation</td>
<td>Parents’ ratings of children’s emotion regulation</td>
</tr>
<tr>
<td><strong>Behavioral Control</strong></td>
<td></td>
</tr>
<tr>
<td>Delay of Gratification Task</td>
<td>Latency to delay gratification (reverse-coded)</td>
</tr>
<tr>
<td>Dinky Toy Task</td>
<td>Latency to touch a dinky toy</td>
</tr>
<tr>
<td>Walk the Line Task</td>
<td>Inhibition of walking speed</td>
</tr>
<tr>
<td></td>
<td>Increase in walking speed</td>
</tr>
<tr>
<td>CPT Task</td>
<td>CPT proportion correct</td>
</tr>
<tr>
<td></td>
<td>CPT proportion of errors of commission</td>
</tr>
<tr>
<td></td>
<td>CPT reaction time</td>
</tr>
<tr>
<td>CBQ Inhibitory Control</td>
<td>Parents’ ratings of children’s inhibitory control</td>
</tr>
<tr>
<td><strong>Cognitive Control</strong></td>
<td></td>
</tr>
<tr>
<td>Tapping Task</td>
<td>Performance on the tapping task</td>
</tr>
<tr>
<td>Day/Night Task</td>
<td>Performance on the day/night task</td>
</tr>
<tr>
<td>Three Pegs Task</td>
<td>Performance on the three pegs task</td>
</tr>
<tr>
<td>CBQ Attentional Focusing</td>
<td>Parents’ ratings of children’s attentional focusing</td>
</tr>
</tbody>
</table>
Table 16 continued

<table>
<thead>
<tr>
<th>Measure</th>
<th>Resulting Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Verbal Ability</strong></td>
<td></td>
</tr>
<tr>
<td>Peabody Picture Vocabulary Test (PPV)</td>
<td>PPV score</td>
</tr>
<tr>
<td><strong>Negative Affectivity</strong></td>
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</tr>
<tr>
<td>CBQ Negative Affectivity</td>
<td>Parent ratings of children’s negative affectivity</td>
</tr>
<tr>
<td><strong>Theory of Mind</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Test Questions (Binomial, Pass/Fail)</strong></td>
<td></td>
</tr>
<tr>
<td>Location False Belief (and controls)</td>
<td>Location false belief question</td>
</tr>
<tr>
<td>Belief-desire Reasoning (and controls)</td>
<td>Belief-desire emotion question #1</td>
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<td>Belief-desire emotion question #2</td>
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<td></td>
<td>Belief-desire emotion question #3</td>
</tr>
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<td></td>
<td>Contents false belief question</td>
</tr>
<tr>
<td></td>
<td>False emotion/belief question</td>
</tr>
<tr>
<td>Second-order False Belief (and controls)</td>
<td>Second-order false belief question</td>
</tr>
<tr>
<td><strong>Composite Scores</strong></td>
<td></td>
</tr>
<tr>
<td>Performance on Test Questions</td>
<td>ToM total score</td>
</tr>
<tr>
<td>Performance on Justification Questions</td>
<td>ToM justification score</td>
</tr>
<tr>
<td>Emotional Identification\footnote{a}</td>
<td>ToM emotional identification score</td>
</tr>
<tr>
<td>Emotional Explanations\footnote{af}</td>
<td>ToM emotional explanations score</td>
</tr>
<tr>
<td>Emotion Regulation Interpretation\footnote{a}</td>
<td>ToM emotion regulation interpretation score</td>
</tr>
</tbody>
</table>

\footnote{a} Score derived from Knowledge of Others’ Feelings Task; \footnote{af} These scores were combined to reflect “emotional interpretation” in subsequent analyses.
Table 17

**Intercorrelations among Inhibitory Control Measures**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<td>-02</td>
<td>-08</td>
<td>.18</td>
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<td>-02</td>
<td>-06</td>
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<td>.05</td>
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<td>.08</td>
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<td>.13</td>
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<td>.18</td>
<td>**</td>
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<td>.27</td>
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</tbody>
</table>

**Note:** Number of participants ranged from 72 to 87 due to some missing data. † Spearman’s correlations were used for all parent report measures.
Relations among Measures of Behavioral Control

To test the hypothesis that indices of behavioral control would be related, zero-order correlations were conducting. Measures of children’s latency to delay gratification (reverse-scored), latency to touch a dinky toy, inhibition of walking speed, increase in walking speed, CPT proportion correct, CPT proportion errors of commission, CPT reaction time, and parents’ report of inhibitory control from the CBQ were included in these analyses. These analyses revealed that the proportion of correct CPT responses was significantly positively related to children’s increase in walking speed, \( r(75) = .30, p < .05 \), and parent’s ratings of inhibitory control from the CBQ, \( r(79) = .34, p < .01 \) (See Table 17). Children with a greater proportion of correct CPT responses showed a greater increase in walking speed and were rated by their parents as exhibiting greater inhibitory control. Additionally, children’s CPT reaction time was significantly negatively related to the proportion of errors of commission during the CPT task, \( r(79) = -.58, p < .001 \). Children with a faster reaction time were less likely to make errors involving responding to an incorrect stimulus on the CPT task. Finally, children’s latency to delay gratification (reverse scored) was negatively related to their parents’ ratings of inhibitory control, \( r(82) = -.33, p < .01 \). Those children who waited longer for the M&M candies were rated by their parents as exhibiting greater inhibitory control.

Relations among Measures of Cognitive Control

To test the hypothesis that the tasks involving executive function would be related, zero-order correlations were conducted. Measures of performance on the tapping, day/night, and three pegs tasks were used in these analyses, as was the parent
rating of attentional focusing from the CBQ. Results revealed that children’s performance on the tapping task was significantly positively related to their performance on the day/night task, \( r(84) = .27, p < .05 \), and to the three pegs task, \( r(84) = .27, p < .05 \) (See Table 17). There was no relation, however, between children’s performance on the day/night task and the three-pegs task, or between the parent rating of attentional focusing and any of the task variables.

**Cross-domain Relations among Measures of Inhibitory Control**

To assess relations among all three indices of inhibitory control, correlation analyses were conducted on all study variables, including the measure of children’s verbal ability (PPV). The PPV measure was significantly negatively related to children’s latency to delay gratification, \( r(85) = -.25, p < .05 \). Because the latency to delay gratification measure was reverse-coded prior to transformation, this finding suggests that children with greater verbal ability showed a greater delay to gratification. The PPV measure was significantly positively related to children’s performance on the tapping task, \( r(84) = .27, p < .05 \), the three-pegs task, \( r(86) = .23, p < .05 \), and the CBQ measure of inhibitory control, \( r(84) = .27, p < .05 \).

An assessment of relations between emotional and behavioral inhibitory control measures revealed that children’s emotion regulation during the disappointment task was significantly positively related to their latency to touch a toy in the dinky toy task, \( r(83) = .26, p < .05 \) and significantly positively related to their CPT reaction time, \( r(78) = .32, p < .01 \) (See Table 17). Also, parents’ reports of emotion regulation from the CBQ was significantly related to the CBQ measure of inhibitory control, \( r(85) = .48, p < .001 \).
After controlling for verbal ability using the PPV variable, these relations remained statistically significant.

There was also a significant positive relation between parents’ report of children’s regulated coping style and the proportion of correct responses on the CPT task, \( r_s (80) = .29, p < .01 \). Thus, children who were rated as more likely to engage in regulated coping strategies when faced with emotionally arousing situations displayed more behavioral control in the CPT task. After controlling for PPV, the relation between parents’ report of regulated coping and CPT proportion correct became marginally significant (\( p = .06 \)).

With respect to indices of emotional and cognitive inhibitory control, parents’ ratings of emotion regulation from the CBQ was significantly positively related to ratings of attentional focusing from the CBQ, \( r_s (85) = .56, p < .001 \) (See Table 17).

Finally, with respect to indices of cognitive and behavioral inhibitory control, children’s performance on the tapping task was significantly positively related to the proportion of correct responses on the CPT task, \( r (78) = .39, p < .001 \), and to parents’ ratings of inhibitory control from the CBQ, \( r (81) = .33, p < .01 \), and negatively related to the proportion of errors of commission, \( r (78) = -.28, p < .05 \) (See Table 17). Parents’ ratings of inhibitory control from the CBQ were positively related to ratings of attentional focusing from the CBQ, \( r (85) = .58, p < .001 \), and negatively related to children’s delay to gratification (reverse scored), \( r (82) = -.33, p < .01 \). After controlling for verbal ability, all relations remained statistically significant.
Composite Measures of Emotion Regulation, Behavioral Control, and Executive Function

Prior to conducting subsequent regression analyses, composite measures of emotion regulation, behavioral control, and executive function were created by averaging all the measures within each category. For the purpose of descriptive clarity, the composite measures reflecting emotional, behavioral, and cognitive control are hereafter referred to as “emotion regulation”, “behavioral control”, and “executive function”, respectively. High scores on each of the composite measures reflected better overall emotion regulation, behavioral control, and executive function. The composite measure of emotion regulation was the average of the three measures of this ability: observed emotion regulation from the disappointment task, parents’ ratings of emotion regulation from the CBQ, and parent’s ratings of regulated coping styles from the Parent Report of Child’s Reaction questionnaire. The composite measure of behavioral control was the average of: CPT proportion of correct responses, (minus) CPT proportion of errors of commission, CPT reaction time, inhibition of speed in the walk-the-line task, increase in speed in the walk-the-line task, latency to touch a dinky toy, (minus) latency to delay gratification (reverse scored), and parent’s report of inhibitory control from the CBQ. Finally, the composite measure of executive function was created by averaging children’s performance on the tapping task, day/night task, and three pegs task with parent’s report of attentional control from the CBQ.
Interaction between Emotion Regulation and Negative Reactivity to Predict

Behavioral Control

To test the hypothesis that emotion regulation and negative reactivity (taken from parent report) had an interactive effect in predicting behavioral control, a hierarchical regression analysis was conducted in which the covariate variable (PPV), emotion regulation, and negative reactivity variables were entered in the first step (See Table 18). In the second step, the interaction term (emotion regulation*negative reactivity) was entered. The main effect of emotion regulation indicated that emotion regulation was a significant predictor of behavioral control after controlling for PPV and negative affectivity, $\beta = .43, p < .01$. There was no main effect of negative affectivity in predicting behavioral control. There was no support for the hypothesis; findings revealed that the interaction between emotion regulation and reactivity did not significantly predict behavioral control beyond the contribution of the main effects.

Interaction between Emotion Regulation and Negative Reactivity to predict Executive Function

A hierarchical regression analysis was also used to test the hypothesis that emotion regulation and negative reactivity would show an interactive effect in predicting cognitive control (See Table 18). The first step consisted of entering the covariate variable (PPV), emotion regulation, and negative reactivity. In the second step, the interaction term (emotion regulation*negative reactivity) was entered. There was a main effect of emotion regulation indicating that emotion regulation was a significant predictor of executive function after controlling for PPV and negative affectivity, $\beta = .27, p < .05$. 
Table 18

*Hierarchical Regression Analyses for Interaction between Emotion Regulation and Negative Affectivity to Predict Behavioral Control and Executive Function (N = 83)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Behavioral Control</th>
<th>Executive Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>R^2</td>
</tr>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal Ability (PPV)</td>
<td>.12</td>
<td>.29</td>
</tr>
<tr>
<td>Emotion Regulation</td>
<td>.42</td>
<td>.27</td>
</tr>
<tr>
<td>Negative Affectivity</td>
<td>.06</td>
<td>.18</td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotion Regulation* Negative</td>
<td>-.05</td>
<td>.18</td>
</tr>
</tbody>
</table>
There was no main effect of negative affectivity in predicting executive function. Again, there was no support for the hypothesis; the interaction between emotion regulation and reactivity did not significantly predict executive function.

*Prediction of Behavioral Control and Executive Function by Composite Measures of Inhibitory Control.*

An ordinary least squares regression analysis was conducted to test whether behavioral control was predicted by emotion regulation, executive function, and verbal ability (PPV). Together, these variables accounted for 22% of the variance in behavioral control (See Table 19). A main effect of emotion regulation was revealed, $t(84) = 2.73$, $p < .01$, after controlling for executive function and PPV, and a main effect of executive function was revealed, $t(84) = 2.78$, $p < .01$, when controlling for emotion regulation and PPV. Thus, both emotion regulation and executive function contributed significantly to the prediction of behavioral control.

Next, a standard multiple regression analysis was conducted to test whether executive function was predicted by emotion regulation, behavioral control, and verbal ability (PPV). Results revealed that 24% of the variance in executive function was explained by these variables (See Table 19). There was a main effect of behavioral control, $t(84) = 2.78$, $p < .01$ and verbal ability, $t(84) = 2.42$, $p < .05$, after controlling each of the other independent variables. However, there was not a significant main effect of emotion regulation. Together these findings reveal that measures of children’s emotion regulation and executive function both provided a meaningful contribution to explaining behavioral control, while children’s executive function ability was best
Table 19

*Regression Analyses for Prediction of Behavioral Control and Executive Function (N=88)*

<table>
<thead>
<tr>
<th>Variables in the model</th>
<th>$\beta$</th>
<th>Standard Error</th>
<th>$R^2$</th>
<th>$F$</th>
</tr>
</thead>
</table>

**Prediction of Behavioral Control**

1. Verbal Ability (PPV)  
   $\beta = -.01$  
   Standard Error = .07  
   $R^2 = .22$  
   $F = 7.8^{**}$

2. Emotion Regulation  
   $\beta = .30^{**}$  
   Standard Error = .11  

3. Executive Function  
   $\beta = .31^{**}$  
   Standard Error = .11

**Prediction of Executive Function**

1. Verbal Ability (PPV)  
   $\beta = .14^*$  
   Standard Error = .06  
   $R^2 = .25$  
   $F = 9.09^{**}$

2. Emotion Regulation  
   $\beta = .20$  
   Standard Error = .10

3. Behavioral Control  
   $\beta = .29^{**}$  
   Standard Error = .10

* $p < .05$; ** $p < .01$
explained by measures of behavioral control and verbal ability; emotion regulation did not provide a significant contribution to explaining this ability.

*Inhibitory Control Factor Structure*

The second aim of the present investigation was to explore the underlying factor structure for explaining the pattern of variation between indices of inhibitory control. Factor analysis is ideally conducted with a large number of cases per variables (Comrey & Lee, 1992). Thus, although there were a total of 15 variables derived from the specific measures of emotional, cognitive, and behavioral inhibitory control, a smaller number of variables were desired for the factor analysis. The selection of a smaller set of variables was driven by information from the correlation matrix of all inhibitory control measures as well as by the overarching goal to adequately represent the a priori division of measures into emotional, cognitive, and behavioral categories to test that factor structure.

First, each measure was considered according to the number and magnitude of correlations ($> r = .2$) that it had with any other index of inhibitory control (see Table 17). The CBQ emotion regulation and the parents’ report of children’s regulated coping measures were included in the factor analysis to represent emotional control. The disappointment task measure of emotion regulation was excluded from these analyses because it showed very few relations with other indices of inhibitory control and no relations with other measures of emotional control. The tapping task, day/night task, and CBQ attention focusing measures were included in the factor analysis to represent cognitive control. Finally, delay of gratification and CBQ inhibitory control were included in the analyses to represent behavioral control. Additionally, it was desired to
include one index of performance on the CPT task. Although the proportion correct variable showed the greatest number of relations with other inhibitory control measures, the proportion of commission errors was included in the factor analysis because this measure showed some relations to other inhibitory control measures and was conceptually a better index of (lack of) behavioral control. Thus, factor analysis was conducted with the following set of eight variables: latency to delay gratification, CPT proportion of errors of commission, CBQ inhibitory control, tapping task, day/night task, CBQ attention focusing, parent report of children’s reactions, and CBQ emotion regulation.

A maximum likelihood factor analysis of the 8 inhibitory control measures was conducted. The Kaiser-Meyer measure of sampling adequacy (.71), and Bartlett’s Test of Sphericity \( p < .001 \) indicated that factor analysis was appropriate. Components with eigenvalues greater than 1 were selected to determine the factor model and varimax rotation was used to interpret the factor matrix. Two factors were extracted that accounted for 38% of the variance. Examination of the scree plot suggested that the two-factor model was appropriate, as did goodness-of-fit statistics, \( \chi^2 (8, N = 70) = 8.55, p = .81 \) (See Table 20). All loadings on the first component were parent questionnaire measures. This factor increased with increasing CBQ attention focusing, CBQ inhibitory control, CBQ emotion regulation, and parent’s report of children’s reactions. The second factor, which represented all of the task measures of inhibitory control increased with increasing tapping task, day/night, and with decreasing errors of commission and latency to delay gratification (reverse coded). Because the latency to delay gratification measure
Table 20

Two-Factor Structure Inhibitory Control

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor Loadings for Two-Factor Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>CBQ Attention Focus</td>
<td>.66</td>
</tr>
<tr>
<td>CBQ Inhibitory Control</td>
<td>.84</td>
</tr>
<tr>
<td>CBQ Emotion Regulation</td>
<td>.68</td>
</tr>
<tr>
<td>Parent Report of Child Reactions</td>
<td>.48</td>
</tr>
<tr>
<td>Tapping Task</td>
<td>.19</td>
</tr>
<tr>
<td>Day/Night Task</td>
<td>-.07</td>
</tr>
<tr>
<td>CPT Errors of Commission</td>
<td>.12</td>
</tr>
<tr>
<td>Latency to Delay Gratification (reverse coded)</td>
<td>-.24</td>
</tr>
</tbody>
</table>

*Note: N = 70. Factor loadings are those derived after Varimax rotation.*

was reverse-coded, this variable was related to the factor in the same direction as the tapping and day/night scores. The results of this factor analysis suggested that a method effect may have driven the division of measures into tasks and parent reports. That is, the variance due to method type (parent report versus task variable) dominated the underlying pattern of associations among variables.

In order to obtain a clearer picture of interrelations among the task measures of inhibitory control (independent of the parent reports), a second maximum likelihood
factor analysis was conducted with the four task measures that were included in the
previous analysis. Again, the Kaiser-Meyer measure of sampling adequacy (.64), and
Bartlett’s Test of Sphericity ($p < .05$) indicated that factor analysis was appropriate. A
single factor was extracted that accounted for 40% of the variance. This factor increased
with increasing tapping task and day/night task performance and with decreasing errors
of commission and delay of gratification (reverse scored). Thus, no underlying factor
structure was identified by these analyses. Possible limitations to these analyses are
discussed in the discussion section of this thesis.

*Prediction of Theory of Mind*

The final goal of the present investigation was to assess relations between
measures of inhibitory control and theory of mind. Recall that the measures of theory of
mind consisted of four continuous composite scores and seven binomial outcome
(pass/fail) variables. It was expected that children’s verbal ability would be related to
their performance on theory of mind tasks, many of which required children to
comprehend short vignettes about others’ behaviors. The relation between children’s
verbal ability (PPV) and the four continuous theory of mind (ToM) variables was
assessed using zero-order correlations. The overall ToM score was significantly
positively related to PPV, $r (82) = .37, p < .01$. Thus, children with better verbal
comprehension ability performed significantly better across the seven questions used to
create this measure of the ToM total score. To assess whether verbal ability was a
significant predictor of success for each of the specific ToM questions, a series of logistic
regressions were conducted with PPV as the only predictor. These analyses revealed that
PPV was a significant predictor of success on the ToM belief desire emotion question #1 (Wald $\chi^2 = 5.60, p < .05$) and the ToM belief desire false emotion question (Wald $\chi^2 = 5.58, p < .05$). Additionally, there was a non-significant trend ($p < .10$) for prediction of success on four other ToM test questions, specifically, location false belief, belief desire emotion #2, belief desire emotion #3, and belief desire false emotion. Because verbal ability was significantly related to children’s performance on theory of mind tasks, it was included as a covariate in subsequent analyses.

*Relations between Individual Measures of Inhibitory Control and Theory of Mind*

Zero-order correlations were conducted to assess the relation between measures of inhibitory control and theory of mind. Children’s ToM total score score was significantly positively related to the proportion of correct responses on the CPT task, $r (76) = .40, p < .001$, the day/night task, $r (81) = .50, p < .001$, and parents’ CBQ ratings of inhibitory control, $r (80) = .30, p < .01$. Additionally, there was a significant positive relation between children’s performance on the tapping task and both the ToM justification score, $r (82) = .23, p < .05$, and the ToM emotion regulation interpretation score, $r (82) = .33, p < .01$. After controlling for PPV, all relations remained significant except that between the tapping task and ToM justification score ($p = .06$).

*Predictive Relations between Theory of Mind and Composite Measures of Emotion Regulation, Executive Function, and Behavioral Control*

To assess relations between theory of mind composite scores and measures of emotion regulation, executive function, and behavioral control, zero-order correlations were first conducted (See Table 21). These analyses were conducted with overall
Table 21
*Intercorrelations among Theory of Mind and Overall Emotion Regulation, Executive Function, and Behavioral Control*

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Theory of Mind Total Score</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Theory of Mind Justification Score</td>
<td>.37**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Theory of Mind Emotion Regulation Interpretation Score</td>
<td>.25*</td>
<td>.24*</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Theory of Mind Emotion Interpretation Score</td>
<td>.10</td>
<td>.13</td>
<td>.08</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Emotion Regulation</td>
<td>.16</td>
<td>-.14</td>
<td>.09</td>
<td>.04</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Executive Function</td>
<td>.43**</td>
<td>.17</td>
<td>.30**</td>
<td>.01</td>
<td>.33**</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>7. Behavioral Control</td>
<td>.35**</td>
<td>.19</td>
<td>.13</td>
<td>.11</td>
<td>.38**</td>
<td>.37**</td>
<td>--</td>
</tr>
</tbody>
</table>

Note.  
N=80.

* p < .05; **p < .01
composite measures of emotion regulation, behavioral control, and executive function which included the CBQ parent measures and parent reports of children’s reactions. There was no relation between the composite measure of emotion regulation and any of the theory of mind composite scores. Executive function was significantly related to the ToM total score, $r(82) = .43, p < .01$, and the ToM emotion regulation interpretation score, $r(82) = .30, p < .01$. Behavioral control was significantly related to the ToM total score, $r(82) = .35, p < .01$. All relations remained statistically significant after controlling for children’s verbal ability (PPV).

The interrelations among theory of mind, emotion regulation, executive function, and behavioral control suggested that executive function had the strongest relation to theory of mind, followed by behavioral control and emotion regulation. To test this model of predicting theory of mind, a series of separate hierarchical regressions were performed on the two ToM composite scores that showed significant relations with the inhibitory control composite scores: 1) the ToM total score and, 2) the ToM emotion regulation interpretation score. Variables were entered into all regressions as follows: PPV and emotion regulation were entered in the first step, behavioral control was entered in the second step, and executive function was entered in the last step.

*Prediction of ToM total score.*

A hierarchical regression analysis was conducted to test whether behavioral control predicted theory of mind after accounting for the variance due to emotion regulation, and whether the prediction by executive function was significant after
Table 22

*Hierarchical Regression Analyses for Emotion Regulation, Behavioral Control, and Executive Function to Predict Theory of Mind Total Score (N=82)*

<table>
<thead>
<tr>
<th>Theory of Mind Total Score</th>
<th>( \beta )</th>
<th>( R^2 )</th>
<th>( \Delta R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal Ability (PPV)</td>
<td>.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotion Regulation</td>
<td>.11</td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral Control</td>
<td>.20</td>
<td>.18</td>
<td>.04†</td>
</tr>
<tr>
<td><strong>Step 3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Executive Function</td>
<td>.32</td>
<td>.26</td>
<td>.08*</td>
</tr>
</tbody>
</table>

* \( p < .01; {\dagger} p < .10 \)
controlling for all other variables (See Table 22). There was not a main effect of emotion regulation in predicting theory of mind. The inclusion of behavioral control in the second step did not contribute significantly to the overall model, however the contribution was marginal ($p = .07$). Finally, executive function contributed significantly to the overall model, $R^2 = .26$, $F (1, 77) = 8.33$, $p < .01$, indicating that this ability was a significant predictor of children’s overall performance on the measures that comprised the ToM total score (i.e., false belief location, belief-desire reasoning, and second-order false belief tasks).

**Prediction of ToM emotion regulation interpretation score.**

A hierarchical regression analysis was conducted to test whether behavioral control predicted theory of mind after accounting for the variance due to emotion regulation, and whether the prediction by executive function was significant after controlling for all other variables (See Table 23). There was no main effect of emotion regulation in predicting theory of mind and the inclusion of behavioral control in the second step did not contribute significantly to the overall model. However, executive function did contributed significantly to the overall model, $R^2 = .15$, $F (1, 77) = 9.55$, $p < .01$. Thus, executive function significantly predicted children’s ToM emotion regulation interpretation score, even after controlling for PPV, emotion regulation, and behavioral control.

**Prediction of Dichotomous Theory of Mind Outcomes**

To test whether emotion regulation, behavioral control, and executive function significantly predicted the dichotomous outcome (pass/fail) of specific ToM test questions, logistic regression analyses were conducted on the following seven ToM test question outcomes: 1) Location False Belief, 2) Belief Desire Emotion #1, 3) Belief Desire Emotion #2, 4) Belief
Table 23

Hierarchical Regression Analyses for Emotion Regulation, Behavioral Control, and Executive Function to Predict Theory of Mind Emotion Regulation Interpretation Score (N=82)

<table>
<thead>
<tr>
<th>Step</th>
<th>Theory of Mind Emotion Regulation Interpretation Score</th>
<th>β</th>
<th>R²</th>
<th>Δ R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Verbal Ability (PPV)</td>
<td>-.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emotion Regulation</td>
<td>.11</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Step 2</td>
<td>Behavioral Control</td>
<td>.09</td>
<td>.04</td>
<td>.01</td>
</tr>
<tr>
<td>Step 3</td>
<td>Executive Function</td>
<td>.37</td>
<td>.15</td>
<td>.11**</td>
</tr>
</tbody>
</table>

**p < .01
Desire Emotion #3, 5) Belief Desire Content False Belief, 6) Belief Desire False Emotion, and 7) Second Order False Belief. Separate logistic regression analyses were conducted with each of the predictors (emotion regulation, behavioral control, and executive function) while controlling for PPV. For each analysis, the composite variable for emotion regulation, behavioral control, or executive function was separately entered as a predictor variable along with the PPV variable. This series of analyses revealed that neither emotion regulation nor behavioral control alone were significant predictors of success on any of the ToM test questions after controlling for PPV. Executive function significantly predicted success on two ToM test questions: belief desire emotion question #1, and the second-order false belief question, and there was a marginal trend for prediction of the ToM belief desire false belief question (p = .06). Moreover, after controlling for the effect of PPV, emotion regulation, and behavioral control in a separate logistic regression analysis, this executive function effect remained significant (See Table 24). Thus, data from both linear and logistic regression analyses suggested that children’s executive function ability was a significant predictor of these ToM measures.

Relations between Executive Function and Behavioral Control Task Batteries and Theory of Mind

The results of the factor analyses from the second aim of this investigation suggested that there may have been a method effect driving the associations among measures inhibitory control. Recall that inhibitory control measures showed better coherence within measurement type (task versus parent report) than between these types of measures. To assess whether composite batteries of behavioral and cognitive
Table 24

Logistic Regression Parameter Estimates for the Prediction of Success on ToM Test Questions by Executive Function

<table>
<thead>
<tr>
<th>Prediction by Executive Function</th>
<th>Prediction by Executive Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Controlling for PPV</td>
</tr>
<tr>
<td></td>
<td>Controlling for PPV, Emotion</td>
</tr>
<tr>
<td></td>
<td>Regulation, and Behavioral Control</td>
</tr>
<tr>
<td>Wald</td>
<td>β</td>
</tr>
<tr>
<td>( \chi^2 )</td>
<td>Ratio</td>
</tr>
<tr>
<td>ToM Belief Desire Emotion #1</td>
<td></td>
</tr>
<tr>
<td>Executive Function</td>
<td></td>
</tr>
<tr>
<td>6.17*</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>.45</td>
</tr>
<tr>
<td>3.06</td>
<td></td>
</tr>
<tr>
<td>ToM Belief Desire False Emotion</td>
<td></td>
</tr>
<tr>
<td>Executive Function</td>
<td></td>
</tr>
<tr>
<td>3.52†</td>
<td>.83</td>
</tr>
<tr>
<td></td>
<td>.44</td>
</tr>
<tr>
<td>2.29</td>
<td></td>
</tr>
<tr>
<td>ToM Second-Order False Belief</td>
<td></td>
</tr>
<tr>
<td>Executive Function</td>
<td></td>
</tr>
<tr>
<td>5.50*</td>
<td>1.99</td>
</tr>
<tr>
<td></td>
<td>.85</td>
</tr>
<tr>
<td>7.33</td>
<td></td>
</tr>
</tbody>
</table>

* \( p < .05 \); † \( p < .01 \)
inhibitory control tasks were significantly related to theory of mind, a second set of logistic regressions were conducted. First, to create the battery of behavioral control tasks, the following measures were averaged: CPT proportion correct, (minus) CPT proportion of errors of commission, CPT reaction time, inhibition of walking speed, latency to touch a dinky toy, and (minus) latency to delay gratification. To create the battery of executive function tasks, the following measures were averaged: tapping task, day/night task, and three pegs task. A battery of observed emotional inhibitory control was not created because only one task measure (disappointment task) was used in the investigation and this measure was not found to be related to theory of mind. The executive function and behavioral control task batteries were significantly related, $r (89) = .35, p < .01$, and this relation was significant after controlling for children’s verbal ability (PPV), $r (84) = .31, p < .05$.

Zero-order correlations (controlling for PPV) were conducted to assess the relations between these inhibitory control task batteries and composite theory of mind scores. The ToM overall composite score was significantly positive related to the behavioral control battery, $r (79) = .29, p < .05$, as was the executive function battery, $r (79) = .29, p < .05$. The executive function battery was also significantly related to the ToM justification score, $r (78) = .27, p < .05$, and the ToM emotion regulation interpretation score, $r (78) = .35, p < .01$.

To assess whether the executive function battery significantly predicted theory of mind ability above and beyond the prediction of PPV and the behavioral control battery, a hierarchical regression analysis was conducted. The behavioral control battery and
PPV were entered in step 1. The executive function control battery was entered in step 2. The results of these analyses are presented in Table 25. These analyses revealed that, after controlling for behavioral control and PPV, executive function contributed significantly to the models for prediction of the ToM justification score and the ToM emotion regulation interpretation score, and showed a marginal trend \( (p = .06) \) for significant contribution to the model for predicting the ToM overall composite score. Thus, these results are consistent with those in which the executive function and behavioral control composite measures included parent reports. Overall, these results suggest that cognitive or executive indices of inhibitory control are the strongest predictors of children’s theory of mind ability.
Table 25

*Hierarchical Regression Analyses for Behavioral and Cognitive Task Batteries to Predict Theory of Mind (N = 83)*

<table>
<thead>
<tr>
<th>Theory of Mind</th>
<th>Theory of Mind</th>
<th>Theory of Mind</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total Score</td>
<td>Justification Score</td>
</tr>
<tr>
<td>Variable</td>
<td>β</td>
<td>R²</td>
</tr>
<tr>
<td>Verbal Ability (PPV)</td>
<td>.31</td>
<td>.03</td>
</tr>
<tr>
<td>Behavioral IC Battery</td>
<td>.27</td>
<td>.19</td>
</tr>
<tr>
<td>Cognitive IC Battery</td>
<td>.21</td>
<td>.23</td>
</tr>
</tbody>
</table>

**p < .01; † p < .01**
Chapter 5

DISCUSSION

The purpose of the present investigation was to examine various measures of inhibitory control ability in young children and to explain the relations between these abilities and theory of mind. This discussion is organized according to the three main goals of this study: (1) to explain relations among emotional, behavioral, and cognitive measures of inhibitory control, (2) to describe the underlying factor structure of inhibitory control in young children, and (3) to explain relations between inhibitory control and theory of mind. Within each section, the primary results are addressed, followed by interpretations and conclusions based on prior theoretical and empirical work.

Relations among Measures of Inhibitory Control

To address the goal of studying preschool children’s inhibitory control, laboratory tasks and parent questionnaires were used to measure emotional, behavioral, and cognitive control based on previous theoretical and empirical work. It was hypothesized that the measures of inhibitory control within each of these domains would show considerable agreement. The findings supported this hypothesis. Specifically, there was agreement among parent measures of emotional control, among task measures of cognitive control, and among both tasks and questionnaire measures of behavioral control.

These findings were consistent with the overall mixed findings of convergence between parent report and observational measures of temperament in previous literature.
(Bridges, Palmer, Morales, Hurtado, and Tsai, 1993; Seifer, Sameroff, Barrett, and Krafchuk, 1994). The degree to which the parent reports tapped the specific inhibitory skills which were measured via laboratory tasks may explain the convergence and divergence between measurement types. For example, the specific emotion-eliciting situations about which parents rated their children in both emotion regulation questionnaires covered a broad range of emotionally arousing circumstances, whereas our observational task was a measure of disappointment specifically. Additionally, whereas parents were asked to report on children’s response tendencies or propensities, we obtained a single measure of one such reaction which may or may not have been representative of children’s typical regulatory responses. Finally, although the observed measure of reactions to the disappointment task incorporated a number of controls to ensure that the task was indeed disappointing (i.e., whether or not children traded in the prize and their self-report of negative feelings), children’s expressions in response to receiving the prize were a function of both their regulatory skills and knowledge of display rules (i.e., social norms concerning emotional expressions) (Cole, 1986). Children may have had the capacity to regulate their emotional expressions (as would be reflected by parents’ ratings of their emotional regulation), but lacked knowledge of the social appropriateness of doing so during the disappointment task.

Likewise, parents’ reports of attentional focusing from the CBQ may not have been related to cognitive control lab tasks because attentional focusing is only one dimension of the skills necessary for success on such tasks (Denckla, 1996). To be successful on the tapping, day/night, and three-pegs tasks, children needed to both focus
attention in order to avoid the influence of distracting information (i.e., the prepotent response), but also produce a novel response, either verbally or physically. Thus, while focused attention may have aided children in inhibiting prepotent responses, this process alone may not have been sufficient to explain success on such tasks.

The degree to which parent report items mapped onto lab tasks may also explain why parents’ report of inhibitory control from the CBQ did show relations to behavioral control tasks. The specific items which comprised the inhibitory control scale of the CBQ were closely linked to the study’s laboratory tasks involving behavioral control. For example, parents were asked to rate their child’s ability to do such things as wait, sit still, and stop prohibited activities, all of which were abilities that were directly relevant to success on the lab tasks. These findings, and those concerning the agreement among other task measures of behavioral control, were consistent with those of previous researchers. Specifically, studies of 22-, 33-, 46-, and 65- month-olds indicate good internal consistency for indices of effortful control, including delay, slowing down of motor activity, and parental measures of inhibitory control (Kochanska, Murray and Coy, 1997; Kochanska, Murray, and Harlan, 2000). With respect to the walking task, the present study found relations with the measure of increasing rather than inhibition of walking speed. Although on face value the ability to increase walking speed may not appear to require inhibition, it is important to note that the instructions given to children for this walking trial were to both “walk fast” and “stay on the line”. Children may have had to call upon a greater amount of bodily control to ensure that they did not step off the walking line but also walked at a faster pace. This type of behavioral control may
parallel that which was necessary for successful performance on the CPT task, which required children to both respond quickly to the correct stimulus but inhibit a response on non-target trials. The relation between children’s performance on the CPT task and their ability to increase speed on the walk-the-line task, therefore, could have been because performance on both tasks elicited children’s ability to maintain a speed-accuracy balance by requiring optimal motor activation and motor inhibition (Band, Ridderinkhof, & van der Molen, 2003).

The relations among lab task measures of cognitive control suggested that the modality by which children were required to execute inhibitory control may have influenced the relations found across these tasks. Recall that the tapping task was related to both the three pegs and day/night tasks, but the latter two tasks were not related. The relation between the tapping and three pegs tasks may have been due to the fact that both tasks required children to physically perform an action that constituted inhibiting a prepotent response (i.e., tapping pegs out of order for three-pegs and tapping the opposite number as the experimenter for the tapping task). The day/night task, on the other hand, consisted of inhibiting a prepotent verbal response. However, like the tapping task, the day/night task also consisted of a series of trials which required children to remember the rules over a longer period of time. The relation between these tasks, therefore, may have been due to their inhibitory requirements in addition to other abilities such as working memory and the ability to sustain effort over longer periods of time (Diamond & Taylor, 1996; Pennington, Bennetto, McAleer, & Roberts, 1996). The three-pegs task may have involved less working memory demands due to the fact that instructions were provided to
the child prior to each trial of this task. These results are comparable to those found in other studies of executive function. For example Carlson and Moses (2001) found many significant relations among a variety of executive function tasks which required children to inhibit a prepotent response. However, these authors did not find a significant relation between the day/night task and a task called “grass/snow” which required children to point to the color (i.e., green or white) which was the opposite of that depicted in a picture. Like the tapping task in the present study, the grass/snow task required children to physically perform the inhibitory response. These results further support the argument that the modality by which children executed a cognitive control response may have influenced the relations in their performance between these tasks.

In sum, there was evidence of agreement among tasks and questionnaires designed to measure preschool children’s emotional, behavioral, and cognitive control which supported the theorized application of these tasks as indices of three important constructs: emotion regulation, behavioral control, and executive function. Because each of these constructs is implicated in children’s development of behavior problems, a greater understanding of the interrelations between these constructs may enable us to better understand the process by which children’s emerging inhibitory competence leads to their social functioning.

Relations across different domains of inhibitory control were also hypothesized. It was expected that emotion regulation would be related to behavioral control and that behavioral control would be related to executive function. From an exploratory standpoint, it was also expected that emotion regulation and executive function would be
related due to the similar processes which were theorized to underlie both. Emotion regulation and negative reactivity were also hypothesized to interact to predict behavioral control and executive function. Finally, it was expected that emotion regulation and executive function would significantly predict behavioral control, while behavioral control would predict executive function above and beyond the effect of emotion regulation.

The findings partially supported these hypotheses. Emotion regulation and behavioral control were related across a number of laboratory tasks including the disappointment task, dinky toys, and CPT, and these relations were confirmed by parent reports. Additionally, behavioral control and executive function showed associations with respect to the tapping and CPT tasks and parent report measures. Finally, parent report measures of emotion regulation agreed with those of cognitive control. Thus, a greater number of links between emotional and behavioral inhibitory control measures and behavioral and cognitive measures were revealed, while indices of emotional control and cognitive control showed the fewest relations. These findings were confirmed when relations were assessed at the composite level. Specifically, children’s behavioral control ability could be attributed to both executive function and emotion regulation, while behavioral control alone predicted executive function after controlling for emotion regulation. Contrary to our expectation, however, negative affectivity did not interact with emotion regulation to predict behavioral control or executive function.

Several theories suggest that the modulation of emotional arousal is important for children’s organization of behavioral strategies (Kopp, 1989; Thompson, 1994). Support
for this argument has been demonstrated by studies which found that children who were slower to express anger and who showed greater modulation of anger performed better on a battery of effortful control tasks, including a snack delay and slowing down of motor activity (Kochanska, Murray, & Harlan, 2000). It is not clear why, in the present study, emotion regulation in the disappointment task was related to children’s latency to touch a toy, but not to latency to delay gratification. It may be that our sample of young children found the dinky toys to be more emotionally-arousing or exciting than the two M&Ms used in the delay of gratification tasks. Children who showed control over their emotions in disappointment may have had an ability to control their emotions, and those skills may have been helpful when they were confronted with a container of toys. This association between emotion regulation and behavioral control is important because it suggests that children’s ability to modulate emotional arousal may be an antecedent to their ability to adapt their behaviors to situational and social demands (Kopp, 1982). Young children’s ability to regulate emotions may enable them to adopt strategies that will contribute to their behavioral self-control (Vaughn, Kopp, Krakow, Johnson, & Schwartz, 1986).

Children’s cognitive control was also found to be related to behavioral control at the level of individual measures and composite measures. This pattern of findings is consistent with those of Cole, Usher, and Cargo (1993) who found executive function (i.e., tapping test, rapid-alternating-stimulus-naming test, hand movement test, block sort, and visual search test), to be related to preschoolers’ attentional and behavioral self-regulation, measured by their ability to resist temptation in a forbidden-object paradigm.
Additionally, Carlson and Moses (2001) found children’s performance on some tasks requiring executive inhibitory abilities (e.g., Grass/Snow task and Card Sort task) to be related to their ability to delay gratification (i.e., to wait, without peeking, while an experimenter wrapped a gift), even after controlling for age, gender, and verbal ability. Carlson and Moses (2001) also did not find a significant relation between the day/night task and the children’s gift delay. The results of the present study add additional support to these findings. Taken together, these results offer empirical support of Fuster’s (1997) suggestion that executive functions are self-organizing and self-regulating, and that their overall purpose is the organization of behavior. Behavioral control may directly influence children’s executive function performance such that children’s ability to modulate their expressive movement during crucial points of executive problem-solving contributes to their success on these tasks (Maccoby, Dowley, Hagen, & Degerman, 1965). On the other hand, executive function may also directly facilitate children’s behavioral control by aiding in the initiation, organization, and flexibility of behavioral activity (Cole, Usher, & Cargo, 1993).

Finally, with respect to relations between measures of emotional and cognitive control, the present study found that the composite measure of emotion regulation did not significantly predict executive function after accounting for the contribution of behavioral control, thus our hypothesis regarding this relation was not supported. This finding calls into question the theoretical work proposing a link between emotion regulation and executive function. Broadly speaking, the emergence of executive function ability is thought to influence emotion regulation by way of strategy selection and use. Kopp
(1989) notes that as infants expand their emotional competence, they begin to enlist cognitive skills into their emotion regulation strategies. Additionally, Calkins (1994) suggests that cognitive development may influence emotion regulation by increasing infants’ understanding of the need for regulation and enabling a greater ability to apply regulatory strategies. Finally, neuropsychological work suggests that both of these inhibitory abilities may be guided by the same brain systems, namely, the frontal lobe region of the brain (Fuster, 1997).

Theoretically, emotional and cognitive control should be related. How might one explain the lack of a strong relation in the present study? A consideration of the one relation found between individual measures of these abilities may offer some insight into this finding. Recall that the only significant relation between specific measures of emotional and cognitive control was that between parent’s reports of children’s emotion regulation and attentional focusing from the CBQ. This finding supports the work of Rothbart and colleagues (e.g., Derryberry & Rothbart, 1997; Rothbart, Posner, & Boylan, 1990) who proposed a link between infants’ and children’s focused attention behaviors (e.g., orienting) and the regulation of emotional behavior by way of the “anterior attentional system” of the frontal cortex. Empirical evidence of this link has been demonstrated by Rothbart, Ziaie, and O’Boyle (1992) who found that four-month-olds who were better at refocusing their attention showed less distress in laboratory situations, and by Stifter and Braungart (1995), who found that orienting behaviors showed a regulatory function in decreasing low levels of 5 month olds’ negative reactivity. Thus, there is some evidence for the role of attentional processes in children’s ability to regulate
their emotions early in life, processes which were not tapped in the present study. Specifically, our measurements of emotion regulation assessed the degree to which children were successful with emotional control, not the process by which they did so. In other words, regulation from the disappointment task was defined according to whether or not children displayed more positive than negative emotion while the experimenter was present. Similarly, parents’ reports of children’s regulated coping assessed whether children were more likely to engage in coping strategies that assume regulation of emotion. It may be, however, that the key to understanding the relations between cognitive control and emotion regulation is to examine the process by which children handle emotionally arousing situations. That is, what strategies do they use to regulate their emotions? It may be that a measure of children’s use of distraction during the disappointment task would be related to executive function because such a measure of emotion regulation would better capture the process by which a greater executive function may be directly related to a greater emotion.

In sum the pattern of relations among measures of inhibitory control in this investigation suggest that children’s ability to modulate emotional arousal enables them to adopt strategies that will contribute to their behavioral self-control. Another important aspect of children’s behavioral control is executive function, which may facilitate behavioral control by aiding in the initiation, organization, and flexibility of motor activity. Finally, the most important predictor of children’s executive function is behavioral control, possibly because this ability helps children to modulate their expressive movement during complex executive tasks.
The second goal of the present investigation was to describe the underlying factor structure for inhibitory control. The approach taken thus far in the study had been to separate inhibitory control according to emotional, behavioral, and cognitive domains of development. According to this approach, inhibitory ability was thought to be a three-dimensional construct, separated by the type of response that children inhibited (e.g., emotional, motor, or mental). While this approach is meaningful on face value, we speculated that an alternative underlying factor structure may provide a more meaningful explanation of the pattern of relations among inhibitory control measures. Although this pursuit was exploratory in nature, we hypothesized that an alternative model may be one that separates inhibitory control not by the type of response that is suppressed, but by the type of goal that the child was pursuing. As such, we expected socially-motivated inhibitory abilities (e.g., delay of gratification, delay in touching a toy, and control of emotional expressiveness) to cohere into a separate factor from non-social indices such as performance on CPT, tapping, and day/night tasks.

The results of the factor analysis indicate that a two-factor model best explained the interrelations among inhibitory control measures. However, this factor model did not support our hypothesis of a social/non-social distinction between inhibitory control measures. Instead, the factor structure suggested that a method effect may have driven the division of measures. That is, parent’s report of inhibitory control lined up on the first factor and laboratory task measures lined up on the second factor, indicating that our measures were separated according to assessment technique.
Given these findings, a follow-up factor analysis was conducted to explore the pattern of interrelations among only the task measures of inhibitory control. This analysis revealed that only a single factor could be extracted from these inhibitory control task variables. Thus, no separable factor structure was identified by these analyses, suggesting that behavioral and cognitive inhibitory control tasks represent a unidimensional concept.

Although there are only a few previous studies to which these results may be compared, previous findings do suggest that inhibitory control measures are separable to some degree. For example, in a study of normal and behaviorally disturbed boys two factors of inhibitory control emerged which represented executive inhibitory control (e.g., Stroop, Trail-making B) and motivational inhibitory control (e.g., Go/No Go, Newman card-playing tasks) (Kindlon, Mezzacappa, & Earls, 1995). Also, Carlson and Moses (2001) performed a principal components analysis using a variety of inhibitory tasks and found two factors to emerge: delay and conflict. Items that fell on the delay scale included Pinball, Gift Delay, Tower Building and KRISP. These tasks were thought to require the child to merely inhibit their responses (e.g., wait until the experimenter gave the signal on the Pinball task), whereas the items that fell on the conflict scale (e.g., Day/Night Stroop, Grass/Snow, Spatial Conflict, Bear/Dragon, the Dimension Change Card Sort, and Whisper) were thought to require the child to not only inhibit a prepotent response, but additionally activate a conflicting, novel response (Carlson & Moses, 2001).
There is also evidence that the construct of executive function can itself be explained by a number of underlying factors. Miyake and colleagues, who have done work on this topic, provide evidence of some dissociation in the deficits of frontal lobe patients with respect to executive function tasks (e.g., failure on Wisconsin Card Sort, but not on Tower of Hanoi) which suggesting that executive function may not be a unitary construct (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). In a study of normal college students, these authors used confirmatory factor analysis to test a three-factor model for tasks that were thought to represent three processes of executive function: mental set shifting, information updating and monitoring, and inhibition of a prepotent response. Their findings supported this hypothesized division of tasks (Miyake, et al., 2000).

Thus, while there is a relative dearth of studies which examine the factor structure of inhibitory control measures, the limited findings suggest that some underlying factor structure may exist to explain the pattern of interrelations among inhibitory control variables. There are a number of limitations in the present study which may explain why our findings did not support the previous research, including sample size, the number of variables which represented different types of inhibitory control, and the moderate size of bivariate correlations among inhibitory control variables.

First, one of the major limitations to these analyses may have been sample size. Due to missing data throughout the data set, the number of cases used in the factor analysis was N= 70. This sample size may not have been large enough to reliably estimate correlations among the variables (e.g., Comrey & Lee, 1992; Tabachnick &
Fidell, 2001). Indeed, some have suggested that at least 300 cases are appropriate for a factor analysis, particularly if there are few high-loading marker variables, as was the case in the present investigation (Comrey & Lee, 1992).

The number of variables included in the factor analyses to represent each of the different types of inhibitory control may have also influenced our results. Specifically, including parent reports, there were two measures of emotional control, three measures of behavioral control, and three measures of cognitive control. Given the initial aim was to determine whether these three types of inhibitory control would emerge as three separate factors or cohere into two factors, a greater number of measures of each type may have been called for. Tabachnick & Fidell (2001) recommend that at least five or six variables should be included to represent each hypothesized factor. Recall that the first factor analysis revealed that the variance due to measurement type best explained two separable factors, whereas the second factor analysis (using only behavioral control and cognitive control task measures) extracted a single unidimensional factor. A greater number of task measures which were thought to represented behavioral and cognitive control may have enabled us to adequately separate these factors. Furthermore, a greater number of task measures of emotional control may have enabled us to include this type of inhibitory control into a factor analysis of task variables and to better understand whether emotional control tasks were likely to line up with measures of behavioral or cognitive control.

The final limitation to the factor analysis may have been the size of bivariate correlations among variables entered into the analysis. The majority of significant intercorrelations among the study’s inhibitory control variables were in the range of $r =$
.25 - .35, and all intercorrelations for task variables used in the second factor analysis were less than $r = .30$. Use of factor analysis for correlations smaller than $r = .30$ is somewhat questionable (Tabachnick & Fidell, 2001). Although the Kaiser-Meyer Measure of Sampling Adequacy and Bartlett’s Test of Sphericity indicated that the use of factor analysis was appropriate for both factor analyses, the moderate size of bivariate correlations may have influenced our ability to extract separable factors.

In sum, contrary to our expectation, indices of inhibitory control did not cohere into separate factors based on the control domains (i.e., emotional, motor, or mental), nor did they line up according to social and non-social motivational dimensions. Rather, task measures of behavioral and cognitive control appeared to represent a unitary construct. However, because of the present study’s limitations, more work should be done on this topic before strong conclusions may be drawn.

*Predictions to Theory of Mind*

An important implication of children’s development of inhibitory skills is the role that these abilities play in children’s social functioning. Because theory of mind is considered to be an important precursor to children’s social competence, the final goal of the present investigation was to examine the relation between children’s inhibitory control ability at 4.5 years and theory of mind performance at 5.5 years. In line with previous work, we hypothesized that behavioral and cognitive inhibitory control would be related to theory of mind. Additionally, we sought to explore the relation between emotional control and theory of mind, as the link between this index of inhibitory control and theory of mind had not been addressed. Finally, we expected that behavioral and
cognitive indices of inhibitory control would be predictors of theory of mind, even after controlling for emotional control.

The assessment of relations between theory of mind (ToM) and both individual and composite measures of inhibitory control revealed that children with better behavioral control and executive function had higher scores on ToM tasks. Contrary to our expectation, however, emotion regulation was not related to theory of mind. Furthermore, when dichotomous outcomes (i.e., pass/fail) on individual ToM test questions were considered, executive function was the only inhibitory control construct that predicted success. This pattern of relations between inhibitory control measures and theory of mind, therefore, indicates that there was a strong link between executive function and theory of mind, and to a lesser extent between behavioral control and theory of mind. It was interesting that among the ToM measures found to be related to executive function was the emotion regulation interpretation score, a task that was introduced by Muris et al. (1999) as part of a new ToM test. This task required children to interpret a situation in which another child was masking her true emotion after falling down. Better performance on this task reflected children’s ability to interpret the girl’s feelings in light of her false presentation (smiling). Although this task has not been used in many studies of theory of mind, it appears that it may have required similar skills as those required for the more commonly-used theory of mind false belief tasks.

We next assessed the predictive relations among composite measures of inhibitory control and theory of mind. It was hypothesized that behavioral control would be a significant predictor of theory of mind after controlling for the effect of emotion
regulation (and children’s verbal ability), and that executive function was a significant predictor of theory of mind above and beyond all other measures of inhibitory control and verbal ability. The findings partially supported our hypotheses. Specifically, behavioral control showed a marginal trend for predicting ToM after controlling for emotion regulation, while executive function predicted ToM after controlling for all other inhibitory control constructs. Furthermore, even when the task batteries of behavioral control and executive function were considered, executive function predicted theory of mind best after controlling for behavioral control. These findings further support the contention that children with greater executive function at 4.5 years perform better on ToM tests, even after controlling for all other inhibitory control abilities.

The specific relations found in the present study between inhibitory control and theory of mind are consistent with those found in previous literature. Carlson and Moses (2001) also found that the day/night task was related to a battery of theory of mind tasks. Additionally, consistent with the present study’s finding that the tapping task was related to some ToM scores, Carlson and Moses (2001) found a relation between the Grass/Snow task, which required children to physically inhibit a prepotent response, and theory of mind. Other researchers have found strong relations between other measures of inhibitory control and executive function (e.g., card sort) and theory of mind (Frye, Zelazo, & Palfai, 1995; Hughes, 1998). Although the present study did not incorporate all of the measures that have been used in previous studies to test this relation, our results lend support to the broader argument that children who perform better on a variety of cognitive measures of inhibitory control also perform better on theory of mind tasks.
The present study’s findings of relations between theory of mind and both individual measures of behavioral control (i.e., CPT proportion correct and parent’s report of inhibitory control) and a composite measure of behavioral control is also interesting. Only one previous study has examined the relation between CPT and theory of mind (Fahie & Symons, 2003). These authors examined the relation between CPT errors of commission and theory of mind, and consistent with the present study, found no relation between these measures. However, the present study did find the proportion of correct responses on the CPT task to be related to theory of mind. Given the argument mentioned previously that better performance on the CPT task may reflect a skill in modulating the balance between speed and accuracy, this finding suggests that this aspect of behavioral control is also related to theory of mind.

Children who were reported by their parents as having greater inhibitory control also showed better theory of mind performance, furthering the argument that there is a relation between behavioral control and theory of mind. Although Carlson and Moses (2001) had expected to find this relation in their study, they found a weak (non-significant) relation between these measures. Recall that items from the inhibitory control CBQ scale ask parents to rate their children’s ability to do such things as sit still, wait in line, and stop a prohibited activity. These abilities have been considered by many to be important to children’s social competence (e.g., Eisenberg, et al., 1995). Specifically, Eisenberg and colleagues found that children who were rated by their parents as more behaviorally regulated (i.e., a measure that included the CBQ inhibitory
control scale), were rated by teachers as more socially appropriate (Eisenberg, et al., 1995).

The hypothesis that children with greater emotion regulation would perform better on theory of mind tasks was not supported. Although this aspect of the study was exploratory, it was expected that similar strategies underlie children’s ability to regulate their emotions and their performance on false belief tasks. One might speculate, however, that measures of children’s ability to deploy emotion regulation strategies, such as attentional control, may be related to theory of mind such that children who are able to exert greater control over their attentional processes (e.g., distraction) are better equipped for the flexible representations necessary to succeed at theory of mind tasks. Future work using measures of children’s use of attentional strategies would clarify whether these processes are related.

Notably, the present study found longitudinal relations between early executive function and later theory of mind. Only one other study to date assessed these relations longitudinally. Hughes (1998) found that executive function skills at 3 years predicted theory of mind at 4 years. The present findings extend those of Hughes (1998) by measuring executive function at 4.5 years and theory of mind and 5.5 years, contributing to the view that these processes are related, even after children have made considerable advances with respect to both skills. Furthermore, given that there is some consensus in the field of theory of mind that typical children develop the ability to understand false belief by the age of 4 years, it is interesting that the present study found significant
variability in theory of mind at the age of 5.5 years, and that this variability may be
due in part by low scores in executive function.

In sum, our findings support the theoretical and empirical hypothesis that
inhibitory control, specifically executive function, is related to theory of mind. Executive
function may serve the purpose of enabling children to hold multiple perspectives in
mind (i.e., their own and those of others) and to reflect on the association between
thoughts and actions (Moses, 2001). Additionally, executive function may facilitate
children’s ability to inhibit their knowledge of the reality of a situation in order to make
predictions based on other’s false representations and beliefs (Moses, 2001). Finally, it
appears that behavioral control has some association to theory of mind, possibly because
children’s ability to exhibit future-oriented organization over their own behaviors may
increase their understanding of others’ behavioral responses.

While the relation between executive function and theory of mind has been
supported, the present study does not offer any evidence of the direction of causality
between these abilities. Some have suggested that executive function ability may be an
antecedent of the ability to understand false beliefs or make conclusions based on
multiple perspectives (Carlson & Moses, 2001; Hughes, 1998), while others argue that
children’s understanding of mental states (and the behaviors that may result from mental
states) is a prerequisite to the ability to exert control over behaviors (Perner & Lang,
1999). Findings from the present study support the latter interpretation such that the
developmental primacy of children’s inhibitory skills appears to be relevant to the
relations observed with theory of mind. Hughes' (1998) study provides perhaps the
strongest support for this direction of effects because she found that executive
function (at age 3) significantly predicted theory of mind (at age 4), but the reverse
prediction was not significant. Furthermore, studies of earliest forms of executive ability
in infancy (e.g., Diamond, 1991) offer additional support of the argument that some
elements of executive ability emerge prior to children’s ability to interpret false belief.
The present study’s design precluded an assessment of the direction of influence between
these abilities because measures of executive function and theory of mind were made at
only one age. Future work, with measure of both abilities at multiple times points, may
offer a greater insight regarding this issue.

Summary

This investigation sought to explain relations among three indices of inhibitory
control in preschool children, emotional control, behavioral control and cognitive control.
The results showed that 4.5 year-old children’s emotion regulation and executive function
were independently important predictors of their ability to exert control over their
behaviors, while children’s executive function performance could mainly be attributed to
their behavioral control ability, not to their control over emotional expressions.
Moreover, both behavioral control and executive function were related to theory of mind
performance one year later, however, executive function was the stronger predictor of
theory of mind even after controlling for the effects of all other types of inhibitory
control.

Our findings provide a snapshot of one stage in the developmental process of
inhibitory control which, together with theories on when these abilities are thought to
develop, gives us better insight on how these processes may work together at this age. First, our findings suggest an additive effect of children’s inhibitory control abilities such that competence in one or more domains of development facilitates better performance in another. Specifically, when children are faced with a situation that calls for behavioral control, such as sitting still and following directions, both the ability to control emotional arousal and to inhibit subdominant mental processes contributes to their success. For example, children may experience frustration when told to hold back from touching a basket full of toys or to sit and wait for a sweet treat. To be successful they must control their emotional reactions to these situations (Thompson, 1994). However, it appears that control over emotional reactions, in and of itself, is not the only predictor of success. In addition to modulating their emotional arousal, children must also exert control over dominant mental responses by applying executive control to the situation. Better executive abilities allows for greater flexibility in selecting of strategies, intensive concentration, or attention to bodily movements (Mathews & Wells, 1999; Wells & Mathews, 1996), thus a greater degree of internal self-monitoring (Kopp, 1982). This might involve reminding themselves of the rules, recalling that waiting (or cleaning up) is the task at hand even though they really want to touch a piece of candy (or continue playing).

Given the proposed additive effect of inhibitory control abilities, some might suggest that emotion regulation, behavioral control, and executive function are independent constructs that feed upon each other to promote social functioning in young children. Findings from the present study suggest that this interpretation would be
limited. Specifically, it appears that the developmental primacy of inhibitory control abilities is relevant to this additive effect such that children incorporate earlier inhibitory abilities into higher-order ones as they develop a more complex self-regulation repertoire. For example, emotion regulation has been proposed to be the earliest of these inhibitory abilities to develop, and is available in immature form in infancy (Stifter, 2002). Behavioral control and executive function are higher-order regulatory abilities that begin to emerge later in life. Behavioral control shows considerable improvements in toddlerhood, when young children begin to internalize social requirements and adjust their behaviors according to situational demands, for example, to sit still and be quiet in social settings where such behaviors are called for (Kopp, 1982). Executive function shows considerable improvement after 3 years of age, when children begin to show a greater ability to flexibly inhibit subdominant mental responses (Livesey & Morgan, 1991).

In line with this developmental course, by 4.5 years, children have some level of each of these abilities at their disposal. In the present study the best explanation of the late-emerging executive function ability appeared to be behavioral control, even after controlling for emotion regulation. Thus, behavioral control may subsume emotion regulation in the prediction of executive ability. By 4.5 years, children may have gained considerable mastery in controlling their behaviors, and this ability may have the most direct relevance to their emerging executive function. This investigation suggests that different forms of inhibitory control are not separate modules of ability that affect one another, but rather, indices of increasing maturity in one ability, the ability to “self
regulate” (Kopp, 1982). As such, the developmental primacy of subcognitive processes relating to emotion may have a direct effect on the automatization and organization of behavior which is then related to higher-order thinking and appraisals (Blair, 2002).

This additive-developmental model can be applied to our findings of relations between inhibitory control and theory of mind one year later. Recall that behavioral control and executive function were both related to theory of mind, but executive function was the strongest predictor of theory of mind after controlling for other types of inhibitory control. Although the inhibitory demands associated with flexibility in organizing behaviors to meet situational demands may have been important to children’s ability to interpret false beliefs, the cognitive inhibition associated with executive function (as measured in the present study) is most directly relevant to this ability. In other words, the same strategies that are needed for children to inhibit prepotent mental information may be those that are important for explaining and interpreting others’ false beliefs. This direct relation between executive function and theory of mind contributes to our understanding of how inhibitory control abilities may have an additive effect over the course of development. It appears that emotion regulation facilitates behavioral control which thereby predicts executive function, and children apply this highest-order self-regulatory ability to their interpretation of social situations involving conflict.

Although we have speculated as to the direction of causality between inhibitory control measures and between inhibitory control and theory of mind, confirmatory evidence of this direction cannot be determined from our investigation. Longitudinal
work that assesses the earliest forms of emotion regulation, executive function, and behavioral control, and measures of these processes at multiple time points, may allow the field to better understand how these processes influence one another across development.

Limitations and Future Research Directions

The present study offers an important replication and extension of work that examines the relations among various types of inhibitory control and theory of mind. However, there were a number of limitations to this investigation that offer a direction for future research on this topic. First, the study’s sample size was relatively small, and may not have allowed for the true relation between variables to be seen as small effects may not have been detected. This issue is particularly important because moderate relations were expected among many of the study variables. Thus, future work should assess relations among these measures of inhibitory control in a larger sample of children.

Also, because of the large number of variables derived from the measures, it was necessary to considerably reduce the data. Although our method of data reduction was guided by previous theoretical and empirical work concerning these measures, some important information about children’s abilities may have been lost as a result of this reduction.

Given the overarching goal of the study to examine relations among different domains of inhibitory control development, a greater number of measures of emotional, behavioral, and cognitive inhibitory control would have considerably improved our ability to gain a reliable index of children’s abilities within each domain and to describe
the pattern of relations between domains. This issue may have been particularly relevant to our description of relations between emotional control and other domains of control. Our assessment of emotion regulation relied entirely on one observational measure and two parent reports of this ability. Given the finding that the variance due to method types dominated some of the observed relations between measures, it would have been desirable to incorporate a greater number of emotion regulation task measures to compare children’s observed control over emotional expressions to observed measures of behavioral and cognitive control.

Finally, as mentioned previously, the relations assessed in the present study were purely correlational, and causal conclusions cannot be drawn from this work. This limitation points to an important direction for future work. Given the findings of the present study, and those of previous researchers, that inhibitory control processes show an interesting pattern of relations to one another and to children’s theory of mind, the next line of work should attempt to trace the developmental course of these processes to explain how they may influence one another over the course of early development. To do so, future research should attempt to capture the earliest indicators of inhibitory control. For example by measuring the emergence of emotion regulation strategies early infancy (e.g., attentional control and other self-soothing strategies) and the emergence of early goal-directed “executive” behavior (e.g., performance on the A not B task across the first year), researchers may be able to better understand how these abilities become related over the course of development, the direction of influence between these abilities, and which processes are considered to be the most primary antecedents of other abilities.
Despite these limitations, this study offers new information about important developmental processes in early childhood and points to a direction for future research.


APPENDICES

Appendix A

Coding of Children’s Facial Expressions during the Disappointment Task

The purpose of this coding scheme is to identify the degree to which children display positive, neutral, or negative facial expressions during the Disappointment Task. This coding system is based on Cole’s (1986) procedures and definitions of facial action units in Ekman and Friesen’s (1978) *Facial Action Coding Systems* (FACS).

Using continuous coding, the following five codes will be used to describe each child’s facial expressions during the EXPERIMENTER PRESENT (30 sec) and EXPERIMENTER ABSENT (60 sec) situations of the disappointment task. Coders will view the task without sound. Coders will record the onset and offset of each of the 5 facial expressions to allow for measurement of duration: high positive, low/medium positive, neutral, low/medium negative, high negative. If the child’s face is unobservable, the facial expression will be coded as missing.

Positive facial expressions include lip corner pull and cheek raise (i.e., smiles). Extreme expressions, or combinations of at least two of these expressions will be considered a higher intensity. Neutral expressions are coded when the child’s expression is considered to be neither positive nor negative. Negative expressions include lip corner depress, chin raise, lip tighten, lip press, lip biting, nose wrinkle, upper lip raise, and inner brow raise. Extreme expressions or combinations of at least two of these expressions will indicate the higher intensity.
Appendix B

Theory of Mind: False Belief Location Vignette

*Video recorded vignette:*

Bradley and Molly are good friends. They are eating some of their favorite cookies.

**Molly:** These are my favorite cookies. They are so yummy!

They eat the cookies for a few minutes, and then Molly’s mother pokes her head in.

**Mother:** Kids, finish up with those cookies.

Bradley and Molly gather up the cookies and put them into a shoebox.

**Bradley:** Let’s put the cookies in here

**Molly:** Ok, they’ll be safe in there

Molly walks out of the room.

**Molly** (as she walks out): I want to get my doll from the other room. I’ll be right back, Bradley

**Bradley:** Ok.

When Molly leaves the room, Bradley removes the cookies from the shoebox and places them into the cabinet. Molly reenters the room.

**Molly:** I want another cookie!

*Questions asked of children:*

Where do you think Molly will look for the cookie? (If no response, ask: In the box or in the cabinet?) [*False-belief question*]

Why will she look there? [*Justification question*]

Where are the cookies really? [*Reality control question*]

Where were the cookies put first of all? [*Reality control question*]
Appendix C

Theory of Mind: False Belief Content Vignette

*Video recorded vignette:*

Bradley and Molly are playing and eating snacks.

**Mom:** Kids, what would you like to drink?

**Bradley:** I’d like to have Coke. That’s my favorite drink

**Molly:** I’ll have some milk, please.

**Bradley:** Do you really like Milk, Molly?

**Molly:** Yup

**Bradley:** Yuck, yuck, I really don’t like Milk at all!!

Mom brings the kids their drinks.

*Questions asked of Children:*

How does Bradley feel when he gets a can of Coke? [*Emotion question]*

Why does he feel that way? [*Emotion reality control question]*

How would Bradley feel if he got some Milk? [*Emotion question]*

Why would he feel that way? [*Emotion reality control question]*

*Video recorded vignette:*

**Bradley:** I have to go to the bathroom!

Bradley leaves the room.

Molly is going to play a little trick on Bradley. She pours out the coke from the can, and instead she pours some milk into the can.

Bradley returns and he is really thirsty. He can see the coke on the table, but he can’t see what’s inside the can.
Questions asked of children:

When Bradley first comes back, how does he feel? Happy or not happy?  
[Emotion-contingent-on-false-belief question]

Why is he happy (or not happy)? [Justification question]

What does Bradley think is in the can? [Contents false-belief question]

What is in the can really? [Contents reality control question]

How will Bradley feel after he has a drink from the can? [Emotion question]

Why will he feel that way? [Emotion reality control question]
Appendix D

Theory of Mind: Second Order False Belief Vignette

Story is acted out by the experimenter using Lego toy pieces for characters on a rug depicting the neighborhood.

Experimenter: “This is a story about John and Mary who live in this neighborhood. John and Mary are playing together in the park. In the park, there is also an ice-cream man in his truck.

[Episode 1:] Mary would like to buy an ice cream, but she has left her money at home. So she is very sad. ‘Don’t be sad’, says the ice-cream man, ‘you can go get your money and buy some ice-cream later. I’ll be here in the park all afternoon.’ ‘Oh good’, says Mary, ‘I’ll be back in the afternoon to buy some ice cream. I’ll make sure I won’t forget my money then.

[Episode 2:] So Mary goes home…She lives in this house. She goes inside the house. Now John is on his own in the park. To his surprise, he sees the ice-cream man leaving the park in his van. ‘Where are you going?’ asks John. The ice-cream man says, ‘I’m going to drive my van to the library. There is no one in the park to buy ice cream, so perhaps I can sell some outside the library.’

[Episode 3:] The ice-cream man drives over to the library. On his way he passes Mary’s house. Mary is looking out of the window and spots the van. ‘Where are you going?’ she asks. ‘I’m going to the library. I’ll be able to sell more ice cream
there’ answers the man. ‘It’s a good think I saw you’ says Mary. Now John doesn’t know that Mary talked to the ice-cream man. He doesn’t know that!

[Episode 4:] Now John has to go home. After lunch he is doing his homework. He can’t do one of the questions. So, he goes over to Mary’s house to ask for help. Mary’s mother answers the door. ‘Is Mary in?’ asks John. ‘Oh,’ says Mary’s mother. ‘She just left. She said she was going to get an ice cream.’ Remember, John doesn’t know that Mary had talked to the ice-cream man. He doesn’t know that! So John runs to look for Mary”.

Questions asked of children:

Where does he think she as gone? [False belief question]

Why does he think she has gone there? [Justification question]

Does Mary know that the ice-cream truck is at the library? [Reality control question]

Does John know that the ice-cream man has talked to Mary? [Reality control question]

Where did Mary go for her ice-cream? [Reality control question]
Appendix E

Theory of Mind: Knowledge of Others’ Feelings

Picture Interpretation 1

*In testing, pictures are 8 ½ x 11 inches

Questions asked of children:

Now I’m going to show you some pictures and ask you questions about them. Take a look at this picture. What has happened? Can you tell something about it?

Who in this picture is afraid? Why is that person afraid?

Who in this picture is happy? Why is that person happy?

Who in this picture is sad? Why is that person sad?

Who in this picture is angry? Why is that person angry?
Questions asked of children:

Take a look at this picture.

What do you think is happening in this picture?

These two boys are saying mean things about the other boy. Suddenly, that boy comes up to them and hears what they are saying. The two boys are surprised.

How does this boy feel? (Point to third boy in the background). Why?

How does this boy feel? (Point to one of the boys in foreground). Why?
Questions asked of children:

Take a look at this picture.

What has happened in this picture?

This girl has fallen and hurt herself.

How do you feel when you hurt yourself?

Can you see from the girl’s face how she really feels?

Is it possible to look happy when you hurt yourself?

This girl has fallen down and hurt herself, but she is smiling. Why do you think that is?
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Publications


Awards