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It has been established that children's executive functioning (EF) skills play an important role in psychopathology (e.g., AD/HD) as well as social and academic competence. However, other than the examination of genetic factors, there remains a limited number of studies examining extrinsic (e.g., parenting) and temperamental factors that contribute to individual differences in the development of EF. The current study examined the role of maternal behavior and emotion regulation in the development of children's "hot" EF of attentional control, which consists of sustained attention and inhibitory control. Hierarchical linear modeling analyses indicated significant growth in both sustained attention and inhibitory control across the toddlerhood to early childhood period. Maternal overcontrol or intrusiveness at age 2 was found to negatively predict initial levels of children's sustained attention as well as children's inhibitory control at age 5. Maternal warmth/responsiveness was also a significant positive predictor of children's inhibitory control at age 5. Emotion regulation at age 2 was found to positively predict initial levels of children's sustained attention and negatively predict children's impulsivity at age 5. These findings are discussed in terms of how maternal and temperamental factors may facilitate the development of attentional control.

DEVELOPMENTAL TRAJECTORIES OF "HOT" EXECUTIVE FUNCTIONS

ACROSS EARLY CHILDHOOD: CONTRIBUTIONS OF

MATERNAL BEHAVIOR AND TEMPERAMENT

By

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To my wonderful, loving, and supportive wife, Marianna, my parents, Thereza and Renato, and my brother, Arthur.

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

Recent research on children's cognitive development has focused on how brain maturation developments (e.g., neuronal mylenation) maps onto behavioral changes in various cognitive skills (Gibson, 1991; Pennington & Ozonoff, 1996). Although higher order cognitive skills—referred to as executive functioning (EF)—vary in definition, there is consensus on their importance for children's adaptive functioning. Deficits in various executive functions have been investigated as they relate to child psychopathology, as well as social and academic competence (Barkley, 1997; Blair, 2003; Gathercole & Pickering, 2000; Pennington & Ozonoff, 1996). More recent research has investigated the association between early deficits in basic "hot" executive functions (i.e., sustained attention and inhibitory control) and the acquisition of later more advanced "cool" executive functions (i.e., working memory and planning abilities). Barkley's (1997) theory on AD/HD, for example, posits that early deficits in inhibitory processes form the basis for later EF deficits such as working memory. Given the importance of early "hot" executive functions as well as their rapid development in early childhood (Carlson, Moses, & Claxton, 2004; Lang & Perner, 2002), it is important to understand which factors contribute to individual differences in their development.

Executive functioning (EF) as a construct

The construct of executive functioning (EF) has been beset by a lack of definitional clarity. Although researchers generally agree that EF involves control and coordination of higher order cognitive operations, which cognitive operations should be included and the measurement of these operations remains a source of controversy (Denckla, 1996; Salthouse, 2005). To illustrate, the following have been included as part of EF: verbal fluency, inhibition, working memory, problem solving, organization, planning, goal selection, goal initiation, goal setting, speed of processing, decision-making, judgment, strategic thinking, fluid intelligence, and executive attention (Baddeley, 1996**;** Barnes, Yaffe, Satariano, & Tager, 2003; Bastin & van der Linden, 2003; Denckla, 1996; Salthouse, 2005; Zelazo & Muller, 2003; Zook, Davalos, DeLosh, & Davis, 2004). Anderson (2002) and Alexander and Stuss (2000) have identified, on the basis of factor analytic studies, four main factors involved in executive functioning (Kelly, 2000; Levin et al., 1991; Welsh, Pennington, & Groisser, 1991). The first factor is the *cognitive flexibility factor*, which involves working memory processes and the ability to shift between response sets and process multiple sources of information. The second factor is the *attentional control factor*, which involves the capacity to sustain attention and selectively attend to specific stimuli while inhibiting prepotent responses. The third factor is the *goal setting factor,* which involves planning abilities and the ability to develop new initiatives and concepts for a future task. The final factor, *information processing factor*, refers to fluency and speed of processing.

These four factors capture the essence of how higher order cognitive operations are controlled and have been among the most cited components of EF (Anderson, 2002; Baddeley, 1996**;** Denckla, 1996; Pennington, Benneto, McAleer, & Roberts, 1996; Welsh, Pennington, & Grossier, 1991; Zelazo & Muller, 2003). It is important to acknowledge that executive functions are related to overall cognitive functioning. Specifically, the influence of general fluid intelligence (which is more closely related to the *information processing factor*) on executive functioning development has been examined in the general population (Zook et al. 2004), in children with AD/HD (MTA Cooperative Group, 1999; Schuck & Crinella, 2005), and in patients with prefrontal cortex lesions (Bechara, Damasio, & Damasio, 2000; Bechara, Tranel, & Damasio, 2002). Together, these studies demonstrate that although fluid intelligence is related to EF, there are still individual differences in EF after accounting for fluid intelligence.

Development of EF

From the neurological perspective, the general development of EF is thought to be a result of the maturation of the prefrontal cortex and its related cortices such as the orbitofrontal cortex (Eslinger, 1996; Zelazo & Muller, 2003). This maturation process can be indexed by the increasing myelination of neuronal axons that allow for the formation of different neuronal pathways within different regions of the brain. The formation of these pathways allows for communication within brain regions through neuronal inhibition or activation of different pathways. This maturation process, however, does not occur on a systematic schedule but is instead characterized by increases in peak activity in specific brain regions during specific time periods. These time periods also coincide with behavioral observations of cognitive performance improvements (Thatcher, 1991).

Based on EEG data, three childhood periods of rapid myelination in the frontal lobes have been identified (Hudspeth & Pribram, 1990). The first spurt occurs between birth and two years of age. During this time period, and more specifically towards the end of the first year of life, myelination in the sensorimotor tracts is nearly comparable to adult levels (Yakovlev & Lecours, 1967). The myelination in the primary motor and sensory areas of the brain during this period is consistent with the emergence of attentional control, including the beginning of the ability to inhibit behaviors, use attentional tracking, and sustain attention (Diamond & Doar, 1989; Espy, 1997; Posner, 2004; Ruff & Capozzoli, 2003). The early development of attentional and inhibitory abilities is consistent with the theoretical and evolutionary concept of “hot” executive functioning. The “hot” aspect of executive functioning refers to the ability to respond quickly to emotional and conditioned stimuli. The “hot” EF’s ability to respond quickly to triggering stimuli is evolutionarily adaptive (e.g., faster ability to activate the fight or flight response to escape danger) and thus, not surprisingly, emerges early in development (Metcalfe & Mischel, 1999; Zelazo & Muller, 2003). The executive function of attentional control, which includes sustained attention and inhibitory control, is inherently part of the “hot” executive system because it is used as an early means to regulate emotional stimuli.

The second brain maturation spurt occurs between the ages of seven and nine and corresponds to the myelination of the upper layers of the cortices. This second spurt is correlated with further maturation of cognitive flexibility, including working memory, and goal setting (i.e., planning) (Anderson et al., 2000; Diamond & Taylor, 1996). This developmental period is associated with the development of the "cool" aspect of EF as it refers to a child's improved ability to form complex representations of thought that can be maintained (i.e., working memory) and used to guide decision making and planning.

The final rapid growth maturation period occurs between the ages of 11 and 13. By the end of this time period children's performance on many executive function tasks are comparable to adults. After this third stage, growth in brain maturation slows but does not cease until early adulthood (Hudspeth & Pribram, 1990).

Although there are different sensitive periods of rapid brain maturation growth, most of them occur prior to adolescence, highlighting the importance of examining early childhood factors that may impact EF development. Given the current study's focus on the development of the early "hot" executive function of attentional control, it is important to highlight the current theoretical model of the development of attentional control.

Development of attentional control

Research on the development of attentional abilities differentiates between three attentional systems (Posner & Petersen, 1990; Rueda, Posner, & Rothbart, 2005; Ruff & Rothbart, 1996). The first system emerges at birth and involves the most basic aspect of attention: alerting, or the state of wakefulness and arousal of the organism. Almost immediately after birth the second system emerges as infants gain the ability to orient. The ability to orient matures rapidly within the first six months indicating an ability to select information from sensory input (Posner, 2004). This ability to select information from sensory input allows infants to not only orient to their environment (including people and objects) but also to track such stimuli. The ability to orient is typically measured in infancy through a habituation paradigm in which an infant's orienting response lessens overtime while the environmental object is unchanged and increases when a novel object is presented (Bornstein, 1990; Colombo, 2004; Posner, 2004).

The third attentional system, which is the focus of the current study, develops towards the end of the second year and is referred to as the executive control of attention (i.e., attentional control). It is referred to as the executive control or attentional control because the organism is now taking voluntary control of their attention to resolve conflicts among thoughts, feelings, or behaviors (Rueda, Posner, & Rothbart, 2005; Ruff & Rothbart, 1996). Two crucial components involved in attentional control are sustained attention and inhibitory control. Sustained attention refers to the toddler's ability to maintain his or her focus on a specific stimulus whereas inhibitory control refers to the ability to withhold prepotent responses that may be inappropriate (Bornstein & Sigman, 1986; Fuentes, 2004; Richards, 2004; Ruff & Rothbart, 1996). Together, sustained attention and inhibitory control facilitate an organism's ability to control his or her attention for the purpose of resolving potential conflicts (Fuentes, 2004, Rueda, Posner, & Rothbart, 2005). Development of this third attentional system (i.e., attentional control) is thought to be a result of not only brain maturation, specifically the anterior cingulate cortex (Luria, 1961; Rothbart, Posner, & Boylan, 1990; Posner, 2004; Posner & Rothbart, 2000), but also an increase in social interactions with the caretaker and the emergence of language (Rothbart, Posner, & Boylan, 1990; Vygotsky, 1962).

Interactions with the caretaker are theorized to facilitate the development of attentional control via joint attention behaviors as well as via emotion regulation assistance (Derryberry & Reed, 2002). Joint attention skills refers to the toddler's ability to follow the caretaker's behaviors by directing his or her gaze, head turning, and using gestures or pointing (Vaughan et al., 2003). Individual differences in such skills have been found to be related to important developmental outcomes such as enhanced language skills and better social abilities (Carpenter, Nagell, & Tomasello, 1998; Mundy & Gomez, 1998). Improvements in attentional control during the second year of life are also a function of infants starting to recognize the caretaker as a viable resource for assisting in emotion regulation strategies (Calkins, 1994; Fox & Calkins, 2003; Kopp, 1989; Rothbart et al., 1992). Through these social interactions, toddlers learn how to use distraction techniques by selectively shifting their attention away from the distressing object or situation.

Motor development also facilitates attentional control as motor movements allow the infant to learn how to use attention as a means of controlling emotional experiences (Kopp, 2002; Rothbart, 1989). For example, maturation of motor skills (i.e., reaching, grasping, and locomotor ability) allows the infant to use self-soothing techniques such as stroking and rubbing their arms and hair as well as moving around (Kopp, 1989). Further development of inhibitory motor control allows the use of more advanced self-comforting strategies such as thumb-sucking (Fox & Calkins, 2003).

As children enter toddlerhood, rapid advances in inhibitory control abilities are seen, especially from 2 to 4 years of age (Espy, 1997; Jones, Rothbart, & Posner, 2003; Kochanska, Murray, & Harlan, 2000; Rothbart & Bates, 2006; Rothbart, Ellis, Rueda, & Posner, 2003). The integration of better inhibitory skills with sustained attentional skills allows children to become more adept at using attentional control. Better attentional control allows children to cope with environmental demands—such as complying with a request made by an adult or delaying gratification and impulsivity (Fox & Calkins, 2003; Kopp, 1982; Ruff & Rothbart, 1996). Children continue to improve their attentional control as they enter school with improvements seen until age 6 (Diamond & Taylor, 1996; Espy, Kaufmann, McDiarmid, & Glisky, 1999) and a stabilization thereafter (Anderson, 2002; Zhou, Hofer, Eisenberg, Reiser, Spinrad, & Fabes, 2007).

Towards an integrated model of attentional control

Although the literature has readily reported on the progression of "hot" EF development and its neural correlates, less theoretical work has been conducted to explain individual differences in such development (Blair, 2002; Colombo, 2004; Fox & Calkins, 2003). A large portion of the variability in children's "hot" EF development has been attributed to genetics as reported in the AD/HD literature (Barkley, 2003; Groot, Sonneville, Stins, & Boomsma, 2004; Polderman et al., 2007) as well as in the genetic disorders (e.g., Fragile X, PKU) literature (Antshel, Epstein, & Waisbren, 2004; Channon, Mockler, & Lee, 2005; Loesch et al., 2003; Mattson, Calargo, & Lang, 2006). However, despite the strong genetic link, there remains a host of other factors (as seen in Figure 1) that have been shown to be related to "hot" EF ranging from child factors (e.g., gender, language, temperament), parenting factors (e.g., maternal psychopathology, maternal speech, attachment, maternal behaviors) to socioeconomic factors (e.g., poverty, neighborhood). By critically analyzing these empirical studies as a whole, the number of important factors for attentional control development greatly decreases. As demonstrated in the next section, the current study identified two crucial factors—maternal behavior and temperament—that can theoretically explain individual differences, above the effects of genetics, in the development of children's "hot" EF of attentional control.

Maternal behavior

Maternal behavior, specifically scaffolding, is perhaps the most widely studied factor thought to facilitate children's cognitive development (Vygotsky, 1978; Wood & Middleton, 1975). There are two main mechanisms by which maternal behaviors are thought to influence children's cognitive development. The first mechanism centers on the concepts of autonomy and motivation. Thus, the caretaker's main role is to provide support and facilitate the acquisition of new skills such as attention, memory, and language abilities. Maternal behaviors that are thought to facilitate learning include the use of appropriate language, responsiveness, sensitivity, and use of control, taking the child's developmental level into consideration (Landry, Miller-Loncar, Smith, & Swank, 2002). On the other hand, maternal overcontrol reflects excessive regulation of children's activities. This type of behavior is also characterized by intrusiveness and use of excessive demands (Gilliom & Shaw, 2004; Moore & Calkins, 2004). Both types of maternal behaviors have an effect on the child's autonomy with one (maternal warmth/responsiveness) reinforcing and motivating it while the other (maternal overcontrol/intrusiveness) is restricting it.

Through these social interactions children eventually learn how to internalize these skills and begin to solve problems independently (Landry, Miller-Loncar, Smith, & Swank, 2002). From this theoretical perspective, an intrusive mother who is frequently interrupting a child's behavior will delay the development of that child's skill by infringing on their autonomy. More specifically tied to the current study's interest in attentional control, an intrusive mother may distract a child's from focusing on his or her task, which would in a sense take away that child's ability to independently practice his or her sustained attention. From this perspective a lack of maternal warmth and responsiveness may also weaken the child's motivation to engage in such task on his or her own as the social reinforcement (i.e., the mother's praise) is not as frequent.

While the first mechanism explains the relation between maternal behaviors and cognitive development as a result of increased autonomy and motivation, more recent work suggests an even stronger biological explanation. Human and animal studies conducted by Hofer and colleagues (1989; 1993; 1994) have documented that the caretaker's behavior not only has a behavioral effect on the offspring but in fact can also influence his or her biological functioning (see Winburg, 2005 for a review). For example, high levels of maternal licking/grooming and arched backed nursing in rats have been shown to affect the neurological systems (i.e., hypothalamic-pituitary-adrenal axis) associated with the stress response (Caldji et al., 1998; Champagne & Meaney, 2001). Lovic and Fleming (2004) also suggested that maternal behaviors may have an influence on the development of the dopamine system, a system closely related to the process of attention (Madras, Miller, & Fischman, 2005). Using this physiological framework for the current study, mothers who have a warm and responsive interaction style may facilitate children's attentional control development via a reduction in their stress levels. On the other hand, maternal behavior that is intrusive and hostile may elevate children's stress levels through the HPA axis which in turn may delay their attentional control development. At the same time, positive and rewarding mother-child interactions may also activate dopamine pathways that are important for the development of attentional control.

Both mechanisms discussed above indicate the importance of examining the role of maternal behaviors in the development of children's attentional control. Focusing on maternal behavior also explains the findings linking maternal education with EF (Bornstein, Hahn, Suwalsky, & Haynes, 2003). For example, less educated mothers are more likely to use ineffective scaffolding techniques— such as interacting with their children in an over controlling and in a less sensitive and responsive manner (Martini, Root, & Jenkins, 2004; Raviv, Kessenich, & Morrison, 2004; Sullivan & McGrath, 1999). Thus, it becomes clear that it is a mother's interaction style with the child that is ultimately important for that child's cognitive and executive function development, not merely maternal education. Maternal behavior also explains why maternal psychopathology and maternal intelligence/speech have been found to be related to EF. For example, a depressed mother is less likely to play with his or her child in an enthusiastic and warm manner and may lack the energy to provide appropriate responses to her child's behaviors. In turn, these less effective maternal behaviors will likely influence her child's EF development (Field, 1995; Meadows, 1996).

General maternal behaviors, outside of those in teaching situations requiring scaffolding techniques, have also shown to be important. For example, global measures of maternal sensitivity have been found to be related to higher levels of joint attention (Raver & Leadbeater, 1995) as well as sustained attention (NICHD, 2005). Maternal styles based on introducing and maintaining strategies also seem to capture infant's attention more efficiently (Findji, 1998). Whereas these positive maternal behaviors have been associated with higher attentional functioning, negative maternal behaviors are also related to deficits in executive attention. For example, children with "hot" executive function deficits (i.e., AD/HD) are more likely to have parents that display negative parental behavior such as negative control strategies as well as not withdrawing control during collaboration tasks (Winsler, 1998). Similarly, high levels of maternal redirecting have also been found to predict poorer infant focused attention (Bono & Stifter, 2003). Maternal intrusiveness has also been found to predict later attention deficits such as distractibility (Jacobvitz & Sroufe, 1987). In terms of the executive function of inhibition, responsive and cognitively stimulating parent-toddler interactions have been found to predict later measures of inhibitory control as measured by the ability to delay gratification as well as lower impulsivity scores (NICHD, 2005, Olson, Bates, & Bayles, 1990).

Temperament

Although theorists differ in the proposed numbers of temperament dimensions and their emphasis (i.e., behavior vs. emotion), they do agree that temperamental differences reflect biological or physiological differences (Calkins, 1994; Fox, 1989; Goldsmith et al., 2000; Kagan, Reznick, & Snidman, 1987; Rothbart & Derryberry, 1981). The two most widely studied temperament dimensions include emotional reactivity and regulation (Rothbart & Bates, 1998). Emotional reactivity is characterized by the infant's latency to respond and threshold of responsiveness and can be measured behaviorally and biologically via cortisol, heart rate, vagal tone, and EEG (Calkins, 1997; Fox et al., 2001; Gunnar, Tout, de Haan, Pierce, & Stansbury, 1996; van Bakel & Riksen-Walraven, 2004). The dimension of emotion regulation refers to an individual's ability to modulate emotional arousal in a way that facilitates adaptive functioning (Calkins, 1994; Eisenberg et al., 1996; Keenan & Shaw, 2003).

Emotion regulation strategies develop from innate responses in infancy to more complex behaviors in childhood. In early infancy (0-3 months), emotion regulation strategies center on innate, reflex patterns of behavior such as sucking, and head-turning, as well as the expression of distress through crying (Kopp, 1989). As mentioned earlier in the EF development section, further motor and visual abilities develop around six months, which allow infants to use more advanced emotion regulation strategies such as self-soothing techniques (i.e., thumb-sucking), turning away and self-distraction (Fox & Calkins, 2003; Kopp, 1989; Rothbart et al., 1992). In the second year of life infants begin to recognize their caregiver as a source to assist their emotion regulation efforts

(Calkins, 1994; Fox & Calkins, 2003; Kopp, 1989; Rothbart et al., 1992). As children enter toddlerhood, they become more adept at integrating attentional control to cope with emotional situations (Fox & Calkins, 2003; Kopp, 1982; Ruff & Rothbart, 1996). Although the importance of the EF of attentional control for emotion regulation has been established, it remains to be tested whether children who have better emotion regulation skills generalize the use of such attentional control to non-emotional settings that have a higher cognitive load.

The main mechanism by which emotion regulation is theoretically thought to be related to EF is via a shared neuronal circuitry. Although it is beyond the scope of the current study to provide detailed physiological analyses of such overlap, it appears that the most evident physiological similarity between the neural circuitry of emotion regulation and "hot" executive functions involves the anterior cingulated cortex (ACC) and the orbitofrontal cortex. The ACC is a medial limbic structure that is involved in both cognitive and emotional processing, although through separate subdivisions (see Beauregard, Levesque, & Paquette, 2004; Bush et al., 2002; Posner & Rothbart, 2000). For successful emotion regulation in children, the rostral region of the ACC is activated in conjunction with activation in the orbitofrontal cortex and dorsolateral prefrontal cortex and along with an inhibitory effect on the amygdala (the region that first detects the arousal or emotion). Thus, a child with good emotion regulation skills who has a history of using such physiological system efficiently during arousing situations should theoretically have an even easier time recruiting the orbitofrontal cortex to use his or her attentional control during non-emotional situations.

Not only is there a strong theoretical basis for examining temperament as a predictor of “hot” executive functioning development, but it may also explain why girls are less likely to have EF deficits (Maitland, Intrieri, Schaie, & Willis, 2000) as they tend to exhibit less intense reactivity and better emotion regulation skills earlier in development compared to boys (see Weinberg et al. 1999 for a review). Once again, this earlier development has been hypothesized to be a result of earlier brain maturation as well as socialization practices that encourage girls to inhibit their anger, which may facilitate learning emotion regulation skills (Andersson, Sonnander, & Sommerfelt, 1998; Underwood, Coie, & Herbsman, 1992). Given the attentional and inhibitory components of emotion regulation, it is not surprising that children with better emotion regulation skills are also less likely to have “hot” EF deficits (Berlin, Bohlin, Nyberg, & Janols, 2004; Walcott & Landau, 2004). Furthermore, emotion regulation skills are intrinsically related to maternal behavior. For example, toddlers who display appropriate emotion regulation, both behaviorally as well as physiologically, are more likely to have mothers who displayed positive guidance characterized by praise and affection (Calkins, Smith, Gill, & Johnson, 1999). Greater maternal sensitivity along with moderate intrusiveness has also been associated with infants with greater emotion regulation levels (Little & Carter, 2005). Thus, the above stated empirical and theoretical evidence clearly indicates that the process of emotion regulation should be considered when examining the normative development of the “hot” EF of attentional control. Given the close reciprocal relation between reactivity and emotion regulation (Calkins, Gill, Johnson, & Smith, 1999; Zimmermann & Stansbury, 2003), it is also important to examine how emotional reactivity may affect attentional control development.

There have been mixed findings in the literature concerning emotion reactivity and executive functioning development. Some studies have found that high behavioral reactivity is associated with deficits in "hot" EF (Calkins et al., 2002; Goldsmith, Lemery, Aksan, & Buss, 2000; Jensen & Rosen, 2004; Wolfe & Bell, 2003), although other studies have found that high behavioral reactivity is positively associated with general cognitive functioning (Belsky, Friedman, & Hsieh, 2001; Maziade, Cote, Boutin, Bernier, & Thivierge, 1987). It has been suggested that a highly reactive child may actually activate environmental resources (e.g., parental behavior) and indirectly promote EF gains (Maziade et al., 1987). However, before coming to such a conclusion, it is important to consider the situations that elicit the child's emotional reactivity.

High emotional reactivity to novel situations has been consistently associated with higher overall cognitive functioning as measured by IQ, language skills, (Bornstein & Sigman, 1986; Fagan, 1984; Thompson, Fagan, & Fulker, 1991) as well as specific executive functions such as memory (Thompson, Fagan, & Fulker, 1991) and attention (Hustedt & Raver, 2002). On the other hand, high emotional reactivity to frustrating or distressing situations is negatively associated with the "hot" of attentional control (Calkins et al., 2002; Goldsmith, Lemery, Aksan, & Buss, 2000; Wolfe & Bell, 2003). Thus, by considering the situation of the reactivity, we can establish that high emotional reactivity to distressing or frustrating situations should be negatively related to a child's attentional control development. It is important to note that some studies find a high reciprocal association between emotional reactivity and emotion regulation (Calkins & Johnson, 1998; Cole, Martin, & Dennis, 2004; Stifter & Braugart, 1995) suggesting that a low level of emotional reactivity or distress is evidence of good emotion regulation skills. When such high associations arise, researchers have combined these constructs into an emotion regulation factor (Hill, Degnan, Calkins, & Keane, 2007).

Emotion regulation and reactivity may also explain the findings between another individual factor, social competence, and EF. Children who are socially competent and do not engage in aggression consistently obtain higher scores in "hot" and "cool" EF (see Riggs, Jahromi, Razza, Dillworth-Bart, & Mueller, 2006 for a review). Additionally, a consistent finding in the field of aggression and social competence is the crucial role of emotion regulation and reactivity. Children that are socially competent as reported by teachers, mothers, and peers have consistently been found to exhibit better emotion regulation skills and are less reactive or labile (Eisenberg et al., 1993; Graziano, Keane, & Calkins, 2007). This is more evidence for the importance of examining both emotion regulation and emotion reactivity in children's EF development as they likely represent a more proximal mechanism, compared to other child factors such as gender and social competence.

Goals & hypotheses of present study

The first goal of the present study is to examine the development of children's attentional control, consisting of sustained attention and inhibitory control, from the toddlerhood to early childhood period. Although recent cross-sectional studies (Betts et al., 2006; Gomez-Perez & Ostrosky-Solis, 2006) have suggested growth in attentional control during this developmental period, no longitudinal studies have been conducted across this developmental period as the few longitudinal studies examining attentional control have focused on either the infancy period or the early school period (Espy et al., 1999; Jones et al., 2003; Rothbart & Bates, 2006; Vaughan et al., 2003). Given that other executive functions such as memory and cognitive flexibility show increases from age 3 to 5 (Stahl & Pry, 2005; Zelazo & Jacques, 1996; Zelazo et al., 2003), it is important to determine whether attentional control demonstrates similar growth across this period. It is expected that children's sustained attention and inhibitory control abilities will increase from 2 to 5.5-years of age.

The second goal of the present study is to examine the role of maternal behavior and temperament in the development of children's "hot" EF of attentional control. A major limitation in the research on the role of maternal behavior in children's cognitive development is that most studies have focused on general measures of cognitive function such as IQ without specifically examining the "hot" EF of attentional control. For example, several studies have found that maternal scaffolding and a generally positive and nurturing mother-infant interaction predicts higher IQ scores (Andersson, Sommerfelt, Sonnander, & Ahlsten, 1996; Fagot & Gauvain, 1997; Morelock, Brown, & Morrissey, 2003; Stams, Juffer, & Van Ijzendoorn, 2002). Additionally, no longitudinal study to date has examined the role of maternal behavior in the development of "hot" EF during the toddlerhood to early childhood period. The current study will extend such research by examining the effects of positive maternal behavior (warmth and responsiveness) and negative maternal behavior (over-control, hostility) on the trajectories of children's sustained attention and inhibitory control from toddlerhood through the early childhood period. It is expected that early positive maternal behavior characterized by warmth and responsiveness (2yrs) will be positively related to the developmental trajectory of early "hot" EF (i.e., sustained attention and inhibitory control) from 2 to 5.5-years of age while early negative maternal behavior (2yrs) characterized by overcontrol or intrusiveness and/or hostility will be negatively related to the developmental trajectory of early "hot" EF.

In terms of temperament, developmental research that has examined the link between emotion regulation/reactivity and attentional control has mainly concentrated on how early attentional abilities facilitate the development of emotion regulation strategies such as distraction or buffer the effects of high reactivity (Belsky, Friedman, &Hsieh, 2001; Kopp, 2002; Rothbart, 1989; Rueda, Posner, & Rothbart, 2005). Despite the fact that emotion regulation skills and attentional abilities co-develop (Kopp, 2002), no study to date has examined whether individual differences in early emotion regulation skills and reactivity can affect the development of attentional control in a non-emotional setting. Finally, similarly to the maternal behavior literature, the role of temperament in "hot" EF development during the toddlerhood to early childhood period remains unexplored. The importance of examining this developmental period has been noted by Berwid and colleagues (2005), especially given that the peak onset of AD/HD occurs during this developmental period. The current study will address these shortcomings by examining whether lower emotional reactivity and better emotion regulation skills in toddlerhood facilitates the development of attentional control across early childhood. It is expected that children's early emotional reactivity at 2 yrs of age will be negatively related to the developmental trajectory of "hot" EF from 2 to 5.5-yrs of age whereas emotion regulation skills will be positively related to the developmental trajectory of "hot" EF.

The final goal of the current study is to examine any potential interactions between temperament and maternal behaviors in the prediction of children's "hot" EF development. Although a detailed discussion is outside of the scope of the current paper, there is good evidence for a bi-directional influence between temperament and maternal behaviors (see Calkins, 2007). Additionally, as early as Thomas and Chess (1977), the concept of "goodness of fit" has described the importance of examining how temperament interacts with parenting to predict various developmental outcomes. More recently outlined by Caspi and Moffit's (2006) gene-environment interactions, negative environmental factors have differential influences on children's development depending on children's genotype. Extending such gene-environment interactions to the current study, a child's temperament may be viewed as an intrinsic factor that moderates the link between an environmental factor and an outcome. Thus, children whose mothers interact in a hostile and/or overcontrolling manner and/or have low levels of warmth and responsiveness (environmental factors) will be less likely to have "hot" EF deficits if they have higher levels of emotion regulation skills (intrinsic factor).

Figure 2 illustrates the theoretical model being tested with the above hypotheses. As seen in this figure, the current study will also control for maternal self-report symptoms of AD/HD and children's IQ (estimated by maternal education in toddlerhood) to ensure that any significant findings are above and beyond the potential effects of genetics and overall intelligence that have been established in previous studies (Groot et al., 2004; MTA Cooperative Group, 1999; Polderman et al., 2007; Schuck & Crinella, 2005; Zook et al. 2004).

CHAPTER II

METHOD

Participants

Participants for this study included 435 children (225 girls) obtained from three different cohorts participating in a larger ongoing longitudinal study. Four hundred and forty seven participants were initially recruited at two years of age through child care centers, the County Health Department, and the local Women, Infants, and Children program. In order to obtain a broad, community-based sample of children with a wide range of disruptive behavior, potential participants were screened using the externalizing subscale of the Child Behavior Checklist (CBCL 2-3; Achenbach, 1992). Further details about the recruitment may be found in Smith, Calkins, Keane, Anastopoulos, and Shelton (2004) and Calkins and Dedmon (2000). The recruitment sample was diverse with sixty-seven percent of the children classified as European American, 27% were African American, 4% were biracial, and 2% were Hispanic. At age 2, the children were primarily from intact families (77%), and families were economically diverse, with Hollingshead (1975) scores ranging from 14 to 66 (M = 39.56). Of the original 447 participants, 399 participated at 4.5 years of age assessment. There were no significant differences between families who did and did not participate in terms of gender, race, 2-year SES, or 2-year externalizing T-scores. When children were 5.5 years of age, 365 families participated, including 4 who did not participate in the 4.5-year assessment.

Again, there were no significant differences between families who did and did not participate at 5.5 years in terms of gender, race, 2-year SES, and 2-year externalizing *T*-scores.

An advantage of growth curve modeling is the ability to account for missing data longitudinally with longitudinal sets that vary in terms of participants per waves (Singer & Willett, 2003). In the current study 341 children had some data (e.g., parent report and/or lab measure) at each time point; an additional 47 children had some data in two time points, while another 47 children had data on only one time point. Thus, a total of 435 children, who had at least one wave of data, were included in the analyses. This final sample of 435 children (225 girls) was racially (67% Caucasian) and economically diverse (Hollingshead scores ranging from 14 to 66 with a mean of 39.48). There were no significant differences in gender, race, or SES between children who provided 1, 2, or 3 waves of data. Additionally, there were no significant demographic differences between this study's sample and the original recruitment sample.

Procedures

The focus of this study involved several laboratory assessments at the 2-year, 4.5-year, and 5.5-year visits. When the children were 2 years of age, mothers brought their children to the laboratory and were videotaped during several tasks designed to elicit emotion regulation and mother– child interaction. The prize in a box task, where cookies or a desirable toy were placed in a clear box that the child was unable to open for 2 minutes, and a high chair task, where the child was placed in a high chair without any toys or snacks for 5 minutes was used to code observed emotion regulation and emotional reactivity (LAB-TAB, Goldsmith & Rothbart, 1993). For the prize in the box task, the mother was asked to limit her interactions with her child, however during the high chair task she was instructed to respond to her child as she deemed was necessary. A teaching task where the mother was instructed to assist the child during a challenging task, a freeplay procedure in which the mother was instructed to play with her child as she would at home, and a clean up task where the mother was to try and get the child to clean up the toys from the freeplay session were all used to code observed maternal behavior. The tasks were ended early if the child was highly distressed or cried hard for more than 30 seconds. During this same visit, children's sustained attention was coded while they watched a 5 minute segment of the videotape "Spot," a short story about a puppy that explores its neighborhood. While in the laboratory, mothers completed various questionnaires.

Follow up assessments took place when children were approximately 4.5 and 5.5 years of age. Similar to the 2 yr visit, children's sustained attention during the 4.5 and 5.5 year visits were coded while they watched a 5 minute segment of the videotape "Spot." Children's inhibitory control at age 5.5 was coded with a Stroop task. Finally, at each year visit, mothers completed various questionnaires.

Measures

Maternal Behavior. Maternal behavior during six mother-child interactions at 2 years of age were coded according to global indices of *warmth/positive affect* (displaying positive affect and warmth toward the child), s*ensitivity/responsiveness* (promptly and appropriately responding to the child's bids to her), *overcontrol/intrusiveness* (exerting influence toward completion of the child's activity using directive methods; displaying a no-nonsense attitude; constantly guiding the child and creating a structured environment), and *hostility* (emotional expressions of anger toward the child). These global codes were adapted from the Early Parenting Coding System (Winslow, Shaw, Bruns, & Kiebler, 1995). Each behavior was coded once for each episode on a 4-point scale (1 = low to 4 = high). Four coders trained on 10% of the videotaped sessions and independently coded another 10% for reliability. The adjusted Kappas for global codes were all above .70.

Emotional Reactivity and Emotion Regulation. Both emotional reactivity and regulation were coded from videotapes of the frustration tasks (Prize in the Box and High Chair). For reactivity, distress was defined as when the child whined, pouted, fussed, cried, screamed, or tantrummed. It was coded in three ways: a) proportion of distress – the amount of time (in seconds) relative to the total time of the task during which the child was distressed, b) global negative reactivity - on a scale from 0, meaning no negative response, to 4, meaning task ended with the child in extreme distress, and c) global episode affect – on a scale from -3, meaning highly distressed affect, to 3, meaning highly positive affect. For regulation, the tasks were coded for global regulation and the frequency and effectiveness of various strategies such as self-stimulation, self-soothing, distraction, and help seeking. Global regulation was coded on a scale from 0, meaning dysregulated or no control of distress, to 4, meaning well regulated or when the child seemed to completely regulate their distress during most of the task. The various regulation strategies were also coded globally on a scale from 0, not used at all, to 2, often used throughout the task. The effectiveness of each strategy was coded globally on a scale from 0, never used, to 4, strategy use was always effective in regulating distress. These measures were used because they were thought to best index a child's level of reactivity and appropriate regulation skills especially during the Prize in the Box and High Chair tasks (Calkins, 1997; Stifter & Braungart, 1995). To reduce the number of analyses, the current study used the *global regulation* code to index emotion regulation and the *global negative reactivity* to index emotional reactivity. The reactivity and regulation codes were averaged across tasks to produce a separate mean score for each.

"Hot" executive functioning measures

Sustained attention

Lab Measure. At 2, 4.5, and 5.5 years of age, children were instructed to watch a 5-minute segment of the videotape "Spot," a short story about a puppy exploring a neighborhood. During this task, several measures of attention were coded. *Duration* referred to the total amount of time the child spent looking at the video, *Longest Continuous Look* refers to the single longest time the child looked at the video, and *Total Number of Looks* refers to the total number of times a child looks at the video. To reduce the number of analyses, *overall duration* was used as this study's laboratory measure of sustained attention. The reliability among coders for the overall duration was excellent (r = .98 for the 2yr visit, r = .96 for the 4yr and 5yr visit).

Parent Report. The Inattention subscale of the AD/HD Rating Scale (DuPaul, Power, Anastopoulos, & Reid, 1998) was also used as a parent measure of children's sustained attention. The Inattention subscale consists of nine items, such as "is easily distracted," "avoids tasks that require sustained mental effort," and "has difficulty sustaining attention in tasks or play activities." Mothers rate the frequency (ranging from 0 = never to 3 = always) in which they observe their children engage in each item asked. The nine items were reversed scored and summed to create a sustained attention summary score with higher numbers indicating higher levels of sustained attention. The AD/HD Rating Scale has been validated for use with both preschool and school age children (DuPaul et al., 1998). The alpha reliability for the Inattention scale for the current study was .83 for the 2 year visit, .89 for the 4.5 year visit, and .90 for the 5.5 year visit. Although this scale is typically used to measure diagnostic criteria for AD/HD, it has been used as a measure of reported difficulty with sustained attention (Hill, Degnan, Calkins, & Keane, 2007).

Teacher Report. The Inattention subscale of the AD/HD Rating Scale (DuPaul et al., 1998) was also used as a teacher measure of children's sustained attention during the kindergarten year. The alpha reliability for the Inattention scale was .94.

Inhibitory control.

Lab Measure. At 5.5-years of age, a Stroop task was used to measure children's inhibitory control. In this task, children were presented with large pictures representing large shapes (animals, geometric figures). Within the larger pictures, smaller shapes were depicted. In half of the trials the small shapes were consistent with the large shape (e.g., a large cat was made up of identical smaller cats) and in the other half the shapes were inconsistent (e.g., large circles made up of small squares). The child was asked to recognize only the smaller shapes in the pictures presented and were instructed to answer as fast as possible. Children could receive a maximum of 48 points: 2 points for each correct answer, 1 point if they initially got it wrong but corrected themselves, and 0 points if they did not get it right. This *total score* was used as this study's measure of inhibitory control at age 5.5.

Parent Report. To obtain a parent measure of children's inhibitory control, the three impulsivity items from the AD/HD Rating Scale (DuPaul, et al., 1998) were used. The impulsivity items include "blurts out answers," "difficulty awaiting turn," and "interrupts/intrudes on others." Mothers rate the frequency (ranging from 0 = never to 3 = always) with which they observe their children engage in each item asked. The three items were reversed scored and summed to create an inhibitory control summary score with higher numbers indicating higher levels of inhibitory control. The alpha reliability for the inhibitory control summary score for the current study was .56 for the 2 year visit, .65 for the 4.5 year visit, and .78 for the 5.5 year visit.

Teacher Report. The three impulsivity items from the AD/HD Rating Scale (DuPaul et al., 1998) were also used to obtain a teacher measure of children's inhibitory control during the kindergarten year. The three items were reversed scored and summed to create an inhibitory control summary score with higher numbers indicating higher levels of inhibitory control. The alpha reliability for the inhibitory control summary score was .87.

CHAPTER III

RESULTS

Data analytic strategy

First, preliminary analyses (data reduction, descriptive statistics, and correlations among predictors) were computed. Next, growth curve analyses were conducted to examine trajectories of "hot" EF across early childhood using hierarchical linear modeling (HLM; Raudenbush & Byrk, 2002). Please see Appendix A for a detailed description of growth curve modeling and the equations used for the current study's analyses. HLM was used because it allows for unbalanced designs so those children with incomplete outcome data could be included in the analyses. Measures of "hot" EF (i.e., sustained attention and inhibitory control) were measured when children were 2, 4.5, and 5.5 years of age. All other variables (i.e., predictors such as maternal behaviors and emotion regulation as well as demographic variables) were assessed when children were 2-years of age. Age was centered at 2-years so that the intercept indicated initial levels of "hot" EF. Linear growth trajectories were fit using full maximum likelihood estimation and the results reported were based on the robust standard errors.

The unconditional means model (UMM) was first tested to determine whether there was sufficient variability in individuals' average scores on the dependent variable averaged over time (sustained attention and inhibitory control). A significant UMM suggests that examining predictors in the model is warranted. Next, the unconditional growth model (UGM) was tested to determine if there is sufficient variability in the data over time. The UGM also addressed the study's first question: whether EF increases from the toddlerhood to early childhood period. A positive UGM would confirm the study's hypothesis as it would indicate that EF increases from the toddlerhood to early childhood period. Next, the variability in interindividual change in "hot" EF were examined by adding 2-year factors (emotion regulation, maternal behaviors, and demographic variables) to predict initial levels of "hot" EF and to predict increases or decreases in "hot" EF from 2-years to 5.5-years. The predictors of EF development (emotion regulation and maternal behaviors) were placed in the model in a step wise fashion. The addition of each predictor that is placed in the model was compared to the previous model using the deviance statistic (when the model was nested within another model) or the Akaike information criterion (AIC) and/or the Bayesian Information Criterion (BIC) when the model was non-nested. The model with smaller deviance or the smaller AIC and/or BIC numbers fits the data better and should be preferred. Differences greater than 10 are considered to provide very strong evidence for favoring the model with the lower AIC and/or BIC score (Kass & Raftery, 1995). This index has been shown to be helpful in comparing non-nested models and penalizes the model for the number of parameters which helps prevent problems with overspecification (Singer & Willet, 2003). Selected interactions of continuous variables were plotted at +/- 1 *SD* from the mean unless otherwise noted (Aiken & West, 1991).

Data reduction and preliminary analyses

Due to the large number of predictors, preliminary analyses focused on reducing the number of predictors as well as creating sustained attention and inhibitory control composites for each time point. Descriptive statistics for all of the study's variables are presented in Table 1. First, the global codes for the maternal behaviors were averaged across the six mother-child interactions as their alphas were highly reliable (.90 for warmth, .81 for overcontrol/intrusiveness, and .82 for responsiveness) The hostility factor was not averaged across tasks due to the low occurrence of maternal hostility in the sample causing a high skewness value of 6.25 (all other maternal behaviors were normally distributed). Thus, maternal hostility was examined as a categorical variable that indicated whether or not hostility was observed. Finally, an examination of the relations between the maternal behavior composites indicated that maternal warmth and responsiveness were high related (r = .80, p<.001) and thus were averaged into a single maternal warmth/responsiveness composite.

Additional analyses revealed the observational measures of emotion regulation and emotional reactivity were highly correlated (r = -.91, p<.001). This is not surprising given that both variables were measured within the same tasks. Thus, a child who in the laboratory is displaying low reactivity during a task can be conceptualized as engaging in regulatory strategies to maintain such low reactivity. Due to this conceptual issue and the empirical evidence of such high correlations, these constructs were combined by creating Z scores of both variables and averaging these standardized scores to create a single measure of emotion regulation.

Associations among predictors

The associations among the study's independent variables are presented in Table 2. Maternal warmth/responsiveness was negatively associated with both maternal overcontrol/intrusiveness and maternal hostility. This indicates that mothers who use a warm and responsiveness interaction style are less likely to interact with their children in an intrusive and/or hostile manner. Maternal overcontrol/intrusiveness was positively related to maternal hostility. Thus, mothers who interacted with their children in an intrusive manner were also more likely to show hostility towards their children during interactions.

Children's emotion regulation skills were negatively associated with maternal overcontrol/intrusiveness and maternal hostility. This indicates that children with better emotion regulation skills were less likely to have mothers who interacted with them in an intrusive or hostile manner compared to children with weaker emotion regulation skills. Maternal self-reported AD/HD symptoms were positively related to maternal hostility, indicating that mothers with higher levels of self-reported AD/HD symptoms were more likely to show hostility when interacting with their children compared to mothers with lower levels of AD/HD symptoms. Finally, maternal education was positively related to maternal responsiveness/warmth and negatively related to maternal overcontrol/intrusiveness and maternal hostility. Hence, this indicates that mothers with higher levels of education were more likely to interact with their children in a warm and responsive manner and less likely to interact with them in an intrusive and hostile manner compared to mothers with lower levels of education.

Associations between lab and parent reports of dependent variables

The association between lab and parent report measures of sustained attention and inhibitory control were first examined to determine the viability of combining them into a single sustained attention composite and inhibitory control composite. Surprisingly, the laboratory measure of sustained attention and maternal report measure were only weakly correlated at the 2-year visit (r =. 11, p<.05) and were not correlated at the 4.5-year (r = .05, p >.05) or 5.5-year visits (r = .02, p>.05). A similar weak association was found between the laboratory measure of inhibitory control at the 5.5-year visit and the maternal report of inhibitory control (r = .11, p<.05). Due to these discrepancies, separate analyses were conducted for the laboratory and maternal report measures of both sustained attention and inhibitory control.

Hierarchical linear modeling for sustained attention

The Unconditional Means Model (UMM) is Model A on Table 3. The Level 1 model has an intercept but no slope. This means that the model assumes that the trajectory for all participants is zero or a straight line, meaning there is no change over time. As indicated on Table 3, the grand means or fixed effects for both the laboratory and maternal measures of sustained attention are significantly different from zero ($\gamma 00$ = 87.25 and 78.10, respectively, both p's <.001). An examination of the random effects or the variance indicates significant change over time in both measures. Both dependent variables also had significant between-person variances that differed from zero ($\sigma^2 0$ = 18.55, p<.02 and 130.65, p <.001), indicating significant individual differences in average sustained attention as measured in the laboratory as well as reported by mothers.

Because these variance components were not zero, the addition of predictors may improve model fit.

The UMM can also gauge the relative magnitude of the variance components ($\sigma^2 e$ and $\sigma^2 0$) by computing the intraclass correlation coefficient (ICC) or ρ (Singer & Willet, 2003). The ICC measures the proportion of total variation in the dependent variable that is among participants. The formula to calculate the ICC is $\rho = \sigma^2 0 / (\sigma^2 0 + \sigma^2 e)$. For sustained attention measured in the laboratory the ICC was 18.55/(18.55 + 181.47) = .09 whereas for maternal report the ICC was 130.65/(130.65 + 120.63) = .52. This indicates that about 9% and 52% of the total variation in sustained attention measured in the laboratory and as reported by mothers were due to individual differences. The ICC is also a measure of the average autocorrelation of the dependent variable overtime. Consequently, the estimated average stability of sustained attention measured in the laboratory and via maternal report overtime was .09 and .52, respectively.

The Unconditional Growth Model (UGM) is depicted as Model B on Table 3. The UGM adds time as a Level 1 predictor of the dependent variables, but adds no Level 2 predictors. Time was computed as total months of age at each laboratory visit and centered at the first time point (i.e., 24 months or 2-years of age) to facilitate interpretation. In the UGM for sustained attention measured in the laboratory, both initial status and rate of change were significantly different from zero. Graphically depicted in Figure 1, the model estimates that children's sustained attention in the laboratory increases from 2-years to 5.5-years. It is also estimates that the average child has a sustained attention score of 81.24 at 2-years with an increase in sustained attention of .36

per month. Moreover, 58% of within-person variation in sustained attention is explained by age. Related to the study's first goal, this indicates that the executive function of sustained attention as measured in the laboratory significantly increases from the toddlerhood to early childhood period.

On the other hand, and graphically depicted in Figure 2, the rate of change of the UGM for sustained attention measured via maternal report was not significantly different from zero. This indicated that maternal report of children's sustained attention was, on average, stable over time and did not show significant growth. Thus, it is estimated that on average the sustained attention score, reported by mothers, was 78.63 at 2-years with a non-significant increase in sustained attention of .02 per month. Once again as related to the study's first goal, this indicates that the executive function of sustained attention as reported by mothers does not show significant growth from the toddlerhood to early childhood period. Although there was a lack of average growth found in sustained attention as reported by mothers, there was a significant Level 2 residual variance, indicating that there was still significant between-person variability in both initial status and rate of change. Significant Level 2 residual variances were also found for the laboratory measure of sustained attention. These significant Level 2 residual variances indicate that additional Level 2 predictors may improve the fit of the model.

To determine whether the addition of time as a Level 1 predictor improved the model, the fit statistics were compared. Because the UMM is nested within the UGM, the deviance statistics can be compared using χ^2. The reduction in deviance due to the addition of time was statistically significant for both the laboratory measure of sustained attention (χ^2 (3) = 8666 - 8124 = 542, p<.001) and the maternal report of attention (χ^2 (3) = 8903 - 8543 = 360, p<.001), thus time is a significant predictor of sustained attention.

Predicting growth in sustained attention (laboratory measure)

To determine the predictors of sustained attention, a series of models investigating the role of temperament and maternal behaviors were conducted. First, demographic variables such as gender, race, SES, and maternal education were examined as well as our control variable, maternal self-report symptoms of AD/HD. Then, the effect of temperament (i.e., emotion regulation) was explored, followed by the maternal behaviors. Finally, a final model with interactions between the predictors was tested. Fit statistics were used throughout the model building process to assure that the optimal model was retained. A correlation table (Table 4), displaying the relation between the independent variables and the various measures of sustained attention across time, is also attached to facilitate the interpretation of the HLM analyses.

Demographic variables in the prediction of sustained attention

No initial status or slope effects were observed in regards to sex, socioeconomic level, or maternal self-report AD/HD symptoms. Thus, boys and girls as well as children with varying levels of SES, and children of mothers with differing levels of AD/HD symptoms had similar initial levels of sustained attention at 2-years of age as well as similar levels of growth in attention across time. On the other hand, these analyses revealed a significant influence of race ($\Pi 0i$ = -8.72, p<.001) and maternal education ($\Pi 0i$ = 2.84, p<.001) on children's initial level of sustained attention. Specifically, minority children had significantly lower sustained attention scores compared to

Caucasian children at 2-years. In addition, children with mothers with higher levels of education had significantly higher sustained attention scores compared to children with mothers with lower levels of education at 2-years. In terms of slope effects (i.e., sustained attention growth), minority children had significantly higher levels of sustained attention growth compared to Caucasian children ($\Pi 1i = .215$, $p<.001$). Children with mothers with higher levels of education had significantly lower levels of growth compared to children with mothers with lower levels of education ($\Pi 1i = -.07$, $p<.01$).

A goodness-of-fit test was conducted with only the significant demographic variables. Comparison of the goodness-of-fit statistics between the UGM (containing just age) and the model with the significant demographic/control variables (nested) suggested a better fit due to a significant reduction in deviance (χ^2 (3) = 8124 – 8071 = 53, $p<.001$). An examination of the significant random effects of the initial status ($\sigma^2 0= 162.33$, $p<.001$) and slope ($\sigma^2 1 = .127$, $p<.001$) for sustained attention suggests that potentially explainable residual variation remains in initial status and slope. This indicates that a subsequent model may benefit from the addition of other level 2 predictors. Only the demographic/control variables that had significant parameters (i.e., race and maternal education) were retained in further models.

Effect of temperament

To determine whether temperament significantly contributed to children's "hot" EF development, the emotion regulation variable was added to the model. Consistent with this study's hypothesis, children's emotion regulation skills significantly predicted the initial status of sustained attention ($\Pi 0i = 8.37$, $p<.05$). Specifically, children with higher levels of emotion regulation skills had significantly better initial levels of sustained attention at 2-years compared to children with lower levels of emotion regulation skills. Next, emotion regulation was also tested in terms of whether it predicted growth in EF across the toddlerhood to early childhood period. Contrary to the study's hypothesis, higher levels of emotion regulation skills marginally predicted lower levels of growth in sustained attention over time ($\Pi 1i = -.202$, $p<.10$). No significant interactions were observed between children's emotion regulation skills and maternal education and race. Comparison of the goodness-of-fit statistics between the model with only age and the demographic/control variables and this new Model, containing the addition of emotion regulation, (non-nested) revealed a lower AIC (7902.13 vs. 8090.69) and BIC (7981.08 vs. 8140.28) statistic suggesting a better fit. Once again, an examination of the significant random effects of the initial status ($\sigma^2 0 =155.04$, $p<.001$) and slope ($\sigma^2 1 = .123$, $p<.001$) suggests that there is sufficient variability remaining regarding the initial status and slope to examine additional predictor variables. Only the significant main effect for emotion regulation was retained in further models.

Effect of maternal behaviors

To determine whether maternal behaviors significantly contributed to children's "hot" EF development, the three maternal behavior variables (warmth/responsiveness, overcontrol/intrusiveness, and hostility) were added to the model. No initial status or slope effects were observed in regards to maternal warmth/responsiveness and maternal hostility. Thus, children who had mothers with higher levels of warmth/responsiveness or lower levels of hostility displayed similar initial levels of sustained attention at 2-years of age as well as similar levels of growth in attention across the toddlerhood to early childhood period compared to children who had mothers with lower levels of warmth/responsiveness or higher levels of hostility. On the other hand, maternal behavior characterized by overcontrol/intrusiveness significantly predicted the initial status of sustained attention ($\Pi 0i = -3.35$, $p<.05$). Specifically, children who had mothers with higher levels of overcontrol/intrusiveness displayed lower initial levels of sustained attention at 2-years compared to children who had mothers with lower levels of overcontrol/intrusiveness. In terms of slope effects, higher levels of maternal overcontrol/intrusiveness marginally predicted higher levels of growth in sustained attention over time ($\Pi 1i = .10$, $p<.10$). In terms of interactions between maternal behaviors, race, and maternal education, the only significant interaction was between maternal behavior characterized by overcontrol/intrusiveness and race, which significantly predicted children's initial sustained attention ($\Pi 1i = -5.97$, $p<.05$) and marginally predicted sustained attention growth overtime ($\Pi 1i = .157$, $p<.10$). This interaction will be explored later in this paper (see the prototypical plots section).

An inspection of the goodness-of-fit statistics between the model with only age and the demographic/control variables and this new Model, containing the addition of maternal overcontrol/intrusiveness, and the interaction between maternal overcontrol/intrusiveness and race revealed a lower AIC (7994.22 vs. 8090.69) and BIC (8063.48 vs. 8140.28) statistic suggesting a better fit. Once again, an examination of the significant random effects of the initial status ($\sigma^2 0=149.11$, $p<.001$) and slope ($\sigma^2 1= .117$, $p<.001$) for both sustained attention suggests that there is sufficient variability remaining regarding the initial status and slope that will benefit from the addition of predictor variables. Only the significant maternal variables (i.e., maternal overcontrol/intrusiveness and the interaction of maternal overcontrol/intrusiveness and race) were retained for future models.

Final model for predicting sustained attention (laboratory measure)

Table 5 contains the final model in the prediction of children's sustained attention development as measured in the laboratory. It combines the significant parameters found within the demographic/control, temperament, and parenting variables. Additionally, it tests the unique contribution of each predictor to ensure, for example, that the effect of emotion regulation on children's sustained attention is not better explained by only examining maternal behavior. Model C examines the joint main effects of emotion regulation and maternal overcontrol/intrusiveness while still examining our significant demographic/control variables (i.e., race and maternal education). Both children's emotion regulation skills and maternal overcontrol/intrusiveness continue to significantly predict children's initial levels of sustained attention as well as its growth across time as previously found. This indicates that both variables predict unique variance towards children's sustained attention development. Model D examines potential interactions between children's emotion regulation skills and maternal overcontrol/intrusiveness as well as previous significant interactions (i.e., race and maternal overcontrol/intrusiveness). The interaction between emotion regulation skills and maternal overcontrol/intrusiveness was not significantly related to the initial status or slope of sustained attention in this final model.

Comparison of the goodness-of-fit statistics between Model D and Model C (non-nested) revealed a higher AIC and BIC statistic suggesting a worse fit. Model E retained only the significant parameters found in the previous model (race, maternal education, emotion regulation, maternal overcontrol/intrusiveness, and the interaction between maternal overcontrol/intrusiveness and race). Comparison of the goodness-of-fit statistics between Model E and Model C (non-nested) revealed a lower AIC and BIC statistic suggesting a better fit. Thus, the best fitted model for the prediction of children's sustained attention was Model E.

Prototypical plot for sustained attention (laboratory measure)

Interaction effects are often difficult to interpret from examination of parameter estimates. The creation of prototypical plots serves as an aid to the interpretation of such findings (Singer & Willett, 2003). A prototypical plot is a graph of the trajectory of a dependent variable for selected values of the predictors. Separate lines are drawn for categorical variables such as gender. For continuous variables, plus and minus one standard deviation from the mean are often picked to represent high and low values of the variable. The full equation that results from the estimated model is written out and the values of the predictors are substituted to obtain predicted scores for each combination of predictor values. Figure 5 illustrates effects of the interaction between race and maternal overcontrol/intrusiveness on sustained attention, while controlling for the effects of maternal education and children's emotion regulation skills. These plots were created using the equation from Model E (Table 5.) Race was dummy coded (0 = Caucasian, 1 = Minority) and the effects of maternal overcontrol/intrusiveness was plotted using plus and minus one standard deviation from the mean. The graph shows that the effect of maternal overcontrol/intrusiveness on the initial status of sustained attention was particularly important for minority children. Specifically, this indicates that the negative effects of maternal overcontrol/intrusiveness on sustained attention at 2 years of age are mostly noticeably present for minority children. However, as shown statistically, minority children tend to catch up with Caucasian children by having significantly higher levels of sustained attention growth from 2-years to 5.5-years of age.

Predictors of maternal report of sustained attention

Although the Unconditional Growth Model for the maternal report of children's sustained attention was not significant, there was significant evidence for between person variability in this measure. In other words, although, on average, children's sustained attention as reported by mothers was relatively stable from 2 to 5.5-years, there was sufficient variability between children's levels of attention (e.g., some children's sustained attention increase, some stay stable, and others decrease overtime) to warrant further analyses.

Demographic variables in the prediction of maternal report of sustained attention

No initial status or slope effects were observed in regards to socioeconomic level, race, or maternal education. This indicates that minority and Caucasian children alike as well as children with varying levels of SES, and children of mothers with differing levels of education had similar initial levels of sustained attention at 2-years of age as well as similar levels of growth in attention across time. However, there was a significant influence of maternal self-report AD/HD symptoms ($\Pi 0i = -.70, p<.001$) and sex ($\Pi 0i =$

6.36, $p<.001$) on children's initial level of sustained attention as reported by mothers. Specifically, girls were found to have higher initial levels of sustained attention at age 2 compared to boys. In addition children with mothers with higher levels of self-reported AD/HD symptoms had significantly lower sustained attention scores compared to children with mothers with lower levels of self-reported AD/HD symptoms at 2-years months. No slope effects were found. This indicates that boys and girls alike as well as children with mothers with varying levels of self-reported AD/HD symptoms displayed similar levels of sustained attention growth across the toddlerhood to early childhood period. Comparison of the goodness-of-fit statistics between the UGM (containing just age) and the final demographic model revealed a lower AIC (4752.91 vs. 8554.56) and BIC (4787.87 vs. 8584.33) statistic suggesting a better fit. An examination of the significant random effect of the initial status ($\sigma^2 0 = 81.63$, $p<.001$) for sustained attention suggests that potentially explainable residual variation remains in initial status. However, a non-significant random effect of the slope ($\sigma^2 1 = .03$, $p>.05$) indicates that there is not sufficient variability across time to explain. Thus, subsequent models may benefit from the addition of other level 2 predictors only for initial status. Only the demographic/control variables that had significant parameters (i.e., sex and maternal self-report symptoms of AD/HD) were retained in future models.

Effect of temperament

Children's emotion regulation skills did not significantly predict the initial status or the slope of sustained attention as reported by mothers. No significant interactions were observed between children's emotion regulation skills and the significant demographic factors (i.e., maternal self-report symptoms of AD/HD and sex).

Effect of maternal behaviors

No main effects for maternal behaviors were found as it relates to sustained attention at 2-years of age (i.e., initial status). There was, however, a significant interaction between maternal hostility and maternal AD/HD self-report symptoms ($\Pi 0i$ = 1.03, $p<.01$). This interaction will be explored later in this paper (see the prototypical plots section). An inspection of the goodness-of-fit statistics between the model with only age and the significant demographics and this new model (non-nested) containing the addition of the maternal hostility and maternal AD/HD self-report symptoms interaction revealed a lower AIC (4722.46 vs. 4752.91) and BIC (4766.11 vs. 4787.87) statistic suggesting a better fit. Once again, an examination of the significant random effect of the initial status ($\sigma^2 0$ = 76.71, $p<.001$) suggests that there is sufficient variability remaining regarding the initial status that the addition of predictor variables could improve the model. Only the variables that had significant parameters were retained for future models.

Final model for predicting maternal report of sustained attention

No significant interactions were found between emotion regulation and maternal behaviors. Thus, the final model for predicting maternal report of sustained attention contained the significant demographic variables (sex and maternal AD/HD self-report symptoms) along with the maternal hostility and maternal AD/HD self-report symptoms interaction.

Prototypical plot for sustained attention maternal report

Figure 6 illustrates the effects of the interaction between maternal self-report symptoms of AD/HD and maternal hostility on sustained attention while controlling for the effect of sex. The effects of self-report symptoms of AD/HD and maternal hostility were plotted using plus and minus one standard deviation from the mean. As one can see from the graph, the protective factor of low maternal hostility on sustained attention was only evident in children who had mothers with low levels of self-reported AD/HD symptoms. This effect is stable from 2-years to 5.5-years of age.

Given the potential for reporter bias (as the mother reported both on her own AD/HD symptoms as well as her child's sustained attention symptoms), post-hoc analyses were also performed using teacher report of children's sustained attention.

Predictors of teacher report of sustained attention

Hierarchical regressions were performed to determine whether early parenting measures, emotion regulation, and any demographic/control variables predicted children's sustained attention in kindergarten.

In terms of demographic/control variables, children's racial status, gender, socioeconomic status, maternal education, and maternal self-report of AD/HD symptoms were examined as possible predictors of children's sustained attention in kindergarten. Maternal education was positively related to children's sustained attention as reported by teachers (r =.21, p<.001). This indicates that children who had mothers with higher levels of education were reported by teachers as having higher levels of sustained attention in kindergarten compared to children who had mothers with lower levels of education.

Children's sex was also related to sustained attention in kindergarten ($t(268) = -4.113$, $p<.001$), with girls displaying significantly higher sustained attention scores (M = 23.25, SD = 5.03) compared to boys (M = 20.23, SD = 7.00). Due to these significant findings, maternal education was controlled in further analyses while separate regressions were conducted for boys and girls.

As shown in Table 6, for boys no variables or interactions were significant in the prediction of sustained attention as reported by teachers. On the other hand, for girls, maternal education and maternal warmth/responsiveness significantly predicted sustained attention in kindergarten. However, the main effect for maternal warmth/responsiveness was qualified by a significant interaction with emotion regulation. There was also a significant interaction between maternal hostility and emotion regulation. These interactions were graphed according to procedures outlined by Aiken and West (1991) and are depicted in Figures 7 and 8. As one can see in Figure 8, the effect of emotion regulation on sustained attention was only evident for girls who had mothers with low levels of hostility. Thus, when high levels of maternal hostility were present, emotion regulation no longer had a significant effect on girls' sustained attention. Additionally, as seen in Figure 7, emotion regulation seemed to buffer the negative effects of low maternal warmth/responsiveness on sustained attention with no effect present with girls who had mothers with high levels of warmth/responsiveness.

Hierarchical linear modeling for inhibitory control

Only the maternal report of inhibitory control (i.e., AD/HD rating scale) was examined by hierarchical linear modeling as the laboratory measures for inhibitory control were not the same across time, and therefore could not be examined via HLM (such analysis will be discussed later in the paper). The Unconditional Means Model (UMM) for the maternal report of inhibitory control is Model A in Table 7. As indicated in Table 7, the grand means or fixed effects for the maternal measure of inhibitory control is significantly different from zero ($\gamma 00 = 71.22$, $p < .001$). An examination of the random effects or the variance components indicate that the estimated within-person variances is also significantly different from zero ($\sigma^2 e = 201.14$, $p < .001$). The dependent variable also had significant between-person variances that differed from zero ($\sigma^2 0 = 166.33$, $p < .001$), indicating significant individual differences in average inhibitory control as reported by mothers. Because both variance components were not zero, additional predictors at may improve model fit. In addition, the ICC for the maternal report of inhibitory control was .45. This indicates that about 45% of the total variation in inhibitory control as reported by mothers was due to individual differences. It also indicates that the estimated average stability of inhibitory control via maternal report overtime was .45.

The Unconditional Growth Model (UGM) is depicted as Model B on Table 7. In the UGM for inhibitory control as reported by mothers, both initial status and slope, were significantly different from zero. Graphically depicted in Figure 9, it is estimated that children's inhibitory control increases from 2 to 5.5-years of age. It is also estimated that the average child has an inhibitory control score of 69.47 at 2-years with an increase in inhibitory control of .11 per month. Consistent with this study's hypothesis, this finding indicates that children's inhibitory control abilities as reported by mothers show a significant increase from the toddlerhood to early childhood period. Moreover, 26% of within-person variation in inhibitory control is explained by age. Further examination of the significant Level 2 residual variances for the maternal report of inhibitory control, which summarize the between-person variability in initial status and rate of change, indicate that additional Level 2 predictors may improve model fit. Additionally, to determine whether the addition of time as a Level 1 predictor improved the model, the fit statistics were compared. Because the UMM is nested within the UGM, the deviance statistic can be used. The reduction in deviance due to the addition of time was statistically significant (χ^2 (3) = 9323 - 8937 = 386, $p<.001$). Once again, a correlation table (Table 8), displaying the relation between the independent variables and the various measures of inhibitory control across time, is attached to facilitate the interpretation of the HLM analyses.

Demographic variables in the prediction of inhibitory control

Models C and D in Table 7 represents the effect of all demographic and control variables on children's inhibitory control as measured via maternal report. No initial status or slope effects were observed in regards to sex, socioeconomic level, or maternal education. This indicates that boys and girls alike as well as children with varying levels of SES, and children of mothers with differing levels of education had similar initial levels of inhibitory control at 2-years of age as well as similar levels of growth in inhibitory control across time. On the other hand, these analyses revealed a significant influence of race and maternal self-report of AD/HD symptoms on children's initial level of inhibitory control. Specifically, Minority children had significantly higher inhibitory control scores, as reported by mothers, compared to Caucasian children at 2-years. In addition children with mothers with higher levels of self-reported AD/HD symptoms had significantly lower inhibitory control scores compared to children with mothers with lower levels of self-reported AD/HD symptoms at 2-years. Neither race or maternal self-report of AD/HD symptoms had an effect in the slope of children's inhibitory control scores. Finally, when Model D was run with only the significant demographic/control variables found in Model C, race no longer had a significant effect on children's initial levels of inhibitory control. Thus, the only remaining demographic/control variable that had a significant influence on children's initial levels of inhibitory control was maternal self-report of AD/HD symptoms. Comparison of the goodness-of-fit statistics between Model B (containing just age) and Model D containing the demographics/control variables (nested) revealed a significant reduction in deviance (χ^2 (3) = 8937 – 4932 = 4005 $p<.001$), suggesting a better fit. An examination of the significant random effects of the initial status ($\sigma^2 0$) and slope ($\sigma^2 1$) for inhibitory control suggests that potentially explainable residual variation remains in initial status and rate of change. This indicates that a subsequent model may benefit from the addition of other level 2 predictors. Only the demographic/control variable that had significant parameters (i.e., maternal self-report of AD/HD symptoms) was retained in future models.

Effect of temperament

A significant effect of emotion regulation skills on children's initial levels of inhibitory control was found ($\Pi 0i$ = 3.99, $p<.05$). Children with higher levels of emotion regulation skills had better initial inhibitory control abilities at age 2, as reported by mothers, compared to children with lower levels of emotion regulation skills. Emotion regulation skills did not significantly predict growth in inhibitory control across time ($\Pi 1i = -.01$, $p>.05$). There was a marginal interaction between emotion regulation skills and maternal self-report of AD/HD symptoms in the prediction of children's initial levels of inhibitory control at 2-years ($\Pi 0i = -.26$, $p<.10$).

Comparison of the goodness-of-fit statistics between Model E from Table 6 (containing only age and the significant demographic variables) and this new model containing the addition of emotion regulation and its interaction (non-nested) revealed a lower AIC (4921.68 vs. 4946.48) and BIC (4960.90 vs. 4977.02) statistic suggesting a better fit. Once again, an examination of the significant random effects of the initial status ($\sigma^2 0= 179.56$, $p<.001$) and slope ($\sigma^2 1=.163$, $p<.001$) for inhibitory control suggests that there is sufficient variability remaining regarding the initial status and slope that will benefit from the addition of predictor variables. Both the emotion regulation variable and maternal self-report of AD/HD symptoms, which had significant parameters, were retained for future models. In addition, the interaction between emotion regulation skills and maternal self-report of AD/HD symptoms will be interpreted in the prototypical plots section.

Effect of maternal behaviors

None of the maternal behaviors had a significant effect on the initial status or slope of children's inhibitory control. Thus, children who had mothers with higher levels of warmth/responsiveness and/or lower levels of hostility and overcontrol/intrusiveness displayed similar levels of inhibitory control at age 2 as well as similar levels of growth in inhibitory control across the toddlerhood to early childhood period compared to children who had mothers with lower levels of warmth/responsiveness and/or higher levels of hostility and overcotrol/intrusiveness. No interactions were significant among maternal behaviors or maternal self-report symptoms of AD/HD. Because none of the maternal variables or interactions were significant, goodness-of-fit analyses were not conducted.

Final model predicting maternal report of inhibitory control

Table 9 contains the final model in the prediction of children's inhibitory control as measured by maternal report. It combines the significant parameters found within the demographic/control, temperament, and parenting variables. Although none of the maternal behaviors had significant direct effects, this final model does test whether these maternal behaviors contribute to children's inhibitory control development via an interaction with emotion regulation, which was not tested in previous models. Model C examines all of the potential interactions between maternal behaviors and emotion regulation skills while also including the main effects for such variables. As one can see, the only interaction that was marginally significant was between emotion regulation skills and maternal hostility (and only as it relates to initial status). Once again, to ensure that this finding was not due to chance (as numerous variables were examined), Model D drops the variables (maternal responsiveness/warmth, maternal overcontrol/intrusiveness) that had no significant findings in Model C or any other previous models. The interaction between emotion regulation and maternal hostility is no longer significant in Model D. Model D also reveals significant main effects for emotion regulation skills and maternal self-report of AD/HD symptoms on children's initial levels of inhibitory control. A marginal interaction between emotion regulation skills and maternal self-report of AD/HD symptoms also emerges. Once again a new model (Model E) was run with only the significant parameters in it to ensure accurate results. Comparison of the goodness-of-fit statistics between Model E and Models C and D (non-nested) revealed a lower AIC and BIC statistic suggesting a better fit. Thus, the best fitting model for the prediction of children's inhibitory control was Model E.

Prototypical plot for inhibitory control

Figure 10 illustrates effects of the interaction between maternal self-report of AD/HD symptoms and emotion regulation skills on inhibitory control. These plots were created using the equation from Model E (Table 9). The effects of maternal self-report of AD/HD symptoms and emotion regulation skills were plotted using plus and minus one standard deviation from the mean. As shown in the graph, the effect of emotion regulation skills on the initial status of inhibitory control was particularly important for children who have mothers with low self-report symptoms of AD/HD. In other words, children's emotion regulation skills did not seem to matter as it relates to inhibitory control if their mothers' self-reported AD/HD symptoms were high. In addition, as shown statistically earlier, no effects were present in the slope or growth of inhibitory control at different levels of maternal self-reported AD/HD symptoms and emotion regulation. Thus, this interaction effect remained constant from 2 to 5.5-years of age.

Given the potential for reporter bias (as the mother reported both on her own AD/HD symptoms as well as her child's inhibitory control), post-hoc analyses were also performed using teacher report of children's inhibitory control.

Predictors of teacher report of inhibitory control

Hierarchical regressions were performed to determine whether early parenting measures, emotion regulation, and any demographic/control variables predicted children's inhibitory control in kindergarten as reported by teachers.

In terms of demographic/control variables, racial status was significantly associated with inhibitory control in kindergarten ($t(254) = 2.02$, $p<.05$) with minority children displaying significantly lower inhibitory control scores ($M = 6.56$, $SD = 2.58$) compared to Caucasian children ($M = 7.20$, $SD = 2.21$). Children's sex was also related to inhibitory control in kindergarten ($t(268) = -3.722$, $p<.001$) with girls displaying significantly higher inhibitory control scores ($M = 7.44$, $SD = 2.19$) compared to boys ($M = 6.38$, $SD = 2.46$). Due to these significant findings, racial status was controlled in further analyses while separate regressions were conducted for boys and girls.

As Table 10 shows, for boys no variables or interactions were significant in the prediction of inhibitory control as reported by teachers. On the other hand, for girls, maternal warmth/responsiveness and emotion regulation significantly predicted inhibitory control in kindergarten. Specifically, girls with higher levels of emotion regulation skills and girls whose mothers displayed higher levels of warmth/responsiveness in toddlerhood had higher levels of inhibitory control in kindergarten. However, the main effect for emotion regulation was qualified by a significant interaction with maternal hostility. This interaction was graphed according to procedures outlined by Aiken and West (1991) and is depicted in Figure 11. As one can see, the effect of emotion regulation on inhibitory control was only evident for girls who had mothers with low levels of hostility. Thus, when high levels of maternal hostility were present, emotion regulation no longer had a significant effect on girls' inhibitory control.

Predictors of laboratory measures of inhibitory control

Because the laboratory measures for inhibitory control were not the same across time, they could not be examined via HLM. In addition, the laboratory measure of inhibitory control at 5.5-years of age (Stroop task) was skewed (-1.68) with a large number of children obtaining perfect or close to perfect scores. As a result, a quartile split was performed and a Multivariate Analysis of Variance (MANOVA) was conducted to determine whether children in the high scoring group ($\geq 75^{th}$ percentile, n = 115) differed from the low scoring group ($\leq 25^{th}$ percentile, n = 82) in terms of early parenting measures and emotion regulation.

Before conducting the MANOVA, demographic/control variables were examined to determine possible covariates. These analyses found that children in the high inhibitory control scoring group had significantly higher levels of maternal education (M= 3.66, SD= .88, $t(204)= 4.75$, $p<.001$) and socioeconomic levels (M=41.56, SD = 11.08, $t(199)=2.81$, $p<.01$) compared to children in the low inhibitory control scoring group (M=3.08, SD =.87 and M=37.28, SD=10.05, respectively). No other differences were noted. As a result of such differences, both SES and maternal education were covaried in the MANOVA. The initial MANOVA was significant ($F(4, 190) = 8.02$, $p<.001$) with significant follow up ANOVAs for maternal warmth/responsiveness ($F(1, 193) = 17.30$, $p<.001$) and maternal overcontrol/intrusiveness ($F(1,193) = 15.50$, $p<.001$). No effect was noted for maternal hostility and emotion regulation. The estimated marginal means (controlling for SES and maternal education) for the low and high inhibitory control groups are depicted in Figure 12.

CHAPTER IV

DISCUSSION

The purpose of the current study was to examine the role of temperament and maternal behavior in the development of children's "hot" EF of attentional control, which consists of sustained attention and inhibitory control. This study attempted to address several gaps in the literature to assess how extrinsic factors (e.g., maternal behavior) and temperamental factors (e.g., emotion regulation) affect the development of sustained attention and inhibitory control. First, sustained attention and inhibitory control were assessed at multiple time points (2.5, 4.5, and 5.5yrs of age) allowing for the use of more advanced statistical tools (i.e., growth curve modeling or hierarchical linear modeling) to determine developmental trajectories. Second, multiple sources of data, such as parent, teacher, and lab measures, were used to determine children's sustained attention and inhibitory control. Third, important control variables such as maternal education and maternal self-report symptoms of AD/HD were examined to ensure that any findings linking maternal behaviors and temperament to executive functioning is above and beyond the effects expected by shared genetics and/or overall intelligence.

The results of this study are presented in a thematic fashion relating back to the original hypotheses and analyses. First, the developmental trajectories of sustained attention and inhibitory control will be discussed in terms of their growth across time. Second, the results within the temperament domain will be discussed using existing research and current theoretical views. Third, the results within the maternal behaviors domain will be discussed in terms of a scaffolding framework. Existing research within the animal literature will also be used to understand the current findings. Fourth, significant interactions between temperament and maternal behaviors will be discussed within a goodness of fit theoretical framework. Finally, an overall summary will be presented along with limitations of the current study as well as directions for future research.

Growth of sustained attention and inhibitory control

Hierarchical linear modeling (HLM) was used to determine the extent to which children's sustained attention and inhibitory control abilities develop during the toddlerhood and early childhood period. It was hypothesized that children's sustained attention and inhibitory control abilities would increase from 2 to 5.5 years of age. Consistent with this hypothesis, the current study found significant growth in the trajectories of both sustained attention and inhibitory control across time. Although recent cross sectional studies (Berwid et al., 2005; Betts et al., 2006; Kochanska & Knaack, 2003; Ruff & Capozzoli, 2003) had suggested increases in sustained attention and inhibitory control over this period, this marks the first study to date that has longitudinally examined this development utilizing growth curve modeling. The significant growth in both sustained attention and inhibitory control between toddlerhood and early childhood is consistent with recent findings showing increases in children's other executive functions between the ages of 3 and 5 years such as the ability to cognitively switch between incompatible rules (Stahl & Pry, 2005; Zelazo & Jacques, 1996: Zelazo et al., 2003).

Another advantage of growth curve modeling is the ability to detect the amount of within person variability in development that can be attributed to the passage of time. The current study found that age alone explained 58% and 26% of within-person variation in sustained attention and inhibitory control development, respectively. This may suggest that a significant portion of children's "hot" executive functioning growth is a function of biological maturation. It is important to note that this age effect cannot untangle any changes in the environment over time that may also affect the development of attentional control such as better language skills. Nevertheless, an assumption that an age effect involves some form of biological maturation is consistent with previous research identifying maturation of the prefrontal cortex, specifically the orbitofrontal cortex, as crucial in the development of both sustained attention and inhibitory control (Jonkman, Lansbergen, & Stauder, 2003; Zelazo & Muller, 2003).

In addition, the low ICC (intraclass correlation coefficient) indicated rapid growth in sustained attention during this time period (i.e., from 2 to 5.5 yrs of age). Such rapid growth is consistent with previous cross-sectional research (Gomez-Perez & Ostrosky-Solis, 2006) as well data indicating that the peak age of onset for AD/HD is considered to be between 3 and 5 years of age (Barkley, 1997; Berwid et al. 2005). A more moderate ICC was found for inhibitory control indicating moderate growth. The differences in the rate of growth in sustained attention and inhibitory control is consistent with previous developmental work suggesting that inhibitory control develops earlier than sustained attention (Fox & Calkins, 2003; Klenberg, Korkman, & Lahti-Nuutila, 2001; Williams, Ponesse, Schachar, Logan, & Tannock, 1999).

Finally, it is also important to note that the growth found in sustained attention was found using the lab task of attention. No significant slope effects were found using parent report of sustained attention. Parents were, however, able to report moderate increases in inhibitory control over time. These interesting reporting differences may indicate that parents are more in tune with observing age appropriate changes in children's inhibitory control over time compared to attention. This is not surprising given that inhibitory control plays an important part in complying to requests and behavioral movements that are more easily observed by parents (Fox & Calkins, 2003). It may be that between the toddlerhood and early childhood period parents have fewer opportunities to judge their children's attention. This is also consistent with research suggesting that parents are more likely to refer children with impulsivity and hyperactivity problems for intervention at an earlier age whereas children with attention problems are often not identified until school entrance (Anastopoulos & Shelton, 2001; Barkley, 2003).

Emotion regulation and "hot" executive functioning development

It has been well established that the development of emotion regulation is dependent on the development of certain aspects of executive functioning such as the use of attention and inhibition (Kopp, 2002; Rueda, Posner, & Rothbart, 2005). Recently, however, researchers such as Fox and Calkins (2003) and Blair (2002) have suggested that temperament may also affect the development of these executive functions. Thus, the current study examined the extent to which children's emotion regulation skills in toddlerhood influence the development of sustained attention and inhibitory control abilities through early childhood. The period from toddlerhood to early childhood was examined as previous research had primarily focused on school age children (Berlin, Bohlin, Nyberg, & Janols, 2004; Walcott & Landau, 2004; Wolfe & Bell, 2003) or infants (Calkins et al., 2002; Goldsmith, Lemery, Aksan, & Buss, 2000; Kochanska, Coy, Tjebkes, & Husarek, 1998). It was hypothesized that emotion regulation skills would be positively related to the developmental trajectories of sustained attention and inhibitory control abilities.

Consistent with this study's hypothesis, toddlers with better emotion regulation skills did display higher initial levels of sustained attention as measured in the laboratory at 2 years of age. No effects were found in terms of the rate of change of sustained attention. This indicates that although children's initial levels of sustained attention varied as a function of their emotion regulation skills, the rate in which their sustained attention abilities grew over time were similar. As mentioned earlier, sustained attention as reported by mothers was, on average, relatively stable over time. Although there was sufficient variability in maternal report of sustained attention to examine predictors of change, no effects were noted for emotion regulation. As discussed earlier, reports of attention are usually better obtained once children reach school, thus post-hoc analyses attempted to examine whether early emotion regulation predicted sustained attention as reported by kindergarten teachers. These analyses revealed that for girls, higher levels of emotion regulation skills in toddlerhood predicted higher levels of sustained attention as reported by teachers in kindergarten. No effects were found for boys; however, the positive effect of emotion regulation on sustained attention for girls was only evident in conditions in which their mothers' behaviors were low in warmth and responsiveness or when their mothers' behaviors were low in hostility. These interactions will be discussed within a goodness of fit framework later in the discussion.

Emotion regulation also had a significant effect on the initial levels of children's inhibitory control as reported by mothers. No effects were found in terms of the rate of change of inhibitory control. This indicates that although children's initial levels of inhibitory control varied as a function of their emotion regulation skills, the rate at which their inhibitory control skills grew over time were similar. However, the positive initial effect of emotion regulation was particularly evident when mothers self-reported low levels of AD/HD symptoms. Once again this interaction will be discussed in more detail later in the discussion. Nevertheless, to reduce reporter effects, post hoc analyses were also conducted with teacher reports of children's inhibitory control. These analyses found that for girls, early emotion regulation skills positively predicted inhibitory control in kindergarten. No effects were obtained for boys. However, once again the positive effect of emotion regulation on inhibitory control for girls was only evident in conditions in which maternal behavior was low in hostility (this interaction will also be discussed later in the discussion).

Finally, although HLM analyses could not be conducted with lab measures of inhibitory control (as they were not the same across time), early emotion regulation was examined as a predictor of inhibitory control in the lab at 5.5 years of age. Contrary to the study's prediction, emotion regulation did not have a significant effect on inhibitory control in the lab, which was measured via the Stroop task. The lack of finding with the lab measure of inhibitory control may be a function of differences in the demands of the lab task compared to how inhibitory control was assessed via parent and teacher reports. Impulsivity items from the AD/HD Rating Scale were used as the measure of inhibitory control for both maternal and teacher reports. Although impulsivity is generally accepted as an indicator of a lack of inhibitory control (Olson, Schilling, & Bates, 1999; Zaparniuk & Taylor, 1997), it is more related to the inhibition of motor and verbal behaviors such as having difficulty awaiting your turn or interrupting others. On the other hand, the Stroop task has a higher cognitive loading as the child must not only inhibit a predominant verbal response but must also activate an appropriate response (Rueda, Posner, & Rothbart, 2005). These different task demands would also explain the weak association found between the lab measure and parent report, which are consistent with previous research (see Avila, Cuenca, Felix, Parcet, & Miranda, 2004 for a review). Additionally, via factor analysis of various lab and parent report measures of inhibitory control, White et al. (1994) distinguished Cognitive Impulsivity (for the lab tasks) and Behavioral Impulsivity (for parent reports). The current study finds a similar inhibitory control distinction and expands the literature by finding that emotion regulation facilitates the inhibition of a predominant response (i.e., behavioral impulsivity) but is not beneficial in choosing and activating a more appropriate response (i.e., cognitive impulsivity).

Among the various analyses and reporters, one common finding that needs further discussion is why children with better emotion regulation skills in toddlerhood had higher initial rates of sustained attention and inhibitory control, but contrary to expectations did not have higher rates of growth in both executive functions across time. For sustained attention, it is important to acknowledge the possibility that this lack of effect in terms of the rate of change was a function of the lab measure of sustained attention becoming too easy. Evidence for this comes from examining the variability in children's performance in the lab task for sustained attention. At 2 years of age, the graph (Figure 3) clearly shows a wide range of variability in children's performance. However, as children got older the variability of the task became smaller and by 5.5 years of age most children were able to sustain their attention during the entire task, which was about 5 minutes. Future studies may be able to address this issue by making the task longer. Lab tasks that are conducted in early childhood such as the continuous performance tests are typically about 15 minutes long (Anastopoulos & Shelton, 2001; Corkum & Siegal, 1993). However, the inability to use the same continuous performance task in earlier ages has prevented researchers from examining developmental trajectories, which necessitate the same tasks across time. The fact that the current study was able to find various initial effects using simply an attention to video task is encouraging and suggests that perhaps this type of design, while making it 15-20 minutes longer, may be useful with older children.

An explanation that encompasses both the sustained attention and inhibitory control lack of findings in terms of the rate of growth comes from a sensitive period perspective. The research literature across species and domains (motor and visual circuitries) have clearly documented that early experience tends to have a higher degree of influence on the development of physiological systems compared to later experiences

(Bornstein, 1989; Colombo, 2004). It may be that both intrinsic and extrinsic influences on human's attentional control system are most sensitive during the first couple of years of life. Theoretical work has hypothesized that early attentional abilities may restructure the central nervous system and long term development (Colombo, 2004). Additionally, EEG data has indicated a rapid growth in neuronal mylenation during the first 2 years of life in brain areas that have been found to be related to attentional control such as the orbitofrontal cortex (Diamond & Doar, 1989; Espy, 1997; Thatcher, 1991). Consistent with these physiological findings and theoretical work, the current study found greater variability in sustained attention during initial status (i.e. 2 years of age). Greater development in inhibitory control during the first 2 years of life has also been well documented (Rothbart, Ziaie, & Boyle, 1992; Kochanska, Murray, Jacques, & Koenig, 1996; Posner & Rothbart, 2000). Thus, it may be that individual differences in attentional control are most readily seen within the first two years, a period of rapid neuronal growth. A leveling off period thereafter occurs when individuals show similar steady growth in attention control. This may indicate that although a toddler with attentional control difficulties at two years of age will steadily improve his or her "hot" EF, he or she will not necessarily "catch up" with his or her peers by kindergarten as the peers will also be improving over time.

In summary, although the current study did not find evidence that better emotion regulation skills increase the developmental trajectory of the "hot" EF of attentional control, better emotion regulation skills does appear to provide a higher starting point for attentional control abilities. One mechanism by which emotion regulation skills facilitate the use of attentional control entail a shared neuronal circuitry, in particular in the anterior cingulate cortex (ACC) and the orbitofrontal cortex. For successful emotion regulation in children, the rostral region of the ACC is activated in conjunction with activation in the orbitofrontal cortex and dorsolateral prefrontal cortex and along with an inhibitory effect on the amygdala (the region that first detects the arousal or emotion). The current study's findings provide evidence that a child who is successful in navigating both physiological systems during internal emotional states is also able to implement such attention and inhibition during non-emotional and more cognitive situations.

Finally, when taking into account maternal and/or teacher reports, the benefits of emotion regulation as it relates to inhibitory control, in particular, seems to be more important for girls. Both teachers and mothers rated girls as having better inhibitory control compared to boys, which is consistent with previous research (Groot et al., 2004). It may be that the socialization of girls' behaviors provides an avenue for better inhibitory control whereas boys are more likely to be accepted when engaged in rough behavior. The socialization of such behavior may be more likely to occur during emotional situations (Andersson, Sonnander, & Sommerfelt, 1998; Underwood, Coie, & Herbsman, 1992). Thus, a girl with better emotion regulation skills during a socialization interaction with her mother may be able to comply with the socialization demands better and consequently develop better inhibitory control in other situations. Boys, on the other hand, are less likely to be socialized into compliance and thus their emotion regulation may not be as clearly linked to their inhibitory behaviors.

Maternal behaviors and "hot" executive functioning development

Maternal behavior, specifically scaffolding, is perhaps the most widely studied factor thought to facilitate children's cognitive development (Vygotsky, 1978; Wood & Middleton, 1975). A major limitation in the research on the role of maternal behavior in children's cognitive development is that most studies have focused on general measures of cognitive function such as IQ. The current study extended such research by examining the effects of positive maternal behavior (warmth and responsiveness) and negative maternal behavior (overcontrol/intrusiveness, hostility) on the trajectories of children's sustained attention and inhibitory control from toddlerhood through the early childhood period. It was hypothesized that positive maternal behavior would be positively related to the developmental trajectory of both sustained attention and inhibitory control whereas negative maternal behavior would be negatively associated with such trajectories.

As hypothesized, negative maternal behavior characterized by overcontrol/intrusiveness was negatively associated with the initial status of sustained attention at 2-years of age as measured in the lab. As discussed earlier the lack of variability in the sustained attention lab task over time prevented a rate of change effect although there was some evidence that children whose mothers engage in such negative behavior improved over time. This is likely a ceiling effect as children whose mothers did not engage in such negative behavior were already displaying such high levels of sustained attention that they did not have room to grow. The negative effects of maternal overcontrol/intrusiveness were particular negative for minority children. This finding contradicts previous research suggesting that a more firm assertive parental behavior is adaptive for minority children (Chao, 2001; Darling & Steinberg, 1993). Minority children in general had lower levels of sustained attention as measured in the laboratory at 2-years. In fact, the significant interaction with maternal overcontrol/intrusiveness was a function of a small number of minority families (n = 5) who were low, meaning 1 standard deviation below the mean, in such dimension. Thus, it appears that the adaptability of maternal overcontrol for minority children does not apply to attentional skills but may in fact be more beneficial for other areas such as behavioral compliance. The finding that minority children obtained lower scores in the lab task of attention is consistent with previous research (Kohl et al., 2000; Mao, 1995) suggesting that families of minority children may not focus on activities that promote attention (such as academic behaviors) and instead focus more on compliance. Minority families' focus on compliance may explain why their children have similar inhibitory control rates compared to Caucasian children as compliance involves one's ability to stop a prepotent response or behavior (Fox and Calkins, 2003).

Maternal overcontrol/intrusiveness also negatively predicted inhibitory control as measured in the lab at 5.5-years of age but not as reported by teachers or parents. Once again this may be a function of the task demands. As stated earlier, inhibitory control as reported by teachers and parents relied on impulsivity items in which the reporter is judging the child's ability to withhold a motor or verbal response whereas the Stroop task has a higher cognitive loading as it entails an additional activation of an appropriate response (Rueda, Posner, & Rothbart, 2005). Mothers who are high on overcontrol tend to be intrusive in their interactions with their children. They will typically interrupt their children's behavior either physically or by telling them that they are not doing something right. This aspect of their behavior may not be detrimental to their children and may even help some children inhibit impulsive motor behaviors. This may explain the lack of associations between maternal overcontrol/intrusiveness and inhibitory control as measured by parents and teachers. On the other hand, mothers who are high on overcontrol are less likely to teach their children the appropriate behaviors to engage in as they may be focusing on what their children should not do rather then what they should do. This type of behavior may explain the current study's finding that children who had mothers with high levels of overcontrol/intrusiveness struggled with the Stroop task as they had not been highly socialized into carefully selecting an alternative solution to a problem.

In terms of positive maternal behavior, maternal warmth and responsiveness significantly predicted better inhibitory control as measured by the Stroop task at age 5.5. Consistent with the notion of scaffolding, maternal behavior characterized by positive affect and appropriate responsiveness encourages children not only to respond to the demands of the situation but also allows them to independently learn how to solve problems. Previous research on the benefits of maternal scaffolding behavior had focused on planning abilities or general cognitive measures (Wood & Middleton, 1975). The current study's findings extend previous research and indicate that toddlers who have mothers who interact with them in a positive and responsive manner, even in non-teaching situations, tend to have better inhibitory control abilities once they are in kindergarten. Positive maternal behavior was not associated with inhibitory control as reported by parents. When examining teacher report, however, maternal positive behavior was associated with better inhibitory control, but only for girls. As mentioned earlier, inhibitory control as measured by teachers and parents focused more on impulsive behaviors. The question becomes why none of the analyses found an effect of maternal behavior on the development of impulsivity for boys.

Impulsivity has been well documented through twin and adoption studies as having high genetic heritability (Eysenck, 1993; Seroczynski, Bergeman, & Coccaro, 1999). Animal studies have also been conducted suggesting high genetic transmission rates of impulsive behaviors (Fairbanks et al, 2004; Fairbanks et al., 1999; Groot et al., 2004; Highle et al., 1996). From these genetic studies, it has been suggested that maternal behaviors are unlikely to affect the development of impulsivity (Gilby, Thorne, Patey, & McIntyre, 2007). However, most of the past human twin studies as well as animal studies have focused on males, as they tend to have disproportionate difficulties with impulsivity (Fairbanks et al., 2004, Gilby et al., 2007). Additionally, it has been recently documented that the neural mechanisms of genetic risk for impulsivity are far more prevalent in males than females (Meyer-Lindenberg et al., 2006). These lines of evidence are consistent with the current study's lack of findings linking maternal behavior to impulsivity, specifically for boys. Thus, it may be that boys' impulsivity is largely due to genetic factors with little influence coming from external sources such as parenting behavior. On the other hand, the current study's finding that maternal warmth and responsiveness predicted less impulsivity in kindergarten for girls is novel. It is interesting to note that one of the few animal studies to use only females found a similar result to the current study. Specifically, Lovic and Fleming (2004) found that maternal behaviors such as 'maternal-like licking' stimulation had a significant and positive effect on female rat's inhibitory abilities later in life. These preliminary findings may indicate that girls at high risk for impulsivity problems may be more amenable to environmental interventions compared to boys.

Positive maternal behaviors had no main effect on the development of children's sustained attention as measured in the laboratory or by parent or teacher report. Maternal education, on the other hand, had a significant effect on children's initial sustained attention status as measured in the laboratory as well as children's sustained attention in kindergarten (as reported by teachers). Maternal education also significantly predicted children's inhibitory control abilities as measured in the laboratory at 5.5-years of age. The current study used maternal education as a rough measure of children's intelligence at 2-years of age. Not surprising and consistent with previous research, children's intelligence estimates were predictive of their "hot" EF of attentional control development. The association of intelligence and attentional control along with a lack of findings linking positive maternal behaviors to the development of sustained attention further supports the notion that the development of attention highly depends on the maturation of the prefrontal cortex and related areas such as the anterior cingulate cortex (Polderman et al., 2007; Posner, 2004).

Finally, it is important to note that maternal self-report symptoms of AD/HD had a significant effect on the initial status of children's sustained attention and inhibitory control, as reported by mothers. However, these findings may be attributed to a shared method variance as no effect was found when examining lab or teacher reports. Mothers with high levels of AD/HD symptoms likely suffer from significant stress and potential executive function deficits, which may make it difficult for them to accurately report on their children's behaviors. Given that the genetic vulnerability of various disorders have gained recent attention in the media, it may also be the case that mothers may see some of their behaviors in the children and automatically assume they may be having similar difficulties.

In summary, it appears that negative maternal behavior characterized by overcontrol/ intrusiveness is consistently detrimental to children's sustained attention and inhibitory control whereas positive maternal behavior (i.e., warmth/responsiveness) appears to be only positive for inhibitory control. It is likely that the mechanism by which positive maternal behavior contributes to children's inhibitory control development is motivation to please one's caretaker. Specifically, complying to a caretaker's request is a skill that inherently necessitates inhibitory control as the child must stop what they are doing and engage in a more desired action. A mother's warm tone of voice may be viewed as motivation for the toddler to act while the caretaker's appropriate responses (either praising good behavior or redirecting for better compliance) could be viewed as a natural reinforcer. Over time, the interplay between mother and child facilitates the development of the child's inhibitory skills and eventually becomes internalized into the child's behavioral repertoire. Once internalized, the child can then apply his or her inhibitory control skills to other situations. This type of skill internalization is similar to how children learn other skills such as planning, problem solving, and emotion regulation (Calkins, 2007; Cassidy, 1994; Wood & Middleton, 1975).

Sustained attention, on the other hand, does not seem to be affected by positive maternal behavior. There is likely less structured opportunities for parents to use their behaviors (i.e., positive affect and responsiveness) to reward children's sustained attention while at the same time a significant portion of sustained attention development may be due to maturation. Although, one may not be able to facilitate sustained attention development, maternal overcontrol/intrusiveness clearly emerged as a maternal behavior that can interfere with not only sustained attention development but also with inhibitory control development. This is consistent with Sandra Scarr's (1992) evolutionary idea that only negative environmental experiences that fall out of the average range of the species will have a detrimental effect on a child's development with no benefits coming from variation of a normal environmental experience (i.e., warmth). Thus, maternal overcontrol/intrusiveness may be a significantly negative environmental experience for the child to cause it to disrupt the child's ability to create his or her own environment (i.e., mature). The disruption of the child's creation of his or her own environment by a mother who is consistently nagging her child or interfering with her child's independence may interfere with various cognitive functions. Previous research in the aggression and temperament literature has found that maternal overcontrol/intrusiveness is particularly damaging to children's behavior (Brenner & Fox, 1998; Calkins, Hungerford, & Dedmon, 2004; Kochanska, 1997). The current study expands the literature by finding evidence that maternal overcontrol/intrusiveness also has negative effects on sustained attention and inhibitory control development.

Emotion regulation and maternal behavior interactions

As early as Thomas and Chess (1977), the field of developmental psychology has recognized the importance of understanding how a child's temperament interacts with his or her environment, most notably parental behavior, to predict an outcome. The study of such interactions or what has been called the "goodness of fit" has mainly focused on predicting externalizing problems (see van Aken, Junger, Verhoeven, van Aken, & Dekovic, 2007 for a review), moral behavior (Kochanska, 1997), and emotion regulation (Calkins, 2002; Calkins, 2004; Dennis, 2006; Gillion et al., 2002). More recently, Caspi and Moffit (2006) outlined the importance of examining gene-environment interactions and provided data showing that negative environmental factors have differential influences on children's development depending on children's genotype. Extending such gene-environment interactions to the current study, it was hypothesized that toddlers who have mothers who interact with them in a hostile and/or overcontrolling manner and/or have low levels of warmth and responsiveness will be less likely to later have deficits in sustained attention and inhibitory control if they have higher levels of emotion regulation skills.

The current study found some significant interactions between emotion regulation and maternal behaviors in the prediction of later sustained attention and inhibitory control. However, these interactions were only found for teacher reports of "hot" EF and were significant only for girls. With that in mind, emotion regulation was found to buffer the negative effects of low maternal warmth/responsiveness on sustained attention with no effect present with girls who had mothers with high levels of warmth/responsiveness. On the other hand and counter to my hypotheses, emotion regulation did not buffer the negative effects of maternal hostility on sustained attention and inhibitory control. Rather, the effect of emotion regulation on both executive functions was only evident for girls who had mothers with low levels of hostility. Thus, when high levels of maternal hostility were present, emotion regulation no longer had a significant effect on girls' sustained attention or inhibitory control.

These lines of evidence may indicate that girls with higher emotion regulation skills can overcome lack of positive parenting behavior in the service of their attentional control development. However, under harsher parenting conditions such as maternal hostility the benefits of their regulation are no longer as viable. It is likely then that girls' regulatory abilities allow them to continue to function independently through an internal motivational system that is not solely relying on the caretaker for support via warmth/responsiveness interactions. However, once the caretaker engages in more intrusive and hostile behaviors towards the girls, their own regulatory abilities cannot buffer them from such negative effects. It is difficult to explain why no buffering effect would occur for boys. Given that boys tend to have more "hot" executive functioning deficits (Barkley, 2003; Maitland, Intrieri, Schaie, & Willis, 2000), one would think that they would have more opportunities to develop protective factors. Once again, it may be that because the genetic heritability for boys is stronger than girls (Meyer-Lindenberg et al., 2006), they are less likely to benefit from environmental buffers.

The lack of buffering effects for emotion regulation on the more intrusive/hostile maternal behaviors is likely a function of a yet to be fully developed emotion regulation system. Early emotion regulation development relies heavily on parenting as an external resource to deal with stressful situations (Calkins, 2007; Calkins & Johnson, 1998; Rothbart & Derryberry, 1981; Fox & Calkins, 2003). However, as children get older they develop their own internal resources to deal with stressful events (Posner & Rothbart, 2000). Consequently, I expect that as children get older and learn their other strategies such as cognitive reappraisal to deal with harsher emotional situations, a buffering effect of emotion regulation would then be more prevalent.

Overall summary of findings and limitations

The purpose of the current study was to examine the role of emotion regulation and maternal behaviors on the development of children's attentional control, consisting of sustained attention and inhibitory control. First, the HLM analyses revealed significant growth in both sustained attention and inhibitory control across the toddlerhood and early childhood period. Second, the current study found that emotion regulation is a significant predictor of toddler's initial sustained attention abilities but did not predict differential growth in sustained attention abilities. The current study's use of multiple reporters also allowed an important distinction in the relation between emotion regulation and inhibitory control that has not been reported in the literature. Specifically, early emotion regulation predicted the development of children's ability to withhold a prepotent response as reported by impulsivity items on the AD/HD Rating scale. However, emotion regulation did not predict performance in a higher cognitive task (i.e., Stroop task) that required an additional activation of an appropriate response.

In terms of the contribution of early maternal behaviors, maternal overcontrol/ intrusiveness as well as maternal warmth/responsiveness were significant predictors of inhibitory control as measured in the laboratory. Maternal warmth/responsiveness also predicted the more impulsive component of inhibitory control (measured by teacher reports) for girls but not for boys. There was less evidence of maternal behaviors affecting children's sustained attention development although maternal overcontrol/intrusiveness had an effect on minority children's initial sustained attention levels. Finally, although the interactions discussed in the previous section provided some evidence for the goodness of fit model as it relates to the development of attentional control, they were limited. Additionally, given the high number of interactions that were tested (18), finding only 3 significant interactions calls into question their validity. Thus, despite a well documented bidirectional relation between emotion regulation and maternal behaviors, the current study finds evidence that they provide independent contributions to the development of attentional control.

In terms of this study's limitations, a couple of methodological issues need to be acknowledged. First, the lab measure of inhibitory control was not available at all time points preventing a trajectory analysis. Second, the lab measure of sustained attention became too easy as children got older limiting the variability of scores. This decreased variability in later time points may explain the lack of significant predictors in the slope or growth rate of sustained attention. In addition, the validity of the laboratory measure of sustained attention remains untested. It would be important for future studies to determine whether children's performance on this laboratory task map onto other established laboratory measures of sustained attention such as the continuous performance tests (CPT) as well as other maternal reports of attention such as the attention focusing subscale of the Child Behavior Questionnaire (CBQ). It is also important to acknowledge the potential influence of overall behavior problems on measurements of attention, especially maternal report. For example, items on the Inattention subscale of the AD/HD Rating scale such as "does not listen" and "does not follow directions" may capture children that are engaging in oppositional behaviors rather than children who are having sustained attention difficulties. Consequently, future research using maternal reports should control for children's behavior problems to ensure a more precise measurement of sustained attention. Finally, the predictors (emotion regulation and maternal behaviors) were time invariant meaning that they were assessed at the initial time point. For the HLM analyses this assumes that such constructs are stable across time. Since emotion regulation abilities are also growing during this developmental period, a model that takes into account such dynamic changes by having multiple measures of emotion regulation across time would provide answers to other potentially interesting questions. For example, does emotion regulation growth or stability predict better sustained attention and/or inhibitory control development? Another important limitation to acknowledge of having time invariant predictors is the inability to determine the directionality of their associations. Thus, although the maternal behaviors and emotion regulation skills were measured at an early point in life, it is plausible to argue that they are a reaction or consequence of children's earlier attentional control abilities. Future studies may be able to address the directionality of their associations by examining whether changes in the trajectories of maternal behavior or emotion regulation overtime directly map onto changes in attentional control.

Despite these limitations, the current study contributed to the literature in two important ways. First, this study's use of hierarchical linear modeling established growth in attentional control, both in sustained attention and inhibitory control, from the toddlerhood to the early childhood period. This was a unique finding as most research had focused on growth during infancy or during school age. It also suggests that implementing interventions during the toddlerhood period, prior to this rapid growth in attentional control, may be helpful for toddlers with initial difficulties, instead of waiting until the preschool period or entrance to formal schooling. Second, the current study showed that although sustained attention and inhibitory control have significant biological maturational influences, their etiology may also involve external factors such as maternal behaviors (in particular negative overcontrolling/intrusive behavior) as well as temperamental factors such as emotion regulation. These results are not surprising given that empirically supported interventions efforts for children with AD/HD and/or aggression (who are assumed to lack inhibitory control abilities) focus not only on biological methods (i.e., medication) but also behavioral interventions (i.e., parent training, parent-child interaction therapy, behavior modification). Future research should aim to examine how early maternal behaviors and emotion regulation interact with physiological maturation of the prefrontal cortex to predict executive functioning development. This type of research is currently being conducted with animal models with intriguing findings on how early maternal behavior has a neurobiological affect on dopamine pathways important for the development of attention (Hall, Wilkinson, Humby, & Robbins, 1999; Lovic & Fleming, 2004). Such research has also suggested that this type of environmental affect on neurobiological pathways has a sensitive period in animals. It would be important to determine if such sensitive period occurs with humans as it would indicate that maternal behaviors are particularly important in the first couple of years of life.

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APPENDIX A: GROWTH CURVE MODELING EXPLANATION

Growth curve modeling can consist of four types of variables: the outcome measure, a measure of time, one or more time-varying predictors, and one or more time-invariant predictors (Singer & Willet, 2003). The outcome measure is the dependent variable of interest that changes over time. In this study, it refers to sustained attention and inhibitory control. Time invariant predictors can influence the growth trajectories but do not change over time as they are measured at only one time point. In this study, maternal behavior (warmth/responsiveness, overcontrol/intrusiveness, and hostility) and children's emotion regulation at 2 years of age will be our time invariant predictors.

Typically, growth curve models are expressed as two-level models. Level 1 refers to time varying predictors that change within persons over time whereas time invariant predictors are referred to as between person variables and reside at Level 2. The Level 1 model represents the estimated within-person change over time for the outcome variable, and the effect of time-varying predictors on this change (Singer & Willet, 2003). The notation for this model as it relates to this study is: $Y_{ij} = \Pi_{0i} + \Pi_{1i}TIME_{ij} + \epsilon_{ij}$. Y_{ij} is sustained attention or inhibitory control for person i at time j, $TIME_{ij}$ is the value of time for person i at time j, Π_{0i} is the initial status, for person i or the value of Y when time is zero, Π_{1i} is the rate of change or the slope of the linear trajectory of person i, and ϵ_{ij} is the within-person error term. The level 1 model also estimates the variance of this error term. When this variance is large, it suggests that additional Level 1 predictors may improve the fit of the model.

At Level 2, the parameters estimated at Level 1 are the outcome variables of new equations, in which time-invariant variables are the predictors. In this study, the time invariant variables are emotion regulation, maternal warmth/responsiveness, maternal overcontrol/intrusiveness, and maternal hostility. The following equations represent the Level 2 model:

$$\Pi 0i = \gamma 00 + \gamma 01REG + \gamma 02MWR + \gamma 03MOC + \gamma 04MHOS + \zeta 0i$$

$$\Pi 1i = \gamma 10 + \gamma 11REG + \gamma 12MWR + \gamma 13MOC + \gamma 14MHOS + \zeta 1i$$

In this model, REG (children's emotion regulation), MWR (maternal warmth/responsiveness), MOC (maternal overcontrol/intrusiveness), and MHOS (maternal hostility) represent the four time-invariant predictors. The Level 2 intercepts $\gamma 00$, $\gamma 10$ are the estimates of the two Level 1 parameters: $\Pi 0i$ (intercept) and $\Pi 1i$ (slope) when all time invariant predictors are zero. In this model, $\gamma 01$, $\gamma 11$ represent the effects of emotion regulation, $\gamma 02$, $\gamma 12$ represent the effects of maternal warmth/responsiveness, $\gamma 03$, $\gamma 13$ represent the effects of the maternal overcontrol/intrusiveness, and $\gamma 04$, $\gamma 14$ represent the effects of maternal hostility. Lastly, the error terms, $\zeta 0i$ and $\zeta 1i$, represent individual differences in the Level 1 parameters that are not explained by the Level 2 predictors. The variances and covariances of these error terms are also estimated in the model. A large error variance for a dependent variable indicates that the prediction of that variable may be improved with the addition of another between-person variable.

APPENDIX B: TABLES

Table 1.

Descriptive statistics for all variables

	M	SD	Min	Max	N
2yr Measures					
Maternal education (P)	3.41	.98	1	5	447
Maternal self-report symptoms of AD/HD (P)	10.60	7.48	0	36	216
Maternal warmth (L)	3.07	.75	1.17	4	428
Maternal responsiveness (L)	3.18	.67	1.17	4	428
Maternal overcontrol/intrusiveness (L)	2.36	.61	1	4	428
Maternal hostility (L)	1.04	.13	1	2.67	428
Emotion reactivity (L)	.79	.89	0	4	423
Emotion regulation (L)	3.27	.89	0	4	423
Sustained attention (L)	.80	.18	.16	1	422
Sustained attention (P)	.79	.14	.33	1	394
Inhibitory control (P)	.70	.18	0	1	394
4yr Measures					
Sustained attention (L)	.91	.09	.41	1	357
Sustained attention (P)	.79	.17	0	1	376
Inhibitory control (P)	.71	.19	0	1	372
5yr Measures					
Sustained attention (L)	.93	.08	.56	1	287
Sustained attention (P)	.80	.17	0	1	324
Sustained attention (T)	21.89	6.18	0	27	270
Inhibitory control (L)	42.55	7.31	19	48	333
Inhibitory control (P)	.73	.21	0	1	321
Inhibitory control (T)	6.96	2.37	0	9	270

(P) = parent report, (L) = laboratory measure, (T) = teacher report

Table 2.

Correlations among predictors

Variable	1	2	3	4	5	6
1. Maternal Education (P)	-					
2. Maternal Self-Report Symptoms of AD/HD (P)	.03	-				
3. Emotion Regulation (L)	-.02	-.02	-			
4. Maternal Responsiveness/Warmth (L)	.35***	.01	.03	-		
5. Maternal Overcontrol/Intrusiveness (L)	-.26***	-.07	-.12*	-.29***	-	
6. Maternal Hostility (L)	-.13**	.14*	-.08+	-.34***	.24***	-

(P) = parent report, (L) = laboratory measure, +p<.10, *p <.05, **p<.01, ***p<.001

Table 3.

Results of model test for the UMM and UGM for sustained attention

	Par	Laboratory Measure Model A (UMM)	Laboratory Measure Model B (UGM)	Maternal Report Model A (UMM)	Maternal Report Model B (UGM)
Fixed Effects Π0i					
Intercept	γ00	87.25*** (.46)	81.24*** (.791)	78.83*** (.65)	78.63*** (.69)
Slope Π1i					
Intercept	γ10		.362** (.026)		.02 (.02)
Random Effects (Variance Components)					
Level 1					
Within person	$\sigma^2 e$	181.47*** (10.01)	76.14*** (6.16)	120.63*** (6.51)	104.28*** (8.23)
Level 2					
In initial status	$\sigma^2 0$	18.55*** (7.29)	191.74*** (18.87)	130.65*** (12.45)	94.58*** (15.16)
In slope	$\sigma^2 1$		.144*** (.021)		.042* (.02)
Covariance	$\sigma^2 01$		-5.21*** (.585)		.739 (.42)
Fit Statistics					
Deviance		8665.94	8124.12	8902.56	8542.56
AIC		8671.94	8136.12	8908.56	8554.56
BIC		8686.85	8165.87	8923.55	8584.33

Note. +p<.09, *p<.05, **p<.01, ***p<.001. UMM = Unconditional means model, UGM = Unconditional growth model

Table 4.

Correlations between independent variables and sustained attention measures across time

	2yr SA (L)	2yr SA (P)	4yr SA (L)	4yr SA (P)	5yr SA (L)	5yr SA (P)	5yr SA (T)
Maternal Education	.23***	.01	.14**	.05	.07	.13*	.21***
Maternal self-report symptoms of AD/HD	.07	-.30***	.07	-.38***	.05	-.29***	-.08
Maternal warmth/ responsiveness	.21***	.00	.23***	.02	.19***	-.02	.14*
Maternal overcontrol/ intrusiveness	-.33***	-.04	-.18**	-.05	-.13*	-.08	-.16*
Maternal hostility	-.15**	-.09+	-.11*	.00	-.10+	-.03	-.03
Emotion regulation	.20***	.07	.15**	.15**	.08	.07	-.01

+p<.10, *p<.05, **p<.01, ***p<.001, SA = sustained attention, IC = inhibitory control, L = laboratory measure, P = parent report, T = teacher report

Table 5.

Results of final model test for the effects of temperament & maternal behaviors on sustained attention (laboratory measure)

	Par	Model A (UMM)	Model B (UGM)	Model C	Model D	**Model E**
Fixed Effects Π_{0i}						
Intercept	γ_{00}	87.25***	81.24***	75.87***	75.65***	75.63***
		(.46)	(.791)	(2.90)	(2.88)	(2.88)
Maternal Education	γ_{01}			2.26**	2.40**	2.40**
				(.783)	(.781)	(.781)
Race	γ_{02}			-6.74***	-5.99***	-5.99***
				(1.67)	(1.70)	(1.70)
Emotion Regulation	γ_{03}			2.67***	2.60***	2.61***
				(.763)	(.759)	(.758)
Maternal OC/I	γ_{04}			-5.22***	-2.77	-2.79+
				(1.31)	(1.69)	(1.69)
Emotion Regulation X Maternal OC/I	γ_{05}				.54	
					(1.09)	
Maternal OC/I X Race	γ_{06}				-5.84*	-5.90*
					(2.61)	(2.61)
Slope Π_{1i}						
Intercept	γ_{10}		.362**	.481***	.487***	.487***
			(.026)	(.10)	(.10)	(.10)
Maternal Education	γ_{11}			-.051+	-.055*	-.055*
				(.027)	(.027)	(.027)
Race	γ_{12}			.165**	.144*	.144*
				(.058)	(.059)	(.059)
Emotion Regulation	γ_{13}			-.06*	-.058*	-.058*
				(.026)	(.026)	(.026)
Maternal OC/I	γ_{14}			.146***	.082	.082
				(.045)	(.057)	(.057)
Emotion Regulation X Maternal OC/I	γ_{15}				-.008	
					(.037)	
Maternal OC/I X Race	γ_{16}				.156+	.158+
					(.09)	(.09)
Random Effects (Variance Components)						
Level 1						
Within person	$\sigma^2 e$	181.47***	76.14***	75.90***	75.95***	75.97***
		(10.01)	(6.16)	(6.24)	(6.25)	(6.25)
Level 2						
In initial status	$\sigma^2 0$	18.55***	191.74***	148.20***	144.90***	145.03***
		(7.29)	(18.87)	(16.14)	(15.95)	(15.95)
In slope	$\sigma^2 1$		.144***	.118***	.116***	.116***
			(.021)	(.02)	(.02)	(.02)
Covariance	$\sigma^2 01$		-5.21***	-4.11***	-4.03***	-4.03***
			(.585)	(.517)	(.511)	(.511)
Fit Statistics						
Deviance		8665.94	8124.12	7839.03	7833.43	7833.83
AIC		8671.94	8136.12	7867.03	7869.43	7865.83
BIC		8686.85	8165.87	7936.07	7958.20	7944.73

Note. +p<.09, *p<.05, **p<.01, ***p<.001. Maternal OC/I = maternal overcontrol/intrusiveness. UMM = Unconditional means model, UGM = Unconditional growth model

Table 6.
Regression analyses testing emotion regulation and maternal behaviors as predictors of children's sustained attention (reported by teachers) at 5.5yrs of age.

Predictor		β	R^2	R^2 Change	F Change
Boys (*n* = 118)					
Step 1.	Maternal Education	.13	.03	.03	3.02
Step 2.	Emotion Regulation	-.15	.06	.03	.832
	Maternal Warmth/Responsiveness	.04			
	Maternal Overcontrol/Intrusiveness	-.12			
	Maternal Hostility	.08			
Step 3.	Emotion Regulation X Maternal Warmth/Responsiveness	.16	.09	.03	1.33
	Emotion Regulation X Maternal Overcontrol/Intrusiveness	-.07			
	Emotion Regulation X Maternal Hostility	.11			
Girls (*n* = 139)					
Step 1.	Maternal Education	.27**	.08	.08	11.39***
Step 2.	Emotion Regulation	.13	.09	.01	.633
	Maternal Warmth/Responsiveness	.24*			
	Maternal Overcontrol/Intrusiveness	-.05			
	Maternal Hostility	-.01			
Step 3.	Emotion Regulation X Maternal Warmth/Responsiveness	-.23*	.17	.08	4.11**
	Emotion Regulation X Maternal Overcontrol/Intrusiveness	-.02			
	Emotion Regulation X Maternal Hostility	-.37***			

*p <.05, **p<.01,***p<.001.

Table 7.

Results of inhibitory control (maternal report) model test for UMM, UGM, and demographics

	Par	Model A (UMM)	Model B (UGM)	Model C	Model D	**Model E**
Fixed Effects Π0i						
Intercept	γ00	71.22*** (.77)	69.47*** (.87)	64.15*** (6.03)	73.93*** (2.06)	67.76*** (1.21)
Sex	γ01			3.10 (2.40)		
Socioeconomic Level	γ02			.08 (.15)		
Race	γ03			5.73* (2.75)	2.88 (2.22)	
Maternal Education	γ04			1.06 (1.56)		
Maternal AD/HD symptoms	γ05			-.622*** (.164)	-.664*** (.137)	-.687*** (.137)
Slope Π1i						
Intercept	γ10		.107*** (.03)	.21 (.22)	.167*** (.04)	.167*** (.04)
Sex	γ11			.08 (.09)		
Socioeconomic Level	γ12			.00 (.01)		
Race	γ13			-.14 (.10)		
Maternal Education	γ14			.04 (.06)		
Maternal AD/HD symptoms	γ15			.00 (.01)		
Random Effects (Variance Components)						
Level 1						
Within person (residual)	σ²e	201.14*** (10.88)	149.79*** (12.44)	142.74*** (15.73)	141.76*** (15.59)	141.64*** (15.57)
Level 2						
In initial status	σ²0	166.33*** (17.25)	163.93*** (24.61)	174.33*** (33.22)	181.51*** (33.72)	185.74*** (34.02)
In slope	σ²1		.141*** (.036)	.151*** (.05)	.161*** (.05)	.162*** (.05)
Covariance	σ²01		-.89 (.74)	-1.79 (.99)	-1.85 (1.01)	-1.93 (1.01)
Fit Statistics						
Deviance		9323.38	8936.66	4920.11	4930.83	4932.48
AIC		9329.38	8948.66	4952.11	4946.83	4946.48
BIC		9344.36	8978.39	5021.92	4981.73	4977.02

Note. +p<.09, *p<.05, **p<.01, ***p<.001. UMM = Unconditional means model, UGM = Unconditional growth model

Table 8.

Correlations between independent variables and inhibitory control measures across time

	2yr IC (P)	4yr IC (P)	5yr IC (P)	5yr IC (T)	5yr IC (L)
Maternal Education	.03	.04	.04	.07	.24***
Maternal self-report symptoms of AD/HD	-.29***	-.26***	-.24***	-.08	.08
Maternal warmth/ responsiveness	.04	.07	.02	.14*	.28***
Maternal overcontrol/ intrusiveness	-.02	-.13*	-.12*	-.13*	-.30***
Maternal hostility	-.06	-.04	-.02	-.05	-.09
Emotion regulation	.10*	.15**	.12*	.02	.00

+p<.10, *p<.05, **p<.01, ***p<.001, SA = sustained attention, IC = inhibitory control, L = laboratory measure, P = parent report, T = teacher

Table 9. *Results of final model test for the effects of temperament & maternal behaviors on inhibitory control (maternal report)*

	Par	Model A (UMM)	Model B (UGM)	Model C	Model D	**Model E**
Fixed Effects $\Pi 0i$						
Intercept	$\gamma 00$	71.22*** (.77)	69.47*** (.87)	69.51*** (6.60)	74.57*** (2.11)	74.98*** (1.87)
Maternal AD/HD Symptoms	$\gamma 01$			-.70*** (.16)	-.69*** (.17)	-.70*** (.14)
Emotion Regulation	$\gamma 02$			9.87 (6.85)	4.51* (2.03)	3.98* (1.70)
Maternal Responsiveness/Warmth	$\gamma 03$			1.48 (1.97)		
Maternal Overcontrol/Intrusiveness	$\gamma 04$			-2.92 (2.23)		
Maternal Hostility	$\gamma 05$			4.57 (4.51)	1.75 (4.29)	
Maternal AD/HD Symptoms X Emotion Regulation	$\gamma 06$			-.24 (.15)	-.28+ (.15)	-.26* (.12)
Emotion Regulation X Maternal Responsiveness/Warmth	$\gamma 07$			-1.46 (2.05)		
Emotion Regulation X Maternal Overcontrol/Intrusiveness	$\gamma 08$			2.93 (2.53)		
Emotion Regulation X Maternal Hostility	$\gamma 09$			-8.80+ (4.85)	-3.35 (3.98)	
Slope $\Pi 1i$						
Intercept	$\gamma 10$		.107*** (.03)	.25 (.24)	.19* (.08)	.17*** (.04)
Maternal AD/HD Symptoms	$\gamma 11$			.00 (.01)	.00 (.01)	
Emotion Regulation	$\gamma 12$			-.31 (.26)	-.03 (.07)	
Maternal Responsiveness/Warmth	$\gamma 13$			-.01 (.07)		
Maternal Overcontrol/Intrusiveness	$\gamma 14$			.07 (.08)		
Maternal Hostility	$\gamma 15$			-.24 (.17)	-.18 (.16)	
Maternal AD/HD Symptoms X Emotion Regulation	$\gamma 16$			.00 (.00)	.00 (.01)	
Emotion Regulation X Maternal Responsiveness/Warmth	$\gamma 17$			.09 (.08)		
Emotion Regulation X Maternal Overcontrol/Intrusiveness	$\gamma 18$			-.02 (.09)		
Emotion Regulation X Maternal Hostility	$\gamma 19$			.20 (.18)	.06 (.15)	
Random Effects (Variance Components)						
Level 1						
Within person	$\sigma^2 e$	201.14*** (10.88)	149.79*** (12.44)	144.23*** (16.07)	143.64*** (15.96)	142.62*** (15.77)
Level 2						
In initial status	$\sigma^2 0$	166.33*** (17.25)	163.93*** (24.61)	169.09*** (33.20)	176.54*** (33.71)	179.66*** (33.80)
In slope	$\sigma^2 1$		.141*** (.036)	.148** (.05)	.156*** (.05)	.164*** (.05)
Covariance	$\sigma^2 01$		-.89 (.74)	-1.58 (1.00)	-1.79+ (1.01)	-1.91+ (1.02)
Fit Statistics						
Deviance		9323.38	8936.66	4871.70	4877.56	4880.2
AIC		9329.38	8948.66	4919.70	4909.56	4898.2
BIC		9344.36	8978.39	5024.17	4979.20	4937.4

Note. +p<.09, *p<.05, **p<.01, ***p<.001 UMM = Unconditional means model, UGM = Unconditional growth model

Table 10.

Regression analyses testing emotion regulation and maternal behaviors as predictors of children's inhibitory control (reported by teachers) at 5.5yrs of age.

Predictor		β	R^2	R^2 Change	F Change
Boys (*n* = 118)					
Step 1.	Race	-.04	.01	.01	1.33
Step 2.	Emotion Regulation	-.14	.03	.02	.574
	Maternal Warmth/Responsiveness	.04			
	Maternal Overcontrol/Intrusiveness	-.12			
	Maternal Hostility	.01			
Step 3.	Emotion Regulation X Maternal Warmth/Responsiveness	.20	.08	.05	1.94
	Emotion Regulation X Maternal Overcontrol/Intrusiveness	-.04			
	Emotion Regulation X Maternal Hostility	.19			
Girls (*n* = 139)					
Step 1.	Race	-.16+	.04	.04	5.54*
Step 2.	Emotion Regulation	.18+	.06	.02	.865
	Maternal Warmth/Responsiveness	.22*			
	Maternal Overcontrol/Intrusiveness	-.07			
	Maternal Hostility	-.03			
Step 3.	Emotion Regulation X Maternal Warmth/Responsiveness	-.12	.15	.09	4.58**
	Emotion Regulation X Maternal Overcontrol/Intrusiveness	.05			
	Emotion Regulation X Maternal Hostility	-.40***			

+p<.08, *p <.05, **p<.01,***p<.001.

APPENDIX C: FIGURES

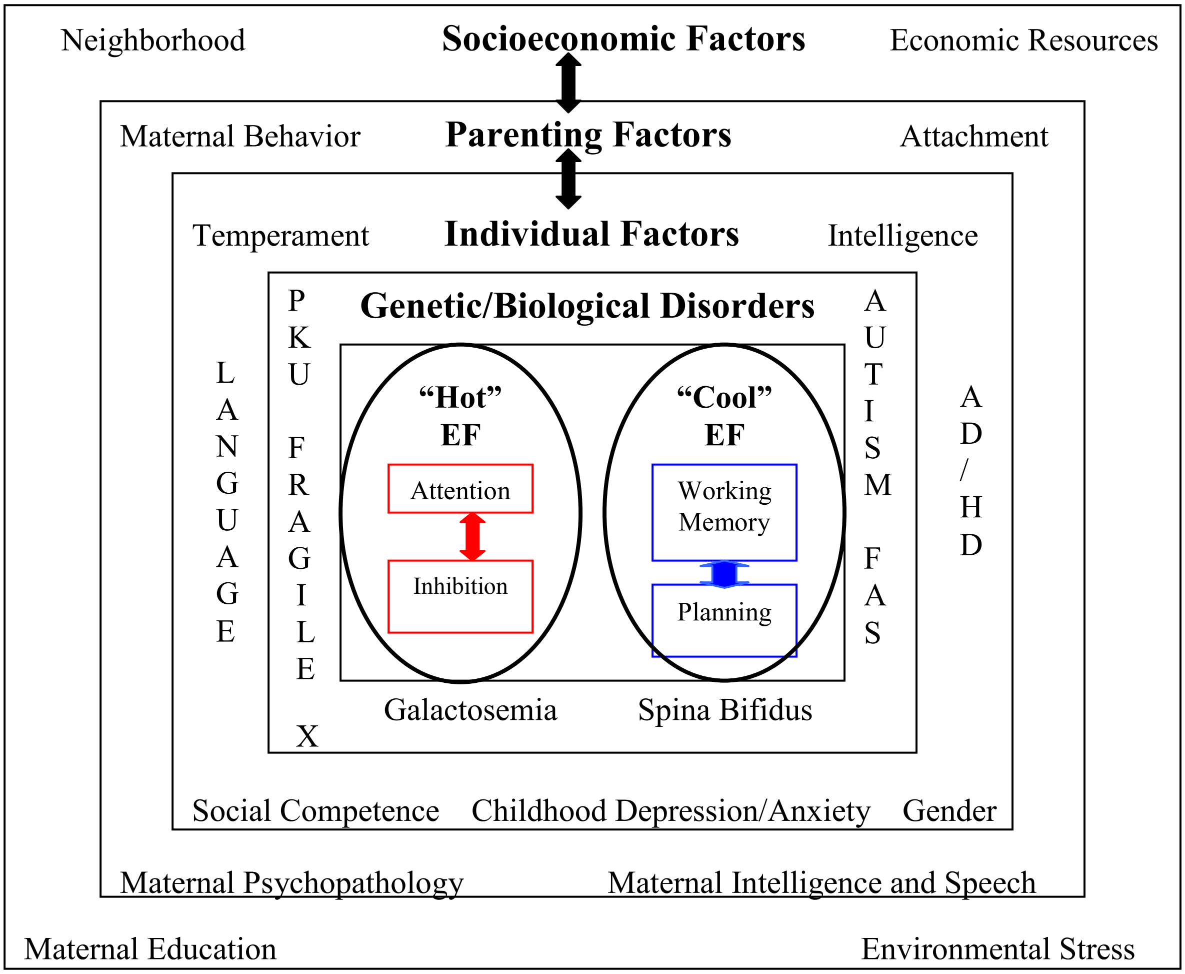

Figure 1. Integrated model on the environmental and biological factors that may affect the development of "hot" and "cool" executive functioning.

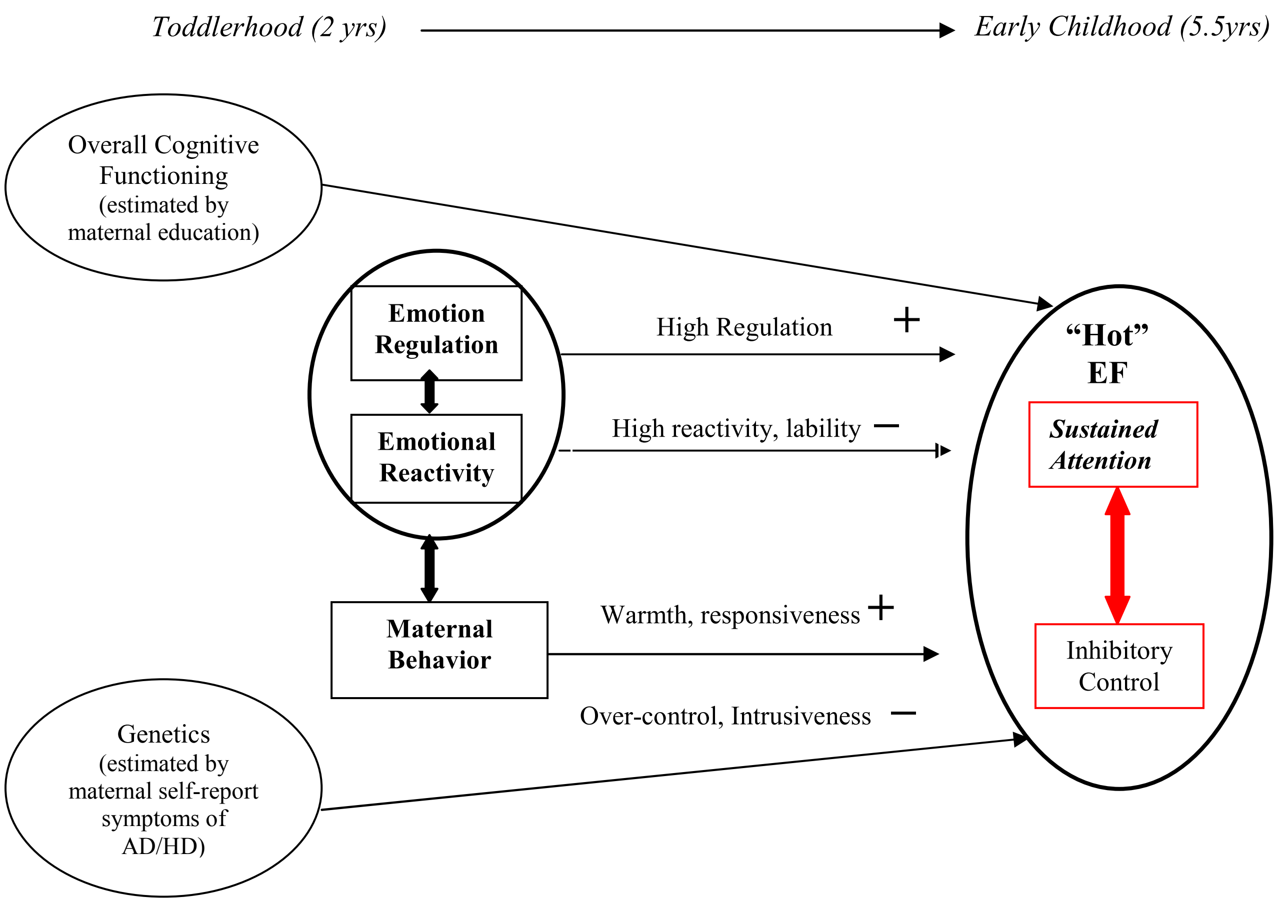

Figure 2. Integrated model on the early development of "hot" executive functions. *EF* = executive functioning.

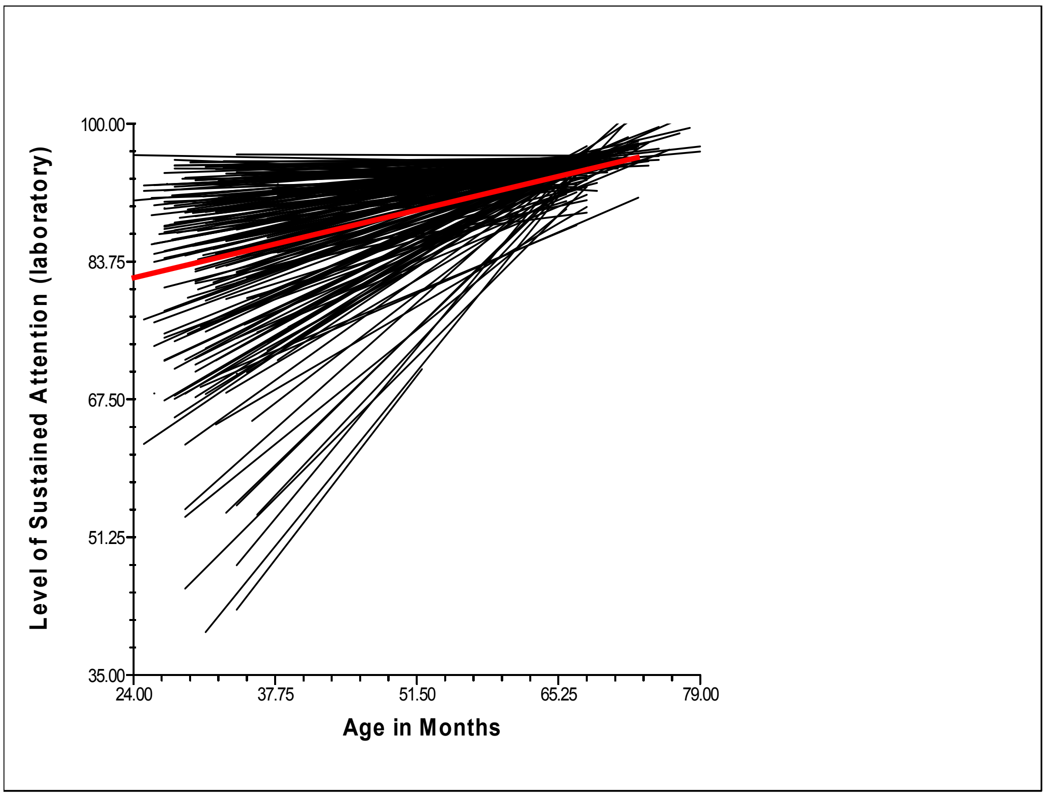

Figure 3. Unconditional growth model for sustained attention (laboratory)

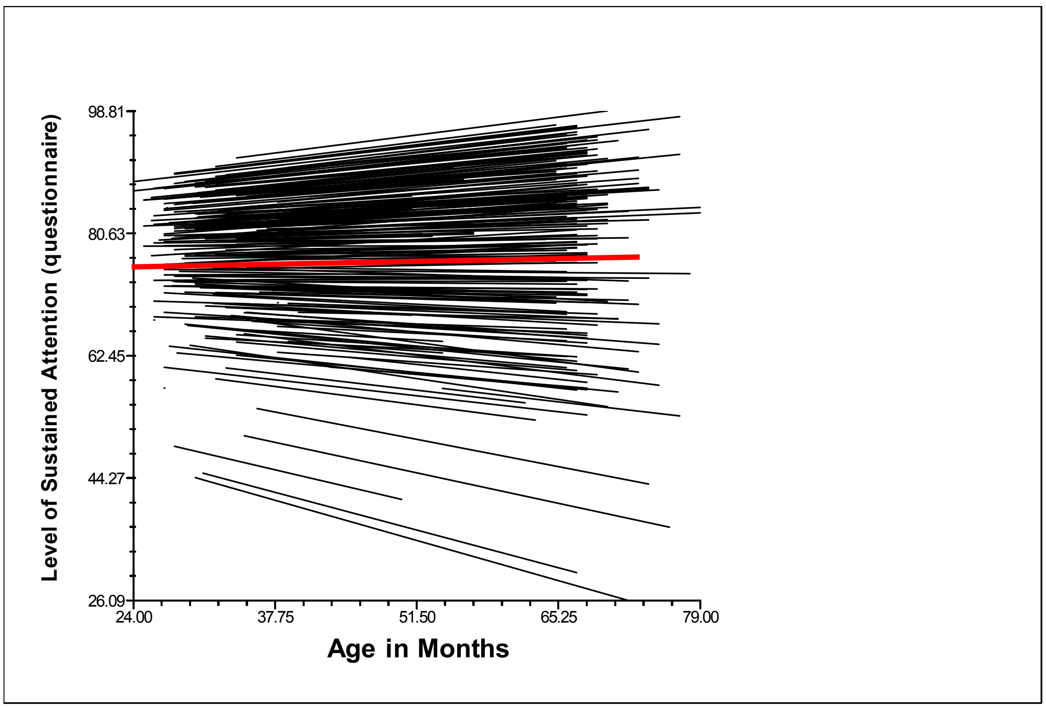

Figure 4. Unconditional growth model for sustained attention (maternal report)

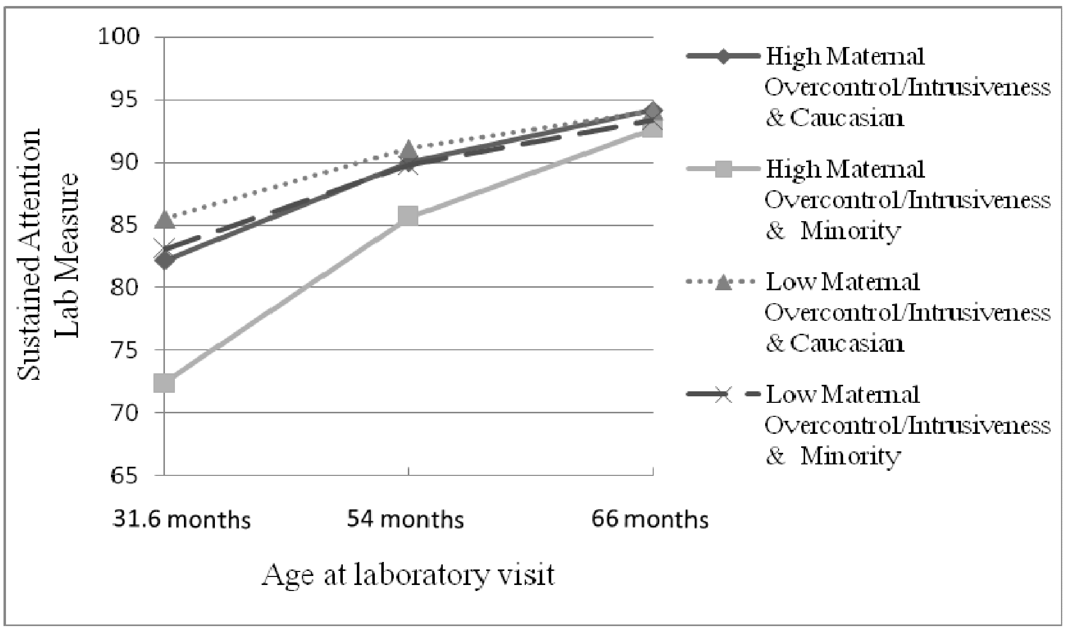

Figure 5. Protypical plot of the interaction between maternal overcontrol/intrusiveness and race

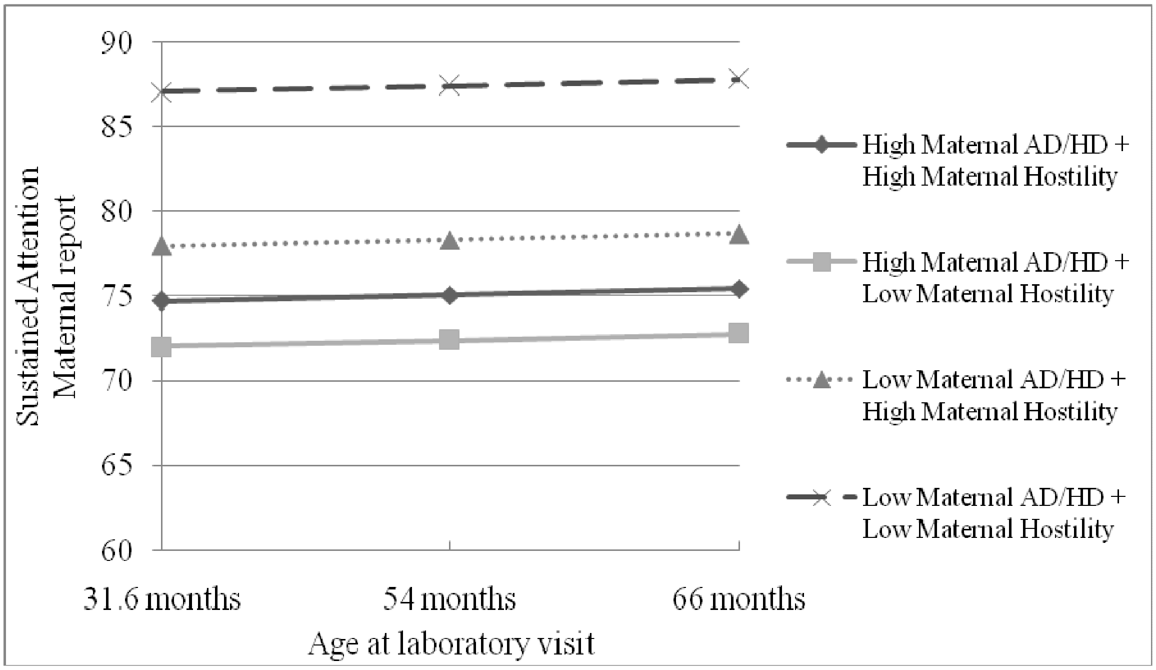

Figure 6. Protypical plot of the interaction between maternal hostility and maternal self-report AD/HD symptoms while controlling for gender.

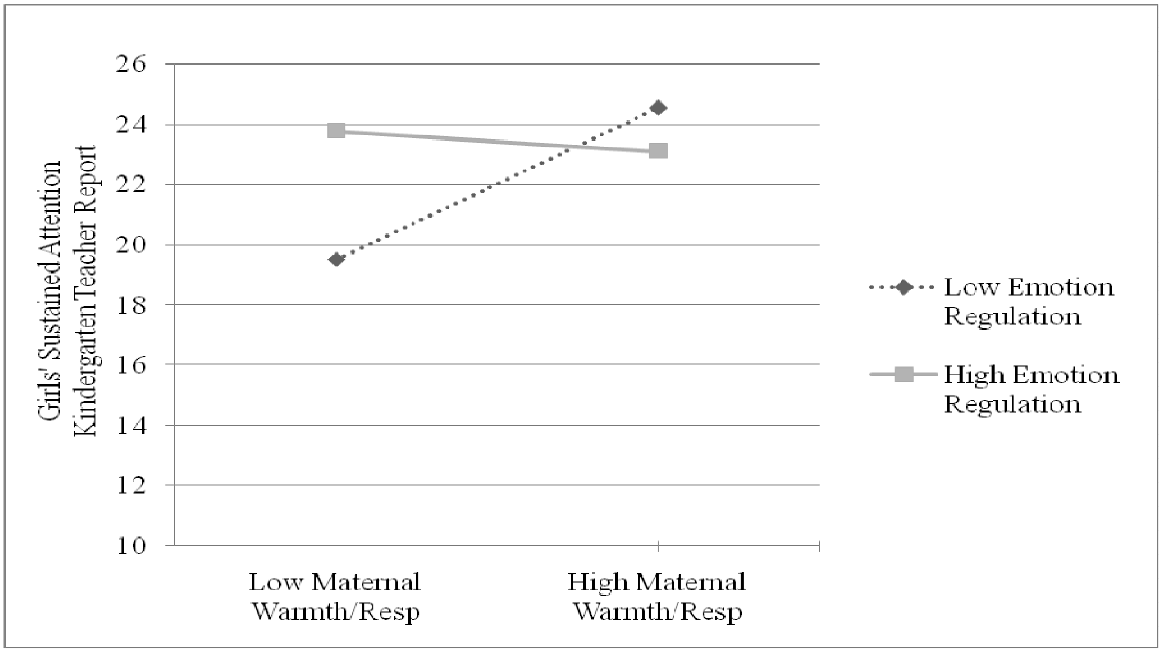

Figure 7. Interaction between emotion regulation and maternal warmth/responsiveness in the prediction of sustained attention in kindergarten.

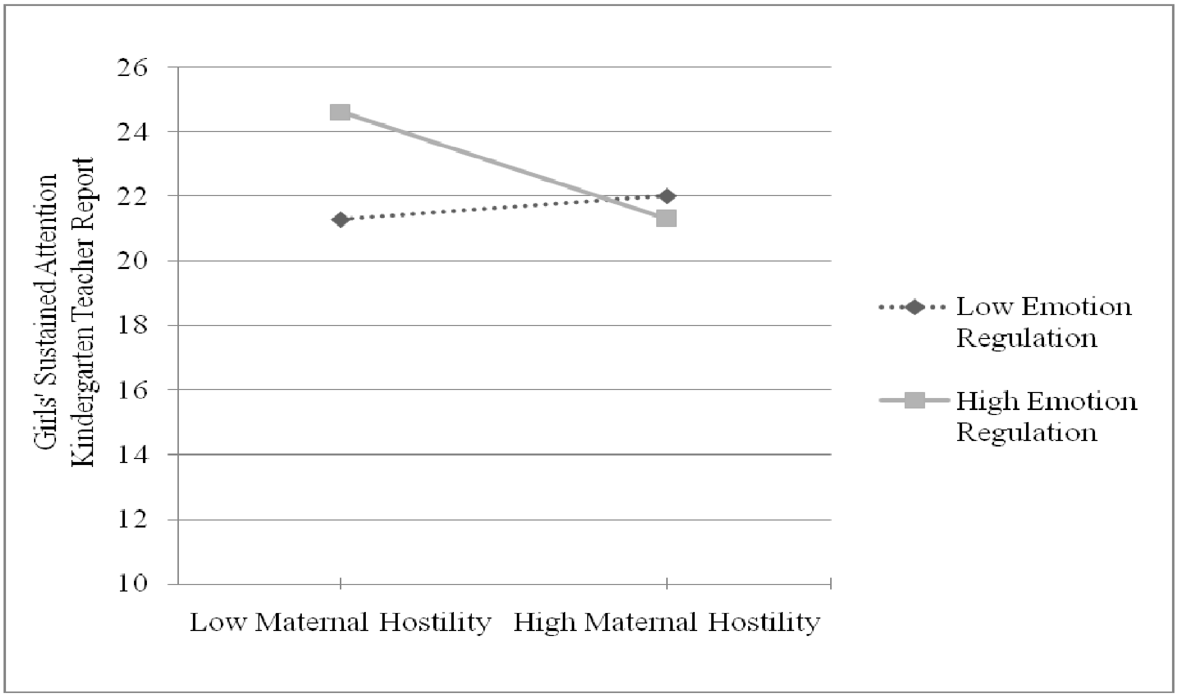

Figure 8. Interaction between emotion regulation and maternal hostility in the prediction of girls' sustained attention in kindergarten.

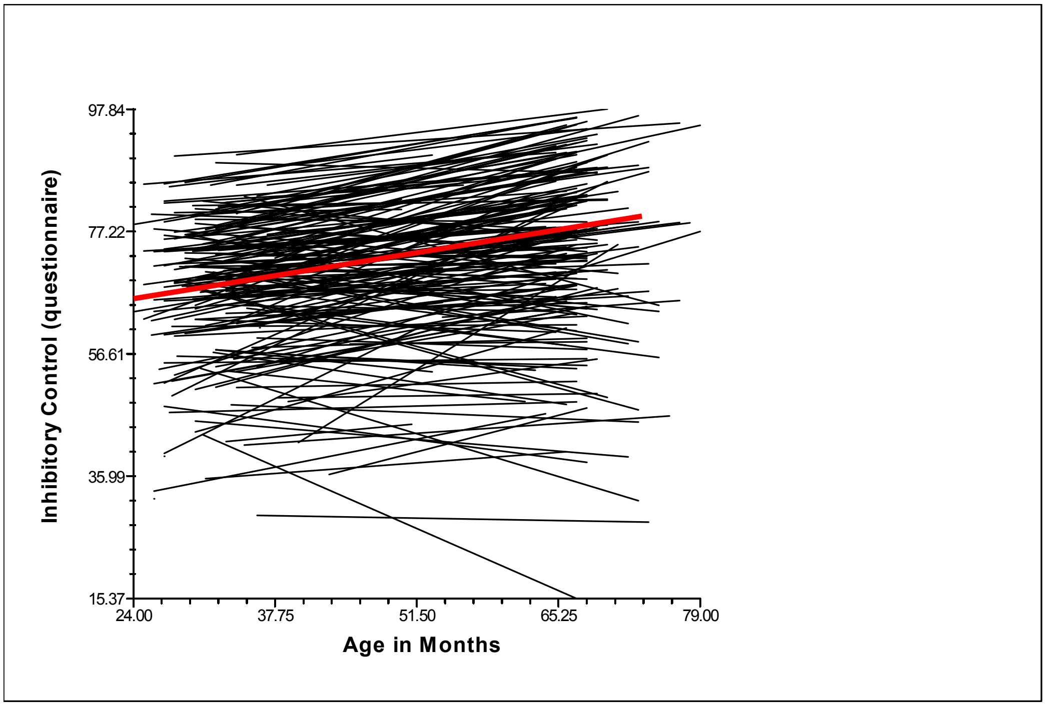

Figure 9. Unconditional growth model for inhibitory control (maternal report)

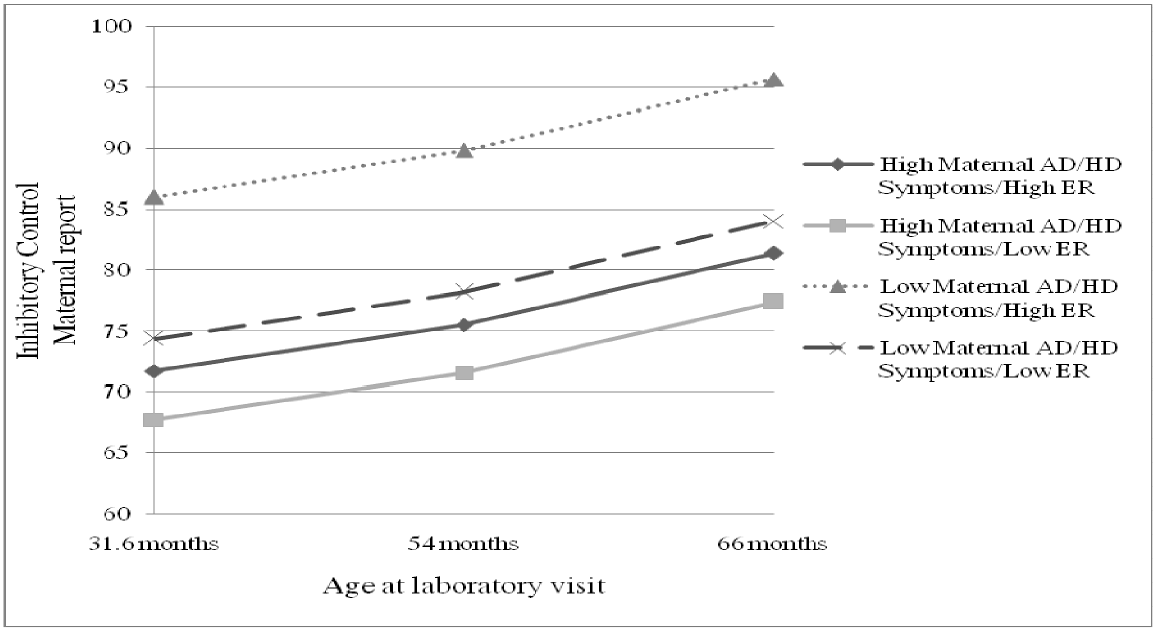

Figure 10. Protypical plot of the interaction between maternal AD/HD symptoms and emotion regulation skills

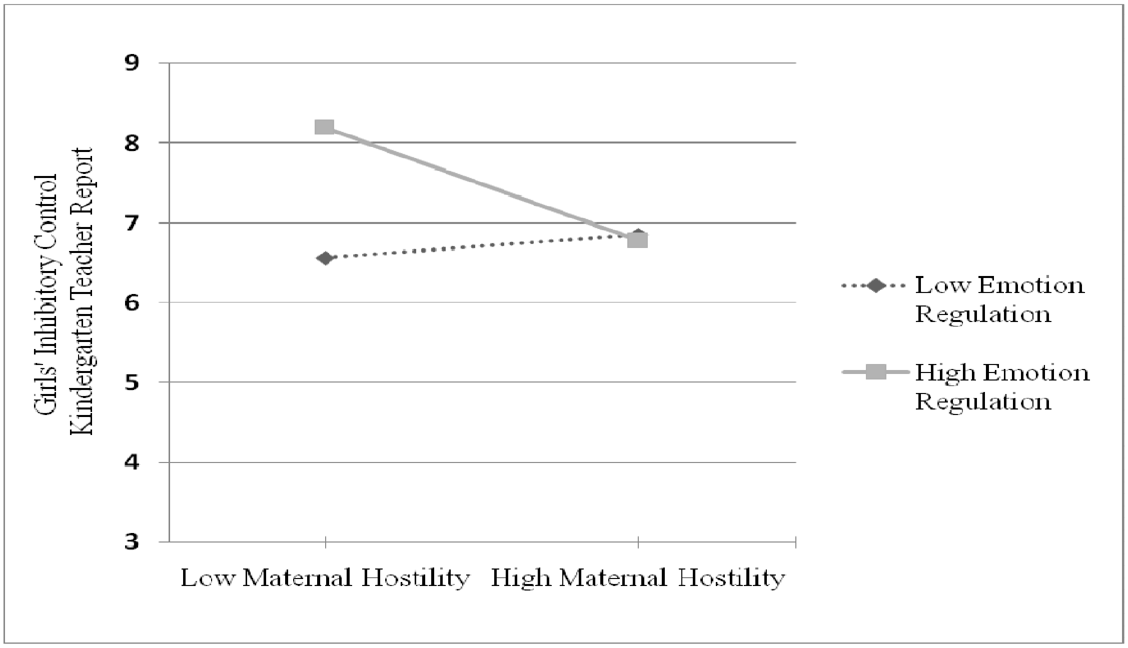

Figure 11. Interaction between emotion regulation and maternal hostility for girls, while controlling for maternal warmth/responsiveness, maternal overcontrol/intrusiveness, and race.

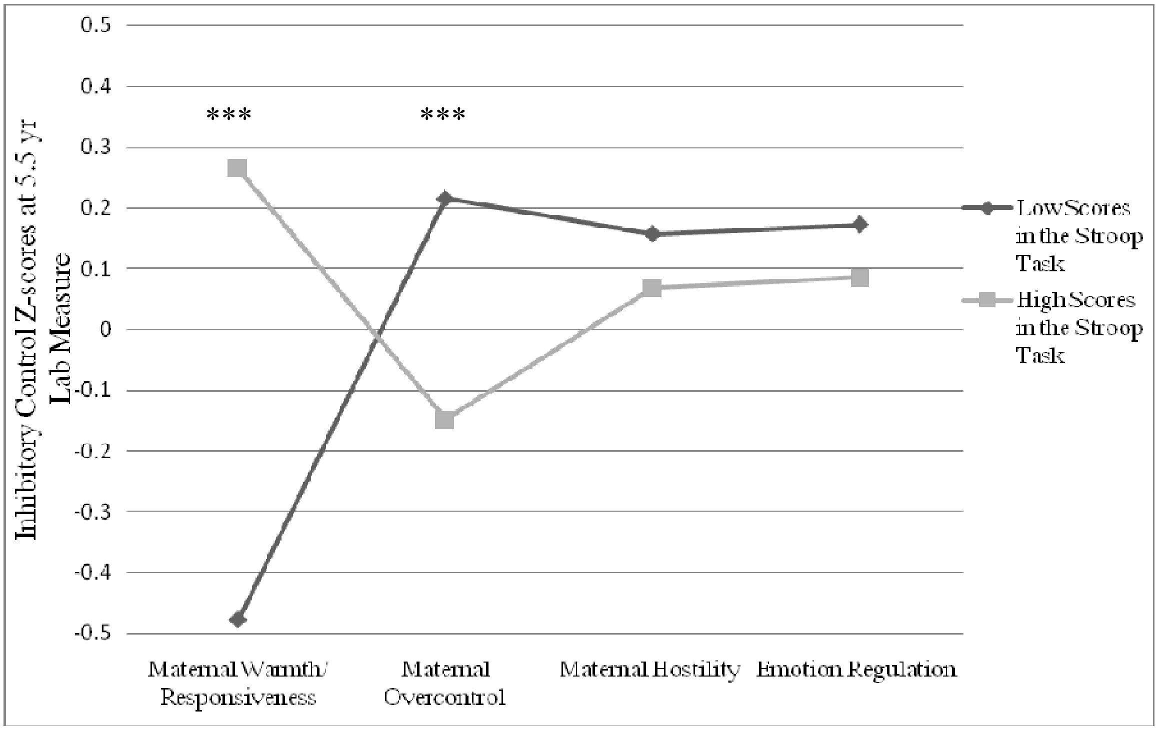

Figure 12. Profiles of children with low vs. high inhibitory control at 5.5yrs of age. *** indicates a significant difference at p<.001 between the groups while controlling for maternal education and SES.