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Mothers' Depressive Symptoms in Infancy and Children's Maladjustment in Early Grade School: The Role of Children's Sustained Attention and Executive Function

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Mothers' Depressive Symptoms in Infancy and Children's Maladjustment in Early Grade School: The Role of Children's Sustained Attention and Executive Function

by

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Dedication

This dissertation is dedicated to my husband, my son, my parents, and grandparents, who offered tremendous love and support for my academic aspiration.

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Mothers' Depressive Symptoms in Infancy and Children's Maladjustment in Early Grade School: The Role of Children's Sustained Attention and Executive Function

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Using longitudinal data from the NICHD Study of Early Child Care and Youth Development (N=1,367), the current study examined the role of children's sustained attention and executive function in promoting their adjustment difficulties in early grade school as mothers' depressive symptoms increase in infancy. Findings demonstrated that, when mothers' depressive symptoms were high in infancy, their children were at risk for poor sustained attention and executive function prior to school entry partly due to mothers' tendencies to become insensitive. Children's poor executive function in turn mediated the relation of mothers' depressive symptoms in infancy to children's poor cognitive and socioemotional adjustment in 3rd grade, independent of poor sustained attention. Findings also suggested the unique role of mothers' depressive symptoms in infancy in predicting children's poor sustained attention, but not executive function. Overall, this study demonstrates the potential role of children's sustained attention and executive function in understanding the developmental risks children of depressed mothers face in early grade school.

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Mothers' depressive symptoms, prevalent among women with young children (Goodman, 2007), place their children at risk for a range of adverse cognitive and socioemotional problems as early as infancy. These children have poor general cognitive and socioemotional functioning as indicated by low IQ, low school achievement, low social competence, and high rates of externalizing behavioral problems and other disruptive behaviors (England & Sim, 2009; Goodman, 2007; Murray, Halligan, & Cooper, 2010; Wang & Dix, 2015). This elevated risk is thought to reflect children's genetic vulnerability, exposure to stressful environments and in particular, the maladaptive affect, cognition, and behavior of their depressed mothers (Goodman & Gotlib, 1999). It is largely unknown, however, what processes in children mothers' depressive symptoms promote that are responsible for this risk. In this article, I focus on two such cognitive processes in children: sustained attention and executive function. Both are considered crucial for the development of complex cognitive and socio-emotional functioning (Ruff & Rothbart, 1996; Zelazo, Müller, Frye, & Marcovitch, 2003). I address four main questions: Do mothers' depressive symptoms in infancy, particularly in the first two years, promote poor sustained attention and executive function in children? If so, what types of parenting account for this risk? Does poor sustained attention partially mediate relations between mothers' depressive symptoms in infancy and children's poor executive function? Do deficits in sustained attention and executive function mediate relations of mothers' depressive symptoms in infancy and children's poor cognitive and socio-emotional adjustment in early grade school?

Mothers' Depressive Symptoms and Children's Adjustment Problems

Mothers' depressive symptoms pose significant risk for a wide range of cognitive and socioemotional adjustment problems in their school-age children. These children have been found to score lower on overall intelligence and have poorer academic performance relative to children of non-depressed mothers (Anderson & Hammen, 1993; Goodman & Tully, 2006). When mothers' depressive symptoms are high, their school-age children also tend to have poorer social functioning, higher rates of anxiety, disruptive behavior disorders, and overall levels of behavioral problems relative to children of non-depressed mothers (see Goodman & Tully, 2006, for a review). Poor cognitive and socioemotional functioning in early grade school is thought to represent children's vulnerabilities to or early signs of the later depression and other developmental problems (Goodman & Tully, 2007). However, it is unclear what processes in children may be responsible to convey the risk of mothers' depressive symptoms to children's cognitive and socioemotional functioning in early grade school. This study examined two such cognitive processes in children – sustained attention and executive function.

The Development of Sustained Attention

Sustained or focused attention is manifested by sustained and active engagement with a stimulus or task (Gaertner, Spinrad, & Eisenberg, 2008). Children's early capacity to maintain sustained attention facilitates the development of aspects of self-regulatory systems (Rueda, Posner, & Rothbart, 2011; Ruff & Rothbart, 1996). Sustained attention is therefore viewed as a precursor of self-regulation (Rueda, Posner, & Rothbart, 2011; Ruff & Rothbart, 1996), which is crucial to children's control of emotions and behaviors, their positive interaction with others, and their engagement in independent learning

(Bronson, 2000). This may be the case because sustained attention limits distraction and enhances active engagement with the environment (Ruff & Capozzoli, 2003; Ruff & Rothbart, 1996). This enables the socialization of emotional and behavioral regulation to occur successfully (Eisenberg, Fabes, Guthrie, & Reiser, 2000; Hill & Braungart-Rieker, 2002; Kochanska, Murray, & Harlan, 2000; Reck & Hund, 2011). Sustained attention is fundamental to children's cognitive competence and has been linked to a range of cognitive skills as early as toddlerhood, including problem-solving, language skills, and school readiness (Bono & Stifter, 2003; Choudhury & Gorman, 2000; Lawson & Ruff, 2004; NICHD, 2003). Deficits in sustained attention are also implicated in poor social skills, externalizing behavioral problems, attention-deficit/hyperactivity disorder (ADHD), schizophrenia, and other psychopathologies (Belsky, Fearon, & Bell, 2007; Carter et al., 2010; Marchetta, Hurks, De Sonneville, Krabbendam, & Jolles, 2008; NICHD, 2009).

Children's ability to regulate attention voluntarily emerges by the end of the second year and keeps increasing during early childhood, paralleling the maturation of prefrontal cortex (Ruff & Rothbart, 1996). Two systems are thought to be involved in this early development (Ruff & Rothbart, 1996). The first system emerges at birth and reflects an automatic orienting to novel stimuli. The second, higher-level system emerges at the end of the second year and involves voluntary or intentional control of attention, which makes possible the emergence of sustained attention. Despite its biological underpinning (Greene, Bellgrove, Gill, & Robertson, 2009; Hatzimanolis et al. 2012), the development of sustained attention is also dependent on environmental influences, particularly parenting (Gauvain, 2001; NICHD, 2005; Ruff & Rothbart, 1996). When characterized

by warmth, sensitivity, and responsiveness, parenting has been shown to promote the development of sustained attention (Belsky, Fearon, & Bell, 2007; Graziano, Calkins, & Keane, 2011; NICHD, 2005). Conversely, mothers' intrusiveness and unresponsiveness undermine sustained attention (Breznitz & Friedman, 1988; Raver & Leadbeater, 1995).

Sustained attention and mothers' sensitivity. Four aspects of sensitive parenting may promote young children's ability to sustain attention. First, sensitive mothers may provide emotional support that facilitates children's sustained engagement with the environment (Gaertner, Spinrad, & Eisenberg, 2008). Emotionally supportive parenting reduces children's anxiety, promotes their willingness to explore the environment, stimulates their interests, and creates a positive atmosphere that increases the enjoyment of tasks (Gaertner, Spinrad, & Eisenberg, 2008; Matas, Arend, & Sroufe, 1978). Indeed, mothers' positive affect and praise during dyadic teaching and problem-solving has been linked with children's increased attention and persistence at tasks (Barocas, Seifer, Sameroff, Andrews, Croft, & Ostrow, 1991; Gaertner, Spinrad, & Eisenberg, 2008).

Second, sensitive mothers tend to be autonomy-supportive. They are child-oriented, provide only necessary assistance, and use indirect means to influence children's behaviors (Dix, 2000). Relative to intrusive mothers, they are less likely to engage in the constant interruption and redirection that interferes with children's spontaneous engagement of tasks (Ruff & Rothbart, 1996). This is consistent with research suggesting that parenting that maintains and builds upon children's ongoing attentional focus is associated with higher sustained attention compared to power-assertive and intrusive strategies that redirect children's focus (Bono & Stifter, 2003;

Gaertner, Spinrad, & Eisenberg, 2008; Landry, Garner, Swank, & Baldwin, 1996).

Third, sensitive mothers may influence young children's growing capacity to sustain attention by effectively regulating young children's negative emotions and arousal, particularly in the early years when children have limited ability to self-regulate their arousal (Ruff & Rothbart, 1996). These mothers are responsive to young children's distress and can effectively regulate children's negative affect by comforting them or meeting their needs. In contrast, if not attended to appropriately, negative emotions and arousal can disrupt young children's attention (Gaertner, Spinrad, & Eisenberg, 2008; Ruff & Rothbart, 1996) and discourage their engagement with the environment (Tronick & Reck, 2009). When highly aroused, children may withdraw by turning away, closing their eyes, or crying for help. Effective emotion regulation occurs less often among insensitive mothers (see Eisenberg, Cumberland, & Spinrad, 1998, for a review). Mothers' intrusiveness, unresponsiveness, and other insensitive behaviors may even become sources of stress and generate arousal in children (Tronick & Reck, 2009).

Fourth, in early development, sensitive mothers may regulate children's attention explicitly and thereby promote children's ability to do so independently (Ruff & Rothbart, 1996). Early in the first year, mothers calm fussy babies or alert and stimulate sleepy babies to keep them engaged with the environment. These early forms of attention regulation may facilitate young infants' ability to focus on external stimuli and are thought to be related to children's tendency to sustain attention (Ruff & Rothbart, 1996). Later in the first year, as infants become capable of shared attention, mothers may enhance infants' attention by stimulating their interests, minimizing potential distractions, and directing them to, and teaching them about, a particular toy or activity (Lawson,

Parrinello, & Ruff, 1992; Lockman & McHale, 1989; Ruff & Rothbart, 1996).

Sustained attention and mothers' depressive symptoms. Each of these four mechanisms may be absent when mothers have depressive symptoms and thus may lead their children to develop poor sustained attention. Mothers' depressive symptoms undermine parenting sensitivity and general parenting competence (see Dix & Meunier, 2009, for a review). First, because they tend to be hostile and negative to their children, mothers with depressive symptoms are less likely to create an emotionally supportive environment (see Lovejoy, Graczyk, O'Hare, & Neuman, 2000, for a review). Second, because they tend to be insensitive to children's needs and to disrupt children's spontaneous engagement with the environment (Lovejoy, Graczyk, O'Hare, & Neuman, 2000), mothers with depressive symptoms are also less likely to support children's autonomy. They tend to be self-focused and to evaluate insensitive and coercive parenting favorably, which are thought to undermine support for children's autonomy (Dix, Gershoff, Meunier, & Miller, 2004; Dix & Meunier, 2009). Third, effective emotional regulation may occur less often when mothers' depressive symptoms increase, because these mothers tend to be negative, insensitive, and unresponsive to children's distress (Dix, Moed, & Anderson, 2014; Lovejoy et al., 2000). This may offer opportunities for children to model negative emotions and may result in failure to socialize constructive emotion regulation in children (Eisenberg, Cumberland, & Spinrad, 1998). Fourth, mothers' depressive symptoms may undermine their ability to provide explicit and effective attentional regulation in the early years because they are insensitive to children's signals and therefore, may fail to offer support that encourages persistence. Overall, this body of research suggests that, as mothers' depressive symptoms increase,

they are less likely to engage in the sensitive parenting that promotes children's emerging ability to sustain attention.

Although this research implies that mothers' depressive symptoms may disrupt children's early-emerging ability to sustain attention, research has yet to demonstrate this relation. To my knowledge, only one study has addressed this issue explicitly. By observing the spontaneous play of 25 mother-toddler dyads, Breznitz and Friedman (1998) found that, as mothers' depressive symptoms increased, they initiated and terminated interactions with toys more frequently, and this was associated with their toddlers' shorter durations of sustained attention relative to toddlers of non-depressed mothers. However, they relied on an extremely small sample and did not examine the relation of maternal depression and children's poor sustained attention as children developed over time. Using a large longitudinal dataset, the current study extends this initial effort to examine the risk of mothers' early depressive symptoms for children's poor sustained attention prior to school entry. Moreover, the current study examined whether mothers' low sensitivity can account for this risk and whether sustained attention mediates the relation of mothers' early depressive symptoms to children inferior cognitive and socio-emotional adjustments in 3rd grade.

The Development of Executive Function

Young children's growing capacity to sustain attention provides a foundation for the development of a second critical set of cognitive processes – executive function (Garon, Bryson, & Smith, 2008). Executive function is a set of inter-related and yet distinct higher-order cognitive processes responsible for purposeful, goal-directed behavior (Anderson, 2002). As a set of general-purpose control mechanisms, executive

function is a core component of the self-regulation that modulates children's cognitions and behaviors (Blair & Ursache, 2011; Miyake & Friedman, 2012). Self-regulation skills have been shown to have broad and enduring implications for people's everyday lives (Mischel et al., 2011; Moffitt et al., 2011). Executive function is important to children's cognitive milestones and academic performance, including theory of mind and perspective taking, false-belief understanding, language development, math and literacy skills, and school readiness (Blair & Razza, 2007; Hughes & Ensor, 2007; Im-Bolter, Johnson, & Pascual-Leone, 2006; Nayfeld, Fuccillo, & Greenfield, 2013). Deficits in executive function have been linked to children's low social competence (Charman, Carroll, & Sturge, 2001; Fahie & Symons, 2003; Razza & Blair, 2009) and behavioral problems (Hughes & Ensor, 2008; Jacobson, Williford, & Pianta, 2011; Wåhlstedt, Thorell, & Bohlin, 2008). Deficits in executive function have also been implicated in autism, ADHD, obsessive-compulsive disorder and other developmental psychopathologies (Pennington & Ozonoff, 1996; Snyder, Kaiser, Warren, & Heller, in press). Moreover, executive function in childhood remains important into adulthood, predicting career and marriage satisfaction, health, income, and criminal activity (Eakin et al., 2004; Moffitt et al., 2011).

The processes that comprise executive function have both unique and shared characteristics (Friedman, Miyake, Young, DeFries, Corley, & Hewitt, 2008; Miyake & Friedman, 2012). While there is ongoing debate on the exact composition of executive function, recent research suggests that it can be conceptualized as a unitary construct that consists of deliberate *inhibition* of irrelevant or inappropriate responses, maintenance or manipulation of relevant information in *working memory* that resists distraction or

interruption, *planning* sequences of appropriate actions, and *shifting* or switching flexibly between tasks or mental sets (Anderson, 2002; Hughes, Ensor, Wilson, & Graham, 2010; Miyake & Friedman, 2012; Wiebe, Sheffield, Nelson, Clark, Chevalier, & Espy, 2011; Wiebe, Morton, Buss, & Spencer, 2014; Zelazo et al., 2003). Consistent with this body of research, the current study uses *inhibition*, *working memory,* and *planning* as indices of executive function.

The interaction of these components enables children to perform executive functions and thereby regulate goal-directed behaviors. Among these components, inhibition is thought to be the fundamental core of executive function (Brocki & Bohlin, 2004) and underpins improvements in children's working memory and planning (McCormack & Atance, 2011; Welsh, 2002). As children's ability to inhibit prepotent but inappropriate responses improves, mental capacity or processing space can be freed to serve working memory (Bjorklund & Harnishfeger, 1990; Conway & Engle, 1994). Inhibition is important to planning because planning appropriate responses places substantial demands on children's abilities to override their tendencies to act impulsively and to inhibit prepotent but irrelevant responses (see McCormack & Atance, 2011, for a review; Asato, Sweeney, & Luna, 2006). It has also been argued that working memory is important in planning because children need to remember their goals while manipulating proposed actions in memory to consider their probably effects and optimal sequence (McCormack & Atance, 2011; Owen, 2005).

Components of executive function – inhibition, working memory, and planning – emerge in task-specific contexts at different points in early childhood, with some aspects emerging in infancy. A rudimentary form of inhibition develops late in the first year as

indicated by infants' abilities to stop an enjoyable activity in response to mothers' request (Kochanska, Tjebkes, & Forman, 1998) and to break an established habit by reaching to a new location, instead of the trained location, for the hidden object (the A-not-B task; Marcovitch & Zelazo, 1999). Children's ability to suppress a dominant response increases in the preschool years as indexed by the delay of gratification paradigm (Mischel, Shoda, & Rodriguez, 1989). In this task, children are shown two treats and told that, if they wait the full period, they will get both, but they can ring a bell at any time and get one. Age differences in the length of time children are able to delay were found: 50% of 2-year-old were able to suppress eating a treat for 20 seconds, 85% of 3-year-old could suppressed for 1 minute, whereas 75% of 4-year-old could suppress for 5 minutes (Carlson, 2005).

The earliest form of working memory also emerges in infancy as indexed by the delayed response task. In this task, a toy is hidden at one of two possible locations, with the location randomly decided from trial to trial. As early as 6-months, infants demonstrated some capacity to hold a representation in mind over a delay (see Pelphrey & Reznick, 2003, for a review). Preschool years evidence improvements in working memory as indicated by the increasing capacity to retain information and the increasing length of time that information can be remembered (Pelphrey & Reznick, 2003). The capacity of working memory continues to increase into childhood and adolescence (Wiebe et al, 2014).

In contrast to early-emerging inhibition and working memory, children's planning ability emerges in the late preschool years as indexed by children's performance on the tower of Hanoi or the tower of London tasks. These tasks typically involve a set of

colored discs or balls that are placed on two or three pegs. Children are directed to convert an initial state of the discs or balls to a goal state, often illustrated by a picture, with minimal numbers of moves. Whereas 4-year-olds exhibited inferior performance due to their limited skill at planning ahead, 5- to 8-year-olds performed significantly better than 4-year-olds (Kaller, Rahm, Spreer, Mader, & Unterrainer, 2008; Luciana & Nelson, 1998).

The development of executive function is thought to be influenced by both biological and social factors. First, young children's developing neural systems promote executive function. Strengthening interactions between frontal and parietal areas, increases in cortical volume, greater structural differentiation, and the dynamics of neural activation are all important to support children's emerging executive function (see Wiebe, Morton, Buss, & Spencer, 2014, for a review). Additionally, recent research suggests that early experience, parenting in particular, may play a central role in the development of executive function. When executive function is conceptualized as a latent construct, mothers' sensitive parenting – characterized by warmth, sensitivity, responsiveness, scaffolding, autonomy support, and mind-mindedness (the tendency to use mental terms while talking to the child) – has been shown to promote executive function (Bernier, Carlson, & Whipple, 2010; Blair, Raver, & Berry, 2014; Hammond, Müller, Carpendale, Bibok, & Liebermann-Finestone, 2012).

Executive function and mothers' sensitivity. In contrast to emotional and motivational mechanisms that link sensitive parenting to children's sustained attention, research emphasizes biological factors as mechanisms that link sensitive parenting to children's executive function. First, positive experiences with mothers have a favorable

impact on the structure of children's developing brains (Glaser, 2000; Nelson & Bloom, 1997; Schore, 1996). For example, the development of the frontal lobe, important to executive function, is influenced positively by sensitivity (Glaser, 2000). Second, sensitive parenting reduces children's physiological responses to stress (Gunnar & Quevedo, 2007). Cortisol, a stress hormone that modulates activity in the prefrontal cortex, partially mediates the relation between parental support and prospective executive function across early development (Blair et al., 2011). Mothers' sensitivity is thought to buffer children from environmental stress (Carlson, 2003) and, in adverse environments, predicts toddlers' low levels of salivary cortisol (Blair & Ursache, 2011). Therefore, highly supportive environments are associated with lower levels of cortisol in children, which in turn account for increases in children's executive function (Blair & Ursache, 2011). Furthermore, one component of sensitive parenting – effective scaffolding (parental verbal or physical support for children's autonomous problem solving) – has been shown to enhance children's executive function (Carlson, 2003; Hammond et al., 2012; Landry, Miller-Loncar, Smith, & Swank, 2002; Matte-Gagné & Bernier, 2011). Offering children age-appropriate strategies while children are engaged actively in problem-solving promotes children's executive function by enhancing early language and memory skills (Landry et al, 2002; Matte-Gagné & Bernier, 2011). In contrast, parents' failure to provide a stimulating environment predicts deficits in children's language capacities and processing speed, which in turn accounts for deficits in children's executive function (Clark, Sheffield, Chevalier, Nelson, Wiebe, & Espy, 2013).

Executive function and mothers' depressive symptoms. As mothers' depressive symptoms increase, sensitive parenting occurs less often (Lovejoy et al., 2000). This may

be responsible for deficits in children's executive function. Indeed, the negative experience of interacting with a depressed mother has been shown to adversely influence children's brain development and stress response system, which in turn may disrupt their executive function (Blair & Ursache, 2011). Recent research suggests that early exposure to adverse environments, including mothers' depressive symptoms, is associated with problematic brain development conceptually related to executive function. These children show reduced neural activity, decreased cerebral volume, abnormal frontal electroencephalography (EEG) activation associated with the expression of emotions, and low striatal and high medial prefrontal cortex (mPFC) activation associated with reward (Blair & Ursache, 2011; Dawson, Frey, Panagiotides, Yamada, Hessl, & Osterling, 1999; De Bellis et al., 1999; Field & Diego, 2008; Morgan, Shaw, & Forbes, 2014). In addition, mothers' depressive symptoms predict high activity in children's stress response system. As early as infancy, children of depressed mothers experience elevated stress, as indicated by high cortisol output and hypothalamic–pituitary–adrenocortical (HPA) axis activity (Azak, Murison, Wentzel-Larsen, Smith, & Gunnar, 2013; Gunnar & Vazquez, 2006). Consistently, the literature on maltreated children also suggests that early exposure to adverse parenting triggers abnormal neurobiological stress responses in children as manifested by HPA axis activation, catecholamine response, and serotogenic response (see Glaser, 2000, for a review).

However, the relations of mothers' depressive symptoms, deficits in children's executive function, and maladjusted cognitive and socio-emotional development have rarely been examined. The few studies that have examined the associations between mothers' depressive symptoms and children's executive function have yielded mixed

results. In one longitudinal study, mothers' depressive symptoms at age 2 and increases in mothers' depressive symptoms from ages 2 to 6 predicted children's poor executive function at age 6 (Hughes, Roman, Hart, & Ensor, 2013). In contrast, another three longitudinal studies failed to link mothers' depressive symptoms with preschoolers' (36-months; Rhoades, Greenberg, Lanza, & Blair, 2011) and adolescents' poor executive function (Klimes-Dougan, Ronsaville, Wiggs, & Martinez, 2006; Micco et al., 2009). Given these contrasting results, it is still unclear whether mother's depressive symptoms in infancy may increase the risk for deficits in children's executive function prior to school entry and what mechanism may account for this risk. The current study explicitly addresses these questions. Moreover, it is unclear whether children's poor executive function may explain the adverse impact of mothers' depressive symptoms on children's subsequent maladjustment. In one study only, children's executive function has been also shown to mediate the concurrent relationship between mothers' depressive symptoms and disruptive behaviors in preschoolers (Hughes & Ensor, 2009). Extending this initial effort, I examine whether low sensitive parenting may explain the adverse impact of mothers' depressive symptoms in infancy on children's executive function and the role that executive function may play in conveying the risk posed by mothers' depressive symptoms in infancy for children's cognitive and socioemotional development in early grade school.

The Interrelation of Sustained Attention and Executive Function

Children's increasing capacity to sustain attention has been widely conceptualized as a fundamental mechanism contributing to the development of executive function and may even be the source of common variance underlying components of executive

function (e.g. Garon, Bryson, & Smith, 2008; Ruff & Rothbart, 1996). However, this notion has rarely been examined empirically, and theoretical explanations that connect sustained attention to executive function are unclear. This may be the case for two reasons. First, a prerequisite to executive function is active goal maintenance (Zelazo & Müller, 2011), the mental capability to resist distraction and to focus on ongoing tasks or goals. Active goal maintenance is more likely to occur when children engage in sustained attention (Ruff & Capozzoli, 2003). In addition, individual differences in executive function are thought to reflect the strength of associations between executive function and goal-relevant representations maintained in the prefrontal cortex (Miyake & Friedman, 2012). As early as in toddlerhood, children's representational abilities to initiate and engage in joint attention predict their subsequent gain in executive function (Miller & Marcovitch, 2015). These representational skills are more likely to develop when sustained attention occurs (Ruff & Rothbart, 1996). Therefore, children's capability to maintain focused attention may be necessary for the emergence of executive function.

Indeed, research provides evidence that sustained attention is associated with inhibition, working memory, and planning, all considered components of executive function. Children with poor sustained attention have difficulty inhibiting dominant and inappropriate responses and resisting the tendency to act impulsively so that an optimal plan may be executed. As early as infancy, individual differences in sustained attention predicted later inhibition (Reck & Hund, 2011; Sethi, Mischel, Aber, Shoda, & Rodriguez, 2000). Sustained attention is also associated with high working memory span among preschoolers and adults (Espy & Bull, 2005; Silver & Feldman, 2005). Finally, deficits in sustained attention are associated with the tendency to respond prematurely

before the optimal plan of actions is executed (Young, Morris, Toone, & Tyson, 2007). Overall, this body of research implies that sustained attention is important to the normal functioning of various components of executive function. It remains unknown, however, whether poor sustained attention is responsible for the adverse effects of mothers' depressive symptoms on children's executive function. The current study thus extends these initial efforts to examine whether children's poor sustained attention mediates, in part, the impact of mothers' early depressive symptoms on deficits in children's executive function.

The Primacy of Early Experience

Exposure to mothers' depressive symptoms may represent a particular risk when children are young (Goodman & Gotlib, 1999). The first two years, in particular, represent a rapid growth in the development of children's sustained attention. By the end of the second year, the fundamental process underlying sustained attention was formed (Ruff & Rothbart, 1996). Therefore, the experiences of the first two years are thought to be crucial to determine individual differences in sustained attention. Furthermore, children's early years constitute a period of neural plasticity (see Bruer, 1999, for a review; Nelson & Bloom, 1997) and thus may be particularly important for the development of sustained attention and executive function. In the first two years of life, particularly, rapid growth occurs in brain volume and synaptic formation (Bruer, 1999; Nelson, Thomas, & de Hann, 2006; Schore, 1994). Enriched environments and sensitive parenting in the early years are thought to enhance brain growth (Bruer, 1999). In addition, children's regulatory systems such as the HPA system and cardiac vagal tone (Stansbury & Gunnar, 1994; Porges, Doussard-Roosevelt, & Maita, 1994) are immature

at birth and develop gradually during the first few years of life. Early experience may thus be particularly important for shaping aspects of the developing brain and emerging regulatory capacities that support the development of sustained attention and executive function (Ruff & Rothbart, 1996; Blair & Ursache, 2011).

The early years may also constitute a sensitive period for exposure to negative parenting and environmental risks. Children's early exposure to family and social risk factors, including mothers' depressive symptoms, has been shown to affect their social cognition, social competence, school readiness, academic performance, and symptoms of psychopathology through mid-adolescence, independent of later factors (Fraley, Roisman, & Haltigan, 2013; Haltigan, Roisman, & Fraley, 2013; Mistry, Benner, Biesanz, Clark, & Howes, 2010; Wang & Dix, 2015). This is consistent with the biological-sensitivity-to-context model, which emphasizes that children who experience stressful environments in the early years are particularly likely to develop heightened stress-reactivity (Boyce & Ellis, 2005). High stress reactivity has been shown to disrupt the development of prefrontal cortex, which underlies executive function (Blair & Ursache, 2011). The importance of early plasticity is also shown by the evidence that the first two years of life represent a critical period for the selection of synaptic connections (Glaser, 2000), a process determined by the environment in which children are embedded (Glaser, 2000). Additionally, in the early years, rapid development in affective and cognitive domains provides the foundation for subsequent cognitive and socio-emotional development (Goodman & Gotlib, 1999). Therefore, disturbance in early development may have an enduring adverse impact on later development. In this study, I examine whether exposure to mothers' depressive symptoms in the first two years of life is a significant risk for the

development of poor sustained attention and executive function, independent of depressive symptoms occurring later?

The Current Study

Using longitudinal data from the NICHD Study of Early Child Care and Youth Development, the current study investigates the relation of mothers' depressive symptoms in infancy, mothers' low sensitivity, children's poor sustained attention and executive function prior to school entry, to children's poor cognitive and socioemotional functioning in early grade school. Five hypotheses were examined. First, when mothers' depressive symptoms are high on average in infancy, children will develop poor sustained attention and executive function at 54-months to 1st grade. Mothers' depressive symptoms in infancy will play a unique and formative role in children's emerging poor sustained attention and executive function, independent of depressive symptoms that occur later at 36- and 54-months. Second, relations between mothers' depressive symptoms in infancy and children's poor sustained attention and executive function will both be mediated by mothers' low sensitivity. Third, the relation of mothers' depressive symptoms in infancy and mothers' low sensitivity to children's poor executive function will be mediated, in part, by children's poor sustained attention. Fourth, independent of poor executive function, sustained attention will mediate the relations of mothers' depressive symptoms in infancy to children's disruptive behavior, poor social competence, and cognitive and academic competence in 3rd grade. Fifth, independent of poor sustained attention, poor executive function will mediate the relations of mothers' depressive symptoms in infancy and children's disruptive behavior, poor social competence, and cognitive and academic competence in third grade.

Methods

Participants

Participants were mothers and children from the NICHD Study of Early Child Care and Youth Development. Starting in 1991, mothers were recruited from hospitals located at 10 sites across the US (Little Rock, AR; Irvine, CA; Lawrence and Topeka, KS; Boston, MA; Philadelphia and Pittsburgh, PA; Charlottesville, VA; Morganton and Hickory, NC; Seattle, WA; and Madison, WI). Mothers were contacted in the hospital shortly after the birth of the target child. Families were excluded if the birth involved medical complications, or if the mother was under 18, unable to speak English, known or acknowledged to have a substance abuse problem, planned to move, lived too far away, or lived in an unsafe neighborhood. Of the 5,265 families who met the eligibility criteria and agreed to be contacted after they returned home from the hospital, randomized call lists were used to enroll two to three families into the study per week at each site. Final recruitment occurred at the first home visit when the infants were 1-month old.

The final sample consisted of 1,364 families and had comparable numbers of boys (52%) and girls (48%). Mothers included in this sample were on average 28-years old (*SD* = 5.63), had 14 years of education (*SD* = 2.51), and had income-to-needs ratios of 3.74 (*SD*= 3.04; an income-to-needs ratio below 2 represents economically disadvantaged families). Most mothers lived with their husbands or partners (85%) and identified themselves as White (80.4%). The rest were African-American (12.9%) or Hispanic (6.1%).

Procedure

Data were collected using research tasks, observations, standardized tests, and

mothers', fathers', and teachers' reports. To avoid potential depression-related biases, mothers' report was used only for their depressive symptoms. Children's sustained attention was measured during the 54-months laboratory visit using a computer-generated test. Executive function was indicated by three components – inhibition, working memory, and planning – and was evaluated individually in the laboratory (inhibition and working memory) and at home (planning) at 54 months (inhibition) or in 1st grade (working memory and planning). Mothers' sensitivity was observed during the 36-months laboratory visit. Child outcomes were obtained in 3rd grade using standardized tests, and fathers' and teachers' reports. Mothers' reports were not included to avoid depression-related biases.

Measures of Predictor Variables

Mothers' early and later depressive symptoms. When children were at 6-, 15-, 24-, 36-, 54-months, and in 1st grade, mothers reported depressive symptoms with the Center for Epidemiologic Studies Depression Scale (Radloff, 1977). Mothers rated the extent to which 20 depression-related states or behaviors occurred in the last week (i.e. "I thought my life had been a failure"; "I felt depressed"). Internal consistency for each wave was excellent (Cronbach's αs = .85 to .91). Research shows that extensive and prolonged, not transient, exposure to mothers' depressive symptoms is the principal risk for children (Campbell, Cohn, & Meyers, 1995). Depressive symptoms at a single time point may reflect poorly the extent to which children have been exposed to depressive symptoms over an extended period. Therefore, to estimate children's average exposure to depressive symptoms in infancy, an early depressive symptoms score was created by averaging scores across the first two years (6-, 15-, and 24-months). Mothers' depressive

symptoms at 6-. 15-, and 24-months were highly correlated (*r*s = .518 to .582, *p*s < .001). On average, mothers' depressive symptoms in infancy were 9.03 (*SD* = 6.90) with 12% of mothers above 15, the conventional cutoff for clinically significant depressive symptoms (Radloff, 1977).

Mothers' sensitivity. When children were 36-months old, mothers' sensitivity was observed in the laboratory during a 15-minute structured interaction (NICHD, 1999). Mothers were asked to show their children age-appropriate toys from three containers in a set order. The first container had markers, stencils, and paper; the second one had dress-up clothes and a cash register; and the third one had blocks with a picture of a model. Interaction was videotaped and sent to a central location where a team of at least five trained coders rated three components of mothers' sensitive parenting on 7-point scales. Mothers' sensitivity is a composite variable that reflects the extent to which they were supportive, were low in hostility, and displayed respect for children's autonomy. The internal consistency was high (Cronbach's α = .78). The validity of this variable has been demonstrated through its predicting a wide range of child outcomes, such as basic cognitive skills, social competence, academic performance, and symptoms of psychopathology (e.g. Fraley, Roisman, & Haltigan, 2013; Friedman et al., 2014; Haltigan, Roisman, & Fraley, 2013; NICHD, 2005).

Sustained attention. Children's sustained attention was assessed during the 54-months laboratory visit using the Continuous Performance Task (CPT; Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956), a widely used test for sustained attention (e.g. NICHD, 2003, 2005). The test was administered to each child individually. In this 7.5-minute computer-generated task, pictures of familiar objects (i.e. butterfly, fish, and

flower) were presented on a two-inch square screen in front of the child. The stimuli were presented in 22 sets with 10 stimuli in each set. The target stimulus (a chair) was randomly presented twice in each set. The child was asked to press a red button immediately after each appearance of the target stimulus. Consistent with prior studies (NICHD 2003, 2005), sustained attention was measured by the numbers of errors of omission, which was the number of times that the child failed to press the button when the target stimulus appeared. The score was reversely coded before being entered into the analyses so that higher scores indicating higher sustained attention. The measure had adequate test-retest reliability (r = .71; Halperin, Sharma, Greenblatt, & Schwartz, 1991). Its validity has been established through its predication of children's school readiness and social skills (e.g. NICHD 2003, 2005, 2009).

Executive function. Children's executive function was indicated by three components – inhibition, working memory, and planning. First, inhibition was observed during the 54-month laboratory visit with the delay of gratification task (Funder, Block, & Block, 1983), a well-known test for children's ability to inhibit dominant or prepotent responses (Mischel, Shoda, & Rodriguez, 1989). In this task, children were first asked to identify their favorite snack among M&Ms, animal crackers, and pretzels. Children were then told that, if they could wait the full period (7-minutes) until the experimenter returned to the room, they would get the large bowl of the favorite snack; yet, they also could ring the bell at any time and get the small bowl of the favorite snack. Both the large and small bowls of the favorite snack were placed in front of children while they waited. Inhibition was measured by the length of time children waited to eat the snack. Although this task has been widely used and the validity of this score has been established (e.g.

Campbell & von Stauffenberg, 2009), the test-retest reliability is unknown.

Second, working memory was assessed with the Memory for Sentences subtest from the Woodcock-Johnson Psycho-Educational Battery (WJ-R; Woodcock & Johnson, 1989). The test was administrated individually to each child during the laboratory visit in 1st grade. It measured children's ability to remember and repeat simple words, phrases, and sentences presented by a tape player, or in special cases, by the examiner. This test had excellent test-retest reliability (r = .94; Woodcock & Johnson, 1989). The validity of this score has been shown through its associations to parenting, day care experience, and children's planning skills (e.g. Friedman et al., 2014; NICHD, 2005).

Third, during the 1st grade home visit, a measure of planning was obtained using the Tower of Hanoi task (Welsh, 1991), a widely used measure of children's planning skills (e.g. Campbell & von Stauffenberg, 2009; NICHD, 2005). This task required children to plan ahead and to develop an optimal sequence of moves that would transform an initial state of rings as shown on children's set of pegs into a goal state of rings as shown on the experimenter's set of pegs. Movement of rings was constrained by three rules: only one ring could be moved at a time; a ring could not be placed on the top of a smaller ring; and rings had to be on a peg or in children's hands. A maximum of 20 moves was allowed. If children did not solve the puzzle using an optimal numbers of moves, they were encouraged to try once more. There were 6 puzzles and each could be solved within 1 to 6 trails. After two consecutive optimal solutions of a given puzzle, a more difficult puzzle was started. The entire task was terminated when children were unable to complete the puzzle twice in succession with the fewest number of moves. Children's planning was indexed by the planning efficacy score, the number of trails the

child needed to complete each puzzle. The score ranged from 0 to 36, with higher scores indicating better planning skills. The internal consistency was high (Cronbach's α = .70; NICHD, 2005). Prior studies have established the validity of this planning score through its relations to parenting, experience at day care, children's cognitive abilities, and reading and math skills (e.g. Friedman et al., 2014; NICHD, 2005).

Measures of Outcome Variables

Cognitive and academic competence. In 3rd grade, children's cognitive and academic competence was assessed using the Woodcock-Johnson Psycho-Educational Battery (Woodcock & Johnson, 1989), a widely used measure of children's cognitive abilities (e.g. Friedman et al., 2014; NICHD, 2003, 2005, 2007). Subsets of the battery were administrated individually to each child as indictors of their cognitive and academic competence. First, picture vocabulary, a test for verbal comprehension, measured children's ability to recognize or to name pictured objects. Six items were presented in a multiple-choice format that required children to point to the correct response. The remaining items asked children to name familiar and unfamiliar pictured objects. Second, verbal analogies measured children's ability to complete phrases with words that indicate appropriate analogies. This test was a mixture of reasoning and verbal comprehension skills. All tests had good test-retest reliability (rs = .63 to .78).

Third, the broad reading score was based on the letter-word identification and passage comprehension subsets. The 100-items that were used to create this score had high internal reliability (Cronbach's α = .93). The letter-word identification test involved the ability to match a pictographic representation of a word with an actual picture of the object and to identify isolated letters and words. The first four passage comprehension

items were presented in a multiple-choice format requiring the child to point to the picture represented by a phrase. The remaining items measured children's skill at reading a short passage and identifying a key missing word that was appropriate to the context of the passage.

Fourth, the broad math score, based on subsets of calculation and applied problems, consisted of 118 items with high internal reliability (Cronbach's α = .89). The calculation measured children's skill at performing mathematical calculations, such as addition, subtraction, multiplication, division, and some geometric, trigonometric, logarithmic, and calculus operations. Decimals, fractions, and whole numbers were involved. The applied problems subset measured children's skill in analyzing and solving practical problems in mathematics.

Social competence. The assessment of social competence was obtained in 3rd grade based on fathers' and teachers' report. First, fathers reported children's social skills using the Social Skills Rating System (SSRS; Gresham & Elliott, 1990), a widely used measure of children's social competence (e.g. NICHD, 2003, 2009; Wang & Dix, 2015). Using a 3-point scales (0 = never, 1 = sometimes, 2 = very often), this 38-item scale measured children's ability to demonstrate socially appropriate behavior, such as sharing, helping, initiating relationships, and controlling anger. The internal consistency of this measure was high (Cronbach's α = .90). Second, using the teacher version of the SSRS, teachers rated children's social skills on 30 items. The internal consistency was excellent (Cronbach's α = .94).

Disruptive behaviors. In 3rd grade, fathers and teachers reported children's disruptive behaviors. Deriving from the Child Behavior Checklist (CBCL; Achenbach,

1991a), fathers reported on 33 items the extent to which children displayed a wide range of delinquent and aggressive behaviors (e.g. lies, steals, fights, destroys things, screams, and is disobedient). This score had excellent internal consistency (Cronbach's α = .87). Teachers' reports were obtained using the Teachers' Report Form (Achenbach, 1991b). On a 34-items scales similar to CBCL, teachers rated children's tendency to display delinquent and aggressive behaviors. The internal consistency was also excellent (Cronbach's α = .95). These scores have been extensively used as indices of children's behavioral problems (e.g. Belsky, Pasco Fearon, & Bell, 2007; Campbell & von Stauffenberg, 2009; Yan & Dix, 2014).

Analysis Plan

Structural equation modeling (SEM; Kline, 2005) can estimate across-time associations, examine latent variables, and test meditational effects in longitudinal associations. This allowed the analyses testing mediations involving mothers' sensitivity, children's poor sustained attention, and children's executive function. SEM also accounts for covariance among predictor variables and allows for the simultaneous estimation of multiple relations. It could thus determine the unique effects of mothers' early depressive symptoms while adjusting for effects of later depressive symptoms. My strategy was to build models incrementally that represented longitudinal associations among mothers' early depressive symptoms, sensitive parenting, children's sustained attention, children's executive function, and children's grade-school maladjustments. In all analyses, a set of demographic and socio-economic status variables were controlled, including data collection site, children's gender, children's race / ethnicity, mothers' education, and the household income-to-needs ratio.

The analyses proceeded in five steps. First, preliminary analyses examined missing data, descriptive statistics, and bivariate correlations for the study's main variables. Confirmatory factor analysis (CFA) was then conducted to determine the validity of latent variables that would be used in subsequent models. These latent constructs included children's executive function and three outcomes in 3rd grade: social competence, disruptive behaviors, and cognitive and academic competence. Second, an SEM examined Hypothesis 1, that mothers' depressive symptoms in infancy would uniquely predict children's poor sustained attention and executive function prior to school entry, independent of depressive symptoms occurring later at 36- and 54-months. Third, a second SEM examined two hypotheses: whether mothers' low sensitivity in early childhood would mediate the relations of mothers' depressive symptoms in infancy to children's poor sustained attention and executive function prior to school entry (Hypothesis 2) and whether children's poor sustained attention would mediate, in part, the relations of mothers' depressive symptoms in infancy and mothers' low sensitivity to children's deficits in executive function (Hypothesis 3). Fourth, a third SEM examined Hypothesis 4, that poor sustained attention would mediate the relations of mothers' depressive symptoms in infancy to children's adjustment difficulties in 3rd grade, including disruptive behavior, low social competence, and cognitive and academic competence. Fifth, a final SEM tested whether children's poor executive function, independent of poor sustained attention, would mediate the relations of mothers' depressive symptoms in infancy to children's adjustment difficulties in 3rd grade (Hypothesis 5). In addition, mothers' later depressive symptoms at 36-, 54-months, and/or 3rd grade were included in all above SEMs to make sure that the main relations of

interests exist independent of the stability of mothers' depressive symptoms across time. Mothers' depressive symptoms in 1st grade were not included because it violated the temporal precedence by using depressive symptoms in 1st grade to predict measures of executive function at 54-months.

All SEM models were conducted in M*plus* 6.12 (Muthén & Muthén, 2007). Mediation was tested using the indirect effects procedure. A significant mediation is supported by significant indirect effects and significant indirect paths that go through the proposed mediator. In all analyses, a standard set of demographic variables was controlled: site, income-to-needs ratio, mothers' education, child ethnicity, and child gender. Missing data were handled using full information maximum likelihood (FIML), enabling the inclusion of all available data in the analyses (Enders, 2001). Maximum likelihood estimation with robust standard errors (MLR) was applied to handle skewed data. Fit indices for SEM models include the chi-square (χ^2) value, comparative fit indices (CFI) and the root-mean-square error of approximation (RMSEA). A close approximate fit is indicated by CFI $\geq$ .95 and RMSEA $\leq$ .06 (Hu & Bentler, 1999). Akaike information critaria (AIC) was used to compare models that are not nested (Kline, 2005).

Results

Preliminary Analyses

Descriptive statistics for main study variables were presented in Table 1. Mothers' depressive symptoms across children's first two years and mothers' later depressive symptoms at 36-, 54-months, and 3rd grade were significantly correlated with all main study variables. Children's sustained attention at 54-months, one proposed mediator, was significantly correlated with all variables except for father-reported social competence and disruptive behaviors. The three indicators of children's executive function (inhibition, working memory, and planning) were correlated significantly with each other as expected. Inhibition was associated significantly with all outcome variables except father-reported disruptive behaviors. Working memory was correlated significantly with all outcome variables. Planning was correlated significantly with all outcome variables except father-reported social competence. Missing data rates for main study variables were between 20.3% and 29.6%, except father-reported social skills and disruptive behaviors in 3rd grade (44.9%).

The Measurement Model

A confirmatory factor analysis was conducted to determine the validity of four latent variables. They included children's executive function and three outcome variables in 3rd grade: cognitive and academic competence, social competence, and disruptive behaviors. The model fit the data well ($\chi^2(37) = 122.44$, CFI = .974, RMSEA = .045). Standardized loadings were displayed in Figure 1. As expected, indicator variables all loaded significantly on each latent variable. Additionally, considering that sustained attention was significantly correlated with all three indicators of executive function (*r*s

= .17 to .24, *p*s < .01), an alternative model was tested to explore the validity of including sustained attention in the latent construct of executive function. In this alternative model, sustained attention was added as a fourth indicator of executive function. Compared to the original model, the alternative model fit the data significantly worse as indicated by the higher AIC value (ΔAIC = 6820.75). Thus, the original model was retained.

Model 1: Examining Hypothesis 1

In Model 1, the relations between mothers' depressive symptoms in infancy and children's sustained attention and executive function prior to school entry were examined. The model fit the data well ($\chi^2(19) = 120.85$, $p = .00$, CFI = .953, RMSEA =.056). Standardized coefficients are presented in Figure 2. Estimated coefficients for covariates (i.e. data collection site, child gender, race / ethnicity, mothers' education, and income-to-needs ratio) are shown in Table 3. Results showed that, independent of mother's later depressive symptoms at 36- and 54-months, mothers' depressive symptoms in infancy significantly predicted children's poor sustained attention and executive function prior to school entry. Mothers' depressive symptoms at 36-months did not predict either children's subsequent sustained attention or executive function, whereas mothers' depressive symptoms at 54-months significantly predicted children's poor concurrent executive function. The indirect effect from mothers' depressive symptoms in infancy to children's sustained attention prior to school entry was not significant (β = -.032, *ns*). In contrast, the indirect effect from mothers' depressive symptoms to children's poor executive function was significant (β = -.013, $p < .05$). As shown in Table 4, only one set of significant indirect paths emerged. Mothers' depressive symptoms in infancy were stable till 54-months, which in turn predicted children's poor executive function (β = -

.011, $p < .01$). This suggested that both mothers' early and later depressive symptoms predicted children's poor sustained attention. Overall, results demonstrated the unique effects of mothers' early depressive symptoms on children's sustained attention, but not on executive function.

Model 2: Examining Hypotheses 2 & 3

A second SEM model was conducted to test the predictions that (a) mothers' low sensitivity in early childhood would mediate the longitudinal associations between mothers' depressive symptoms in infancy and children's poor sustained attention and executive function prior to school entry (Hypothesis 2), and (b) children's poor sustained attention would mediate associations between mothers' depressive symptoms in infancy and children's poor executive function (Hypothesis 3). The model fit the data relatively well ($\chi^2(29) = 146.17$, $p = .00$, CFI = .951, RMSEA = .052). Standardized coefficients for relations of main interests are displayed in Figure 3. Standardized and unstandardized coefficients for covariates are presented in Table 3.

Significant indirect effects from mothers' depressive symptoms in infancy to children's poor sustained attention at 54-months emerged ($\beta = -.022$, $p < .05$). The significant indirect paths were shown in Table 4. Mothers' depressive symptoms across children's first two years predicted mothers' low sensitivity at 36-months, which in turn predicted children's poor sustained attention at 54-months ($\beta = -.019$, $p < .05$). Results thus supported Hypothesis 2 by showing that mothers' low sensitivity mediated the relations between mother's depressive symptoms in infancy and children's poor sustained attention prior to school entry.

Results also supported Hypothesis 3. The indirect effects from mothers'

depressive symptoms in infancy to children's poor executive function prior to school entry were significant (β= -.056, p < .05). Three sets of indirect paths were significant: (a) mothers' depressive symptoms in infancy predicted mothers' low sensitivity at 36-months, which in turn predicted children's poor executive function (β = -.045, p =.001); (b) mothers' depressive symptoms in infancy predicted mothers' low sensitivity at 36-months, which in turn predicted children's poor sustained attention at 54-months, which then predicted children's poor executive function (β = -.01, p < .05); and (c) mothers' depressive symptoms in infancy were stable to 54-months, which in turn predicted children's poor executive function prior to school entry (β = -.022, p < .05). These results showed that the relations between mothers' depressive symptoms in infancy and children's poor executive function were mediated in part by mothers' low sensitivity and children's subsequent poor sustained attention.

Model 3: Examining Hypothesis 4

Model 3 examined the predication that children's poor sustained attention would mediate longitudinal associations between mothers' depressive symptoms in infancy and children's adjustment difficulties in 3rd grade. The model fit the data relatively well ($\chi^2(95)$ = 432.61, p = .00, CFI = .953, RMSEA = .059). Standardized coefficients among the main variables are presented in Figure 4. Three aspects of children's adjustment difficulties were investigated, including disruptive behaviors, low social competence, and cognitive and academic competence. I examined whether sustained attention mediated the relations of mothers' depressive symptoms in infancy to each aspect of adjustment difficulties. Estimated coefficients for covariates are present in Table 3.

Results showed that longitudinal associations between mothers' depressive

symptoms in infancy and each aspect of children's adjustment difficulties in 3rd grade were mediated by children's poor sustained attention. Significant indirect paths were displayed in Table 4. First, children's poor sustained attention partially mediated the relations between mothers' depressive symptoms in infancy and children's low cognitive and academic competence in 3rd grade. Significant indirect effects emerged (β = -.01, p < .05). Specifically, there were two sets of significant indirect paths: (a) mothers' depressive symptoms in infancy predicted mothers' low sensitivity at 36-months, which predicted children's poor sustained attention at 54-months, which in turn predicted children's low cognitive and academic competence in 3rd grade (β = -.01, p < .05); and (b) mothers' depressive symptoms in infancy were stable up to 3rd grade, when they predicted, concurrently, children's low cognitive and academic competence (β = -.01, p < .05).

Second, results suggested that children's poor sustained attention partially mediated the relations of mothers' depressive symptoms in infancy to children's low social competence in 3rd grade. Significant indirect effects emerged (β = -.02, p < .01). Two sets of significant indirect paths were identified: (a) mothers' depressive symptoms in infancy predicted their low sensitivity at 36-months, which predicted children's poor sustained attention at 54-months, which in turn predicted children's low social competence in 3rd grade (β = -.01, p < .05); and (b) mothers' depressive symptoms in infancy were stable up to 3rd grade, when they predicted children's low concurrent social competence (β = -.01, p < .01).

Third, children's poor sustained attention was also found to partially mediate the relations between mothers' depressive symptoms in infancy and children's disruptive

behavior in 3rd grade. Significant indirect effects emerged (β = .01, p < .05). Two sets of significant indirect paths included: (a) mothers' depressive symptoms in infancy predicted their low sensitivity at 36-months, which then predicted children's poor sustained attention at 54-months, which in turn predicted children's disruptive behavior in 3rd grade (β = .01, p < .05); and (b) mothers' depressive symptoms in infancy were stable up to 3rd grade, when they predicted children's concurrent disruptive behavior (β = .01, p < .05).

Model 4: Examining Hypothesis 5

A final SEM model added executive function as a mediator and evaluated the predication that children's poor executive function prior to school entry would mediate the longitudinal associations between mothers' depressive symptoms in infancy and children's adjustment difficulties in 3rd grade, independent of children's poor sustained attention. The model fit the data well ($\chi^2(139) = 473.79$, p = .00, CFI = .957, RMSEA = .048). Standardized coefficients are displayed in Figure 5. Estimated coefficients for covariates are displayed in Table 3.

Results revealed that children's poor executive function mediated the relations of mothers' depressive symptoms in infancy to each of the three aspects of children's poor outcomes in 3rd grade. Significant indirect paths were displayed in Table 4. First, the longitudinal associations between mothers' depressive symptoms in infancy and children's low cognitive and academic competence in 3rd grade was mediated by children's poor executive function prior to school entry. Significant indirect effects emerged (β = -.04, p < .05). Two sets of indirect paths were significant. (a) Mothers' depressive symptoms in infancy predicted mothers' low sensitivity at 36-months, which

then predicted children's poor sustained attention at 54-months, which in turn predicted children's poor executive function prior to school entry. Poor executive function then predicted children's low cognitive and academic competence in 3rd grade (β = -.01, p < .05). In addition, (b) mothers' depressive symptoms in infancy predicted mothers' low sensitivity at 36-months, which then predicted children's poor executive function prior to school entry. Poor executive function in turn predicted children's low cognitive and academic competence in 3rd grade (β = -.03, p < .01). Both sets of significant indirect paths went through children's poor executive function, which supported its mediating role. Additionally, when children's executive function was added to Model 4, children's poor sustained attention no longer predicted their 3rd-grade poor outcomes independent of executive function. Instead, children's poor sustained attention influenced their poor cognitive and academic competence via its relation to poor executive function.

Second, results demonstrated that children's poor executive function partially mediated the longitudinal relations between mothers' depressive symptoms in infancy and children's low social competence in 3rd grade. Significant indirect effects emerged (β = -.02, p < .01). Mothers' depressive symptoms in infancy predicted children's low social competence in 3rd grade through two sets of significant indirect paths. (a) Mothers' depressive symptoms in infancy predicted their low sensitivity at 36-months, which then predicted children's poor executive function prior to school entry, which in turn predicted children's low social competence in 3rd grade (β = -.01, p < .05). Additionally, (b) mothers' depressive symptoms in infancy were stable up to 3rd grade, when they predicted children's poor concurrent social competence (β = -.01, p < .01). Children's poor executive function thus mediated in part the longitudinal associations between

mothers' depressive symptoms in infancy and children's low social competence in early grade school.

Third, results showed that children's poor executive function partially mediated the relations between mothers' depressive symptoms in infancy and children's disruptive behavior in 3rd grade. Significant indirect effects emerged ($\beta = .02$, $p < .05$). Two sets of significant indirect paths were identified. (a) Mothers' depressive symptoms in infancy predicted their low sensitivity at 36-months, which then predicted children's poor executive function prior to school entry, which in turn predicted children's disruptive behavior in 3rd grade ($\beta = .01$, $p < .05$). In addition, (b) mothers' depressive symptoms in infancy were stable up to 3rd grade, when they predicted children's concurrent disruptive behavior ($\beta = .01$, $p < .05$). Because children's poor executive function was involved in one of the significant indirect paths, its mediating role was supported.

Discussion

Mothers' depressive symptoms are an established risk factor for children's poor cognitive and socioemotional adjustment (England & Sim, 2009; Goodman, 2007; Wang & Dix, 2015). Yet, little is known about the processes in children that are responsible for this risk. Using longitudinal data across a seven-year period, this study examined the roles that deficits in children's sustained attention and executive function play in promoting their adjustment difficulties in the face of mothers' depressive symptoms. Three findings stand out. First, to my knowledge, this study is among the first to show, not only that mothers' depressive symptoms placed children at risk for poor sustained attention and executive function, but that these cognitive processes mediated the relations of mothers' depressive symptoms in infancy to children's poor cognitive and socioemotional functioning 7 years later in third grade. Second, this study revealed that mothers' insensitivity and children's poor sustained attention were mechanisms underpinning the relations of mothers' depressive symptoms in infancy to children's poor executive function. Mothers' depressive symptoms in infancy predicted relatively insensitive parenting in early childhood, which in turn predicted children's poor executive function prior to school entry both directly and indirectly via poor sustained attention. Third, this study demonstrated the unique effects of mothers' depressive symptoms in infancy on children's emerging sustained attention. Mothers' depressive symptoms across the first two years, but not depressive symptoms that occurred later, predicted children's poor sustained attention prior to school entry. Overall, this study contributed to the literature by demonstrating that, when they occur early in infancy, mothers' depressive symptoms – by undermining maternal sensitivity – may play a

formative role in the development of children's poor sustained attention and executive function that promote their subsequent poor cognitive and socioemotional outcomes in third grade.

Mothers' Depressive Symptoms and Children's Poor Sustained Attention and Executive Function

The finding supported Hypothesis 1. When mothers' depressive symptoms were high across the first two years, their children were more likely to display poor sustained attention and executive function prior to school entry. These children tend to be easily distracted and less likely to stay focused on immediate tasks for prolonged periods. They also tend to display inferior executive function by maintaining goals poorly, resisting temptations poorly, and failing to take time to think and plan carefully before acting.

These results contribute to the scant literature that examines the adverse impact of mothers' depressive symptoms on children's emerging sustained attention and executive function. Consistent with Breznith and Friedman (1998), this study suggests that mothers' depressive symptoms in infancy are associated with subsequent impairment in children's sustained attention. While the Breznith and Friedman's study (1998) used cross-sectional data and relied on an extremely small sample (n = 25), this study examined this relation across a seven-year period in a large national sample. This finding is important because it shows the unique and enduring effect of mothers' depressive symptoms in early years: independent of later depressive symptoms, early symptoms uniquely predict children's poor sustained attention three years later when children are ready for school.

Moreover, this study demonstrated the adverse impact of mothers' depressive symptoms on the development of children's executive function. This finding is consistent

with results from another study in which both mothers' depressive symptoms at age 2 and their increases from ages 2 to 6 predicted children's poor executive function at age 6 (Hughes et al, 2013). At the same time, this finding contrasts with null results reported in three other studies of executive function of preschoolers and adolescents exposed to mothers' depressive symptoms (Klimes-Dougan et al., 2006; Micco et al., 2009; Rhoades et al., 2011). Two considerations may explain these contrasting results. First, it may result from examining children at different age groups. The ages of children in the Hughes and colleagues' study (2013) and the current study were overlapping. In contrast, three studies that reported inconsistent results examined either younger (36-months; Rhoades et al., 2011) or older children (adolescents; Klimes-Dougan et al., 2006; Micco et al., 2009). While 36-months may be too early to test children's executive function reliably (Wiebe et al., 2014), adolescents may spend less time in close proximity with their mothers than do young children and thus may be less affected by mothers' depressive symptoms. Second, these contrasting findings may reflect different measures of depressive symptoms. All three studies that produced null results treated mothers' depressive symptoms as categorical variables, whereas both the Hughes and colleagues' study (2013) and this study treated depressive symptoms as a continuous variable, which may increase the sensitivity with which mothers' depressive symptoms are measured (Hughes et al., 2013).

The Mediation of Mothers' Sensitivity

The finding supported Hypothesis 2: the associations between mothers' depressive symptoms in infancy and children's poor sustained attention and executive function prior to school entry were mediated not only by tendencies for early depressive symptoms to persist across development, but also by tendencies for early depressive

symptoms to predict insensitive parenting in early childhood. Mothers' insensitivity, in turn, predicted children's poor sustained attention and executive function two years later. This suggests, when high across early development, mothers' depressive symptoms may undermine the development of children's sustained attention and executive function partly by promoting mothers' insensitivity and unresponsiveness. This is consistent with literature suggesting that effective parenting and supportive family environment promote the development of children's sustained attention and executive function (e.g. Fay-Stammbach, Hawes, & Meredith, 2014; Hughes & Ensor, 2009; Razaa, Martin, & Brooks-Gunn, 2010). The current study extends this literature by demonstrating that the relation of mothers' insensitivity to children's poor sustained attention and executive function can help explain the maladjustment of children whose mothers are high in depressive symptoms.

Although mothers' insensitivity has been demonstrated to mediate the relations of their early depressive symptoms to children's subsequent inferior performance in both sustained attention and executive function, the underlying processes through which mothers' sensitivity influences children's emerging sustained attention, one the one hand, and executive function, on the other hand, may be different. On the one hand, mothers' sensitivity may promote children's sustained attention by affecting children's emotional and motivational processes. Consistent with attachment theory (Ainsworth, Blehar, Waters, & Wall, 1978), by being responsive to children's emotional cues, mothers may help children effectively cope with negative affect and arousal that might decrease children's interest in and comfort with exploring the environment (Gaertner, Spinrad, & Eisenberg, 1998; Ruff & Rothbart, 1996; Tronick & Reck, 2009). Sensitive mothers may

also offer sufficient support and regulation as needed so that children are exposed to minimal distractions and are encouraged to maintain engagement (Bono & Stifter, 2003; Landry et al., 1996). On the other hand, mothers' sensitivity may promote children's executive function by affecting their biological and cognitive processes. This may occur because sensitive parenting reduces children's physiological responses to stress (e.g. cortisol; Gunnar & Quevedo, 2007; Kuhlman, Olson, & Lopez-Duran, 2014), promotes the development in the frontal lobe (Hughes & Baylin, 2012), and facilitates early language and memory capacities (Barnett, Gustafsson, Deng, Mills-Koonce, & Cox, 2012). All of these are positively associated with increases in children's executive function (Blair et al., 2011; Glaser, 2000; Hammond et al., 2012; Matte-Gagné & Bernier, 2011).

The Interrelation Between Sustained Attention and Executive Function

The results supported Hypothesis 3. In the face of mothers' depressive symptoms in infancy, their insensitivity indirectly predicted children's poor executive function later through its relation to children's poor sustained attention. This demonstrates that children's poor sustained attention may help to understand their inferior executive function when exposed to mothers' depressive symptoms in early years. This supports the proposal that children's ability to maintain focused attention for prolonged periods may be a prerequisite to executive function. To my knowledge, this study is among the first to demonstrate the potential of children's poor sustained attention to undermine their executive function as a latent construct. This finding is in line with prior research demonstrating the importance of sustained attention to the development of individual components of executive function. Sustained attention enables children to better inhibit

impulsive responses and distractions (Reck & Hund, 2011; Sethi et al., 2000), plan possible solutions (Young et al., 2007), and maintain goal-relevant information in memory (Espy & Bull, 2005; Silver & Feldman, 2005); all are essential components of executive function.

Sustained attention may facilitate the development of executive function in two ways. First, when children can sustain attention, they are more likely to maintain their goals actively (Ruff & Capozzoli, 2003), which is a prerequisite to executive function (Zelazo & Müller, 2011). Second, when children can sustain attention, they are more likely to benefit from socialization that fosters their representational skills (e.g. language), which is predicative of gains in executive function (Miller & Marcovitch, 2015). Overall, the finding suggests that, in the face of mothers' depressive symptoms in infancy and asscociated insensitive parenting, the development of children's sustained attention may be undermined, which in turn may contribute to their inferior executive function.

Sustained Attention and Executive Function as Mediators

Findings supported Hypotheses 4 and 5. They revealed that, when mothers' depressive symptoms were high across the first two years, their children tend to experience cognitive and socioemotional difficulties in third grade partly because early depressive symptoms predicted deficits in children's sustained attention and executive function. Independent of poor sustained attention, children's poor executive function mediated the associations between mothers' depressive symptoms in infancy and children's adjustment difficulties 7 years later in third grade. This mediation was present when predicting children's disruptive behavior, low social competence, and cognitive and academic competence. Consistent with studies suggesting that executive function predicts

children's cognitive and socioemotional functioning (e.g. Fahie & Symons, 2003; Hughes & Ensor, 2008; Razza & Blair, 2009; Robinson et al., 2014), this study further demonstrated the mediating role of executive function in understanding the developmental risks children of depressed mothers face. Why would children's inferior executive function increase their risks for various forms of cognitive and socioemotional maladjustment later? I now turn to this question.

Executive function and subsequent cognitive and academic competence. When mother' depressive symptoms are in infancy, children's inferior executive function may have a direct adverse effect on their cognitive and academic competence. Executive function – the ability to attend, inhibit distractions, and process relevant information – is essential to cognitive and academic functioning (Duncan et al., 2007). Academic instruction that demands high-order cognitive skills – comparison, reasoning, and reflection – and requires representation of hierarchical rule structures is particularly likely to rely on executive function (Nayfeld, Fuccillo, & Greenfield, 2013). Additionally, executive function facilitates children's self-regulatory capacities (Blair & Ursache, 2010). Regulation of emotion, attention, and physiological responses to stress has been shown to be crucial to children's cognitive and academic performance above and beyond general intelligence (Blair & Razza, 2007; McClelland et al., 2007; Normandeau & Guay, 1998). As children learn to self-regulate, they become able to elicit patient scaffolding from mothers (Choe, Olson, & Sameroff, 2013), to engage in classroom learning (Véronneau, Hiatt Racer, Fosco, & Dishion, 2014), and to persist in the face of challenges (Pelletier, Fortier, Vallerand, & Brière, 2001). All of these are thought to enhance cognitive and academic competence. Therefore, it seems likely that exposure to

mothers' depressive symptoms may undermine children's emerging executive function, which in turn impedes later cognitive and academic performance directly (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009).

In addition, these effects may be indirect, due to children's poor executive function hindering the development of learning-related behaviors, as mothers' depressive symptoms increase in infancy. Learning-related behaviors reflect children's effective adaption to classroom demands and learning tasks (Morgan, Farkas, Hillemeier, & Maczuga, 2009). They include following teachers' instructions, attending to course materials, abiding by classroom rules, and engaging in learning activities (Morgan et al., 2009). As a higher-order cognitive process, executive function is thought to facilitate children's learning-related behaviors by strengthening their capacities to attend to class materials and resist distractions (Neuenschwander, Röthlisberger, Cimeli, & Roebers, 2012; Sasser, Bierman, & Heinrichs, 2015). Supporting this proposal, executive function has been shown to predict preschool and kindergarten children's learning-related behaviors, including active engagement, motivation, attention, persistence, and appropriate study habits (Brock et al., 2009; Denham, Warren-Khot, Bassett, & Perna, 2012; Neuenschwander et al., 2012; Sasser, Bierman, & Heinrichs, 2015). Learning-related behaviors, in turn, are crucial to school performance because they facilitate children's ability to participate actively in classroom learning (Stipek, Newton, & Chudgar, 2010). Not surprisingly, well-developed learning-related behaviors have been shown to foster children's academic progress (Ladd & Dinella, 2009) and general reading and math competence (Hirvonen, Tolvanen, Aunola, & Nurmi, 2012; Sasser, Bierman, & Heinrichs, 2015). Thus, deficits in children's learning-related behaviors, due to poor

executive function, may account in part for why children of depressed mothers display poor cognitive functioning in early grade school.

Executive function and subsequent socioemotional adjustment. When mothers have depressive symptoms in infancy, children's inferior executive functioning may lead to their low socioemotional functioning directly. Executive function is conceptualized as an important component of self-regulation (Blair & Ursache, 2010). Poor executive function has been associated with children's difficulty regulating emotion, behavior, and cognition in goal-directed ways (Blair & Ursache, 2010; Fuster, 2002). In frustrating situations, children with poor executive function are less likely to modulate attention away from negative cues, to resist the temptation to act impulsively, and to regulate negative affect appropriately (Calkins & Dedmon, 2000; Eisenberg et al., 2001; Moffitt, 2003; Olsen et al., 2011); all of these are indicators of behavioral problems and low social competence (Choe, Olson, & Sameroff , 2013; Eisenberg et al., 2000; Eisenberg et al., 2001). Indeed, disturbance in children's self-regulation has been linked to low popularity (Spinrad et al., 2006), aggressive peer interactions (Olson et al., 2011), poor social competence (Garner & Waajid, 2012), and externalizing problems in young children (Murray & Kochanska, 2002; Olson, Sameroff, Kerr, Lopez, & Wellman, 2005). Overall, in the face of mothers' depressive symptoms in infancy, children's poor executives function may directly lead to disruptive behaviors and low social competence in early grade school because of their inferior self-regulatory capabilities.

Moreover, these effects may be indirect. As mothers' depressive symptoms increase in infancy, children's poor socioemotional outcomes in early grade school may reflect their inferior theory of mind and false belief understanding associated with poor

executive function (Blair & Razza, 2007; see Devine and Hughes, 2014 for a review). The development of executive function promotes children's theory of mind (Devine & Hughes, 2014), that is, the ability to attend to and reflect on their own and others' mental states. To succeed in the traditional change-of-location false belief task, a common measure of theory of mind, children need to track the location of an object, hold in mind the information known by an absent character, and override their own correct knowledge so as to attribute a false belief to the character. All of these rely on executive function heavily (Devine & Hughes, 2014; Russell, Mauthner, Sharpe, & Tidswell, 1991). Evidence demonstrates a relation between executive function and theory of mind. Four-year-olds' executive function, as indicated by planning and flexibility, predicted their theory of mind one year later, but not vice versa (Hughes, 1998). A recent meta-analysis revealed that the association between early executive function and later theory of mind, particularly false belief understanding, was significantly stronger than the reverse association (Devine and Hughes, 2014). Inferior theory of mind in turn is implicated in children's poor social competence (Razza & Blair, 2009). Children who demonstrate good theory of mind are better at interpreting others' perceptions, desires, and beliefs (Kuhn, 2000) and at understanding the association between others' mental states and actions (Gopnik & Astington, 1988). These understandings are essential to social competence (Capage & Watson, 2001; Liddle & Nettle, 2006). In addition, inferior theory of mind adversely affects children's social behavior. Children with advanced ability at understanding other's mental states are more likely to be sensitive to others' thoughts and feelings and accordingly, to engage in helping, comforting, and other prosocial behaviors (Caputi, Lecce, Pagnin, & Banerjee, 2012; Lalonde & Chandler,

1995; Nelson & Crick, 1999; Slaughter, Dennis, & Pritchard, 2002). Conversely, children with inferior theory of mind are more likely to act aggressively (Capage & Watson, 2001; Olson, Lopez-Duran, Lunkenheimer, Chang, & Sameroff, 2011; Renouf et al., 2010). Therefore, poor socioemotional functioning of children of depressed mothers may reflect their poor executive function and its adverse impact on their mental ability to understand and make inference of other's mental states.

The Impact of Early versus Later Depressive Symptoms

The proposal that, when they present across the first two years, mothers' depressive symptoms would uniquely predict children's poor sustained attention and executive function prior to school entry were partially supported. Independent to depressive symptoms that occurred from 36-months to third grade, mothers' depressive symptoms in infancy had a unique effect on children's poor sustained attention, but not executive function. This suggests that, when they occur in the first two years, mothers' depressive symptoms may exert a unique and formative role in the emergence of children's sustained attention. Consistent with prior studies (Yan & Dix, 2014; Wang & Dix, 2015), the finding demonstrates the legacy of depressive symptoms occurring early in development and the persistence of their adverse impact independent of later experiences. When they occur early, mothers' depressive symptoms have been shown to uniquely predict low mutually responsive mother-child interactions, maladaptive interpretations of social events, externalizing behaviors, and low social competence and academic performance at school entry (Yan & Dix, 2014; Wang & Dix, 2015). Extending these efforts, the current study thus further demonstrates the legacy of mothers' depressive symptoms in infancy for predicting children's sustained attention.

This finding is also consistent with the proposals that the first two years are a critical period for the development of sustained attention (Ruff & Rothbart, 1996). By the end of the second year, children's ability to regulate attention voluntarily emerges (Ruff & Rothbart, 1996). Although sustain attention keeps increasing during the preschool years (Ruff & Capozzoli, 2003), some fundamental processes underlying attention are in place by 24 months (Colombo, 2001; Richards & Cronise, 2000; Richards & Turner, 2001). These include the ability to remain alert, to inhibit attention to distractions, to detect and recognize objects, and to orient and shift attention to a particular spatial locus (see Colombo, 2001, for a review). By 24-months, the attention of young children in many ways resembles that of adults. As suggested by the attentional inertia model, the attention of infants and toddlers to audiovisual stimuli operates in a way that also holds among adults, that is, an increasing engagement of attention over the course of a look (Richards & Cronise, 2000). Therefore, early depressive symptoms may play a unique role in the development of children's sustained attention due to their adverse impact on formative skills that underlie sustained attention and remain functioning throughout the life span.

The unique effect of mothers' depressive symptoms in infancy on children's executive function was not found. This may reflect the fact that components of executive function develop at various ages spanning infancy, toddlerhood, and early childhood (Zezalo et al., 2003). The developmental period from 2 to 5 years, in particular, is marked by dramatic increases in executive function (Wiebe et al., 2014). During this period, children show increasing ability to plan (Kaller et al., 2008; Luciana & Nelson, 1998), to maintain multiple pieces of information simultaneously (Logie & Pearson, 1997;

Simmering, 2012), and to inhibit responses incompatible with immediate tasks (Dowsett & Livesey, 2000; Gerardi-Caulton, 2000). Thus, mothers' depressive symptoms in early childhood may continue to influence the development of children's executive function beyond the first two years.

Limitations

Among the strengths of this study are its longitudinal design, use of structural equation modeling, and use of multi-informant data. However, several aspects of this study limit the generalizability of its findings. First, given that it utilized a longitudinal design and examined mediation by testing indirect effects, this study cannot specify causal relationships. It is possible that third variables that are beyond the scope of the current study may also contribute to the observed associations. One possibility is genetics. Genetic factors are thought to exert influences on children's cognitive and socioemotional adjustment through interacting with environmental factors (e.g. Cheung, Harden, & Tucker-Drob, 2014; Guimond et al., 2014; Rivizzigno et al., 2014). This may result from children's differential susceptibility to adverse parenting and other environmental factors (Pluess & Belsky 2011). Children high in negative emotionality, for example, may be more affected by mothers' insensitive parenting than others low in negative emotionality (Pluess & Belsky 2011). Hence, it is likely that genetic factors in children may help explain, to some extent, individual differences in vulnerability to mothers' depressive symptoms and insensitivity (Goodman & Gotlib, 1999) as part of the etiology for children's subsequent poor sustained attention, executive function, and adjustment (Friedman et al. 2008; Greene et al., 2009; Groot, de Sonneville, Stins, & Boomsma, 2004). Second, mothers in this study were not clinically depressed. Caution should be exercised when generalizing findings to clinical populations. Third, this study was based on a mostly White U.S. sample. Thus, findings may not generalize to children in racially and ethically diverse groups and in non-Western societies.

Conclusions

The current study shows that, due to their links to children's deficits in sustained attention and executive function, mothers' depressive symptoms in infancy constitute a risk for children's poor cognitive and socioemotional adjustment 7 years later. These cognitive deficits in children's sustained attention and executive function reflect in part depressed mothers' tendency to become insensitive. That mothers' depressive symptoms in infancy predict children's poor sustained attention independent of later depressive symptoms demonstrates the unique impact of symptoms in infancy. These relations demonstrate the potential importance of early developing cognitive processes in children when understanding why mothers' depressive symptoms undermine children's both cognitive and socioemotional adjustment. Children's emerging cognitive abilities to maintain sustained, to resist distractions, to hold multiple pieces of information in mind, and to plan accordingly appear to be crucial to understand the developmental risks children of depressed mothers face.

Findings of this study can potentially inform interventions in three ways. First, timing may be important. While interventions to improve children's executive function may be helpful throughout early childhood, interventions to foster children's sustained attention may need to begin in infancy or toddlerhood. Second, interventions to enhance children's sustained attention and executive function may need to focus on improving their depressed mothers' sensitivity. Third, interventions to foster the cognitive and socioemotional adjustment of children of depressed mothers may need to focus on improving children's sustained attention and executive function.

Table 1

Bivariate correlations and descriptive statistics for main study variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1. Mothers' DEP in infancy	--																
2. Mothers' DEP at 36-months	.61**	--															
3. Mothers' DEP at 54-months	.53**	.52**	--														
4. Mothers' DEP in 3rd grade	.52**	.39**	.45**	--													
5. Mothers' sensitivity	-.28**	-.22**	-.25**	-.23**	--												
6. Sustained attention	-.14**	-.07*	-.11**	-.09**	.18**	--											
Executive function																	
7. Inhibition	-.18**	-.11**	-.20**	-.15**	.28**	.24**	--										
8. Working memory	-.15**	-.13**	-.17**	-.16**	.33**	.17**	.29**	--									
9. Planning	-.11**	-.08*	-.10**	-.08*	.13**	.23**	.14**	.18**	--								
Cognitive & academic competence																	
10. Picture vocabularies	-.20**	-.15**	-.16**	-.16**	.32**	.16**	.26**	.53**	.18**	--							
11. Verbal analogies	-.16**	-.13**	-.17**	-.10**	.30**	.23**	.25**	.48**	.22**	.56**	--						
12. Broad reading	-.19**	-.12**	-.17**	-.16**	.30**	.22**	.29**	.57**	.22**	.63**	.61**	--					
13. Broad math	-.23**	-.17**	-.21**	-.19**	.29**	.26**	.23**	.43**	.28**	.52**	.59**	.69**	--				
Social competence																	
14. Teachers' report	-.22**	-.08*	-.11**	-.19**	.23**	.16**	.16**	.20**	.18**	.23**	.23**	.26**	.28**	--			
15. Fathers' report	-.15**	-.11**	-.13**	-.17**	.21**	.06	.12**	.14**	.01	.20**	.14**	.22**	.17**	.31**	--		
Disruptive behavior																	
16. Teachers' report	.20**	.09**	.14**	.18**	-.29**	-.19**	-.18**	-.17**	-.18**	-.19**	-.22**	-.21**	-.21**	-.61**	-.30**	--	
17. Fathers' report	.16**	.10**	.10**	.14**	-.14**	-.06	-.06	-.11**	-.11**	-.13**	-.11**	-.15**	-.11**	-.23**	-.48**	.38**	--
M	9.03	9.22	9.83	9.09	17.19	32.87	4.48	98.51	14.38	105.47	109.21	111.05	116.26	102.23	104.29	51.51	46.86
SD	6.90	8.31	8.70	8.86	2.78	7.59	3.01	14.94	6.75	14.80	17.23	14.03	17.28	14.48	15.57	9.36	9.20
N	1088	1202	1077	1027	1161	1002	961	1018	999	1014	1013	1011	1012	975	749	982	751

Note. DEP = depressive symptoms. * $p < .05$, ** $p < .01$.

Table 2

Fitting indices and model comparisons

	Model Fit						Model Comparison
Models	χ^2	*df*	*c*	CFI	RMSEA	AIC	ΔAIC
Measurement Models:							
Original	122.44	37	1.003	.974	.045	77391.19	--
Alternative: including SA in EF	170.45	47	1.007	.963	.048	84211.94	6820.75
Model 1 testing Hypothesis 1	120.85	19	.999	.953	.056	34884.51	--
Model 2 testing Hypotheses 2 & 3	146.17	29	1.004	.951	.052	49189.72	14305.21
Model 3 testing Hypothesis 4	432.61	95	1.043	.953	.059	89298.99	40109.27
Model 4 testing Hypothesis 5	473.79	139	1.021	.957	.048	107140.23	17841.24

Note. CFI = comparative fit indices; RMSEA = the root-mean-square error of approximation. *c* = scaling correction factor for the maximum likelihood estimation with robust standard errors (MLR). SA = sustained attention; EF = executive function. Dashes indicate the baseline model.

Table 3

Unstandardized and standardized coefficient estimates for covariates

	Covariates									
	Site		Child gender		Ethnicity		Mothers' education		Income-to-needs ratio	
Outcomes	*b* (*SE*)	*β*	*b* (*SE*)	*β*	*b* (*SE*)	*β*	*b* (*SE*)	*β*	*b* (*SE*)	*β*
Model 1										
Dep (36-months)	.04(.08)	.01	.71(.42)	.04	-.87(.43)*	-.05*	-.19(.10)	-.06	-.03(.07)	-.01
Dep (54-months)	-.02(.08)	-.01	-.95(.47)*	-.06*	-1.30(.61)*	-.07*	-.48(.12)***	-.14***	-.12(.09)	-.04
Child SA	-.21(.09)*	-.08*	1.02(.50)*	.07*	1.51(.65)*	.09*	.38(.11)**	.11**	.04(.10)	-.01
Child EF	-.01(.02)	.02	.26(.13)*	.09*	.78(.15)***	.24***	.24(.07)***	.19***	.08(.04)*	.10*
Model 2										
Dep (36-months)	.03(.07)	.10	.59(.42)	.04	-.82(.41)*	-.05*	-.24(.10)*	-.07*	-.03(.08)	-.01
Dep (54-months)	-.04(.08)	-.01	-.83(.44)	-.05	-1.24(.53)*	-.07*	-.27(.10)**	-.08**	-.05(.08)	-.02
Sensitivity	-.01(.03)	-.01	.42(.15)**	.08**	.71(.20)***	.12***	.34(.04)***	.31***	.14(.04)***	.13***
Child SA	-.18(.09)*	-.07*	1.04(.49)*	.07*	1.08(.59)*	.07*	.34(.11)**	.11**	.01(.10)	.01
Child EF	-.03(.02)	.06	.11(.13)	.04	.59(.14)***	.19***	.18(.03)***	.30***	.06(.04)	.10
Model 3										
Dep (36-months)	.02(.07)	.01	.60(.42)	.04	-.81(.41)*	-.05*	-.24(.10)*	-.07*	-.03(.08)	-.01
Dep (54-months)	-.04(.08)	-.01	-.82(.44)	-.05	-1.21(.53)*	-.07*	-.27(.10)**	-.08**	-.10(.08)	-.02
Dep (3rd grade)	-.01(.09)	-.01	.97(.49)*	.06*	-.16(.53)	-.01	-.25(.11)*	-.07*	-.20(.12)	-.06
Sensitivity	-.01(.03)	-.01	.43(.15)**	.08**	.72(.20)***	.12***	.34(.04)***	.31***	.14(.03)***	.13***
Child SA	-.19(.09)*	-.07*	1.05(.49)*	.07*	1.06(.59)	.07	.33(.11)**	.11**	.02(.10)	.01
Child CAC	.28(.13)*	.06*	.78(.79)	.03	3.93(1.05)*	.15***	1.75(.20)***	.34***	.40(.16)**	.08**
Child SC	-.06(.09)	-.03	.26(.52)	.02	.90(.64)	.07	.61(.14)***	.24***	.07(.12)	.03
Child DB	-.01(.10)	-.01	-.08(.59)	-.01	-1.86(.82)*	-.10*	-.66(.14)***	-.18***	.01(.13)	.01
Model 4										
Dep (36-months)	.02(.07)	.01	.59(.42)	.04	-.79(.41)*	-.05*	-.25(.10)*	-.07*	-.03(.08)	-.01
Dep (54-months)	-.04(.08)	-.02	-.84(.44)*	-.05*	-1.21(.52)*	-.07*	-.27(.10)**	-.08**	-.06(.08)	-.02
Dep (3rd grade)	-.05(.08)	-.02	.87(.47)	.05	-.05(.52)	-.01	-.09(.11)	-.03	-.12(.11)	-.04
Sensitivity	-.01(.03)	-.01	.42(.15)**	.08**	.72(.20)***	.12***	.34(.04)***	.31***	.14(.03)***	.13***
Child SA	-.19(.09)*	-.07*	1.06(.49)*	.07*	1.08(.59)*	.07*	.34(.11)**	.11**	.02(.10)	.01
Child EF	.03(.02)	.06	.08(.10)	.03	.49(.11)***	.18***	.16(.03)***	.31***	.04(.03)	.09
Child CAC	.01(.15)	.01	-.52(.87)	-.02	-1.49(1.17)	-.05	-.15(.27)	-.03	-.12(.24)	-.03
Child SC	-.11(.09)	-.05	.05(.52)	.01	-.04(.70)	-.01	.27(.15)*	.10*	-.02(.11)	-.01
Child DB	.04(.11)	.01	.11(.60)	.01	-.97(.86)	-.05	-.34(.18)*	-.10*	.09(.13)	.03

Note. Dep = mothers' depressive symptoms. SA = sustained attention. EF = executive function. CAC = cognitive and academic competence. SC = social competence. DB = disruptive behavior. * $p < .05$. ** $p < .01$. *** $p < .001$.

Table 4

Standardized coefficients of significant indirect paths from mothers' depressive symptoms in infancy

	β	*p*
Model 1		
Predicting EF		
DEP36 -> DEP54	-.049	.004
Model 2		
Predicting SA		
Sensitivity	-.02	.018
Predicting EF		
Sensitivity	-.045	.001
Sensitivity -> SA	-.005	.026
DEP36 -> DEP54	-.022	.02
Model 3		
Predicting Cognitive & Academic Competence		
Sensitivity -> SA	-.004	.03
DEP36 -> DEP54	-.006	.017
Predicting Social Competence		
Sensitivity -> SA	-.003	.044
DEP36 -> DEP54	-.011	.004
Predicting Disruptive Behavior		
Sensitivity -> SA	.003	.035
DEP36 -> DEP54	.007	.02
Model 4		
Predicting Cognitive & Academic Competence		
Sensitivity -> EF	-.034	.003
Sensitivity -> SA -> EF	-.004	.035
Predicting Social Competence		
Sensitivity -> EF	-.012	.027
DEP36 -> DEP54 -> DEPG3	-.008	.009
Predicting Disruptive Behavior		
Sensitivity -> EF	.008	.032
DEP36 -> DEP54 -> DEPG3	.005	.037

Note. EF = executive function. SA = sustained attention. DEP36 = mothers' depressive symptoms at 36-months. DEP54 = mothers' depressive symptoms at 54-months. DEPG3 = mothers' depressive symptoms in 3rd grade.

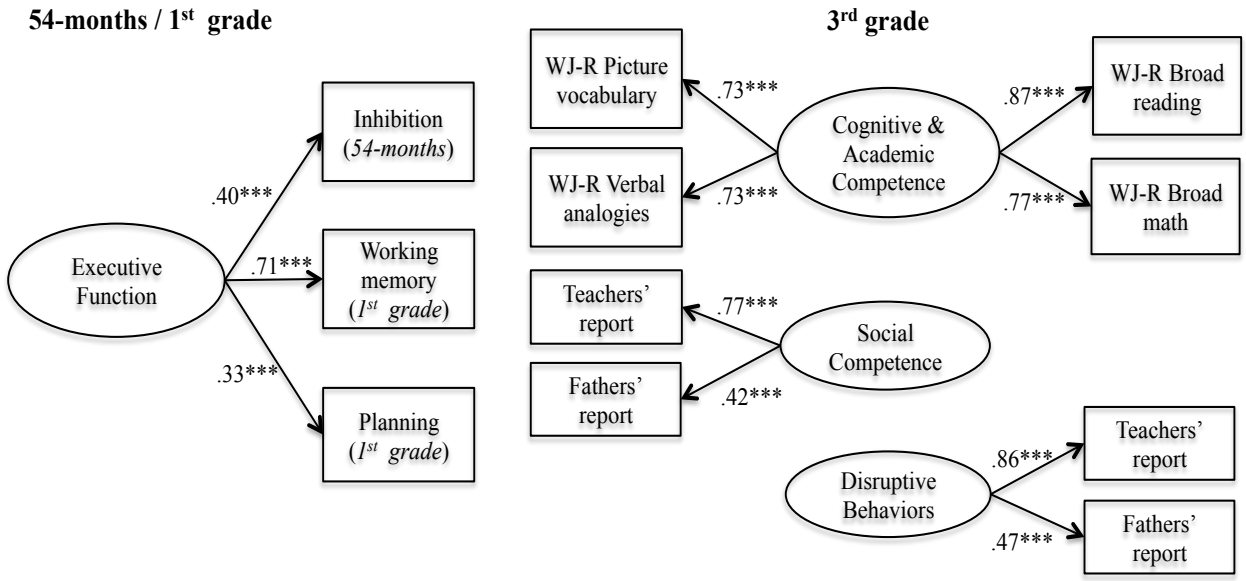

Figure 1. The confirmatory factor analysis model testing the validity of latent variables. Standardized coefficients are presented. *** $p < .001$. $\chi^2(37) = 122.44$, CFI = .974, RMSEA = .045.

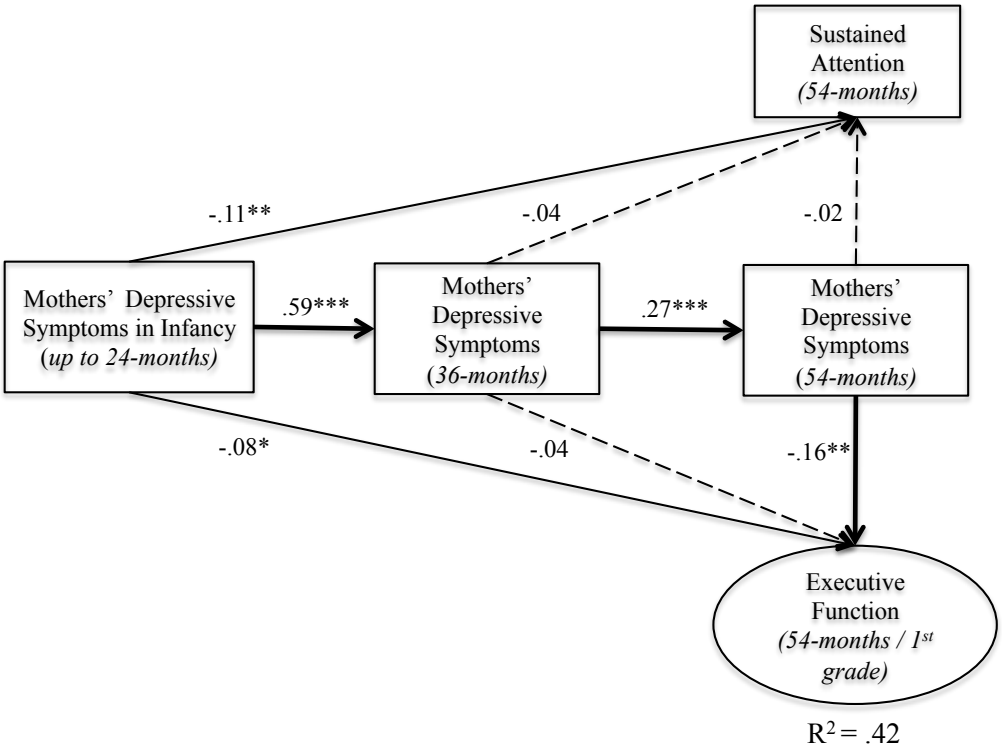

Figure 2. Model 1: the structural equation model testing Hypothesis 1. Standardized coefficients are presented. Bold lines represent significant indirect paths from mothers' depressive symptoms in infancy to children's executive function. Dashed lines represent nonsignificant paths. * $p < .05$. ** $p < .01$. *** $p < .001$. $\chi^2(19) = 120.85$, $p = .00$, CFI = .953, RMSEA =.056.

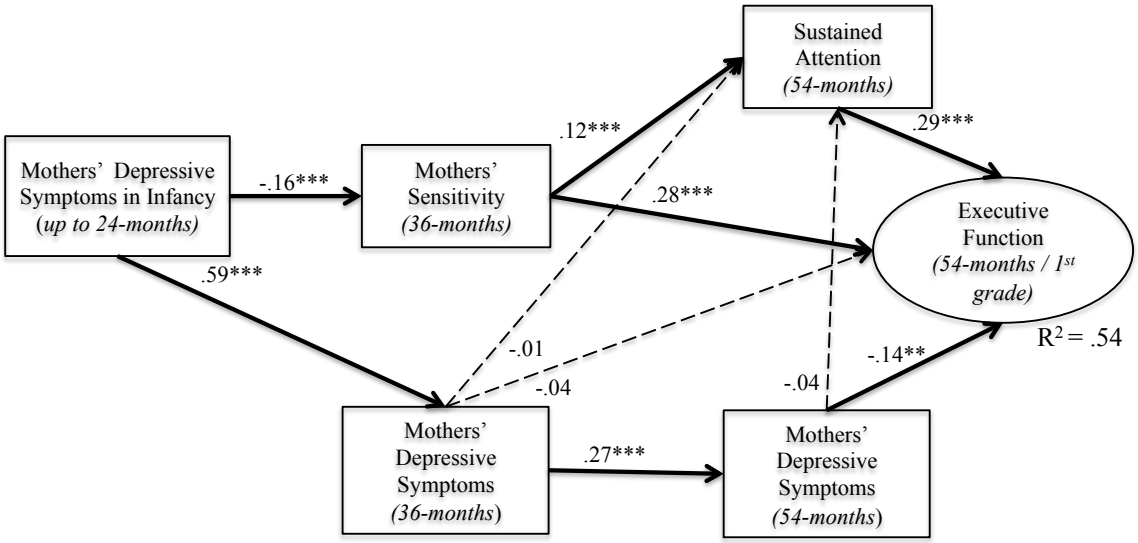

Figure 3. Model 2: the structural equation model testing Hypotheses 2 & 3. Standardized coefficients are presented. Bolded paths represent significant indirect paths. Dashed lines represent nonsignificant paths. ** $p < .01$. *** $p < .001$. $\chi^2(29) = 146.17$, $p = .00$, CFI = .951, RMSEA = .052.

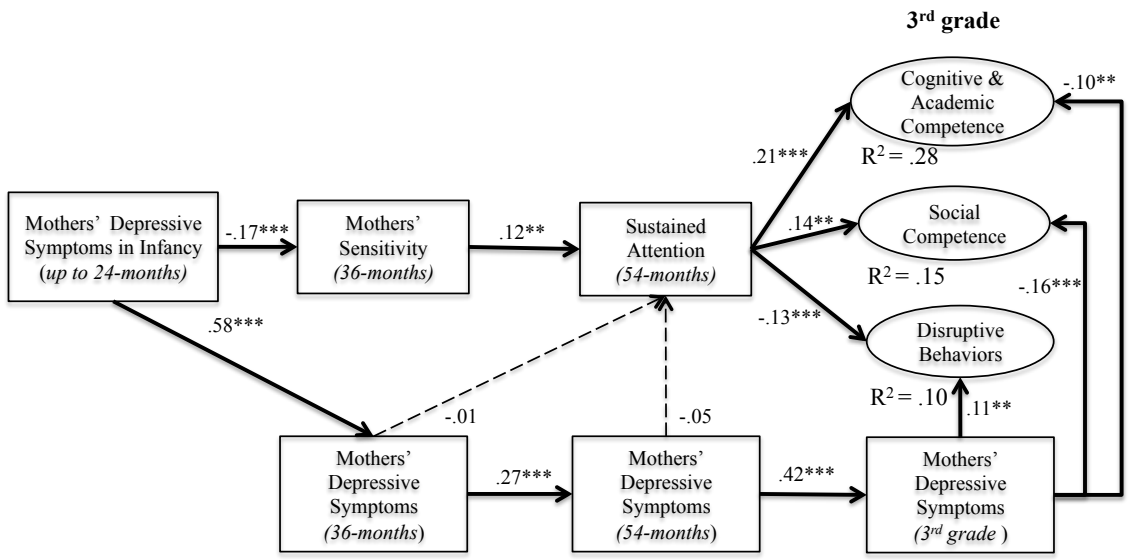

Figure 4. Model 3: the structural equation model testing Hypothesis 4. Standardized coefficients are presented. Bolded paths represent significant indirect paths. Dashed lines represent nonsignificant paths. ** $p < .01$. *** $p < .001$. $\chi^2(95) = 432.61$, $p = .00$, CFI = .953, RMSEA = .059.

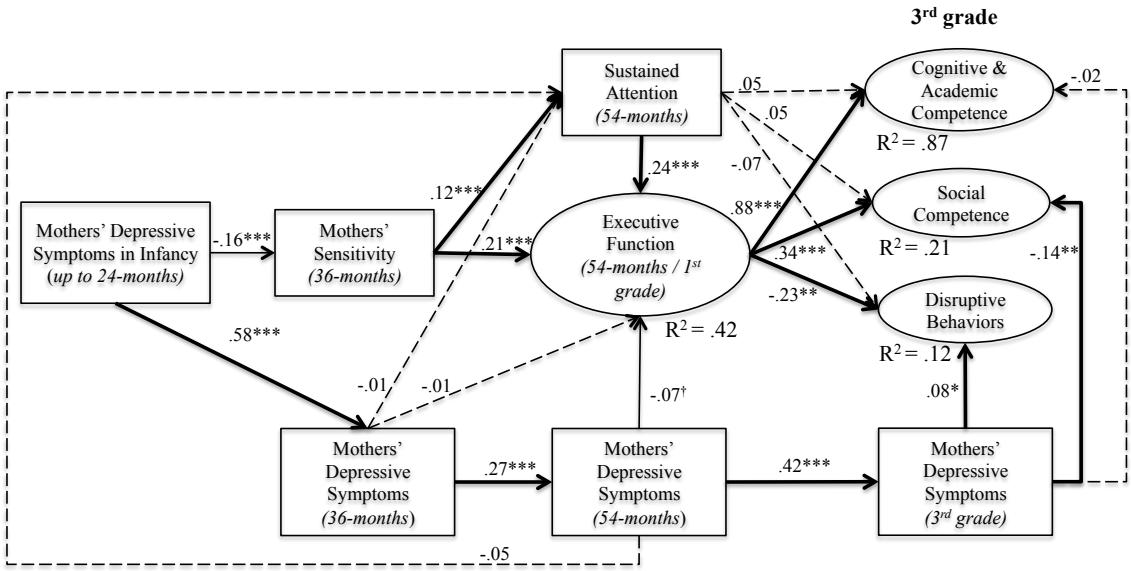

Figure 5. Model 4: the structural equation model testing Hypothesis 5. Standardized coefficients are presented. Bolded paths represent significant indirect. Dashed lines represent nonsignificant paths. † $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$. $\chi^2(139) = 473.79$, $p = .00$, CFI = .957, RMSEA = .048.

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