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Maternal Depressive Symptoms, Mother-Child Interactions, and Children's Executive Function

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This study examined the independent and mediated associations between maternal depression symptoms (MDS), mother-child interaction, and child executive function (EF) in a prospective longitudinal sample of 1,037 children (50% boys) from predominantly low-income and rural communities. When children were 6, 15 and 24 months of age, mothers reported their level of depressive symptomatology. At 24 and 36 months of age, mother-child interactions during play were rated for warmth-sensitivity and harsh-intrusiveness, and dyadic joint attention and maternal language complexity were assessed from a book sharing activity. Children's EF (i.e., inhibitory control, working memory, and set shifting) were assessed at ages 36 and 48 months using a battery of six tasks. Results indicated that MDS at ages 15 and 24 months were negatively associated with children's EF at age 48 months. Additionally, harsh-intrusive mother-child interactions partially mediated this link. Although warmth-sensitivity, dyadic joint attention and maternal language complexity were all longitudinally related to EF, they did not serve as mediating mechanisms between MDS and EF. These results were obtained while controlling for multiple demographic factors, children's earlier cognitive abilities, maternal general distress and childcare experiences. Findings from this study identify 1 mechanism through which early exposure to MDS could be related to children's EF.

Keywords: maternal depression, executive function, parental sensitivity, parental intrusiveness, dyadic joint attention

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Accumulating evidence suggests that distal and proximal factors within children's early caregiving environments are associated with the emergence of executive function (e.g., Blair et al., 2011; Fay-Stammbach, Hawes, & Meredith, 2014; Hughes & Ensor, 2009). Two aspects of the caregiving environment that have received attention in this line of research are maternal depressive symptoms (MDS) and mother-child interaction. Exposure to elevated MDS during early childhood has been related to lower EF during childhood and adolescence (Belleau, Phillips, Birmaher, Axelson, & Ladouceur, 2013; Comas, Valentino, & Borkowski, 2014; Hughes, Roman, Hart, & Ensor, 2013; Pearson et al., 2016). Further, both broad dimensions of early mother-child interaction as

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well as specific experiences and stimulation provided within mother-child interactions have been related to children's EF (Bernier, Carlson, & Whipple, 2010; Blair et al., 2011; Cuevas et al., 2014; Fay-Stammbach et al., 2014; Gueron-Sela et al., 2016; Hughes & Ensor, 2009). However, what remains understudied are the independent and mediated links between MDS, mother-child interaction and child EF, a line of research with the potential to inform critical prevention and intervention programs. Thus, the main goal of the current study was to examine the associations between MDS, mother-child interaction during toddlerhood, and child EF at the preschool period. We focused our investigation on broad dimensions of mother-child interaction (i.e., warmth-sensitivity and harsh-intrusiveness), as well as on specific experiences and stimulation provided within mother-child interactions that are theorized to support children's emerging executive abilities (i.e., dyadic joint attention, and maternal language complexity).

An additional unique aspect of this study was examining these relations among families residing in low-income, rural areas. Rural communities are often characterized by high poverty rates, low educational attainment, and reduced formal support services (Vernon-Feagans & Cox, 2013), all of which have been associated with higher risk for MDS and deficits in children's EF (Brody, Murry, Kim, & Brown, 2002; Raver, Blair, & Willoughby, 2013). As such, an in-depth understanding of potential associations between MDS, parenting and children's EF is especially relevant within the context of rural poverty.

The Development of EF

It is generally agreed that EF includes three related yet distinct components (Miyake & Friedman, 2012): inhibitory control (the ability to inhibit automatic, or prepotent, responses to facilitate task completion), working memory (the ability to monitor and update information for task relevance), and set shifting (the ability to flexibly switch between tasks or mental sets). EF develops rapidly throughout the first 5 years of life, with gradual improvements in attention regulation giving way to the emergence of more complex EF components (Garon, Bryson, & Smith, 2008). During the first three years, infants gain increased voluntary control over attention including the ability to focus on relevant aspects of a task, disengage attention when necessary, and sustain attention for longer periods of time (Garon et al., 2008). These attentional systems contribute to the child's ability to selectively attend to and focus on specific tasks, a necessary first step in goal-directed behavior that underlies EF. The emergence of the executive attention network between 3 to 5 years of age further supports EF abilities by enabling children to resolve increasing levels of conflict (Posner & Rothbart, 1998), such as holding a rule in mind, detecting mismatch between dominant and subdominant responses, and responding according to the retained rule. These advances form a foundation for the development of EF abilities, which rely strongly on the ability to resolve conflict. Thus, the toddlerhood period, which coincides with the emergence of the executive attention network, may be a period in which children are particularly susceptible to environmental experiences that support or hinder their emerging cognitive control skills (Camerota, Willoughby, Cox, Greenberg, & the Family Life Project Investigators, 2015; Comas et al., 2014).

Maternal Depressive Symptoms and Children's EF

There is growing evidence for the negative associations between exposure to MDS, particularly during early childhood, and later EF ability (e.g., Belleau et al., 2013; Comas et al., 2014; Hughes et al., 2013; Pearson et al., 2016). Goodman and colleagues (2011) propose that early childhood may be a sensitive period for studying the associations between MDS and child outcomes because young children strongly rely on their mothers for external regulation of emotion and attention. In support of this claim, Hughes and colleagues (2013) found that elevated MDS throughout early childhood (ages 2 to 6 years) were related to lower EF abilities at age 6 years. Further, Comas and colleagues (2014) reported that whereas MDS during early childhood (ages 3 and 5 years) were a significant predictor of EF at age 18 years, MDS during middle childhood (ages 8 and 10 years) were not. However, it is unknown whether these relations with EF appear as early as the preschool period, a time when EF develops rapidly. Thus, in the current study we focus on the links between exposure to MDS during toddlerhood (ages 15 and 24 months) and children's emerging EF at ages 3 and 4 years.

Mother-Child Interaction and EF

Extant literature suggests that both broad dimensions of early mother-child interaction as well as specific experiences and stimulation provided within mother-child interactions are related to children's EF during the preschool years (Bernier et al., 2010; Blair et al., 2011; Camerota et al., 2015; Cuevas et al., 2014; Devine, Bignardi, & Hughes, 2016; Fay-Stammbach et al., 2014; Gueron-Sela et al., 2016; Hughes & Ensor, 2009). In order to understand the unique contributions of these multiple aspects of children's interactions with mothers, in the current study we focus on aspects of mother-child interactions that earlier research suggests may play a role in the development of children's EF abilities both in terms of broad dimensions (i.e., warmth-sensitivity and harsh-intrusiveness), and specific experiences and stimulation (i.e., dyadic joint attention, and maternal language complexity).

Warmth-sensitivity and harsh-intrusiveness. It is theorized that a mother's ability to appropriately interpret and respond to her child's signals contributes to the child's ability to integrate these experiences into an emerging set of self-regulatory skills, which lay the foundation for higher order cognitive control abilities in early childhood, such as EF (Posner & Rothbart, 1998; Swingler, Perry, & Calkins, 2015). Indeed, previous studies have linked higher levels of maternal sensitivity during toddlerhood with later improved performance on EF tasks (Bernier et al., 2010; Gueron-Sela et al., 2016). Furthermore, warm-sensitive mother-child interactions across ages 7–36 months positively predicted children's EF performance at 3 and 5 years of age in several analyses that used the current dataset (e.g., Blair et al., 2011; Blair, Raver, Berry, & the Family Life Project Investigators, 2014; Camerota et al., 2015).

On the other hand, harsh-intrusive mother-child interactions may impinge on children's ability to exercise control over their attention and to successfully practice goal-directed behavior (Graziano, Keane, & Calkins, 2010), which are considered crucial precursors for the development of EF (Garon et al., 2008). In support of these notions, previous research indicated that harsh-intrusive mother-child interactions across ages 10–36 months were negatively related to children's EF at ages 36 and 48 months (Cuevas et al., 2014; Devine et al., 2016). Further, an analysis from the current dataset demonstrated that harsh-intrusive maternal behaviors during infancy negatively predicted children's EF at age 36 months over and above the effect of maternal sensitivity (Blair et al., 2011), highlighting that these two parenting behaviors make unique contributions to children's EF.

It is important to note that the previous studies from the current data set focused on broad characteristics of the parent–child relationship. In the current study, we aimed to expand these previous findings by examining additional aspects of parent–child interactions that have not yet been considered within the current data set, namely dyadic joint attention and maternal language complexity. The simultaneous examination of both broad dimensions and specific experiences and stimulation provided within mother-child interactions can enhance our understanding of the multiple ways by which early caregiving can be related to development of children's EF.

Dyadic joint attention. Specific experiences with mother-child interaction, such as social contingency within joint attention, may provide an optimal social structure for practicing executive control skills (Morales, Mundy, Crowson, Neal, & Delgado, 2005; Raver, 1996). Through these dyadic experiences, children learn how to sustain attention and focus on specific tasks (Yu & Smith, 2016), a necessary first step in goal-directed behavior that underlies EF (Garon et al., 2008). For example, dyadic joint attention with the mother during free-play at age 24 months was positively related to the use of efficient regulatory strategies in the face of a distressing situation (Morales et al., 2005; Raver, 1996). Furthermore, prolonged dyadic joint attention with a social partner at age 12 months was related to better inhibitory control at age 36 months (Vaughan Van Hecke et al., 2012). Together, these lines of research suggest that recurrent experiences of dyadic joint attention within the mother-child dyad may be related to later EF skills. However, it is important to consider that sustained dyadic joint attention with the caregiver may reflect the child's early social applications of executive attention skills (Mundy, 2003). Thus, it is important to consider the role of children's early executive abilities EF when examining longitudinal links between dyadic joint attention and children's EF.

Maternal language complexity. Language input from caregivers is an additional aspect of caregiving that is theorized to support the development of children's EF (Carlson, 2003). During parent—child book sharing tasks, parents have the opportunity to ask questions and produce abstract utterances that stimulate advanced reasoning and metalinguistic awareness (Baker & Vernon-Feagans, 2015), which in turn may contribute to the ability to monitor and control the use of language in the service of employing executive control processes. For example, more elaborative parental utterances that were contingent upon the child's current activity were related to better attention set-sifting abilities at age 24 months (Bibok, Carpendale, & Müller, 2009). Thus, the complexity of mothers' language input during mother-child interactions can serve as an additional aspect of caregiving that is associated with children's EF.

MDS, Mother-Child Interaction and Children's EF

There are four main mechanisms that have been proposed to explain the associations between MDS and children's developmental outcomes, including heritability, dysfunctional neuroregulatory systems, exposure to mother's maladaptive cognitions and behaviors during mother-child interactions, and exposure to stressful environments (Goodman & Gotlib, 1999). As a first step in understanding the mechanisms linking MDS and children's EF, the current study considered the role of mother-child interactions. We elected to focus on this potential mechanism because of the established links between mother-child interactions and children's EF, and between MDS and less optimal mother-child interactions.

Mothers experiencing depressive symptoms may find parenting challenging, particularly during toddlerhood (NICHD Early Child Care Research Network, 1999). The transition from infancy to toddlerhood is marked by a number of changes in children's mobility, verbal ability, and bids for autonomy, making day-to-day interactions more challenging than they were at earlier ages (Verhoeven, Junger, Van Aken, Deković, & Van Aken, 2007). Although there is variability in the association between maternal depression symptoms and parenting behaviors, the affective, cognitive, and physical symptoms that characterize depression (e.g., sad mood, loss of interest, fatigue, and poor concentration) may hinder mothers' ability to adjust to these challenging circumstances and to provide appropriate support for children's emerging cognitive and social-emotional skills (Goodman & Gotlib, 1999).

There is evidence that all four aspects of mother-child interactions mentioned above are linked to MDS. The presence of depressive symptoms in mothers has been often associated with less *sensitive* mother-child interactions (e.g., Campbell, Matestic, von Stauffenberg, Mohan, & Kirchner, 2007). Mothers with depressive symptoms display greater affective discoordination in interactions with their infants and toddlers, as well as reduced likelihood to repair these errors (Jameson, Gelfand, Kulcsar, & Teti, 1997; Weinberg, Olson, Beeghly, & Tronick, 2006). MDS has also be associated with a *harsh-intrusive* pattern of mother-child interaction (Field, 2010). In depressed states, negative affect (i.e., distress, irritability, and anger) is increased, which may reduce mothers' ability to tolerate normative child behavior and result in overreliance on coercive parenting techniques (Lovejoy, Graczyk, O'Hare, & Neuman, 2000). For example, MDS has been associated with elevated use of physical discipline, as well as heightened levels of conflict, coercion, and hostility during mother-child interactions in infancy and early childhood (Hoffman & Drotar, 1991; Lovejoy et al., 2000).

The ability to initiate and maintain *dyadic joint attention* within a parent–child interaction may also be limited among mothers with depressive symptoms. Mothers who experience depressive symptoms often appear preoccupied and inattentive to their children's communicative bids, and are less likely to coordinate and focus attention while interacting with their toddlers (Goldsmith & Rogoff, 1997). Finally, mothers experiencing depressive symptoms also differ in the type of *language input* they provide to their children, including less repetition, fewer explanations, suggestions and questions, and overall reduced lexical input (Field, 2010; Rowe, Pan, & Ayoub, 2005).

Maternal Depressive Symptoms and Child EF in the Context of Rural Poverty

Dealing with depressive symptoms may be particularly challenging for mothers living in rural areas due to the unique challenges associated with rural life, including a restricted range of employment opportunities, the absence of a public transportation system, difficulties in obtaining physical and mental health services, and high levels of poverty (Brody, Jack, Murray, Landers-Potts, & Liburd, 2001; Tickamyer & Duncan, 1990). A study conducted by Brody and colleagues (2002) on African American families living in rural areas found that higher maternal psychological functioning (i.e., lower levels of depression, and higher optimism and self-esteem) was related to more involved and vigilant parenting behaviors and higher quality parent–child discussions which, in turn, predicted higher rates of planful, goal-directed behaviors in early adolescence (Brody et al., 2002). In the current study, we aim to extend this work to examine the links between early exposure to MDS and EF in early childhood. It is particularly important to examine the key contexts for children's early EF development, in order to identify possible ports of entry for interventions that can enable at-risk, rural children to gain needed readiness skills prior to school entry.

The Current Study

Although there is evidence that MDS have adverse effects on children's EF (Hughes et al., 2013), the mechanisms underlying these relations are unknown. Understanding this link is crucial, given that deficits in EF may be one of the factors accounting for the wide range of cognitive and socioemotional problems evident among children exposed to MDS. The current study aimed to address this gap by examining mother-child interaction as a potential mechanism for the link between MDS and child EF. To this aim, we employed a multiple mechanism approach that enabled us to examine various caregiving experiences that are longitudinally related to the development of EF in children.

We hypothesized that elevated MDS during toddlerhood (ages 15 and 24 months) would be associated with lower levels of warmth-sensitivity and higher levels of harsh-intrusiveness during play, as well as less dyadic joint attention and less complex language input during a book sharing activity at ages 24 and 36 months, which, in turn, would be associated with children's lower EF abilities in the preschool period (ages 36 and 48). These time points were chosen based on previous research that demonstrated that there are significant age-related improvements in all three EF components during this time period (Garon et al., 2008). Finally, in order to examine the specific contribution of MDS during the toddlerhood period to mother-child interactions and child EF, we also controlled for earlier levels of MDS (age 6 months), as well as general levels of maternal distress at age 15 months.

Method

Participants

The Family Life Project (FLP) is a large longitudinal study of children and families living in rural, lower income communities in the United States. Families that lived in two major geographical areas of high poverty (including three counties in North Carolina and three counties in Pennsylvania) were recruited using a stratified random sampling procedure yielding a representative sample of 1,292 families recruited over a 1-year period at the time mothers gave birth. Families in poverty in both geographical areas were oversampled and African American families were oversampled in North Carolina, ensuring that we had sufficient power to test complex questions related to poverty. See Willoughby et al. (2013) for additional information on recruitment and sampling. The current analyses are based upon a subsample of 1,037 children (50% boys) and their biological mothers who completed at least one EF assessment when the child was 36 or 48 months of age. In this subsample, 43% of the children were African American, 81% of mothers had obtained a high school degree, 15% of mothers had a college degree and approximately 76% of the families were below 200% of the poverty level. This subsample does not differ from the complete sample in terms of poverty status at recruitment, child gender, or ethnicity (all $p > .05$). However, mothers in this subsample were less likely to have a high school degree compared to primary caregivers in the original sample, $\chi^2(1) = 6.00$, $p < .05$.

Procedures

Data for the current analysis were collected during home visits when children were approximately 2, 6, 15, 24, 36 and 48 months of age. All study protocols were approved by the relevant ethical review boards, and appropriate consent was obtained from all research participants. At the 2-month assessment, demographic information about the families was collected. At the 6, 15 and 24 month assessments, mothers reported about their depressive symptoms via self-report questionnaires. At the 24- and 36-month assessments, mothers and children engaged in a 10-min semistructured play interaction where they were provided with three puzzles of increasing difficulty. Each mother was instructed that the task was for the child to complete, but she could help as needed. The play interaction was video recorded and later rated for warmth-sensitivity and harsh-intrusiveness. Mothers and children also participated in a book sharing activity in which mothers were asked to "go through" a wordless picture book with their children as they normally would, and to indicate to the research assistant when the activity was over. Dyadic joint attention was live rated during the book sharing activity by a trained research assistant using the Observer software. Maternal language input from the book sharing activity was transcribed and rated for language complexity. At 36 and 48 months, children completed a battery of EF tasks that consisted of measures of working memory, set shifting, and inhibitory control.

Measures

Maternal depressive symptoms. Mothers reported on their depressive symptoms during the 6-, 15-, and 24-month assessments. At 6 and 15 months, MDS were reported using the Brief Symptom Inventory-18 (BSI-18; Derogatis & Savitz, 2000), a validated self-report measure consisting of 18 items. The six items of the depression scale define a spectrum of depressive symptoms such as "feeling blue" in the preceding seven days, and are rated on a 5-point Likert scale from 0 (not at all) to 4 (extremely). Ratings across the six items were averaged to create a total depressive symptoms score, with higher scores indicating more severe MDS (Cronbach's alpha = .83). At 24 months, mothers reported depressive symptoms using the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977), a 20-item inventory of depression symptoms (e.g., "I felt sad") rated on a 4-point Likert scale that ranges from 0 (rarely or none of the time) to 3 (most or all of the time). Ratings across the 20 items were averaged to create a total depressive symptoms score, with higher scores indicating more severe MDS (Cronbach's alpha = .80). Both the CES-D and the BSI have been widely used in community studies, including samples of low income African American mothers (e.g., Brody et al., 2002; Kotchick, Dorsey, & Heller, 2005). The rates of risk for clinical depression in our sample were relatively low [6% for BSI at 6 months and 9% for BSI at 15 months (cutoff ≥63), 13% for CESD at 24 months (cutoff ≥23)].

Mother-Child Interaction

Warmth-sensitivity and harsh-intrusiveness. Mother—child interactions during the play tasks at 24 and 36 months were rated using a scheme developed by Cox and Crnic (2002) and based on the NICHD Early Child Care Research Network (1999) scheme. The interactions were rated for the constructs of sensitivity, intrusiveness, detachment, stimulation of cognitive development, positive regard, negative regard and animation. Global ratings of mothers' behaviors were made on a 1–7 scale, with values ranging from not at all characteristic to highly characteristic. Each rater was trained to be reliable with a master rater, and reliability checks were completed on approximately 30% of the recorded interactions (ICC > .80 for all pairs of raters).

An exploratory factor analysis conducted with oblique rotation (i.e., Promax) suggested that the individual scale scores loaded heavily onto two underlying factors that represent two dimensions of parent–child interaction: *Warmth-sensitivity* which included the sensitivity, detachment (reverse scored), stimulation of cognitive development, positive regard, and animation scales, and *harsh-intrusiveness* which included the intrusiveness and negative regard scales. We created composite scores of warmth-sensitivity and harsh-intrusiveness by taking the mean across multiple parenting scales. This two composite score approach has been widely used in previous analyses with FLP data (FLP Key Investigators, 2013).

Dyadic joint attention. Mother-child interactions during the book sharing activity were live rated by a research assistant to assess joint attention between the mother and the child using the Early Attention to Reading Situations rating system (EARS; Feagans, Kipp, & Blood, 1994). At each time point mothers were given a wordless picture book to review before the session began. The mother was asked to go through the book and talk to the child about the book as she might normally do. After approximately 10 min the research assistant (RA) would ask the mother to stop if the picture book task had not ended. The RA used a laptop computer that was programmed to receive observational ratings every five seconds. The RA rated the child's focus of attention at the 5 second beep into one of 5 mutually exclusive categories (i.e., look at book, look at the caregiver, gaze aversion, look at RA/camera, off task and joint attention). The joint attention category reflected whether the child's eyes were focused on the same page of the book as the mother's eyes. For example, when both the mother and child looked at the same page of the book at the same time, joint attention was rated. Research assistants practiced the rating system with pilot children until acceptable reliability was reached with the master rater (Cohen's Kappas of at least .70). Five selected video recordings of the book sharing activity were then rated by the master rater every 6 months, to confirm and maintain a Cohen's Kappa of at least .70 for each rater. Because the length of the book sharing activity varied, raw frequency scores were converted to proportion scores to be used in analyses. We created a mean proportion score at each time point that represented the proportion of 5 second intervals in which joint attention was observed.

Maternal language complexity. The mother-child book sharing sessions were transcribed using the Systematic Analysis of Language Transcripts software (SALT; Miller & Chapman, 1985). Transcribers were trained by a master transcriber, and transcribed 20 mother—child sessions that were reviewed by the master transcriber to ensure accuracy. As an ongoing check and for training reliability purposes, transcripts were regularly reviewed by the master transcriber and discussed at weekly research group meetings to ensure consistency in transcription. Further, the master transcriber and the transcribers often conferred over the video if it was difficult to transcribe (e.g., due to audio issues or the fact that it is sometimes difficult to discern whether the mother is actually using a real word). Thus, consensus was employed throughout. Finally, SALT software was used to find any further errors or omissions in the transcripts. Each SALT transcript yielded numerous language variables, which the SALT software was designed to automatically calculate. Our analysis focused on maternal language complexity. Consistent with previous analysis with FLP data (FLP Key Investigators, 2013), language complexity was indicated from the mean length of utterance (MLU) in morphemes. A morpheme is the smallest meaning unit in the language. Thus words such as "boy/s" and "work/ed" each contain two morphemes. MLU is calculated as the average number of morphemes per utterance.

Children's EF. The EF tasks were presented in an open spiral bound flip book format at the 36- and 48-month assessments. For each task, children first had to pass a set of training trials to ensure comprehension of task procedures. The battery of EF tasks included two measures of working memory, three measures of inhibitory control, and one measure of set shifting. The psychometric properties of this task battery are reported elsewhere (Willoughby, Wirth, Blair, & the Family Life Project Investigators, 2012). We have previously demonstrated measurement equivalence of the EF tasks as a function of poverty in the current sample (Willoughby et al., 2012). We also reported similar conclusions for measurement as a function of household poverty and caregiver education in a different sample (Willoughby & Blair, 2016).

Working memory span (working memory). This task was based upon principles described by Kane and Engle (e.g., Kane & Engle, 2003). Children were shown a picture of a house with an animal and a colored circle inside. The children were asked to name and hold in mind both pieces of information. Next, the children were shown an empty house and asked to recall the animal or color that was previously in the house. The task increased in difficulty such that children were required to recall information from up to four houses at a time. Responses were summarized as the number of items answered correctly within each item set. Although the working memory spam task was administered at all three assessments, only the first 11 items were administered at the 36-month assessment (based on the results of pilot testing and test burden, the 4-house trials were omitted), whereas all 19 items were administered at the 48-month assessments.

Pick-the-Picture game (working memory). The Pick-the-Picture task is a pointing task (Cragg & Nation, 2007) in which children were instructed to touch each picture one at a time, so that every picture "gets a turn." For example, in the 2-picture condition, they might see a page of an apple and dog. For the first page, they pick (touch) either of the two pictures. For the second page they are requested to pick a different picture. Children received two each of 2- picture, 3-picture, 4-picture, and 6-picture sets. Responses were summarized as the number of items consecutively answered correctly in each picture set beginning with the first item in the set. Through pilot testing, it appeared that the task was too difficult for many children at age 36 months; hence, it was only administered at the 48-month assessment.

Silly Sounds Stroop (inhibitory control). This task was based upon the Day/Night Stroop task (Gerstadt, Hong, & Diamond, 1994). Children were presented with pictures of a cat and dog, and the experimenter asked them to make the sounds of a dog and a cat. The experimenter then introduced the Silly Sounds game, in which dogs make the sounds of cats and vice versa. Then side-by-side pictures of cats and dogs were presented in random order. The experimenter pointed to the first picture and asked what sound this animal makes in the Silly Sounds game and then pointed to the adjacent picture and asked the same question. A total of 36 pictures were presented. Responses (correct, incorrect) to the first item on each page were used for purposes of scoring.

Spatial conflict (inhibitory control). This is a Simon task similar to that used by Gerardi-Caulton (2000). In this task, the examiner placed a response card, which has a picture of a car on the left side and picture of a boat on the right side, in front of the child. The examiner then turned flip book pages that depicted either a car or boat. The child was instructed to touch the car on his or her response card when the flip book page showed a car and to touch the boat on the response card when the page showed a boat ("touch your car when you see a car, touch your boat when you see a boat"). Across the first eight trials, cars and boat were depicted centrally. These items provide an opportunity to teach the child the task ("touch your car when you see a car, touch your boat when you see a boat"). For items 9–22, items were presented laterally (e.g., the stimulus was presented on the left side of the test booklet and the correct response required that the child touch the left side of his or her response card). For items 23–35, cars and boat begin to be depicted contra-laterally (e.g., the stimulus was presented on the left side of the test booklet and the correct response required that the child touch the right side of his or her response card). Items presented contra-laterally required inhibitory control from the previously established prepotent response in order to be answered correctly. Responses (correct, incorrect) to contra-laterally presented items were used for purposes of scoring. At 48 months, task stimuli were arrows rather than boats.

Animal Go/No-Go (inhibitory control). This is a standard go no-go task (e.g., Durston et al., 2002) presented in a flip book format. Children were presented with a large button that clicked when pressed. They were instructed to click the button every time that they saw an animal (i.e., go) except when that animal was a pig (i.e., no-go). Each page depicted a line drawing of one of seven possible animals. The task presents varying numbers of go trials prior to each no-go trial, including, in standard order, 1-go, 3-go, 3-go, 5-go, 1-go, 1-go, and 3-go trials. Responses (correct, incorrect) to no-go trials were used for purposes of scoring.

Something's the Same Game (Attention Set-Shifting). This task is based on the Flexible Item Selection Task (FIST; Jacques & Zelazo, 2001). In this task, children were shown a page containing two pictures that were similar along one dimension (content, color, or size), and the experimenter explicitly stated the dimension of similarity. The next page presented the same two pictures, and an additional new third picture which was similar to one of the first two pictures along a dimension that is different from that of the similarity of the first two pictures (e.g., if the first two pictures were similar along the dimension of shape, the third card would be similar to one of the first two along the dimension of color or size.) Children were asked to choose which of the two original pictures was the same as the new picture. Twenty trials were presented (15 at the 36-month assessment). Responses (correct, incorrect) to all but the first item were used for scoring (the first item was excluded from scoring because incorrect answers were corrected in order to teach the task).

EF scoring. Consistent with the analytic approach reported in previous reports on the current study sample (Willoughby et al., 2012), item response theory (IRT) models were used to create expected a posteriori (EAP) scores for each task at each assessment. EAP scores were scaled on a z-score metric, where a value of 0 represented the average task performance at the 48- month assessment. Positive and negative values for EAPs refer to above and below average scores, relative to age 48 months. The mean EAP score across all completed tasks at a given assessment was used as a measure of the child's EF ability at that time point.

Covariates. Ethnicity, family income and maternal education were controlled for based on previous research that linked these variables to maternal depressive symptoms, parenting behaviors and children's EF in early childhood (e.g., Bernier, Carlson, Deschênes, & Matte-Gagné, 2012; NICHD Early Child Care Research Network, 1999). Child sex was controlled following previous research showing that boys tend to do worse on tasks of EF (Willoughby & Blair, 2016) and are rated as having more EF problems by parents compared to girls (Camerota, Willoughby, Kuhn, & Blair, 2016). Child's ethnicity and sex were reported by the child's primary caregiver at the time of recruitment. Income-to-needs ratio was determined using the mothers' self-reported total household income from all sources when the child was 15, 24, and 36 months old. Aggregated household income was divided by the U.S. poverty threshold for the year (adjusted for family size and household composition) to create an income-to-needs ratio for each family at each time point. The average income-to-needs ratio across 15 to 36 months was retained as a single indicator. Maternal education was measured at the 2-month visit and is retained as two binary variables that indicate whether the mother had obtained a high school and/or college degree. Given the previously demonstrated link between childcare experiences and EF in this sample (Berry, Blair, Ursache, Willoughby, Granger, & the Family Life Project Key Investigators, 2014), we additionally controlled for maternal report of total childcare hours, as well as observer reports of childcare quality (HOME; Caldwell & Bradley, 1984) in the primary childcare setting at 15, 24 and 36 months. Both of these measures were averaged across the three assessments (see Berry et al., 2014 for further information about the quality composite). In order to tap into what is unique to EF beyond general cognitive functioning, we used the Mental Development Index of the Bayley Scales of Infant Development (MDI; Bayley, 1993) at 15 months to control for general cognition. Finally, in order to untangle the specific role of depressive symptoms during the toddlerhood period, we also controlled for maternal general distress at 15 months, which was a composite of the anxiety, somatization and hostility scales from the BSI (Derogatis & Savitz, 2000) and earlier levels of MDS (age 6 months).

Missing Data

Ten percent of children (n = 109) had missing EF data at age 36 months, and 7% (n = 79) had missing EF data at age 48 months. Further, 2% of the children (n = 20) had missing data on maternal depressive symptoms from age 15 months, and 4% (n = 42) had missing MDS data from age 24 months. Regarding mother-child interaction variables, at 24 months, 7% (n = 66) of dyads were missing joint attention data, 9% (n = 93) were missing language complexity data, and 8% (n = 87) were missing warmth-sensitivity and harsh-intrusiveness data. At 36 months, 6% (n = 60) of dyads were missing joint attention data, 6% (n = 59) were missing language complexity data, and 5% (n = 50) were missing warmth-sensitivity and harsh-intrusiveness data. Full-information maximum likelihood (FIML) estimation with robust standard errors was used to retain the full sample.

Analytic Plan

Descriptive statistics were computed using SAS version 9.3. Path models were estimated in Mplus version 7.31 (Muthén & Muthén, Los Angeles CA). All models were adjusted for the complex sampling design (i.e., oversampling for poverty and African American ethnicity) by accounting for probability weight variables in the analysis. We first tested the direct associations between MDS and children's EF by estimating a path model in which autoregressive paths across each time point of MDS (6, 15 and 24 months) to EF at 36 months and 48 months were specified. In addition, direct paths from MDS at both 6 and 15 months to EF at both 36 and 48 months were specified. This enabled us to examine the links between MDS at 24 months and EF at 36 and 48 months of age while controlling for previous measurements of MDS, in addition to examining the direct associations between MDS at 6 and 15 months and children's EF. Next, in order to examine the mediating role of parent–child interactions we estimated a partial autoregressive cross-lagged (ARCL) panel model. Autoregressive paths were specified within measurements of MDS (6, 15, 24 months), warmth-sensitivity (24, 36 months), harsh-intrusiveness (24, 36 months), dyadic joint attention (24, 36 months), language complexity (24, 36 months) and child EF (36, 48 months). Similar to the first model, direct paths between MDS at 6 and 15 months and EF at 36 and 48 months were also specified. Cross-lagged paths were specified between MDS at 15 months and the mother-child interaction constructs at 24 months (i.e., warmth-sensitivity, harsh-intrusiveness, dyadic joint attention and language complexity), and MDS at 24 months and the mother-child interaction constructs at 36 months. All concurrent associations between variables within time points were estimated. We followed a theoretically driven approach to the inclusion of covariates in the model. That is, the focal variables in the model were regressed on the covariates that have been previously found to be related to this construct. For example, child EF at age 48 months was regressed on child gender, ethnicity, general child cognitive ability, household income, maternal education, total childcare hours, childcare quality and general maternal distress. A full description of the paths estimated from covariates to the main variables can be found in the supplementary material.

Results

Table 1 presents unweighted means, standard deviations, and correlations for all study variables.

Direct Links Between MDS and Child EF

We first assessed the direct associations between MDS and child EF in a path model. The autoregressive paths across MDS time points were significant (β = .17-.57, $p < .01$). In addition, there were significant direct links between MDS at 15 and 24 months and EF at 48 months ($\beta = -.09$, $p = .05$; $\beta = -.09$, $p = .03$, respectively), as well as an indirect link between MDS at 6 months and EF at 48 months through MDS at 15 months ($\beta = -.02$, $p = .04$) and through MDS at 24 months ($\beta = -.05$, $p = .05$). There were no significant direct or indirect link between MDS at all three time points and EF at 36 months. The model fit the data well, $\chi^2(6) = 8.02$, $p = .23$, CFI = .99, RMSEA = .01 (90% RMSEA confidence interval: .000 - .047).

The Mediating Role of Mother-Child Interactions

We next tested the direct and indirect associations between MDS and child EF through mother-child interactions in a partial ARCL model (see Figure 1). Model fit was adequate, $\chi^2(61) = 111.53$, $p < .001$, CFI = .98, RMSEA = .03 (90% RMSEA confidence interval: .020 - .036). There were no longer significant direct links between MDS at 15 ($\beta = -.08$, $p = .07$) and 24 months ($\beta = -.05$, $p = .19$) and child EF at 48 months when mediating paths were modeled. However, MDS at 15 months was significantly linked to harsh-intrusiveness at 24 months ($\beta = .17$ $p = .001$), and MDS at 24 months was significantly linked to warmth-sensitivity at 36 months ($\beta = -.07$, $p = .008$). In addition, there were significant links between the mother-child interaction constructs at 36 months and EF at 48 months including harsh-intrusiveness ($\beta = -.15$, $p < .001$), dyadic joint attention ($\beta = .08$, $p = .01$) and language complexity ($\beta = .06$, $p = .05$). A full description of all paths estimated in the model can be found in the supplementary material.

Indirect effects. The previous results indicated that MDS at 15 months were associated with harsh-intrusiveness at 24 months, which was associated with harsh-intrusiveness at 36 months, and finally EF at 48 months. These results were suggestive of one possible indirect path through which MDS were associated with EF. This indirect path was significant ($\beta = -.009$, $p = .01$). No other specific indirect paths between MDS and EF were significant.

Sensitivity Analysis

Acknowledging modest rates of clinically depressed individuals in our sample (6% at 6 months, 9% at 15 months and 13% at 24

Table 1
Unweighted Descriptive Statistics and Bivariate Correlations Between Study Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. MDS 6m	—																					
2. MDS 15m	.57	—																				
3. MDS 24m	.48	.52	—																			
4. Harsh-intrusiveness 24m	.14	.18	.23	—																		
5. Harsh-intrusiveness 36m	.11	.14	.20	.50	—																	
6. Warm-sensitivity 24m	−.10	−.14	−.22	−.53	−.40	—																
7. Warm-sensitivity 36m	−.07	−.11	−.24	−.38	−.48	.62	—															
8. Dyadic joint attention 24m	−.08	−.04†	−.10	−.21	−.22	.25	.18	—														
9. Dyadic joint attention 36m	−.00†	−.04†	−.08	−.14	−.13	.16	.16	.15	—													
10. Language input 24m	−.00†	−.02†	−.09	−.10	−.12	.19	.18	.14	.05†	—												
11. Language input 36m	−.03†	−.03†	−.09	−.09	−.11	.17	.20	.09	.14	.43	—											
12. EF 36m	.00†	−.04†	−.09	−.25	−.29	.26	.26	.15	.07	.06†	.10	—										
13. EF 48m	−.04†	−.10	−.15	−.31	−.40	.36	.35	.22	.16	.15	.16	.36	—									
14. Child ethnicity (AA = 1)	.03†	.11	.13	.35	.36	−.36	−.38	−.10	−.11	.00†	.02†	−.30	−.33	—								
15. Child sex (Male = 1)	−.01†	−.02†	−.03†	.07	.12	−.01†	−.04	−.06	.01†	−.08	−.09	−.10	−.15	.01†	—							
16. Income-to-needs ratio	−.15	−.17	−.20	−.31	−.26	.41	.40	.15	.08	.12	.10	.21	.26	−.37	.04	—						
17. Maternal high school degree	−.06†	−.09	−.14	−.25	−.25	.31	.30	.10	.04†	.09	.11	.12	.28	−.11	−.02†	.27	—					
18. Maternal college degree	−.13	−.14	−.20	−.26	−.27	.40	.35	.11	.06	.16	.17	.20	.27	−.25	.02	.55	.20	—				
19. Child care hours	.00†	−.08	−.06†	−.20	−.12	.16	.14	.10	.10	.06†	.12	.08	.20	−.23	−.04†	.17	.08	.13	—			
20. Child care quality	−.03	−.10	−.11	−.21	−.25	.22	.22	.00†	.01†	.07†	.13	.17	.22	−.30	−.03†	.25	.11	.18	.62	—		
21. Child cognitive ability	−.07	−.09	−.12	−.26	−.25	.31	.25	.17	.11	.13	.13	.21	.37	−.27	−.11	.21	.12	.18	.20	.20	—	
22. Maternal general distress	.46	.77	.51	.10	.07	−.09	−.08	−.03†	−.02†	.01†	−.00†	−.01†	−.03†	.03†	−.04†	−.12	−.09	−.13	−.09	−.13	−.08	—
M/%	.37	.44	.40	2.40	2.27	2.91	2.88	.38	.47	3.59	4.06	−.53	−.11	43%	50%	1.85	81%	15%	−.01	−.04	96.4	.40
SD	.54	.69	.63	.63	.80	.80	.71	.23	.20	1.03	.76	.54	.51	—	—	1.5	—	—	.87	.92	10.5	.49

Note. All correlations significant at $p < .05$, except where indicated (†); m = months.

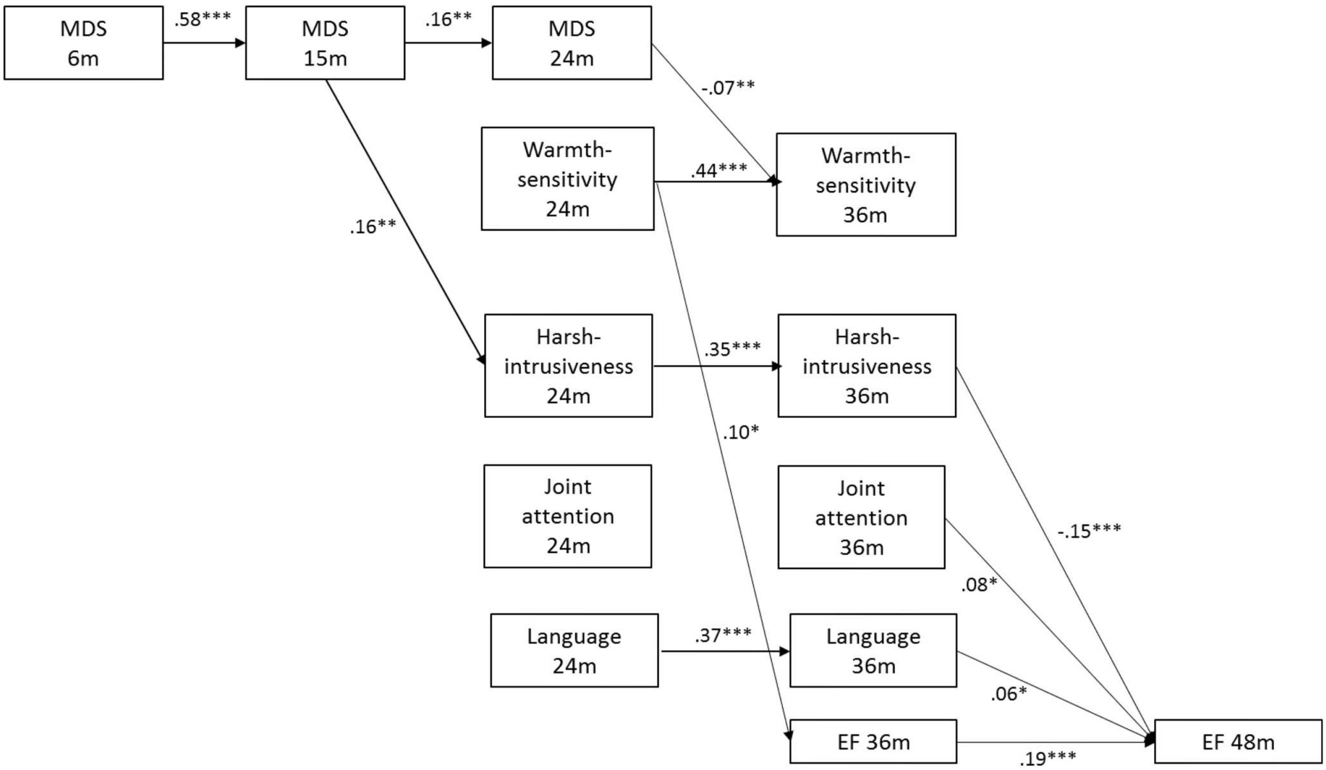

Figure 1. Partial ARCL model: $\chi^2(61) = 111.53$, $p < .001$, RMSEA = .03, CFI = .98, SRMR = .02. For ease of presentation only significant paths are included in the figure; The following covariates were included in the model, but are not depicted in this figure: family income to needs, child ethnicity, child sex, child cognitive ability at age 15 months, maternal education, child care hours, child care quality, maternal general distress; All concurrent associations within time points were estimated but are not presented; m = months; * $p < .05$. ** $p < .01$. *** $p < .001$.

months), we reran the above models replacing our continuous measure of depressive symptoms with dichotomous measures. These dichotomous measure indicated whether an individual's *T* score on the BSI at ages 6 and 15 months (cutoff ≥63) and/or CESD raw score at age 24 months (cutoff ≥23) were clinically elevated. The reference group was comprised of individuals who did not report clinically elevated levels of depression. Repeating the above analysis with dichotomous measures of depression did not change any of our substantive conclusions. The only meaningful difference between the models was that in the dichotomous version of the mediation model, MDS at 15 months had both direct ($\beta = -.10$, $p = .007$) and indirect links via harsh-intrusiveness ($\beta = -.006$, $p = .03$) to EF at 48 months.

Discussion

To our knowledge this study was the first to explicitly examine the longitudinal associations between maternal reports of depressive symptoms, multiple aspects of mother-child interaction, and children's EF using a large, predominantly low-income sample of mothers and their children residing in rural areas. We found that MDS during toddlerhood were negatively linked to children's EF at the preschool period. In addition, harsh-intrusive mother-child interactions during toddlerhood partially mediated this link. Although warmth-sensitivity, dyadic joint attention and maternal language complexity were all independently and longitudinally related to EF, they did not serve as mediating mechanisms between MDS and EF.

Consistent with previous research (Comas et al., 2014; Hughes et al., 2013; Pearson et al., 2016), MDS were related to children's lower EF. We expand existing findings by demonstrating that these links are evident when assessing EF as early as age 48 months. By testing the unique links between MDS at three different time points and EF, we also show that whereas MDS during toddlerhood (15 and 24 months) were negatively linked with later EF, MDS during infancy (6 months) were not. These findings imply that exposure to MDS during toddlerhood may be particularly critical for the development of EF. Interestingly, MDS at both 15 months and 24 were not directly linked to EF at age 36 months. It may be that EF are not fully consolidated by age 36 months (Garon et al., 2008), and thus the difficulties in EF associated with MDS may not yet be manifested.

Findings from this study also demonstrate that the link between MDS and child EF is partially mediated by harsh-intrusive mother-child interactions. This indirect link is in line with the integrative model for the transmission of risk to children of depressed mothers (Goodman & Gotlib, 1999). According to this model, the presence of depressive symptoms in mothers is associated with negative cognitions, behaviors, and affect that limit their ability to meet their children's social and emotional needs. These unmet needs, in turn, impede on children's development of social and cognitive skills (Goodman & Gotlib, 1999). Intrusive mother-child interactions are characterized by interventions that are not responsive to infants' affect, state, or interest and are often in direct competition to the infants' own focus of attention (Swingler, Perry, Calkins, & Bell, 2017). Thus, intrusive caregiving behavior may create rapidly shifting sources of arousal and stimulation that actively interfere with the child's ability to practice effective control of attention and goal-directed behavior (Gaertner, Spinrad, & Eisenberg, 2008; Graziano et al., 2010), which are important building blocks for later EF ability (Garon et al., 2008). Although MDS were initially correlated with all aspects of mother-child interactions, MDS only predicted harsh-intrusiveness at 24 months and warm-sensitivity at 36 months in the path model. It is possible that the initial correlations between MDS and dyadic joint attention and maternal language complexity can be explained by their mutual links to environmental conditions such as income-to-needs, maternal education and ethnicity which were controlled for in the path model. Previous research supports this idea by demonstrating that these environmental conditions are related to both MDS (Goodman et al., 2011) and mother-child interaction (e.g., Lengua, Honorado, & Bush, 2007). Because the links between MDS and these aspects of mother-child interaction were nonsignificant there was no reason to consider them as mediating mechanisms.

Findings from this study demonstrate that all four aspects of mother-child interaction have unique longitudinal links to children's EF. Extending findings from previous research on mother-child interaction and EF (e.g., Blair et al., 2011, 2014; Camerota et al., 2015), dyadic joint attention and maternal language complexity at 36 months were independently associated with higher EF at 48 months, after controlling for earlier levels of EF and broad dimensions of mother-child interactions (i.e., warmth-sensitivity and harsh-intrusiveness). These findings support the idea that multiple aspects of parent–child interactions can contribute to children's EF (Bernier et al., 2010; Fay-Stammbach et al., 2014; Hughes & Ensor, 2009), highlighting the importance of an integrative approach that extends beyond the traditional focus on broad dimensions of parent–child interaction.

Study Limitations and Conclusions

Limitations should be noted when considering the findings from the current study. First, although our use of multiple time points and an autoregressive cross-lagged modeling approach provides a test of possible causality, our findings are correlational in nature and we cannot infer causal link between MDS, mother-child interaction, and child EF. Second, although the indirect path between MDS, harsh-intrusiveness, and EF was significant, the independent effect size was small, limiting the ability to draw extensive conclusions based on these findings. The small magnitude of this effect is not surprising, given that we simultaneously estimated multiple indirect paths that involve correlated constructs. Finally, this study was a first step in understanding the mechanisms linking MDS and children's EF. As such, we focused on one domain that underlies the link between MDS and children's EF, namely mother-child interactions. Research has identified additional pathways, including genetic factors, dysfunctional neuroregulatory systems, and exposure to stressful life events (Goodman & Gotlib, 1999) that may also be relevant for understanding this link. Examining multiple mediating and moderating pathways is an important next step for better understanding the risk for EF deficits that is associated with exposure to MDS.

Despite these limitations, the present study has a number of strengths including the use of a prospective design, the large and racially diverse sample, the rural setting, and the observational measures of mother-child interaction and EF. Our findings expand the accumulating evidence on the risk associated with exposure to MDS, as it is the first to examine the links between MDS, mother-child interaction and children's EF. While such relations have previously been explored in the context of children's emotional regulatory abilities (e.g., Kam et al., 2011), expanding these findings to the context of children's cognitive regulatory skills is important given that EF is critical to various aspects of children's social-emotional and academic functioning (Raver et al., 2011). The results from this study also imply that harsh-intrusive mother-child interactions may be particularly critical in the process linking MDS to child EF. These findings may have clinical implications, particularly for families residing in rural areas. Efforts should be made to target mothers experiencing depressive symptoms in the implementation of intervention programs which focus on reducing harsh-intrusive dyadic interactions. Because mothers in rural areas often lack the resources to actively seek parenting guidance and support, home-based interventions that target mother-child interactions (e.g., Dozier et al., 2006) could be particularly beneficial in the context of rural poverty.

References

Baker, C. E., & Vernon-Feagans, L. (2015). Fathers' language input during shared book activities: Links to children's kindergarten achievement. *Journal of Applied Developmental Psychology, 36,* 53–59. http://dx.doi.org/10.1016/j.appdev.2014.11.009

Bayley, N. (1993). *Bayley scales of infant development: Manual*. New York, NY: Psychological Corporation.

Belleau, E. L., Phillips, M. L., Birmaher, B., Axelson, D. A., & Ladouceur, C. D. (2013). Aberrant executive attention in unaffected youth at familial risk for mood disorders. *Journal of Affective Disorders, 147,* 397–400. http://dx.doi.org/10.1016/j.jad.2012.08.020

Bernier, A., Carlson, S. M., Deschênes, M., & Matte-Gagné, C. (2012). Social factors in the development of early executive functioning: A closer look at the caregiving environment. *Developmental Science, 15,* 12–24. http://dx.doi.org/10.1111/j.1467-7687.2011.01093.x

Bernier, A., Carlson, S. M., & Whipple, N. (2010). From external regulation to self-regulation: Early parenting precursors of young children's executive functioning. *Child Development, 81,* 326–339. http://dx.doi.org/10.1111/j.1467-8624.2009.01397.x

Berry, D., Blair, C., Ursache, A., Willoughby, M. T., & Granger, D. A., & the Family Life Project Key Investigators. (2014). Early childcare, executive functioning, and the moderating role of early stress physiology. *Developmental Psychology, 50,* 1250–1261. http://dx.doi.org/10.1037/a0034700

Bibok, M. B., Carpendale, J. I., & Müller, U. (2009). Parental scaffolding and the development of executive function. *New Directions for Child and Adolescent Development, 2009,* 17–34. http://dx.doi.org/10.1002/cd.233

Blair, C., Granger, D. A., Willoughby, M., Mills-Koonce, R., Cox, M., Greenberg, M. T., . . . the FLP Investigators. (2011). Salivary cortisol mediates effects of poverty and parenting on executive functions in early childhood. *Child Development, 82,* 1970–1984. http://dx.doi.org/10.1111/j.1467-8624.2011.01643.x

Blair, C., Raver, C. C., & Berry, D. J., & the Family Life Project Investigators. (2014). Two approaches to estimating the effect of parenting on the development of executive function in early childhood. *Developmental Psychology, 50,* 554–565. http://dx.doi.org/10.1037/a0033647

Brody, G. H., Jack, L., Jr., Murry, V. M., Landers-Potts, M., & Liburd, L. (2001). Heuristic model linking contextual processes to self-management in African American adults with type 2 diabetes. *The Diabetes Educator, 27,* 685–693. http://dx.doi.org/10.1177/014572170102700509

Brody, G. H., Murry, V. M., Kim, S., & Brown, A. C. (2002). Longitudinal pathways to competence and psychological adjustment among African American children living in rural single-parent households. *Child Development, 73,* 1505–1516. http://dx.doi.org/10.1111/1467-8624.00486

Caldwell, B. M., & Bradley, R. H. (1984). *Home Observation for Measurement of the Environment*. Little Rock, Arkansas: University of Arkansas Press.

Camerota, M., Willoughby, M. T., Cox, M., & Greenberg, M. T., & the Family Life Project Investigators. (2015). Executive function in low birth weight preschoolers: The moderating effect of parenting. *Journal of Abnormal Child Psychology, 43,* 1551–1562. http://dx.doi.org/10.1007/s10802-015-0032-9

Camerota, M., Willoughby, M. T., Kuhn, L. J., & Blair, C. B. (2016). The Childhood Executive Functioning Inventory (CHEXI): Factor structure, measurement invariance, and correlates in US preschoolers. *Child Neuropsychology*. Advance online publication. http://dx.doi.org/10.1080/09297049.2016.1247795

Campbell, S. B., Matestic, P., von Stauffenberg, C., Mohan, R., & Kirchner, T. (2007). Trajectories of maternal depressive symptoms, maternal sensitivity, and children's functioning at school entry. *Developmental Psychology, 43,* 1202–1215. http://dx.doi.org/10.1037/0012-1649.43.5.1202

Carlson, S. M. (2003). Executive function in context: Development, measurement, theory, and experience. *Monographs of the Society for Research in Child Development, 68,* 138–151. http://dx.doi.org/10.1111/j.1540-5834.2003.06803012.x

Comas, M., Valentino, K., & Borkowski, J. G. (2014). Maternal depressive symptoms and child temperament: Longitudinal associations with executive functioning. *Journal of Applied Developmental Psychology, 35,* 156–167. http://dx.doi.org/10.1016/j.appdev.2014.03.005

Cox, M., & Crnic, K. (2002). *Qualitative ratings for parent–child interaction at 3–12 months of age*. Unpublished manuscript, University of North Carolina at Chapel Hill.

Cragg, L., & Nation, K. (2007). Self-ordered pointing as a test of working memory in typically developing children. *Memory, 15,* 526–535. http://dx.doi.org/10.1080/09658210701390750

Cuevas, K., Deater-Deckard, K., Kim-Spoon, J., Watson, A. J., Morasch, K. C., & Bell, M. A. (2014). What's mom got to do with it? Contributions of maternal executive function and caregiving to the development of executive function across early childhood. *Developmental Science, 17,* 224–238. http://dx.doi.org/10.1111/desc.12073

Derogatis, L. R., & Savitz, K. L. (2000). The SCL–90 –R and Brief Symptom Inventory (BSI) in primary care. In M. E. Maruish (Ed.), *Handbook of psychological assessment in primary care settings* (pp. 297–334). Mahwah, NJ: Erlbaum.

Devine, R. T., Bignardi, G., & Hughes, C. (2016). Executive function mediates the relations between parental behaviors and children's early academic ability. *Frontiers in Psychology, 7,* 1902. http://dx.doi.org/10.3389/fpsyg.2016.01902

Dozier, M., Peloso, E., Lindhiem, O., Gordon, M. K., Manni, M., Sepulveda, S., . . . Levine, S. (2006). Developing evidence-based interventions for foster children: An example of a randomized clinical trial with infants and toddlers. *Journal of Social Issues, 62,* 767–785. http://dx.doi.org/10.1111/j.1540-4560.2006.00486.x

Durston, S., Thomas, K. M., Yang, Y. H., Ulug, A. M., Zimmerman, R. D., & Casey, B. J. (2002). A neural basis for the development of inhibitory control. *Developmental Science, 5,* F9–F16. http://dx.doi.org/10.1111/1467-7687.00235

Fay-Stammbach, T., Hawes, D. J., & Meredith, P. (2014). Parenting influences on executive function in early childhood: A review. *Child Development Perspectives, 8,* 258–264. http://dx.doi.org/10.1111/cdep.12095

Feagans, L. V., Kipp, E., & Blood, I. (1994). The effects of otitis media on the attention skills of day-care-attending toddlers. *Developmental Psychology, 30,* 701. http://dx.doi.org/10.1037/0012-1649.30.5.701

Field, T. (2010). Postpartum depression effects on early interactions, parenting, and safety practices: A review. *Infant Behavior & Development, 33,* 1–6. http://dx.doi.org/10.1016/j.infbeh.2009.10.005

FLP Key Investigators. (2013). Cumulative risk and its relation to parenting and child outcomes at 36 months. *Monographs of the Society for Research in Child Development, 78,* 66–91. http://dx.doi.org/10.1111/mono.12051

Gaertner, B. M., Spinrad, T. L., & Eisenberg, N. (2008). Focused attention in toddlers: Measurement, stability, and relations to negative emotion and parenting. *Infant and Child Development, 17,* 339–363. http://dx.doi.org/10.1002/icd.580

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin, 134,* 31–60. http://dx.doi.org/10.1037/0033-2909.134.1.31

Gerardi-Caulton, G. (2000). Sensitivity to spatial conflict and the development of self-regulation in children 24–36 months of age. *Developmental Science, 3,* 397–404. http://dx.doi.org/10.1111/1467-7687.00134

Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: Performance of children 3 1/2–7 years old on a Stroop-like day-night test. *Cognition, 53,* 129–153. http://dx.doi.org/10.1016/0010-0277(94)90068-X

Goldsmith, D. F., & Rogoff, B. (1997). Mothers' and toddlers' coordinated joint focus of attention: Variations with maternal dysphoric symptoms. *Developmental Psychology, 33,* 113–119. http://dx.doi.org/10.1037/0012-1649.33.1.113

Goodman, S. H., & Gotlib, I. H. (1999). Risk for psychopathology in the children of depressed mothers: A developmental model for understanding mechanisms of transmission. *Psychological Review, 106,* 458–490. http://dx.doi.org/10.1037/0033-295X.106.3.458

Goodman, S. H., Rouse, M. H., Connell, A. M., Broth, M. R., Hall, C. M., & Heyward, D. (2011). Maternal depression and child psychopathology: A meta-analytic review. *Clinical Child and Family Psychology Review, 14,* 1–27. http://dx.doi.org/10.1007/s10567-010-0080-1

Graziano, P. A., Keane, S. P., & Calkins, S. D. (2010). Maternal behavior and children's early emotion regulation skills differentially predict development of children's reactive control and later effortful control. *Infant and Child Development, 19,* 333–353.

Gueron-Sela, N., Wagner, N. J., Propper, C. B., Mills-Koonce, W. R., Moore, G. A., & Cox, M. J. (2016). The interaction between child respiratory sinus arrhythmia and early sensitive parenting in the prediction of children's executive functions. *Infancy, 22,* 1–19.

Hoffman, Y., & Drotar, D. (1991). The Impact of Postpartum Depressed Mood on Mother-Infant Interaction: Like Mother Like Baby? *Infant Mental Health Journal, 12,* 65–80. http://dx.doi.org/10.1002/1097-0355(199121)12:1<65::AID-IMHJ2280120107>3.0.CO;2-T

Hughes, C. H., & Ensor, R. A. (2009). How do families help or hinder the emergence of early executive function? *New Directions for Child and Adolescent Development, 2009,* 35–50. http://dx.doi.org/10.1002/cd.234

Hughes, C., Roman, G., Hart, M. J., & Ensor, R. (2013). Does maternal depression predict young children's executive function? - a 4-year longitudinal study. *Journal of Child Psychology and Psychiatry, 54,* 169–177. http://dx.doi.org/10.1111/jcpp.12014

Jacques, S., & Zelazo, P. D. (2001). The Flexible Item Selection Task (FIST): A measure of executive function in preschoolers. *Developmental*

Neuropsychology, 20, 573–591. http://dx.doi.org/10.1207/S15326942DN2003_2

Jameson, P. B., Gelfand, D. M., Kulcsar, E., & Teti, D. M. (1997). Mother-toddler interaction patterns associated with maternal depression. *Development and Psychopathology, 9,* 537–550. http://dx.doi.org/10.1017/S0954579497001296

Kam, C. M., Greenberg, M. T., Bierman, K. L., Coie, J. D., Dodge, K. A., Foster, M. E., . . . the Conduct Problems Prevention Research Group. (2011). Maternal depressive symptoms and child social preference during the early school years: Mediation by maternal warmth and child emotion regulation. *Journal of Abnormal Child Psychology, 39,* 365–377. http://dx.doi.org/10.1007/s10802-010-9468-0

Kane, M. J., & Engle, R. W. (2003). Working-memory capacity and the control of attention: The contributions of goal neglect, response competition, and task set to Stroop interference. *Journal of Experimental Psychology: General, 132,* 47–70. http://dx.doi.org/10.1037/0096-3445.132.1.47

Kotchick, B. A., Dorsey, S., & Heller, L. (2005). Predictors of parenting among African American single mothers: Personal and contextual factors. *Journal of Marriage and Family, 67,* 448–460. http://dx.doi.org/10.1111/j.0022-2445.2005.00127.x

Lengua, L. J., Honorado, E., & Bush, N. R. (2007). Contextual risk and parenting as predictors of effortful control and social competence in preschool children. *Journal of Applied Developmental Psychology, 28,* 40–55. http://dx.doi.org/10.1016/j.appdev.2006.10.001

Lovejoy, M. C., Graczyk, P. A., O'Hare, E., & Neuman, G. (2000). Maternal depression and parenting behavior: A meta-analytic review. *Clinical Psychology Review, 20,* 561–592. http://dx.doi.org/10.1016/S0272-7358(98)00100-7

Miller, J. F., & Chapman, R. S. (1985). *Systematic analysis of language transcripts*. Language Analysis Laboratory, Waisman Center on Mental Retardation and Human Development Madison. WI: University of Wisconsin-Madison.

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science, 21,* 8–14. http://dx.doi.org/10.1177/0963721411429458

Morales, M., Mundy, P., Crowson, M., Neal, R., & Delgado, C. (2005). Individual differences in infant attention skills, joint attention, and emotion regulation behavior. *International Journal of Behavioral Development, 29,* 259–263. http://dx.doi.org/10.1177/01650250444000432

Mundy, P. (2003). Annotation: The neural basis of social impairments in autism: The role of the dorsal medial-frontal cortex and anterior cingulate system. *Journal of Child Psychology and Psychiatry, 44,* 793–809. http://dx.doi.org/10.1111/1469-7610.00165

NICHD Early Child Care Research Network. (1999). Chronicity of maternal depressive symptoms, maternal sensitivity, and child functioning at 36 months. *Developmental Psychology, 35,* 1297–1310. http://dx.doi.org/10.1037/0012-1649.35.5.1297

Pearson, R. M., Bornstein, M. H., Cordero, M., Scerif, G., Mahedy, L., Evans, J., . . . Stein, A. (2016). Maternal perinatal mental health and offspring academic achievement at age 16: The mediating role of childhood executive function. *Journal of Child Psychology and Psychiatry, 57,* 491–501. http://dx.doi.org/10.1111/jcpp.12483

Posner, M. I., & Rothbart, M. K. (1998). Summary and commentary: Developing attentional skills. In J. E. Richards (Ed.), *Cognitive neuroscience of attention: A developmental perspective* (pp. 317–323). Mahwah, NJ: Erlbaum.

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1,* 385–401. http://dx.doi.org/10.1177/014662167700100306

Raver, C. C. (1996). Relations between social contingency in mother-child interaction and 2-year-olds' social competence. *Developmental Psychology, 32,* 850–859. http://dx.doi.org/10.1037/0012-1649.32.5.850

Raver, C. C., Blair, C., & Willoughby, M. (2013). Poverty as a predictor of 4-year-olds' executive function: New perspectives on models of differential susceptibility. *Developmental Psychology, 49,* 292–304. http://dx.doi.org/10.1037/a0028343

Raver, C. C., Jones, S. M., Li-Grining, C., Zhai, F., Bub, K., & Pressler, E. (2011). CSRP's Impact on low-income preschoolers' preacademic skills: Self-regulation as a mediating mechanism. *Child Development, 82,* 362–378. http://dx.doi.org/10.1111/j.1467-8624.2010.01561.x

Rowe, M. L., Pan, B. A., & Ayoub, C. (2005). Predictors of Variation in Maternal Talk to Children: A Longitudinal Study of Low-Income Families. *Parenting: Science and Practice, 5,* 259–283. http://dx.doi.org/10.1207/s15327922par0503_3

Swingler, M. M., Perry, N. B., & Calkins, S. D. (2015). Neural plasticity and the development of attention: Intrinsic and extrinsic influences. *Development and Psychopathology, 27,* 443–457. http://dx.doi.org/10.1017/S0954579415000085

Swingler, M. M., Perry, N. B., Calkins, S. D., & Bell, M. A. (2017). Maternal behavior predicts infant neurophysiological and behavioral attention processes in the first year. *Developmental Psychology, 53,* 13–27. http://dx.doi.org/10.1037/dev0000187

Tickamyer, A. R., & Duncan, C. M. (1990). Poverty and opportunity structure in rural America. *Annual Review of Sociology, 16,* 67–86. http://dx.doi.org/10.1146/annurev.so.16.080190.000435

Vaughan Van Hecke, A., Mundy, P., Block, J. J., Delgado, C. E. F., Parlade, M. V., Pomares, Y. B., & Hobson, J. A. (2012). Infant responding to joint attention, executive processes, and self-regulation in preschool children. *Infant Behavior & Development, 35,* 303–311. http://dx.doi.org/10.1016/j.infbeh.2011.12.001

Verhoeven, M., Junger, M., Van Aken, C., Deković, M., & Van Aken, M. A. (2007). Parenting during toddlerhood: Contributions of parental, contextual, and child characteristics. *Journal of Family Issues, 28,* 1663–1691. http://dx.doi.org/10.1177/0192513X07302098

Vernon-Feagans, L., & Cox, M. (2013). I. Poverty, rurality, parenting, and risk: An introduction. *Monographs of the Society for Research in Child Development, 78,* 1–23. http://dx.doi.org/10.1111/mono.12047

Weinberg, M. K., Olson, K. L., Beeghly, M., & Tronick, E. Z. (2006). Making up is hard to do, especially for mothers with high levels of depressive symptoms and their infant sons. *Journal of Child Psychology and Psychiatry, and Allied Disciplines, 47,* 670–683. http://dx.doi.org/10.1111/j.1469-7610.2005.01545.x

Willoughby, M. T., & Blair, C. B. (2016). Longitudinal measurement of executive function in preschoolers. In J. A. Griffen, P. McCardle, & L. Freund (Eds.), *Executive function in preschool age children: Integrating measurement, neurodevelopment, and translational research. Washington,* DC: American Psychological Association. http://dx.doi.org/10.1037/14797-005

Willoughby, M., Burchinal, M., Garrett-Peters, P., Mills-Koonce, R., Vernon-Feagans, L., & Cox, M. (2013). II. Recruitment of the family life project sample. *Monographs of the Society for Research in Child Development, 78,* 24–35. http://dx.doi.org/10.1111/mono.12048

Willoughby, M. T., Wirth, R. J., & Blair, C. B., & the Family Life Project Investigators. (2012). Executive function in early childhood: Longitudinal measurement invariance and developmental change. *Psychological Assessment, 24,* 418–431. http://dx.doi.org/10.1037/a0025779

Yu, C., & Smith, L. B. (2016). The social origins of sustained attention in one-year-old human infants. *Current Biology, 26,* 1235–1240. http://dx.doi.org/10.1016/j.cub.2016.03.026

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