Growth in Child Executive Function and Maternal Depressive Symptoms: Maternal Sensitivity as a Mediator

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Introduction

Executive function (EF) in childhood plays an important role in children's future development. EF is a set of higher cognitive processes that allow individuals to execute goal directed behavior in a novel, problem solving context (Welsh, Friedman, & Slieker, 2006). Children with better EF skills may show positive developmental outcomes, such as higher socio-emotional competence or academic achievement, compared to their counterparts with poorer EF skills. With this growing recognition of the critical role of EF, there has been considerable attention to children's EF skills at different developmental stages. However, it is relatively less known about the trajectories of child EF over time. Child EF development is susceptible to child-rearing environments. Individual differences in the developmental trajectories of child EF skills may be associated with different child-rearing environments. Depressed mothers may create an unsupportive child-rearing environment because of their behavior or cognitive patterns (Cummings & Davies, 1994). Thus, this study aimed to examine the processes by which maternal depressive symptoms were associated with developmental trajectories of child EF through maternal parenting behavior, in particular, maternal sensitivity.

The developmental trajectories of child executive function

In regard to the important role of early EF, over the past several decades there has been considerable attention to the development of child EF, including its conceptualization, its emergence and development, its measurement, and the predictors and developmental consequences of earlier EF skills (Blair & Razza, 2007; Clark, Pritchard, & Woodward, 2010; Hughes & Ensor, 2011; Hughes, Ensor, Wilson, & Graham, 2010; Jerman, Reynolds, & Swanson, 2012; Kim et al., 2013; Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000; Portilla, et al., 2014). EF consists of several components that are separable but interrelated to each other (Garon et al., 2008; Lehto, Juujärvi, Kooistra & Pulkkinen, 2003). The components include: a) inhibitory control, the ability to withhold a prepotent response; b) attention flexibility, the ability to shift attention between two- or multiple-dimensions; and c) working memory, updating, monitoring, and manipulating information (Miyake et al., 2000). While this three-dimensional construct is prevalently used, planning skills are considered a higher level of EF as it requires the multiple EF components to work together simultaneously (Anderson, 2002). Overall, EF skills emerge during infancy and mature through middle childhood to adolescence, with certain components developing at different time points and rates (Best, Miller, & Jones, 2009). Whereas inhibitory control and attention flexibility skills dramatically increase in preschool years, working memory and planning skills grow rapidly from early elementary grades to adolescence (Anderson, 2002; Best et al., 2009; Carlson & Moses, 2001; Carlson, Moses, & Claxton, 2004; Gathercole, Pickering, Ambridge, & Wearing, 2003; Graham, 2010; Hughes et al., 2010; Huizinga, Dolan, & van der Molen, 2006). Despite the clear evidence of persistent growth in child EF from infancy through adolescence, less is known about the developmental trajectories of individual children's EF during middle childhood.

A line of research has focused on normative developmental levels of EF in different age groups using cross-sectional data sets (e.g., Espy, Bull, Martin, & Stroup, 2006; Huizinga & Smidts, 2006; Wiebe, Espy, & Charak, 2008), whereas few studies have looked into trajectories of child EF using longitudinal data (i.e., Hughes et al., 2010; Hughes & Ensor, 2011; Jerman, Reynolds, & Swanson, 2012; Kronenberger, Pisoni, Harris, Hoen, Xu, & Miyamoto, 2013; Swanson, Jerman, & Zheng, 2008). Within the literature examining trajectories of child EF, a majority of studies tend to focus on the associations between different developmental trajectories of child EF skills and their developmental outcomes, such as emotional and behavioral problems, and academic achievement (Hughes et al., 2010; Hughes & Ensor, 2011; Jerman et al., 2012; Kronenberger et al., 2013; Swanson et al., 2008). For example, children who showed greater gains in working memory from grade 1 to 3 gained more increases in math skills (Swanson et al., 2008). Children's greater gains in EF skills, including working memory and inhibitory control, from 4 to 6 years of age, were related to higher levels of socio-emotional competence and low levels of emotional problems (e.g., hyperactivity) at 6 years of age (Hughes & Ensor, 2012). Those studies provide evidence of developmental changes in EF skills over time and the developmental trajectories of EF are predictive of developmental outcomes. However, it is relatively less studied about developmental trajectories of child EF over a relatively longer period of time. To fill the gap in the literature, this study aimed to examine the trajectories of EF during middle childhood, in particular from grade 1 through 5.

Maternal depressive symptoms and EF development

It is critical to understand the course of EF development in respect to negative consequences of poor EF skills (Blair & Razza, 2007; Brock et al., 2009; Bull & Scerif, 2001; Clark, Pritchard, & Woodward, 2010; Deater-Deckard, Mullineaux, Petrill, & Thompson, 2009;

Gathercole & Pickering, 2000; Portiall et al., 2014; Valente et al., 2014). One of the important questions that remains is what are contributing or undermining factors to the development of child EF. EF development is susceptible to contextual influences (Lewis & Carpendale, 2009). A supportive environment (e.g., caregivers' emotional and cognitive support) may facilitate the development of child EF skills, whereas an unsupportive environment (e.g., family financial strain) may undermine the development of EF (De Bellis, 2001). Among the contextual factors, familial context may have greater influences on child EF development, compared to other contexts such as school or neighborhood (Bibok, Carpendale, & Müller, 2009). For example, it has been found that low family socio economic status, unstable family structure, and caregivers' psychological problems (e.g., depression, anxiety), and insecure attachment between a caregiver and a child are associated with poor child EF (Buss, Davis, Hobel, & Sandman, 2011; Fahie, & Symons, 2003, Hughes et al. 2013; Mackay, 2005; Sarsour et al. 2011). Considering that typically, mothers are primary caregivers of a child, maternal characteristics or behavior can be important factors that may facilitate or undermine children's cognitive development. Among maternal influences, maternal depressive symptoms are suggested as a risk factor that undermines child development in many different aspects, including socio-emotional and cognitive skills (Cummings & Davies, 1994; Elgar, Curtis, McGrath, Waschbusch, & Stewart, 2003; Evans et al., 2012; Luoma et al., 2001; Lyons-Ruth, Easterbrooks, & Cibelli, 1997; Surkan 2007). It is estimated that 1 out of 10 mothers experiences depression at any given year (Ertel, Rich-Edwards, & Koenen, 2011). Considering such prevalence of mothers' experiencing depressive episodes, it is important to consider maternal depressive symptoms an adverse familial context (Brown and Harris 1978). Despite the possibility of the adverse effects of maternal depressive symptoms on child EF, few empirical studies have examined the associations between maternal depressive symptoms and child EF (e.g., Hughes et al., 2013).

One of the characteristics of maternal depressive symptoms is that mothers may change the levels of depressive symptoms over time. (Campbell et al., 2007; Hughes et al., 2013; Luoma et al., 2015; Wu, Selig, Roberts, & Steele, 2011). For example, mothers who were tracked from a month after the target's child birth through 36 months showed a decreasing fashion of their depressive symptoms (Wu et al., 2011). After child's birth, mothers may experience relatively severe depressive symptoms. However, as new mothers adopt their role as a mother, they may show a decrease in depressive symptoms (Horowitz & Goodman, 2004). Trajectories of maternal depressive symptoms may explain individual differences in child EF growth. Thus, it was aimed to investigate the trajectories of maternal depressive symptoms from 6 months of the target child's age through grade 5. Since it is very common that new mothers tend to experience postpartum depressive symptoms after birth and it may last several weeks or months, maternal depressive symptoms from birth to several months may not reflect everyday depressive symptoms. Thus, maternal depressive symptoms until 5 months were excluded in the current study. It was hypothesized that mothers would decline their depressive symptoms from 6 months 1 to grade 5.

Maternal depressive symptoms in early childhood have been considered a predictor for child cognitive development, as it is found to predict other aspects of child development (Campbell, Matestic, von Stauffenberg, Mohan, & Kirchner, 2007). Both chronicity and severity of maternal depressive symptoms have associations with child development, including socio-emotional competence and cognitive ability (e.g., Brennan et al., 2000). When mothers experience chronic and severe depressive symptoms in early childhood, children may be at risk to have poor socio-emotional and cognitive skills (NICHD ECCRN, 1999). For example, mothers with greater severity and chronicity of depressive symptoms though pregnancy to 5 years are more likely to have children who show lower cognitive skills (e.g., poor language skills) at school entry (Brennan et al., 2000). As much of the evidence indicates that maternal depressive symptoms change over time, several studies examined the trajectories of maternal depressive symptoms in early childhood (Campbell et al., 2007; Hughes et al., 2011). For example, Campbell et al. (2007) found that children whose mothers displayed increased depressive symptoms or whose mothers showing chronic depressive symptoms from 6 months to grade 1 showed poorer cognitive skills (e.g., poor memory and vocabulary skills), compared to their counterparts whose mothers showed consistently low or moderate levels of depressive symptoms. The findings imply that individual differences in trajectories of maternal depressive symptoms may be associated with individual differences in child EF skills. Hughes and colleagues (2013) examined whether changes in maternal depressive symptoms predicted child EF skills. They found that maternal depressive symptoms declined through age 2 to 6, and higher initial levels and slower decline in maternal depressive symptoms predicted lower levels of EF at age 6. In this way, mothers may show changes in their depressive symptoms over time and the changes may predict children's individual differences in cognitive outcomes.

Although prior work have provided evidence of the associations between changes in maternal depressive symptoms and child EF skills, one limitation of the prior research is that it tends to focus on child EF outcomes assessed at a single time point. This approach may overlook the longitudinal process of child EF development, while maternal characteristics are also changing. Responding to the gap in the literature, the second aim of the study was to investigate the associations between trajectories of maternal depressive symptoms and trajectories of child

EF. Considering the important role of the early rearing environment, maternal depressive symptoms assessed from 6 months of target child's age through grade 5 were included for the trajectories. It was hypothesized that first, low level of maternal depressive symptoms at 6 months and faster decreases in maternal depressive symptoms from 6 months to grade 5 would predict better EF at grade 1 and faster increases in EF during middle childhood.

Maternal sensitivity as mediator in the relation between maternal depressive symptoms and child EF

Considering the suggested link between trajectories of maternal depressive symptoms and child EF, it may be important to investigate the processes by which maternal depressive symptoms from early childhood through middle childhood are associated with child EF in elementary grades. One possible underlying mechanism can be maternal behavior (Cummings & Davies, 1994; van Doorn et al., 2016). Depressed mothers are often characterized as disengaged in social interactions, less responsive to child's cues, exhibiting more criticism, rejection and hostility to the child (Cox, Puckering, Pound & Mills, 1987; Hammen, 1988; other citations). Because of such characteristics of depressed mothers, it is argued that depressed mothers may show low levels of sensitivity. Sensitivity can be defined as the ability to recognize child's signals accurately and to respond to them in a prompt and adequate manner (Mills-Koonce et al., 2008). Those mothers may fail to provide immediate, appropriate responses to child's physical, emotional, and cognitive needs, be disengaged with their child's activities, and show less positive interactions with their child but more hostility (Brennan, Hammen, Anderson, Bor, Najman, & Williams, 2000; Campbell et al., 2004; Elgar, Mills, McGrath, Waschbusch, & Brownridge, 2007; Hughes et al., 2013; Lovejoy, Graczyk, O'Hare, & Neuman, 2000; Reck et al., 2004; Stein, Gath, Bucher, Bond, Day, & Cooper, 1991). Attachment theory provides a framework that mothers who lack of sensitive responses may be associated with negative child developmental outcomes, including child cognitive skills (Bowlby, 1982). Maternal depressed symptoms may undermine the development of secure mother-child attachments and those mothers may fail to build the emotional bond with their child (Cummings & Cicchetti, 1990). Maternal depressive symptoms may interfere with the quality of parenting behavior. Mothers with severe depressive symptoms may not be able to provide emotional support, encourage child's autonomy, and stimulate child's cognitive development. In contrast, sensitive mothers may be able to provide a supportive child-rearing environment, which in turn facilitates children's EF development (Bernier et al., 2010).

Mothers may change their sensitivity levels, as they may show changes in depressive symptoms. Maternal sensitivity may decline or increase, depending on different stages of child development. Some mothers showed a decline in sensitivity from 6 months through 36 months, while sensitivity remained stable for other mothers (Mills-Koonce, Gariepy, Sutton, & Cox. 2008). The trajectories of maternal sensitivity may be related to the trajectories of maternal depressive symptoms. Concurrent associations between trajectories of maternal depressive symptoms and sensitivity have been found (e.g., Campbell, Cohn, & Meyers, 1995; Campbell et al. 2008). Mothers with chronic depressive symptoms from 15 to 36 months showed decreased levels of sensitivity over time (Campbell et al., 2008). However, the longitudinal associations between the trajectories of maternal depressive symptoms and the trajectories of sensitivity is less explored, although maternal depression can be considered a predictor of low levels of maternal sensitivity. Responding to the gap, this study aimed to examine whether the overall changes in maternal depressive symptoms from infancy through grade 5 would predict changes in maternal sensitivity during preschool years and middle childhood, especially from 36 months through grade 5. Lastly, this study aimed to investigate the mediating role of maternal sensitivity trajectories in the association between maternal depressive symptoms trajectories and child EF growth trajectories.

Method

Participants

The sample of this study was drawn from the National Institute of Child Health and Human Development (NICHD) Study of Early Child Care and Youth Development (SECCYD), including 1,364 primary mother-child dyads at 8 different time points, from the focal child's age at 6 month to 5^{th} grade (boys = 705; girls = 659). Trained staff had a home visit to administer the surveys and observation at 1, 15, and 24 months, while the families visited the laboratory at 36 and 54 months, and grade 1, 3, and 5. Most children were Caucasian (80.4%), 12.9% were African-American, and 6.7% were other ethnicities. Similarly, a majority of the mothers were Caucasian (82.6%) and 12.8% were African-American, and 4.6% were other ethnicities. At 1 month of the child's age, mothers' age ranged between 18 and 46 years (M = 28.11, SD = 5.63), and 64.6% of the mothers showed less than bachelor's degree and 35.3% bachelor's degree or above. At the time of focal child's age at 1 month, most of the mothers were married and living with their spouse (76.5%) and 8.9% were living with their partner.

The retention rate from 6 month to grade 5 was 68.16%. Missing data (31.84%) were missing at random using Little's MCAR test, as Little's (1988) MCAR (missing completely at random) test was not significant (normed $\chi^2 = 2618.89$, $p = 1.00$). Full information maximum likelihood was applied to handle the missing data.

Measures

Executive function (Planning skills) was assessed by *the Tower of Hanoi task* (Scholnick & Freidman, 1993) at 1st, 3rd, and 5th grade. This task consists of a set of doughnut-like discs with three different sizes and three pegs in a row. Children were asked to build a pyramid-like structure by placing the discs on the peg. The rules were as follows: a) children were allowed to move only one disc at a time; b) children were allowed to move only the top disc when there was more than one disc on a peg; and c) children were not allowed to place a larger disc on a smaller disc. Children had to make a minimum number of moves to achieve the perfect solution. The number of attempts the child made to reach the perfect solution was calculated and then reversed. The higher total scores indicated the better planning skills.

Maternal depressive symptoms were assessed with the *Center for Epidemiological Studies Depression Scale* (CES-D; Radloff, 1977) at the time of 6, 15, 24, 36, and 54 months of the child's age, and grade 1, 3, and 5. The measure consisted of 20 items and each item stated a depressive symptomology. Mothers self-rated the frequency of each symptomology during the past week on a 4-point Likert scale (0 = less than 1 day; 1 = 1-2 days; 2 = 3-4 days; and 3 = 5-7 days.

Maternal sensitivity was measured with observation on a mother-child semi-structured play in a laboratory context (NICHD Early Child Care Research Network, 1999) at child's age 36 and 54 months, and grade 1, 3 and 5. Three subscales, *Supportive Presence, Respect for Child's Autonomy,* and *Hostility*, were scored on a 1 to 7 point-scale. A composite score of maternal sensitivity was created by combining *Supportive Presence, Respect for Child Autonomy,* and *Hostility* (Reserved score).

Covariates include child sex, maternal education, and family income-to-needs ratio. The target child's sex was reported by mothers. Boys and girls were coded as 0 and 1, respectively.

When the target child was 1 month of age, family income was reported by the mothers. Mothers self-reported how many years they have received education. The ratio of family income-to-needs was calculated by dividing total family income by the poverty threshold for the family size (U.S. Bureau of the Census, 1999).

Analytic plans

Regarding the first research question, unconditional growth models for maternal depressive symptoms, maternal sensitivity, and child EF, were examined, separately, using latent growth curve modeling. In regards to the second research question, the initial levels (the intercept) and the changes (the slope) in maternal depressive symptoms were used as predictors and the initial levels and changes in child executive function were included as dependent variables. As maternal sensitivity (both the intercept and changes) was hypothesized as a mediator, the indirect effects of changes in maternal depressive symptoms (both intercept and slope) on child executive function growth (both intercept and slope) through changes in maternal sensitivity (both intercept and slope) were examined. Bootstrapped standard errors were computed using 3000 draws in order to obtain bootstrap confidence intervals for the indirect effects. Total indirect, specific indirect, and total effects were estimated. For the direct and indirect paths, child sex, and maternal education and family income-to-needs ratio were included in the analyses as covariates.

Results

First, descriptive statistics on maternal depressive symptoms, maternal sensitivity, and child executive function are provided in Table 1. Second, we examined unconditional growth models for maternal depressive symptoms and sensitivity, and child executive function. Finally, we examined the mediation model whether changes in maternal depressive symptoms would predict child executive function growth through changes in maternal sensitivity. The descriptive statistics of the variables are presented in Table 1. As presented in Table 2, maternal depressive symptoms and maternal sensitivity showed moderate levels of negative correlations. Mostly, maternal depressive symptoms were negatively correlated with children's EF. Maternal sensitivity was positively correlated with child executive function over time.

Developmental trajectories of maternal depressive symptoms and sensitivity, and child EF

Growth in maternal depressive symptoms

The unconditional growth curve model of maternal depressive symptoms was estimated. The latent growth model fit the changes maternal depressive symptoms ($\chi^2_{(31)} = 102.002$, $p < .001$; CFI = .963; RMSEA = .042) and maternal depressive symptoms declined over time (Figure 1(a)). As presented in Table 3, the mean of the depressive symptoms intercept was significantly different from zero, and there were individual differences in the mean of the intercept among the mothers. The mean of the slope was different from zero, indicating that maternal depressive symptoms decreased over time. There were significant variances around the slope of maternal depressive symptoms. The intercept of maternal depressive symptoms was negatively correlated with the slope of depressive symptoms (r = -0.332, $p < .001$).

Growth in maternal sensitivity

The unconditional growth curve model of maternal sensitivity was estimated, including maternal sensitivity composite scores assessed at 36 and 54 months, and grade 1, 3, and 5. The changes in maternal sensitivity fit the data ($\chi^2_{(10)} = 50.481$, p < .001; CFI = .961; RMSEA < .057) and maternal sensitivity decreased over time (Figure 1(b)). Both the mean of maternal sensitivity intercept and slope were significantly different from zero. Maternal sensitivity tended to decrease over time. There were significant individual differences in both of the intercept and slope of sensitivity among the mothers. The intercept of maternal sensitivity was negatively correlated with the slope of maternal sensitivity (r = -.592, $p < .001$).

Growth in children's EF

The unconditional growth model of children's EF was estimated. As shown in Figure 1, the growth model was not linear, thus the EF score for the second time point was freely estimated. The latent growth model fit the changes in children's EF ($\chi^2_{(1)} = .466$, $p = .495$; CFI = 1.000; RMSEA < .001; SRMR = .008) and children showed increases in executive function over time (Figure 1(c)). The mean and the slope of EF was significantly different from zero. The variance of the intercept and the slope were significant as well. In the previous analysis, the correlation between the intercept and the slope of EF was not significant, thus the correlation between the intercept and the slope was set to zero.

Mediation model

Regarding the second research question, maternal depressive symptoms intercept and slope were included as the predictors, child executive function intercept and slope as the outcomes, and maternal sensitivity intercept and slope as the mediators. The mediation model including the significant covariates fit the data ($\chi^2_{(154)} = 495.347$, $p < .001$; CFI = .926; RMSEA = .043). There were three significant direct associations (see Figure 2): high levels of maternal depressive symptoms at 6 months (intercept) predicted low levels of maternal sensitivity at 36 months (intercept). Higher levels of maternal sensitivity at 36 months (intercept) were predictive of higher levels of child EF at grade 1 (intercept) and faster increases from grade 1 through grade

5 (slope). Two indirect associations were found to be significant. First, low levels of maternal depressive symptoms at 6 months (intercept) predicted high levels of child EF at grade 1 (intercept) through increased levels of maternal sensitivity intercept (B = -.065, SE = .202, p = .001; β = -.091, SE = .027, p = .001). Second, low levels of the maternal depressive symptoms intercept were predictive of greater increases in child EF through increased levels of maternal sensitivity at 36 months (B = -.047, SE = .202, p = .019; β = -.057, SE = .025, p = .021).

Discussion

Although the longitudinal association between maternal depressive symptoms and poor child EF has been established, what is less known is the mechanism linking maternal depressive symptoms and child EF skills. Our findings suggest that children's early exposure to maternal depressive symptoms has longitudinal associations with their EF growth, both initial levels and growth rates through decreased maternal sensitivity.

Overall, mothers showed declines in their depressive symptoms from 6 months of the target child's age through grade 5, as expected. This result partially supports Hughes et al.'s (2013) work in which mothers showed decreases in their depressive symptoms from 2 to 4 years. The overall trajectories still declined when we examined the trajectories of maternal depressive symptoms over a wider range of time period. Unexpectedly, neither initial levels of maternal depressive symptoms nor the slope were directly associated with growth in child EF skills. These findings are not consistent with prior work in which longer chronicity, greater severity, or slower decreases in maternal depressive levels were associated with more negative developmental outcomes, including poor socio-emotional and cognitive skills (Brennen et al., 2000; Campbell et al., 2007; Cents et al., 2013; Hughes et al., 2013). One of the possible reasons for the inconsistency can be explained by the different time periods when maternal depressive symptoms and child developmental outcomes were assessed across the studies. Previous studies tend to included maternal depressive symptoms assessed in early childhood, for example, from 6 to 36 months, or 2 to 4 years, and child EF skills assessed around preschool years or during the transition to a first grade. Unlike the previous studies, our study included maternal depressive symptoms assessed from infancy through grade 5 and child EF growth from grade 1 to 5.

Maternal depressive symptoms at 6 months were predictive of low levels of maternal sensitivity at 36 months. This finding suggests that maternal depressive symptoms in infancy have enduring consequences on mothers' sensitivity levels in the early preschool year. This finding replicated prior work that found mothers with severe or/and chronic depressive symptoms may have less optimal interactions with their children (Campbell et al., 2004, 2007; NICHD ECCRN, 1999a). Mothers with elevated levels of depressive symptoms may not have emotional availability that enable them to promptly respond to child's needs (Lovejoy et al., 2000; Stein et al., 1990; Reck et al., 2004), thus failing to be appropriately attuned to children's cognitive needs (Murray, Fiori-Cowley, Hooper, & Cooper, 1996). Some studies may argue that maternal depressive symptoms may coexist with lack of sensitivity (Campbell et al., 2004; Murray et al., 1996), whereas others may argue that early severity or chronicity of maternal depressive symptoms may undermine their sensitivity later (Kluczniok et al., 2016; van Doorn et al., 2016). This study confirms that early maternal depressive may be predictive of low levels of sensitivity in the future. However, it is important to note that our results cannot claim the casual relations between high levels of maternal depressive symptoms and low sensitivity, given the nature of this study which is not an experimental design.

Expectedly, child EF, in particular planning skills, increased over the course of elementary school grades. Our finding supports the theoretical perspective of EF development which assumes that child planning skills increase during middle childhood (e.g., Best, 2005). Especially, considering that much of the prior research investigated age-related changes in child EF at different age groups using cross-sectional data set (Espy, Bull, Martin, & Stroup, 2006; Huizinga & Smidts, 2006; Wiebe, Espy, & Charak, 2008), our finding provides evidence that children persistently improve their EF skills even after early childhood. The trajectories of child EF skills were predicted by maternal sensitivity at 36 months: higher levels of maternal sensitivity at 36 months were predictive of better EF skills at grade 1 as well as faster growth in child EF from grade 1 to 5. As the components of maternal sensitivity of our study include maternal supportive presence, respect for child's autonomy, and hostility, mothers who tend to offer comfort at the time of child's experiencing distress, help children solve challenging tasks, be less critical may be predictive of high levels of EF at grade 1, and furthermore facilitate children's growth in EF skills over the course of elementary grades. This study may have more emphasis on the role of maternal sensitivity in preschool years, rather than children's early exposure to maternal severe depressive symptoms in regards with child EF development.

Finally, low levels of maternal sensitivity at 36 months served a mediator between the associations between high levels of maternal depressive symptoms at 6 months and low EF skills at grade. In addition, the mediation link was significant when the slope of child EF was included as the outcome. When mothers showed more depressive symptom at 6 months, those mothers showed low sensitivity at 36 months, which in turn predicted slower rates of growth in child EF skills from grade 1 to grade 5. These findings replicated previous studies in which maternal behavior mediated the association between their depressive symptoms and child developmental outcomes. Elgar and colleagues (2007) found that poor quality of maternal behavior, including less nurturance, more rejection, and less monitoring, mediated the associations between high levels of maternal depressive symptoms and poor children's outcomes (e.g., more emotional/behavioral problems and low levels of social skills). Considering that previous studies tended to include maternal depressive symptoms and behavior, and child developmental outcomes assessed at a single time point, our study extends the previous understanding of the processes by which changes in both maternal depressive symptoms and sensitivity are predictive of developmental trajectories of child EF by looking into the changes in the three variables simultaneously for a relatively longer time period.

There are several strengths of the present study. First, the present study is the first to examine the mechanism linking maternal depressive symptoms to child EF skills by considering changes in maternal depressive symptoms and sensitivity levels and trajectories of child EF skills simultaneously. This may reflect the dynamic in which children consistently develop EF skills under the influences of their rearing environment that is ever changing. Second, maternal depressive symptoms and sensitivity were assessed at multiple time points from 6 months to grade 5, and from 36 months to grade 5, respectively. This research design may better capture the processes by which the developmental course of child EF skills is related to changes in maternal characteristics. Third, this study included maternal sensitivity observed during mother-child interactions. Thus, in our study it may be less biased in terms of the measurement of maternal sensitivity, compared to studies in which maternal sensitivity tended to be assessed by maternal self-report. This is because of the nature of depressive mothers who are more likely to give biased responses on their own behavior (Kraemer et al. 2003). Lastly, this study contributes to increasing our understanding of processes by which maternal sensitivity serves a mechanism linking changes in maternal depressive symptoms to growth in child EF skills.

There are several limitations of the present study. First, this study relied on self-ratings of maternal depressive symptoms. Another limitation concerns our approach to examining the trajectories of maternal depressive symptoms for the whole sample may have made authors overlooked the individual difference in the trajectories. In other words, there may be individual differences in depressive symptoms among the mothers, rather than all the mothers display the homogenous trajectory of sensitivity (Mills-Koonce et al., 2008). Lastly, among several components of EF, only planning skills were included in the present study. Given the fact that children may show consistent increases in working memory during middle childhood along with the planning skills, exploring the developmental trajectories of working memory during middle childhood may help understand the developmental course of EF skills in middle childhood.

In regards to future directions, first, there is a need for exploring other mechanisms linking maternal depressive symptoms and child EF skills. It is possible that maternal depressive symptoms may be related to other aspects of maternal behavior, such as maternal scaffolding. Maternal scaffolding can be defined as mother's support for a child's performance during challenging tasks (Vygotsky, 1974). Depressed mothers may show lack of scaffolding behavior, as depressed mothers tend to be less structuring during the challenging tasks (Kluczniok, 2016). In this way, finding out other mechanism underlying the associations between maternal depressive symptoms and child EF skills will greatly extend our current understanding of the course of child EF skills within the family context.

Although the term, maternal sensitivity, may reflect bidirectional nature between a mother and a child, most of the studies tend to assess maternal sensitivity by observing/assessing maternal behavior. Few studies included child's responses to maternal behavior to assess maternal sensitivity (e.g., Kluczniok et al., 2016). Measure for maternal sensitivity can include not only maternal behavior but also child's response to maternal behavior, as sensitivity is meant to be a dyadic construct (Biringen, Derscheid, Vliegen, Closson, Easterbrooks, 2014). Regarding the mutual influences of mother-child behavior, recent studies have suggested transactional nature between maternal behavior and child developmental outcomes, including child EF skills (Blair, Raver, & Berry, 2012). In particular, Blair et al. (2012) found that maternal responsiveness at 36 months was a predictor for child EF growth from 36 to 60 months, while higher levels of child EF at 36 months predicted more increases in maternal responsiveness from 36 to 60 months. It will provide meaningful information whether children's EF would contribute to maternal characteristics, such as individual differences in maternal depressive symptoms or sensitivity.

Table 1

Descriptives of maternal depressive symptoms and sensitivity, and child executive function

Variables	N	Mean (SD)	Range	Skewness	Kurtosis
Maternal depressive symptoms					
6 month	1278	8.95 (8.34)	0 – 52	1.72	3.62
15 month	1241	9.08 (8.18)	0 – 54	1.55	2.80
24 month	1119	9.40 (8.63)	0 – 51	1.59	2.80
36 month	1202	8.98 (8.31)	0 – 57	1.50	2.63
54 month	1077	9.83 (8.70)	0 – 55	1.44	2.34
Grade 1	1009	8.39 (8.47)	0 – 50	1.55	2.51
Grade 3	1026	9.08 (8.85)	0 – 55	1.52	2.59
Grade 5	1019	8.73 (8.62)	0 – 49	1.70	3.41
Maternal sensitivity					
36 month	1161	17.19 (2.78)	4 – 21	-1.37	2.77
54 month	1040	16.95 (2.91)	4 – 21	-1.37	2.50
Grade 1	1004	16.88 (3.03)	5 – 21	-1.10	1.19
Grade 3	982	16.34 (2.50)	4 – 21	-.84	1.16
Grade 5	929	16.50 (2.42)	7 – 21	-.84	.52
Child executive function					
Grade 1	998	14.379 (45.598)	0 – 34	0.42	-0.35
Grade 3	1101	17.183 (59.123)	0 – 35	-0.17	-0.79
Grade 5	1002	22.867 (58.173)	0 – 36	-0.72	0.11

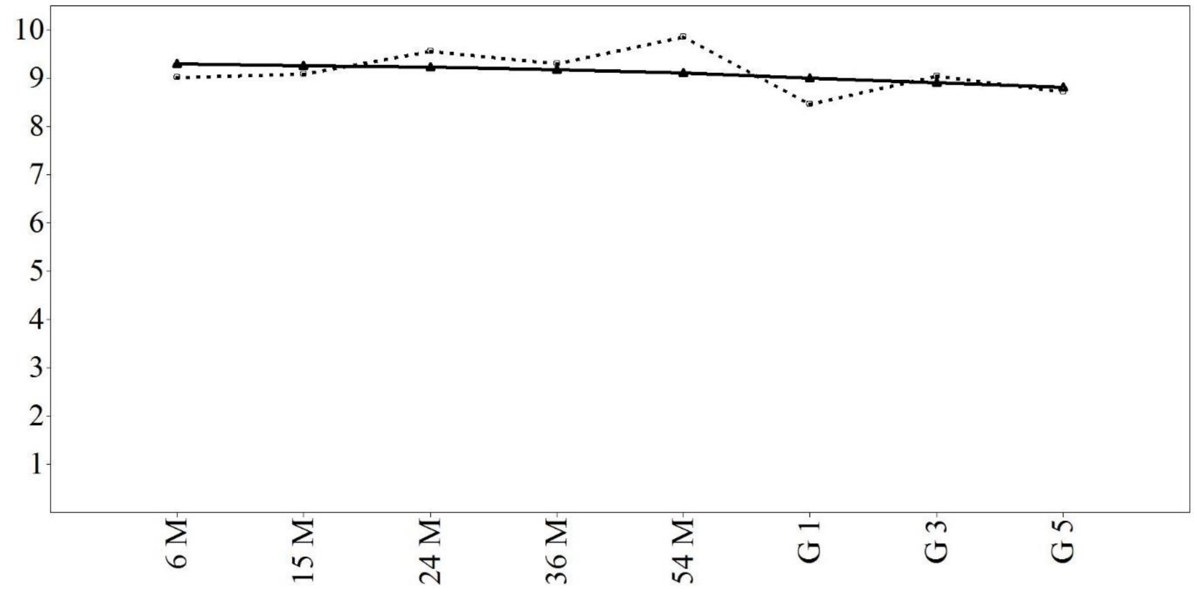

Figure 1(a). Developmental trajectories of maternal depressive symptoms.

Note: Solid line = estimated means; and dotted line = sample means.

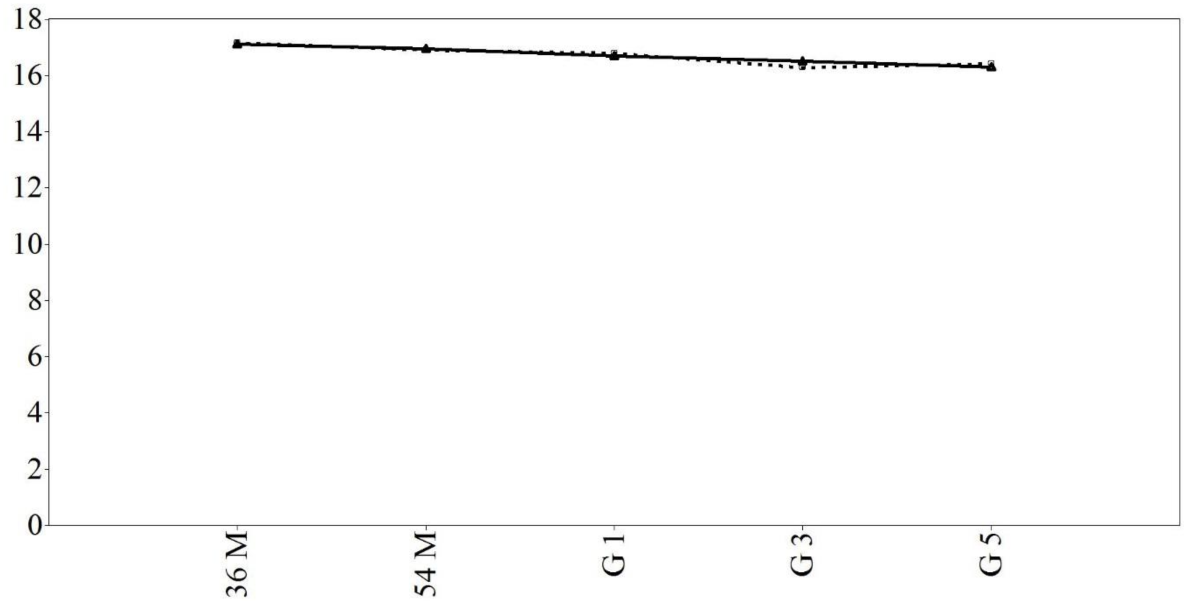

Figure 1(b). Developmental trajectories of maternal sensitivity.

Note: Solid line = estimated means; and dotted line = sample means.

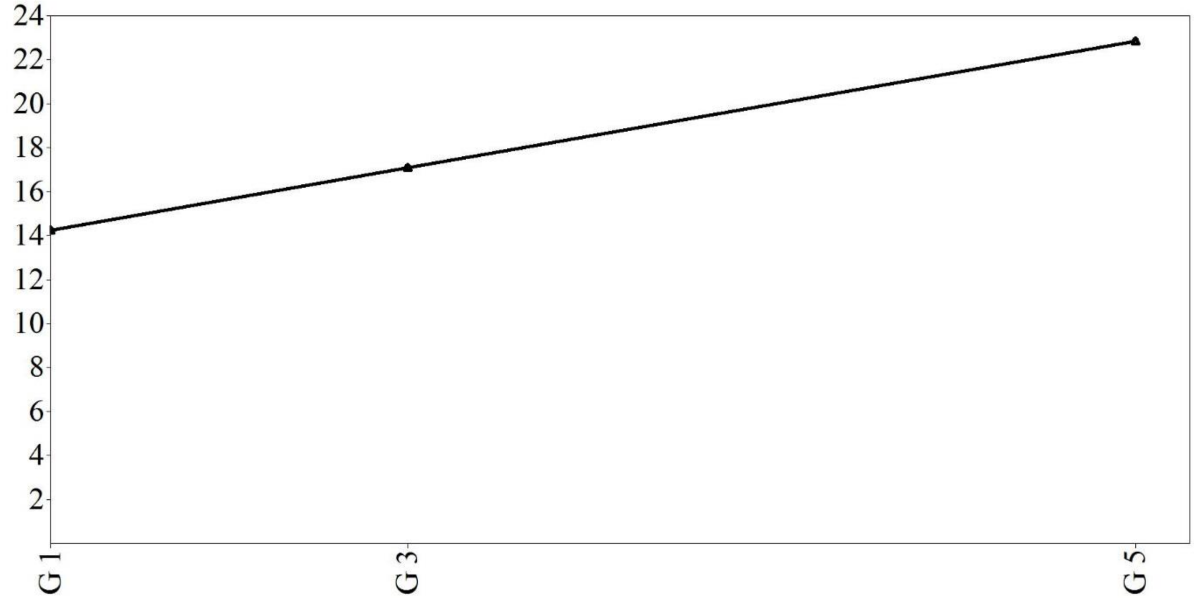

Figure 1(c). Developmental trajectories of child executive function.

Note: Solid line = estimated means; and dotted line = sample means.

Table 2

Correlations among maternal depressive symptoms and sensitivity, and child executive function

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. MDEP 6M	1															
2. MDEP 15M	.58**	1														
3. MDEP 24M	.52**	.53**	1													
4. MDEP 36M	.47**	.50**	.54**	1												
5. MDEP 54M	.42**	.39**	.50**	.52**	1											
6. MDEP G1	.41**	.44**	.51**	.46**	.51**	1										
7. MDEP G3	.41**	.42**	.45**	.39**	.45**	.53**	1									
8. MDEP G5	.39**	.40**	.48**	.40**	.43**	.47**	.58**	1								
9. MSEN 36M	-.20**	-.22**	-.27**	-.22**	-.25**	-.18**	-.23**	-.18**	1							
10. MSEN 54M	-.21**	-.19**	-.25**	-.17**	-.18**	-.20**	-.18**	-.18**	.52**	1						
11. MSEN G1	-.17**	-.17**	-.20**	-.16**	-.24**	-.13**	-.18**	-.18**	.50**	.49**	1					
12. MSEN G3	-.16**	-.17**	-.24**	-.19**	-.20**	-.14**	-.22**	-.18**	.38**	.39**	.46**	1				
13. MSEN G5	-.16**	-.16**	-.23**	-.18**	-.24**	-.18**	-.24**	-.17**	.40**	.38**	.43**	.47**	1			
14. CEF G1	-.04	-.06	-.16**	-.08*	-.10**	-.08*	-.08*	-.11**	.13**	.21**	.13**	.15**	.08*	1		
15. CEF G3	-.10**	-.13**	-.20**	-.14**	-.16**	-.12**	-.13**	-.10**	.21**	.22**	.19**	.19**	.18**	.38**	1	
16. CEF G5	-.11**	-.10**	-.15**	-.10**	-.16**	-.10**	-.14**	-.10**	.21**	.24**	.21**	.23**	.21**	.36**	.49**	1

***p < .001; **p < .01; *p < .05.

Note. MDEP = Maternal depressive symptoms; MSEN = Maternal sensitivity; CEF = Child executive function; M = Months; and G = Grade.

Table 3

Unconditional growth curve models for maternal depressive symptoms and sensitivity, and children's EF

Maternal depressive symptoms				
	Unstandardized			
	Mean (SD)	p	Variance (SD)	p
Intercept	9.293 (.198)	< .001	39.042 (2.389)	< .001
slope	-.114 (.058)	.049	1.533 (.223)	< .001
I with S	-2.566 (SE = .624), p < .001			
Maternal sensitivity				
Intercept	17.111 (.077)	< .001	4.824 (.440)	< .001
Slope	-.513 (.054)	< .001	.865 (.193)	< .001
I with S	-1.210 (SE = .247), p < .001			
Child EF				
Intercept	14.239 (.213)	< .001	19.487 (1.602)	< .001
Slope	8.616 (.260)	< .001	29.815 (6.418)	< .001
I with S	.000 (SE .000), p = 999			

Note. I = intercept; S = slope.

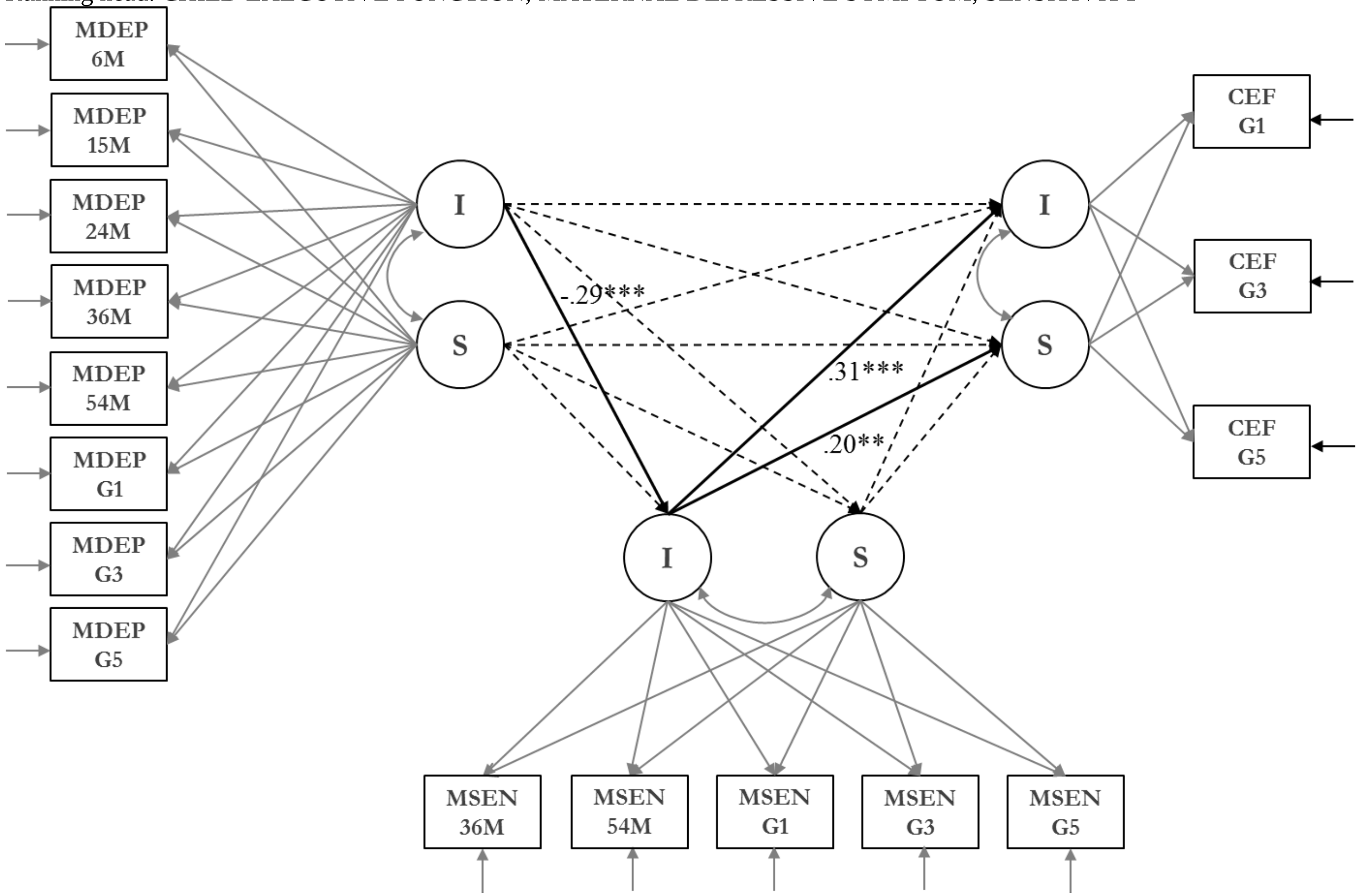

Figure 2. Changes in maternal depressive symptoms and growth in child executive function: Changes in maternal sensitivity as a mediator.

Note. I = Intercept; S = Slope; MDEP = Maternal depressive symptoms; MSEN = maternal sensitivity; CEF = Child executive function; M = Months; G = Grade; dotted lines are insignificant paths; and bold lined are significant paths.

***$p < .001$; **$p < .01$; *$p < .05$.

References

Biringen, Z., Derscheid, D., Vliegen, N., Closson, L., & Easterbrooks, M. A. (2014). Emotional availability (EA): Theoretical background, empirical research using the EA Scales, and clinical applications. *Developmental Review, 34*(2), 114 – 167.

Blair, C., Raver, C. C., & Berry, D. J. (2013). Two approaches to estimating the effect of parenting on the development of executive function in early childhood. *Developmental Psychology*, *50*(2), 554 - 565.

Brennan, P. A., Hammen, C., Andersen, M. J., Bor, W., Najman, J. M., & Williams, G. M., (2000). Chronicity, severity and timing of maternal depressive symptoms: relationships with child outcomes at age 5. *Developmental Psychology, 36*(6), 759 – 766.

Cents, R. A., Diamantopoulou, S., Hudziak, J. J., Jaddoe, V. W., Hofman, A., Verhulst, F. C., Lambregtse-van, . B. M. P., ... Tiemeier, H. (2013). Trajectories of maternal depressive symptoms predict child problem behaviour: the Generation R study. *Psychological Medicine*, *43*(1), 13 - 25.

Elgar, F. J., Curtis, L. J., McGrath, P. J., Waschbusch, D. A., & Stewart, S. H. (2003) Antecedent–consequence conditions in maternal mood and child adjustment: A four-year cross-lagged study. *Journal of Clinical Child and Adolescent Psychology, 32*, 362–374.

Elgar, F. J., McGrath, P. J., Waschbusch, D. A., Stewart, S. H., & Curtis, L. J. (2004). Mutual influences on maternal mood and child adjustment problems. *Clinical Psychology Review, 24*, 441–459.

Ertel, K. A., Rich-Edwards, J. W., & Koenen, K. C. (2011). Maternal Depression in the United States: Nationally representative rates and risks. *Journal of Women's Health*, *20*(11), 1609–1617.

Horowitz, J. A., & Goodman, J. (2004). A longitudinal study of maternal depression postpartum symptoms. *Research and Theory for Nursing Practice, 18*, 149-163.

Hughes, C., & Ensor, R. (2011). Individual differences in growth in executive function across the transition to school predict externalizing and internalizing behaviors and self-perceived academic success at 6 years of age. *Journal of Experimental Child Psychology, 108*(3), 664 – 676.

Hughes, C., Ensor, R., Wilson, A., & Graham, A. (2010). Tracking executive function across the transition to school: a latent variable approach. *Developmental neuropsychology, 53*(1), 20 – 36.

Huizinga, M., Dolan, C. V., & van der Molen, M. W. (2006). Age-related change in executive function: Developmental trends and a latent variable analysis. *Neuropsychologia, 44*(11), 2017–2036.

Huizinga, M., & Smidts, D. P. (2006). Age-related changes in executive function: A normative study with the dutch version of the Behavior Rating Inventory of Executive Function (BRIEF). *Child Neuropsychology, 17*, 51–66.

Kluczniok, D., Boedeker, K., Fuchs, A., Hindi, A. C., Fydrich, T., Fuehrer, D., Dittrich, K., ... Bermpohl, F. (2016). Emotional availability in mother-child interaction: The effects of maternal depression in remission and additional history of childhood abuse. *Depression & Anxiety, 33*(7), 648 – 657.

Luoma, I., Korhonen, M., Salmelin, R. K., Helminen, M., & Tamminen, T. (2015). Long-term trajectories of maternal depressive symptoms and their antenatal predictors. *Journal of Affective Disorders, 170*, 30-8.

Murray, L., Fiori-Cowley, A., Hooper, R., & Cooper, P. (1996). The impact of postnatal depression and associated adversity on early mother-infant interactions and later infant outcome. *Child Development*, *67*(5), 2512 – 2526.

National Institute of Child Health and Human Development Early Child Care Research Network. (1999a). The course of maternal depressive symptoms, maternal sensitivity, and child outcomes. *Developmental Psychology, 35*, 1297–1310.

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.

van Doorn, M. M. E. M., Kuijpers, R. C. W. M., Lichtwarck-Aschoff, A., Bodden, D., Jansen, M., & Granic, I. (2016). Does mother-child interaction mediate the relation between maternal depressive symptoms and children’s mental health problems?. *Journal of Child and Family Studies, 25*(4), 1257 – 1268.

Wang, L., Wu, T., Anderson, J. L., & Florence, J. E. (2011). Prevalence and risk factors of maternal depression during the first three years of child rearing. *Journal of Women's Health*, *20*(5), 711-718.

Wu, Y. P., Selig, J. P., Roberts, M. C., & Steele, R. G. (2011). Trajectories of postpartum maternal depressive symptoms and children's social skills. *Journal of Child and Family Studies, 20,* 4, 414-423.