The Development of Executive Function in the Family Context during Early and Middle Childhood

DISSERTATION

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Abstract

Children exhibit rapid growth in executive function (EF) skills during preschool years and consistently increase EF through adolescence. Acquisition of EF skills in childhood is one of the keys to positive long term adaptations, thus it is critical to examine the processes by which children develop EF skills during childhood. EF development is susceptible to environmental influences, especially familial contexts. The current dissertation presents findings of three studies that focused on familial factors that can contribute to children’s EF development as well as children’s role in constructing their environment.

Chapter 1 presents conceptualizations of children’s EF and a theoretical framework explaining how children develop EF within familial contexts. Chapters 2, 3, and 4 present results of the three studies. The first study investigated the interactions between profiles of familial risks and children’s temperament to predict children’s EF outcomes. A latent profile analysis was used to capture meaningful profiles of mothers based on five familial risks, including low maternal education, low family income-to-needs ratio and maternal depressive symptoms, anxiety, and stress. In addition, the interactions between family risk profiles and children’s emotionality were investigated to predict child EF outcomes (inhibitory control and attention flexibility). Children’s emotionality included positive emotionality (PE) and negative emotionality (NE). Four profiles of mothers were identified: Higher SES-healthy, Lower SES-healthy, Lower SES-average mental health, and Lower SES-poor mental health. Children in the Higher SES healthy group showed better EF outcomes than those in the Lower SES-poor mental health. Children’s high PE was
associated with high EF exclusively in the Lower SES-poor mental health group. Low levels of children’s NE predicted high EF only in the Lower SES-poor mental health group.

Chapter 3 presents results of the second study. The goal of the second paper was to examine the mediating role of maternal sensitivity trajectories (36 months to 5th grade) in the association between trajectories of maternal depressive symptoms (6 months to 5th grade) and growth of children’s EF (1st to 5th grade). The results revealed that maternal sensitivity at 36 months mediated the association between low maternal depressive symptoms at 6 months and children’s planning skills, both high planning skills at 1st grade and a faster increase in EF skills from 1st grade through 5th grade.

In chapter 4 findings of the third paper were presented. The aim of the third study was to investigate the transactional associations between maternal parenting (sensitivity and scaffolding) and children’s EF skills across three waves, age 3, 4, and 5. In the first autoregressive cross-lagged model, repeatedly measured constructs of maternal sensitivity, maternal scaffolding, and child inhibitory control were included. The second model included the two maternal parenting constructs and child attention flexibility. As a result, two transactional relations were found: a) between maternal sensitivity and child inhibitory control and b) between maternal scaffolding and child attention flexibility. Finally, in chapter 5 findings of the three studies are discussed with a focus on implications for enhancing children’s EF skills by creating a supportive environment.
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Fields of Study

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# Table of Contents

Abstract ....................................................................................................................... ii

Acknowledgements ...................................................................................................... iv

Vita ............................................................................................................................... v

Fields of Study ........................................................................................................... vi

Table of Contents ....................................................................................................... vii

List of Tables ............................................................................................................... ix

List of Figures ............................................................................................................ x

Chapter 1: Introduction ........................................................................................... 1

Chapter 2: Interactions between Profiles of Familial Risks and Preschoolers’ Emotionality in Predicting Executive Function: A Person-Centered Approach ........................................... 11

Method ....................................................................................................................... 18

Results ....................................................................................................................... 23

Discussion .................................................................................................................. 26

Chapter 3: Maternal Depressive Symptoms and the Growth of Child Executive Function:
Mediation by Maternal Sensitivity ........................................................................... 38

Method ....................................................................................................................... 46
Chapter 4: The Transactional Relations between Maternal Parenting and Child Executive Function

Chapter 5: Conclusions
List of Tables

Table 2. 1. Descriptive Statistics and Bivariate Correlations .................................................. 33
Table 2. 2. Fit Statistics for LPA Models with 1- to 6-class Models based on the Five Familial Risks................................................................................................................................. 34
Table 2. 3. Mean Comparisons of Risk Factors between Subgroups ........................................ 35
Table 2. 4. The Associations between Child Emotionality and Child EF in Different Subgroups ............................................................................................................................................. 36
Table 3. 1. Descriptive Statistics of Maternal Depressive Symptoms and Sensitivity, and Child EF .................................................................................................................................................. 61
Table 3. 2. Correlations among Maternal Depressive Symptoms and Sensitivity, and Child EF 62
Table 3. 3. Unconditional Growth Curve Models for Maternal Depressive Symptoms and Sensitivity, and Child EF .................................................................................................................. 64
Table 4. 1. Descriptive Statistics and Bivariate Correlations ...................................................... 88
List of Figures

Figure 2. 1. Means of the familial risk indicators of each identified profile. ........................................... 37

Figure 3. 1. Developmental trajectories of maternal depressive symptoms and sensitivity, and child EF................................................................................................................................. 65

Figure 3. 2. Changes in maternal depressive symptoms and growth in child EF: Changes in maternal sensitivity as a mediator........................................................................................................ 66

Figure 4. 1. Autoregressive and cross-lagged models for maternal sensitivity, maternal scaffolding, child inhibitory control, and child attention flexibility.............................................. 90

Figure 4. 2. Adjusted Model 1: Standardized path coefficients for significant paths of the child inhibitory control model. ........................................................................................................ 91

Figure 4. 3. Adjusted Model 2: Standardized path coefficients for significant paths of the child attention flexibility model.................................................................................................. 92
Chapter 1: Introduction

Executive function (EF) refers to a set of higher cognitive processes that enable individuals to exhibit goal-directed behavior in a novel, problem-solving context (Welsh, Friedman, & Sliker, 2006). The cognitive processes include recognizing a goal, planning strategies to achieve a goal, carrying out the plan, monitoring an entire problem-solving process, and revising strategies if necessary. EF consists of several components that are interrelated with each other. Basic components of EF include inhibitory control, attention flexibility, and working memory (Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003; Miyake et al., 2000). Inhibitory control is the ability to suppress an automatic response and activate a non-dominant response. Attention flexibility can be defined as the ability to shift attention between two or multiple rules. Working memory involves holding pieces of information in mind and manipulating them. Planning skills are considered a higher level of EF. In order to execute planning skills, multiple basic components of EF need to work together simultaneously (Scholnick & Friedman, 1993). Each component of EF emerges in different developmental time periods and shows varied rates of growth (Anderson, 2002). The preschool years are a critical time period when inhibitory control exhibits dramatic improvement, while attention flexibility and working memory emerge and consistently increase (Best, Miller, & Jones 2009). Young children may use planning skills to resolve a simple problem. As children enter elementary school, they gradually obtain the ability to execute planning skills in a complex problem-solving context (Luciana, Collins, Olson, &
Schissel, 2009). Developing appropriate levels of EF in early childhood is important because children with higher levels of EF tend to show more positive future outcomes, such as building positive relationships with peers and teachers in school, displaying less internal or external problems, and better academic achievement (Blair & Razza, 2007; Clark, Pritchard, & Woodward, 2010; Kim et al., 2013; Portilla, et al., 2014). Considering the important role of child early EF, it is critical to examine contributing factors to the development of EF in early childhood.

**Familial Environment and Child EF Development**

The development of EF is susceptible to contextual influences (Noble, Norman, & Farah, 2005). A supportive environment may facilitate the development of EF, whereas children living in an unsupportive environment may be at risk for developing maladaptive EF (De Bellis, 2001). A familial context is a very important rearing environment for children’s EF development (Lewis & Carpendale, 2009). The bioecological theory (Bronfenbrenner, 2006) provides a theoretical framework that explains how children’s development occurs within multiple contexts. Multiple contexts include a microsystem and a macrosystem, and a microsystem is nested in a macrosystem. A microsystem is a proximal environment that directly affects a child’s life. A familial environment is one of the microsystem, for example, family stress and parenting behavior. A macrosystem is a broader context that may affect child development through a microsystem (e.g., policy, cultural value, family income). The elements of the macrosystem are not directly associated with child development; however, those are indirectly related with child outcomes through the elements of the microsystem (e.g., parenting). The bioecological framework has been used to investigate how distal and proximal contexts jointly predict child
outcomes including socio-emotional and cognitive aspect (e.g., Chien & Misry, 2012). Empirical studies have also supported the bioecological model in relation to child EF development. Prior work has provided evidence that both a macrosystem such as family SES (Mackay, 2005) and a microsystem such as maternal parenting (Bernier, Carlson, & Whipple, 2010) contribute to EF development. However, studies focused on how individual familial factors work together to predict child EF outcomes are lacking. Therefore, it is important to examine the complex processes by which children develop EF skills within multiple contexts, both distal and proximal environments.

**Family socio-economic status (SES) and child EF.** Among microsystem factors, socio-economic disparities are well-known to be a risk for child maladaptive functioning (Smith, Brooks-Gunn, & Klebanov, 1997). There has been empirical evidence that poverty is linked to child poor mental health, lack of self-regulation and low scores on standardized reading and math tests (e.g., Evans & Kim, 2013; Gershoff, Aber, Ravoer, & Lennon 2007; Malecki, & Demaray, 2006). In addition, Morris et al.’s (2003) study using randomized experiments revealed a causal relation between poverty and adverse child outcomes. In their study, increases in household income were related to more school engagement and social skills. Parental education is another important aspect of family SES. Children of less educated mothers tend to have difficulty developing appropriate levels of child cognitive functioning (Duncan & Magnuson, 2012). The association between family SES and poor outcomes for children has been reported in studies including EF skills as child outcomes. Consistent with previous work, children from low SES families tend to exhibit poor EF outcomes (Sarsour et al, 2011). Sarsour and colleagues found that low family SES, measured by family income-to-needs ratio and maternal education
was negatively associated with three EF components, inhibitory control, attention flexibility, and working memory, respectively.

**Parental mental health and child EF.** In addition to family SES, parental characteristics may play a significant role in child development. Parental mental health is characteristic that is closely related to child developmental outcomes (Cummings & Davies, 1994). Poor parental mental health, such as depression, can put children at risk for adverse outcomes (McManus & Poehlmann, 2012). Maternal depression is a well-established risk for children’s maladaptive cognitive functioning (Kiernan, & Huerta, 2008; Liu et al., 2017). A large portion of new mothers tend to experience elevated depressive symptoms, some of which qualify as clinical depression (Wang, Wu, Anderson, & Florence, 2011). Moreover, maternal depression is likely to elicit paternal depression (Goodman & Golib, 1999). The link to poor outcomes for children is also present when both parents display parental depression (Downey & Coyne, 1990). For example, children of depressed fathers showed more behavioral problems, compared to those of fathers with less depressive symptoms (Ramchandani, Stein, Evans, O’Connor, & the ALSPAC Study Team, 2005).

In addition, stress-related symptoms are also one of the important aspects of mental health (World Health Organization, 2002). There has been empirical evidence that stress and depressive symptoms are highly associated (Hurley, Black, Papas, & Caufield, 2008; Pascoe, 1990; Reider & Taylor, 2015). It has also been found that parental stress can be a risk for child maladaptive functioning (Neider & Reiter, 2004). It has been suggested that parental stress may directly interfere with children’s well-being or socio-emotional development. This is because parental negative emotion eliciting from stress can be contagious so that children may also
experiences negative emotions (Denham, Mitchell-Copeland, Strandberg, Auerbach, & Blair, 1997). In early childhood, parents often experience high levels of stress that arises from childcare and discipline (Kuczynski & Kochanska, 1990). For example, preschool age children whose primary caregivers reported high levels of parenting stress showed low levels of social competence and more internal/externalizing behaviors (Anthony et al., 2005). With regard to the detrimental effect of poor parental mental health, it is important to consider parental mental health problems as a possible risk for maladaptive EF development.

**Parenting and child EF.** There has been growing recognition of the critical role of parenting on child cognitive development, as it is believed that parenting may directly affect child brain development (De Bellis, 2001). High quality of parent-child interactions, such as a mother’s overall responsiveness to child’s needs, are associated with better regulation skills in emotion and cognition (Kopp, 1982). Young children rely on parental control for appropriate behavioral and emotional control. From this external regulation processes, children gradually learn how to regulate behavior and attention on their own. In addition, mothers’ direct offers of problem-solving strategies can help children better improve cognitive flexibility (Farrant, Maybery, & Fletcher, 2011; Hammond, Muller, Carpendale, Bibok, & Liebermann-Finestone, 2012). When mothers provide clear and specific instructions on how to resolve a problem, children may learn how to set a goal and achieve it step-by-step. Ultimately, this may improve their cognitive processes. Considering the important role of parenting in developing control processes, great attention has been given to how parenting contributes to the development of child EF skills (Fay-Stammbach, Hawes, & Meredith, 2014).
**Interrelations among familial factors.** Often, aspects of family environment (e.g., family SES and parenting, stress) do not work in isolation, rather, they work together in shaping children’s development (Lanza, Rhoeades, Nix, & Greenberg, 2011). Different rearing environments, consisting of different constellations of familial risks, may be associated with individual differences in children’s outcomes. For example, not all children of mothers with mental health issues are equally at risk of maladaptive cognitive development, but rather, cognitive development of those children may vary depending on other familial factors, such as family poverty levels (Lanza, Rhaodes, & Greenberg, 2010; Rhoades et al., 2013). For example, in their study Pratt et al. (2016) considered family SES, parental mental health, and parenting risks together to predict child school readiness. Three combinations of familial risks were found. Children with low risk (high family SES, two-parent home, low parental mental depressive symptoms and harsh parenting) showed higher school readiness than those with family SES risk (low family SES, single-parent home and low parental depressive symptoms and harsh parenting). Children with family SES risk exhibited better school readiness, compared to those with maternal mental health and parenting risk. Given the interrelations of familial risks, this integrative approach may help understand how children would show differences in EF skills depending on different configurations of risks.

**Parenting as a mediator linking a familial environment and child EF outcomes.** Familial environmental factors may be involved in complex processes that influence children’s development. In particular, parenting behavior that is the most proximal to children’s everyday experience may mediate the effects of distal familial factors such as SES and parental mental health on child outcomes (Yeung, Linver, & Brooks-Gunn, 2002). Family poverty, one of the
important components of family SES, may interfere with parental ability to provide positive parenting (Lugo-Gil & Tamis Lemonda. 2008). Furthermore, maternal or paternal health problems are linked to child maladaptive functioning through negative parenting as well. For example, parents experiencing great amounts of stress are likely to exhibit negative parenting, lack of warmth and cognitive stimulation, and use of physical punishment, and in turn, children showed low socio-emotional competence later (Gershoff et al., 2007). Another important aspect of parental mental health is parental depression, as parental depression may undermine overall children’s psychological well-being and socio-emotional/cognitive outcomes (Goodman, 2007). Parenting is suggested to mediate the link between parental depressive symptoms and child poor outcome (Goodman & Gotlib, 1999). For example, mothers with severe depressive symptoms may not be able to provide high quality parenting, acting more critically and more intrusively towards a child (Lovejoy, Graczyk, O'Hare, & Neuman, 2000). Such a lack of positive interactions may interfere with the development of cognitive skills. The investigation of parenting as a mechanism linking a familial risk and child EF outcomes is necessary, as it would provide information regarding the complex processes by which multiple familial factors predict later child EF outcomes.

**Children’s Role in the Development of EF**

**Interactions between child characteristics and a rearing environment.** Although the development of EF is subject to environmental influences, children also play an active role in this developmental process in a direct or indirect way. The ecological perspective posits that child characteristics, such as temperament, interact with a rearing environment in predicting developmental outcomes (Bonfenbrenner & Morris, 2006). Child temperament may change the
strength of the association between an environmental factor and child outcomes (Kiff, Leangua, & Zalewski, 2011). The temperament-environment interactions may occur because some children may be more vulnerable to their rearing environment, while others are more resilient, depending on their temperamental traits (Belsky & Pluess, 2009). For example, for children with lower levels of temperamental fearfulness, positive-mother child relationships were associated with better child social outcomes (e.g., rule following), whereas the association was not significant for children displaying higher fearfulness (Kochanska, Aksan, & Joy, 2007). Most studies have focused on child negative emotionality such as emotional reactivity reflecting expression of frustration or sadness (Crawford, Schrock, & Woodruff-Borden, 2011), while relatively less is known about the possible moderating role of child positive emotionality (e.g., excitement). The examination of interactions between child temperamental emotionality (both positive and negative emotionality) and a rearing environment in relation to EF outcomes may extend the bioecological model from child behavioral regulation to EF development.

**Transactional relations between a rearing environment and child EF outcomes.** Both the bioecological and transactional perspectives models (Sameroff, 2009) posit that the relation between children and the rearing environment is bidirectional. The transactional model of child development indicates that certain child characteristics (e.g., temperament) evoke different parental responses, which in turn contribute to differences in child developmental outcomes (Sameroff & MacKenzie, 2003). For example, children’s high levels of temperamental negative emotionality predicted maternal intrusive behavior and later intrusiveness elicited more negative emotionality of children (Perry, Collar, Calkins, & Bell, 2017). Consistent with findings on temperament, children with better cognitive skills (e.g., reading skills) and lower behavioral
problems predicted higher quality of parenting behavior, characterized by greater warmth and less use of power assertion (Ansari & Crosnoe, 2015). When children are able to regulate their emotion, behavior or cognition, mothers tend to be attuned to children’s cues. As a result, this may facilitate children’s acquisition of regulation skills (Perry, Mackler, Calkins, & Keane, 2014). EF is part of regulation processes, thus children’s different EF skills may elicit differing levels of parenting quality, and this may help or interfere with the development of child EF.

Considering the important role of a familial environment in child EF development, the current dissertation presents on how multiple familial factors are longitudinally associated with child EF. This includes a focus on interrelations of familial factors, mechanisms linking familial factors and child EF outcomes. Furthermore, children’s active role in contributing to their EF development was considered in the present dissertation.

**The Current Dissertation**

**Structure**

The dissertation consists of three studies. Chapter 2 presents the first study which focused on multiple familial risks and their interactive roles in predicting child EF outcomes. In addition, interactions between familial risks and child emotionality (positive and negative emotionality) were examined. The second paper is presented in chapter 3. The aim of the second study was to investigate how children develop EF skills during elementary school years, and whether maternal depressive symptoms in early childhood predict EF skills through maternal sensitivity. The third study presented in chapter 4 examined the transactional relations between maternal parenting (sensitivity and scaffolding) and child EF development during preschool years. Finally, integrative discussion across the three studies was presented in chapter 5.
Data

Data for the current dissertation come from two sources. For Study 1 and Study 3, data were drawn from a larger, longitudinal research project that was designed to examine how children develop cognitive and emotional regulation in a family context. Participants were recruited from a large Midwestern city at three time points, when children were 3, 4, and 5 years-old. At the enrollment, 126 mother-child dyads were included.

For Study 2, the sample was drawn from the NICHD Study of Early Child Care and Youth Development (SECCYD), including 1,364 primary mother-child dyads. Participants were recruited from hospitals in 10 states across the U.S. Data were collected from children’s birth to 15 years of age. Eight time points from 6 months to 5th grade were included in Study 2. The sample was not a nationally representative sample. However, demographic characteristics of the families (household income and ethnicity) were similar to families in the nation (NICHD Early Child Care Research Network, 1999b).
Chapter 2: Interactions between Profiles of Familial Risks and Preschoolers’ Emotionality in Predicting Executive Function: A Person-Centered Approach

Executive function (EF) refers to a set of higher cognitive processes that enables individuals to execute goal-directed behavior (Welsh, Friedman, & Slieker, 2006). EF in early childhood is critical to future developmental outcomes, such as academic achievement and socio-emotional competence (Blair & Razza, 2007; Kim et al., 2013). Considering that EF development is susceptible to environmental influences (Noble, Norman, & Farah, 2005), it is important to examine what contributes to the development of EF in early childhood. Multiple familial factors have been found to pose risks for children’s EF development, including low family socio-economic status (SES) and poor maternal mental health (Mezzacappa, 2004; Buss, Davis, Hobel, & Sandman, 2011). Recent studies suggest that multiple risks tend to interact with each other in predicting children’s developmental outcomes (e.g., Lanza, Rhoades, Nix, & Greenberg, 2011). A person-centered approach may provide a holistic view of the interrelations of risks because it allows one to consider how multiple risks work together. Thus, we used a person-centered approach to examine whether mothers can be classified into meaningful subgroups, based on similar patterns of the familial risks. In addition, we examined the interactions between familial risk profiles and children’s temperament emotionality (positive and negative emotionality) in predicting child EF outcomes.

**EF in Early Childhood**
EF consists of several interrelated components, including inhibitory control, attention flexibility, and working memory (Anderson, 2002). Inhibitory control refers to the ability to withhold a prepotent response; attention flexibility is the ability to shift attention between two- or multiple-dimensions; and working memory involves updating, monitoring, and manipulating information. Overall, EF skills emerge during infancy and mature through middle childhood to adolescence, with certain components appearing at different time points and developing at different rates (Huizinga et al., 2006). The preschool period is a critical time in which children develop and improve their EF skills rapidly (Anderson, 2002; Best, Miller, & Jones, 2009; Carlson & Moses, 2001). The current study included two core components of EF, inhibitory control and attention flexibility, as previous literature has suggested that an unsupportive familial environment, such as low family SES, showed direct associations with low levels of children’s inhibitory control and attention flexibility (Sarsour et al., 2011).

**Familial Risks for Children’s EF Development**

Early exposure to family adversity is related to poor childhood developmental outcomes (Belsky, Pasco Fearon, & Bell, 2007). It has been identified that unstable family structure (Mackay, 2005), family SES (Mezzacappa, 2004), and parental mental health problems (Hughes, Roman, Hart, & Ensor, 2013) may undermine the development of children’s EF. Children consistently living in socioeconomically disadvantaged families, characterized by low family income and parental education, tend to show poorer general cognitive skills, compared to those living in families with high SES (Noble, McCandliss, & Farah, 2007; Noble, Norman, & Farah, 2005). Moreover, maternal mental health problems, such as depression and anxiety, are associated with poor child cognitive functioning (Cummings & Davis; 1994; Guajardo, Snyder,
& Petersen, 2009; Liu et al., 2017). For example, children whose mothers exhibit high levels of depressive (Hughes, Roman, Hart, & Ensor, 2013) or anxiety symptoms (Buss et al., 2011) tend to show poor EF skills. Severely depressed mothers may fail to recognize children’s cognitive needs, and as a result, their children may not receive appropriate stimulations to develop EF skills (Goodman, 2007). In addition, maternal stress has been consistently associated with depressive and anxiety symptoms (e.g., Hurley, Black, Papas, & Caufield, 2008). For example, maternal stress from both acute and chronic stressors had a longitudinal relation with depressive symptoms (Reid & Taylor). Mothers who displayed high levels of depressive symptoms, anxiety, or stress tend to be unresponsive to their children during mother-child interactions (Hurley et al., 2008), which in turn may interfere with child cognitive development (Campbell, Mateus, von Stauffenberg, Mohan, & Kirchner, 2007). The majority of previous work examined whether a single or a few familial risks would predict children’s developmental outcomes. Although this line of studies has provided valuable information regarding how each familial risk is related to the development of children’s EF (e.g., Fitzpatrick, McKinnon, Blair, & Willoughby, 2014), one limitation is that this variable-centered approach may fail to consider how multiple familial risks work together.

Compared to the variable-centered approach, a person-centered approach allows one to consider the interplay of multiple risks in a more integrative way, as a person-centered approach considers multiple risks simultaneously and classifies individuals into heterogeneous latent subgroups with similar patterns (Muthén & Muthén. 2000; Jobe-Shields, Anders, Parra, & Williams, 2015). Moreover, children’s developmental outcomes may vary in different subgroups created from familial risks (e.g., Sturje-Apple, Davies, & Cummings, 2010). Much of this line of
work has examined children’s socio-emotional development or academic achievement as the outcome (e.g., Lanza, Tan, & Bray, 2013). For example, Lanza and colleagues (2010) examined whether Urban African American, Urban White, and Rural White children were identified into subgroups based on the patterns of children’s individual characteristics (e.g., general intelligence), family (e.g., single parenthood, maternal stress, depression) and community risk factors (e.g., school-level poverty), and whether children’s externalizing problems and academic achievement in 5th grade would differ depending on class memberships. It was found that overall children who were from single parent families and whose family had a history of parents’ problems (e.g., substance use, arrest) showed poorer academic achievement and more externalizing problems than those who were from a low risk group, characterized by a two parent-home and low risk for each factor. To date, only a few studies have utilized a person-centered approach in relation to child EF development (Rhoades et al., 2013). Rhoades and colleagues (2013) identified six risk profiles based on various familial risks (e.g., maternal marital status, household income depressive symptoms) in infancy. Additionally, they found that mothers classified into the more disadvantaged groups (e.g., unmarried, poor, greater mental issues) showed lower quality parenting behavior, and their children showed poorer EF skills, compared to the mothers in less disadvantaged groups. In this way, a person-centered approach allows one to examine how different familial risks work together in relation to children’s development.

Although prior work using a person-centered approach has extended our understanding of how multiple risks work together in regard to children’s outcomes, there is a limitation of the prior work due to its use of dichotomous risk measures which only indicates the presence or
absence of a risk but not level or severity of each risk factor. (e.g., Lanza et al., 2010; Rhoades et al., 2013). Whereas the dichotomous approach may have its own strengths in terms of intuition and clear interpretability (Lanza et al., 2011), it may reduce individual differences in each risk factor. Compared to this approach, the use of continuous risk variables may show higher reliability and better capture associations with other related variables (Stöber, Dette, & Musch, 2002). In this study we included familial risks as continuous variables and controlled for earlier values of children’s EF outcomes when comparing individual differences in EF skills in different subgroups.

The Interactions between Familial Risks and Child Emotionality in Predicting Child EF

While family context may affect the development of children’s EF, children’s individual characteristics may also interact with environmental factors (Bronfenbrenner & Morris, 1998; 2006). Among the individual characteristics of children, temperament has been suggested to interact with children’s rearing environment in relation to their developmental outcomes (Kiff, Lengua, & Zelawski, 2011). Specifically, there has been empirical evidence that the affective aspect of children’s temperament, both positive emotionality (PE) and negative emotionality (NE), may change the strength of the relations between the rearing environment and their cognitive outcomes (Hayden, Klein, Durbin, & Olino, 2006).

PE is defined as the tendency to display positive mood, for example, excitement and joy. Empirical studies have showed that children displaying greater amounts of positive emotions in daily life show more effective cognitive processing (Hayden, Klein, Durbin, & Olino, 2006) and higher levels of effortful control, a construct closely related to EF. Considering that earlier effortful control has been shown to predict later EF (Comas, Valentino, & Borkowski, 2014), it
is reasonable to expect that high levels of children’s PE may predict high EF skills. In addition to the direct association between PE and EF, PE may interact with the familial context in relation to children’s EF development. Individuals expressing a greater amount of positive emotions may seek social interactions, which in turn secure resources that may stimulate cognitive processes (Fredrickson, 2001). It can be argued that PE may buffer the adverse effects of multiple environmental risks on their cognitive skills. Children with high PE are more motivated to be engaged in learning activities in the social context, when there is a lack of resources in the rearing environment (Valiente, Swanson, & Eisenberg, 2012).

NE refers to the propensity to display negative moods, such as anger, sadness, and fear. Empirical studies have shown that children displaying a great amount of NE tend to show adverse outcomes later, such as poor socio-emotional and cognitive skills (Sanson, Hempill, Smart, 2004; Suurland et al., 2016). It is argued that children experiencing intense NE, such as irritability, may have difficulty processing information, and adults or competent peers may not be willing to interact with those children who display higher amounts of negative emotion, such as frustration (Lawson & Ruff, 2004). As a result, those children may have less opportunities to be exposed to social interactions that may stimulate cognitive development. In contrast, other studies have found no evidence for the relation between NE and cognitive processes (e.g., Hayden et al., 2006). Hongwanishkul and colleagues (2005) found that children’s NE including discomfort, fear, anger, soothability (reversed), and sadness, was not associated with any components of EF. The inconsistent findings regarding the association of children’s NE and cognitive functioning implies that the strength of the association may vary, depending on different contexts. It has also suggested that child NE may interact with contextual factors in
predicting children’s developmental outcomes (Belsky & Pluess, 2009). More closely related to children’s EF, empirical work has found that children’s NE interacted with family poverty-related risks and this interaction was associated with children’s EF skills later on (Raver, McCoy, Lowenstein, & Pess, 2013). Although there are possible interactions between profiles of risks and children’s temperament, most of the previous work did not consider the possible interactions. To address this gap in the literature, the last aim of our study was to investigate whether the association between the children’s PE/NE and EF may vary, depending on different subgroups of the familial risks.

The current study

Using a person-centered approach, first we examined profiles of mothers based on a set of family demographic and maternal mental health risks, including maternal education, family income-to-needs-ratio, and maternal depressive symptoms, anxiety, and stress. Second, we investigated whether the subgroups would interact with children’s temperamental emotionality, both PE and NE, at 3 years of age to predict children’s EF skills at age 4. For children’s EF, two components, inhibitory control and attention flexibility, were included in the moderation models, respectively. The inclusion of inhibitory control and attention flexibility in separate models was based on previous findings that weak to modest correlations among individual tasks tapping different components of EF exist and therefore, young children’s EF may not be a unitary construct (Willoughby, Holochwost, Blanton, & Blair, 2014). Lastly, marginal means of child EF skills (inhibitory control and attention flexibility) at age 4 were compared between subgroups after controlling for child EF at age 3 and child emotionality (PE or NE).
Regarding the first aim of the present study, we hypothesized the following subgroups of mothers based on the 5 family risk indicators: a) Low risk group, b) Demographic risk group, c) Maternal mental health risk group, and d) Dual risk group, both family SES and maternal mental health risks. Second, there would be interactions between familial risk profiles and child emotionality (PE and NE). Specifically, for only children in the Dual risk group, their PE at age 3 would be positively associated with EF a year later, whereas their NE at age 3 would predict low EF at age 4. Lastly, it is predicted that children of the Low risk group would show better EF skills, compared to those in the Higher risk groups, after the effects of the covariates were statistically removed.

Method

Participants

The sample for this study was drawn from a larger longitudinal study designed to investigate how familial environments were associated with children’s emotional and cognitive regulation. Mothers qualified for the research if they a) were at or above 21 years of age; b) had a biological child at the age of 3 - 3.5 years old; and c) had not been diagnosed with any psychiatric disorders other than depression, either with or without co-occurring anxiety. Children were included if they had not been diagnosed with any developmental delay or disorders. Only one child per family was allowed to participate. The current study included data collected when children were 3 (T1) and 4 years old (T2). At T1, 126 mother-child dyads were included (maternal mean age = 31.02; SD = 5.39; child mean age = 3.23; SD = .19; 65 girls) and 109 dyads at T2 (87% retention). At T1 18% of the responses were missing and at T2 18%. Little’s MCAR test showed that the data were missing completely at random, \( \chi^2(43) = 35.14, p = .78 \).
Procedures and Measures

At each time point, the mother-child dyads participated in a 2.5-3.5 hour laboratory visit. During the visits, children were administered a set of developmentally appropriate EF tasks tapping into two components of EF, inhibitory control and attention flexibility. All the familial risk variables were assessed at T1.

Maternal education. Mothers self-reported the number of years that they had received education. Maternal education was coded “1 = less than grade school,” “2 = grade 7 – 9,” “3 = grade 10 – 11,” “4 = high school diploma or GED,” “5 = some college,” “6 = Junior college or associate degree,” “7 = Bachelor’s degree,” and “8 = graduate degree.”

Family income-to-needs ratio. Income-to-needs-ratio was calculated from dividing mothers’ report of household income by total reported family income by the poverty threshold for the family size (U.S. Bureau of the Census, 1999).

Maternal depressive symptoms. The Beck Depression Inventory (BDI-II; Beck, Steer, Ball, & Ranieri, 1996) was used to assess maternal depressive symptoms. The BDI contained 21 items and each item stated mothers’ current depressive symptomatology. For each item, mothers rated their symptoms on a 4-point scale, 0 to 3. An example of an item is “Sadness” and it was assessed from “0 = I do not feel sad” to “3 = I am so sad or unhappy that I can’t stand it.” The total scores of maternal depressive symptoms were summed from the scores of the 21 items. Cronbach’s alpha for BDI was .95.

Maternal anxiety. The State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) was used to measure maternal anxiety. Among the two subscales of this measure, State anxiety (how the mother feels right now) and Trait anxiety (how the mother generally feels), the Trait
anxiety was included. Mothers self-rated how they generally felt on a 4-point scale, ranging from “1 = almost never” to “4 = almost always.” Example items are “I worry too much over something that really doesn’t matter” and “Some unimportant thought runs through my mind and bothers me.” The total state anxiety score was calculated by summing the scores of the 20 items. Cronbach’s alpha was .96.

**Parenting stress.** The Parenting Daily Hassles scale (PDH; Crnic & Greenberg, 1990) was used to measure maternal parenting stress by asking mothers how they felt about typical everyday events they encountered with their children, including the target child and his/her siblings. Mothers self-rated their stress levels on the two subscales, Challenging behavior (7 items) and the Parenting tasks (8 items), using a 5-point scale, “1 = Very low” to “5 = Very high.” An example of the Challenging behavior subscale is “Kids resist or struggle with me over bed-time,” and an example of the Parenting tasks is “The kids schedules (like pre-school or other activities) interfere with meeting your own household needs.” The total scores for the Challenging behavior subscale were calculated by summing scores of the 7 items and the total score of the Parenting tasks subscale was also summed from scores of the 8 items. The total scores of each subscale were standardized and summed into a composite score of parenting stress. Cronbach’s alphas for the Challenging behavior and the Parenting tasks were .87 and .86, respectively.

**Child emotionality.** Children’s PE was assessed with the smiling/laughter subscale (6 items) of the Children’s Behavior Questionnaire (CBQ; Putnam & Rothbart, 2006). Mothers rated their child’s behavior on a 7-point scale, ranging from “1 = extremely untrue” to “7 = extremely true.” An example of an item was “My child often laughs out loud in play with other
children.” The total score was calculated by summing scores of the items. Children’s negative emotionality (NE) was assessed using the CBQ as well, including three subscales, sadness (7 items), anger/frustration (6 items), and fear (6 items). An example of an item was “My child cries sadly when a favorite toy gets lost or broken” (sadness). A composite of NE was calculated by summing the total scores of the three subscales. Cronbach’s alphas for PE and NE were .71 and .72.

**Child inhibitory control.** The Day/night task (Gerstadt, Hong, & Diamond, 1994) and the Shape task (Kochanska, Murry, & Coy, 1997) were used to measure children’s inhibitory control at T1 and T2. In the Day/night task, the child was instructed to point at a picture of a day sky when the experimenter said “night,” and a picture of a night sky when the experimenter said “day.” The full performance was scored as “0 = incorrect,” “1 = incorrect on the first attempt but self-corrected,” and “2 = correct on the first attempt.” Second, in the Shape task, there were 24 pictures of geometric shapes and animals. Each shape was filled with smaller shapes (e.g., a drawing of a large dog that contains smaller cats inside). First, the child was primed to name the large shapes and then was asked to name the smaller shapes. Half of the trials were consistent, in which the large shape and the small shapes inside were the same (e.g., small moons inside a large moon), and half were inconsistent, where the large and small shapes were different (e.g., small stars inside of a large moon). The total score of the Shape task was calculated by summing the item scores of inconsistent trials. The total scores of the Day/night and Shape tasks were standardized and combined into a composite score of child inhibitory control.

**Child attention flexibility.** The Dimensional Changing Card Sort task (DCCS; Zelazo et al., 2003) was used to assess child attention flexibility at T1 and T2. The child was asked to first
sort a set of cards by one dimension (e.g., color) and then sort the same cards by another
dimension (e.g., shape). Six pre-switch trials with the first dimension and 6 post-switch trials
with the second dimension were administered. For each trial, “1” was given to a correct response
and “0” to an incorrect response. Accuracy scores were calculated by summing the number of
correct responses on the post-switch trials. Child’s reaction time for each trial was measured,
beginning from when the child first saw the target card until they finally responded. The
distribution of the accuracy scores were negatively skewed. To correct the skewness, we used the
method adapted from Zelazo and colleagues (Zelazo et al., 2013). For those who received 100%
accuracy on the post-switch trials, a reaction time score (the medium reaction time across all
post-switch trials for each child) was added. Reaction time scores were reversed so that higher
scores on reaction time indicated better abilities. Both of the accuracy scores and reaction time
scores were standardized and combined into one final score of attention flexibility.

**Analytic plan**

Regarding the first aim of the current study, Latent Profile Analysis (LPA) was
conducted to identify the different subgroups of mothers based on the familial risks using Mplus
7.4 (Muthén & Muthén, 1998–2015). The five familial risk factors, maternal education, income-
to-needs ratio, and maternal depressive symptoms, anxiety, and stress, assessed at T1 were
included as observed indicators for the LPA model. The scores of each familial risk were
standardized for ease of interpretation when the levels of each risk factor were compared. To
determine the model that best described the familial risks, multiple sets of starting values were
specified to test model identification. Next, to examine the interaction between familial risk
profiles and child emotionality in predicting later EF, four regression analyses (Model 1-Model 4
in Table 2.5), with child inhibitory control and attention flexibility, as well as PE and NE, tested in separate models while controlling for the relevant EF variable at previous time point. In the Models 1 and 2, inhibitory control was the dependent variable. For the interaction effect, the association between child PE (or NE) and inhibitory control was estimated within each familial risk subgroup. Similarly, in the Models 3 and 4, the association between PE (or NE) and attention flexibility was tested within each subgroup for the interaction effect.

Results

Descriptive statistics and correlations of the variables are presented in Table 2.1. Demographic variables were highly correlated with each other, and there were positive, high correlations among maternal mental health variables (maternal depressive symptoms, anxiety, and stress). Each EF construct assessed at T1 was moderately correlated with the same construct at T2. Children’s PE was negatively correlated with maternal mental health variables at small to moderate levels, while high NE was positively correlated with high levels of maternal mental health variables.

Familial Risk Profiles

LPA was used to identify subgroups of mothers, based on the similarity of the familial risks, including maternal education, family income-to-needs ratio, and maternal depressive symptoms, anxiety, and stress. Separate LPA models with varying sets of starting values and different numbers of classes, 1-6 classes, were estimated to determine the model that best described the class memberships. Several criteria were used to determine the best fitting model: a) Bayesian Information Criteria (BIC); b) p values of Vuong-Lo-Mendell-Rubin (VLMR), c) Lo-Mendell-Rubin (LMR), d) Bootstrapped Likelihood Ratio Test (BLRT), and e)
Interpretability of the class memberships as well as a reasonable number of mothers assigned into each class (Jung & Wickrama, 2008).

The 4-class model was selected based on our criteria described above. As presented in Table 2.2, the 4-class model showed the second smallest BIC, and the 6-class showed the smallest. However, for the 6-class model, the number of mothers in one subgroup was too small, consisted of only 3 mothers. Based on Jung et al.’s (2008) suggestion, the 6-class model was not selected due to the small number of mothers in one subgroup. Regarding the 5-class model, the insignificant $p$ values of VLMR and LMR suggested that 4 classes were sufficient but 5 classes were not needed. In addition, the 4-class model was most interpretable with a reasonable number of mothers in each group. Figure 2.1 shows the profiles of four classes, with standardized means for the familial risk variables. Unstandardized means of the risks across the four subgroups were as follows (maternal stress was in z-scores when it was created): a) maternal education, $G_1 = 7.65$; $G_2 = 5.82$; $G_3 = 6.17$; $G_4 = 5.43$); b) family income-to-needs ratio, $G_1 = 5.80$; $G_2 = 1.98$; $G_3 = 1.71$; $G_4 = 2.09$; c) maternal depressive symptoms, $G_1 = 7.24$; $G_2 = 5.38$; $G_3 = 17.56$; $G_4 = 38.09$; and d) maternal anxiety, $G_1 = 16.65$; $G_2 = 15.43$; $G_3 = 25.38$; $G_4 = 32.07$. As presented in Table 2.3, the means of familial risks were compared between subgroups using an ANOVA. The analyses revealed significant differences among the subgroups on the five familial risks: for maternal education, $F(3, 122) = 8.28, p < .001$; for income-to-needs ration $F(3, 122) = 43.39, p < .001$; for depressive symptoms $F(3, 122) = 238.27, p < .001$; for anxiety, $F(3, 122) = 185.32, p < .001$; for stress $F(3, 122) = 20.256, p < .001$. Tukey’s test was used for the post hoc analysis to compare the means of individual risk factors between subgroups of the mothers. The post hoc group comparisons are presented in Table 2.3.
Based on results of the post hoc analysis, characteristics of the four identified subgroups are described as follows: the Higher SES-healthy group (13.5%) tended to have the highest levels of education and income-to-needs ratio among the four subgroups, and lower levels of maternal depressive symptoms, anxiety, and stress. The Lower SES-healthy group (35.7%) was characterized by relatively low maternal education and income-to-needs ratio as well as low maternal mental health risks. The Lower SES-average mental health group (32.5%) was characterized by lower maternal education and family income-to-needs ratio, as well as moderate levels on maternal mental health risks. Lastly, the Lower SES-poor mental health group (18.3%) was identified as including multiple familial risks, as the mothers in this group showed relatively low levels of education and the highest levels of maternal mental health risks.

**Interactions between Class Memberships and Child Emotionality in Relation to Child EF**

In regards to the interaction models, as shown in Table 2.4, PE was associated with high levels of inhibitory control (see Model 1) only in the Lower SES-poor mental health group. However, none of the associations between NE and inhibitory control were significant across the four subgroups (Model 2). In only the Lower SES-poor mental health group, PE predicted low attention flexibility (Model 3), whereas NE predicted low attention flexibility (Model 4).

Marginal means of subgroups on EF outcomes, after controlling for covariates, were also compared. Results indicated that the mean of inhibitory control for children in the Higher SES-healthy group was better than those assigned into the Lower SES-average mental health ($B = .87, SE = .45, p = .05$) and Lower SES-poor mental health groups ($B = .51, SE = .22, p = .02$). Similarly, children in the Higher SES-healthy group showed better attention flexibility than those in the Lower income-poor mental health group ($B = 2.07, SE = 1.07, p = .05$).
Discussion

The present study advances our understanding of how multiple familial risks are prospectively associated with children’s EF development. Specifically, the utilization of a person-centered approach provided a holistic perspective to examine the complex constellations of multiple familial risks in relation to children’s EF outcomes by considering the interrelated nature of familial risks, such as the correlates between demographic risks and maternal mental health risks (e.g., Campbell et al., 2007). Regarding the first and second research aims, our findings support literature that low SES and maternal mental health risks may compromise the development of children’s EF. Moreover, the interactions between mothers’ risk profiles and children’s emotionality revealed in which familial context children’s emotionality was associated with later EF outcomes. We found that overall children’s high levels of PE and low levels of NE at age 3 predicted better EF skills at age 4 exclusively in the subgroup with dual risks, that is relatively low family SES and high maternal depressive symptoms, anxiety, and stress. Thus, high PE and low NE played a protective role in the development of EF for children who lived in a disadvantaged environment. Findings of the current study enhance our understanding of children’s EF development by providing insights into how children’s emotionality and the familial context interact to promote or impede inhibitory control and attention flexibility abilities.

Four subgroups of mothers were identified: Higher SES-healthy, Lower SES-healthy, Lower SES-average mental health, and Lower SES-poor mental health. This finding supports our hypothesis regarding the subgroups: one with low risk, one with family SES risk, one with maternal mental health risk, and the last with dual risks. Our finding of the Lower SES-poor
mental health can be supported by previous findings suggesting that depressed mothers may be at greater risk to experience other types of adversities, such as financial difficulties (Ertel, Rich-Edwards, & Koene, 2011), and mothers living in poverty or with low education may be more likely to suffer from depressive symptoms (Eamon et al., 2001; Khajehei & Doherty, 2017; Wang, Anderson, & Florence, 2011). Furthermore, our finding supports prior work using a person-centered approach. Similar to our profiles, Rhoades et al. (2011) also found a low risk group consisted of mothers with good mental health and high income, as well as a high risk group with low income and multiple mental health problems.

Regarding our second research aim, children in the Higher SES-healthy group exhibited higher EF skills than those in the Lower SES-poor mental health group. The findings are in line with prior work in which family demographic risk, such as low maternal education and family poverty, and maternal mental health risk, such as maternal depressive symptoms and anxiety, were found to compromise the development of children’s EF (Buss et al., 2011; Hughes et al., 2013; Mezzacappa, 2004). Taking a more nuanced look at the profiles, our result partially supports prior work using a person-centered approach. Similar to our finding, Rhoades and colleagues’ (2011) also found that children of mothers in the low risk group (married, not in poverty, and mentally healthy) exhibited better EF skills than children in other groups (poverty with varied levels of maternal mental health problems). However, in Rhoades et al.’s (2011) study family poverty was suggested as the strongest risk factor that undermined the development of children’s EF, which was inconsistent with our finding. In our study, children did not show deficits in EF as long as mothers were in reasonably good mental health, regardless of their income levels. Thus, our findings may suggest that maternal mental health can serve as a
protective role for children’s EF development by buffering the adverse effects of low family SES. One possible reason for this inconsistency may be attributable to different demographic characteristics of the samples. In Rhoades et al.’s study, participants were from predominantly low-income households, whereas our sample consisted of a small percentage of families under the poverty line with almost half of the mothers having a college or graduate education.

Our finding has implications about the critical role that maternal psychological health plays in children’s EF development. Mothers with psychological issues may lack sensitivity, which in turn undermines the development of children’s EF skills. When mothers experience severe depressive symptoms or anxiety, they may not be emotionally available to respond to children’s needs (Reck et al., 2004; Zelkowitz, Papageorgiou, Bardin, & Wang, 2009), thus failing to provide appropriate stimulus for children’s cognitive skills (Murray, Fiori-Cowley, Hooper, & Cooper, 1996). In addition, highly anxious mothers tend to be more intrusive or over-controlling to their child’s behavior, compared to mothers without an anxiety issue (Becker & Ginsburg, 2011; Feldman, 2007). As a result, those mothers are not supportive of children’s autonomy, which is an important predictor of children’s EF development (Matte-Gagné & Bernier, 2011). Overall maternal emotional distress, including depressive symptom, anxiety, and stress, may decrease mothers’ ability to have reciprocal, positive interactions with their child, thus those mothers may not have difficulty being engaged with their child (Woodruff-Borden, Morrow, Bourland, & Cambron, 2002).

Regarding our last research aim which addressed whether children’s temperamental emotionality, both PE and NE, would interact with class membership in predicting children’s EF outcomes, we found that children’s PE and NE at age 3 interacted with class memberships in
predicting children’s EF skills a year later. In particular, the positive association between PE and inhibitory control was significant only for the children in the Lower SES-poor mental health group but not in the other three groups. Our finding indicates that for children who live in a disadvantaged environment in which mothers have low education and experience high depressive symptoms, anxiety, and stress, high PE may serve to protect them from the adverse effect of the environment on their EF development. The protective role of PE is supported by studies on adults, which suggest that individuals who display a great amount of positive emotion expression tend to be more engaged with social interactions, thus they are more likely to be provided with appropriate cognitive stimulus from their environment (Tugade et al., 2004).

Unexpectedly, children’s high levels of PE at age 3 predicted low attention flexibility at age 4 in the Lower SES-poor mental health group. This may be explained by the nature of the measure used to access attention flexibility. In prior work, it is suggested that children’s higher PE may predict better cognitive skills, such as being cognitively flexible in a problem solving context (Hayden et al., 2006). However, when we used the Dimensional Changing Card Sort task in which children were asked to sort a set of cards by two different dimensions (e.g., color, shape), children who displayed intense levels of positive emotion may have been too excited to maintain their focus in order to remember and follow the switching rule. To some extent, expression of a great amount of positive emotion may benefit children in terms of securing resources that can stimulate certain types of cognitive skills. However, children who are easily emotionally aroused may have difficulty holding their excitement in order to successfully complete the rule switching task. This may be consistent with previous work revealing that children showing extreme levels of positive emotion expression may experience negative
developmental outcomes, such as difficulty in regulating negative emotions (Fredrickson & Losada, 2005; Dennis, Hong, & Solomon, 2010), which may negatively impact attention control and attention focusing (Calkins & Bell, 2009).

A similar pattern was found for the interaction of NE and class membership, as in the high risk group NE was negatively associated with attention flexibility. This finding only partially replicated previous work because the association between children’s temperament including NE and EF varied in different environments (Coma et al., 2014). In their longitudinal study on adolescents’ EF skills, Coma and colleagues (2014) found that when maternal depressive symptoms were high, there was no association between children’s NE and EF; in contrast, children’s NE was associated with EF when their mothers showed average or low maternal depressive symptoms. The inconsistency may be that Coma et al. included a single risk factor, maternal depressive symptoms, whereas our study examined the associations between various combinations of multiple familial risks and children’s EF.

The current study has several limitations and also suggests several future directions. The sample size was small. The sample consisted of mostly highly educated mothers and only a few of the mothers experienced severe poverty. Therefore, findings from the current study may not be generalizable to other populations. The use of a larger sample size may help to better understand the characteristics of disadvantaged families. In addition, methodologically a larger sample size is preferred for a latent profile analysis. Another limitation is that there may be other types of familial risk factors, in addition to the five that we investigated. For example, maternal or paternal parenting behavior, such as sensitivity and scaffolding, may be related to children’s EF skills (Bernier, Carlson, & Whipple, 2010; Ciciolla et al., 2013; Meuwissen & Carlson,
Therefore, the inclusion of the early childcare environment as one of the indicators of risks may help to increase our understanding of how childcare quality works together with the familial environment in promoting or compromising children’s EF development.

This study extends our understanding of the processes by which multiple familial contexts are prospectively associated with children’s EF development by utilizing a person-centered method which provided a more holistic perspective. This person-centered approach showed that specific combinations of familial risks contribute to EF development differently. Second, we considered individual differences in each familial risk by treating each risk as a continuous variable, rather than categorizing whether an individual was below or above a cutoff. Third, both PE and NE, affective aspects of children’s temperament, were included in our study. PE and NE have been considered predictors of children’s general cognitive functioning (e.g., Valienti et al., 2012). Our study extends previous work by investigating the specific links between children’s PE/NE and EF. More importantly, the investigation of the interactive roles of latent subgroups of familial risks and children’s temperament, PE and NE, is conceptually and methodologically important. Our findings of the interaction between children’s temperament and rearing environment may provide valuable information about whether children’s high PE or low NE can serve a protective role in buffering adverse environmental effects on children’s EF. In this way, it can provide an explanation why children’s high PE or low NE may promote their EF development in some contexts but not others.

Findings of the current study have several implications for early prevention and intervention. When mothers are at dual risk of low family SES and poor maternal mental health, mothers of those children should be intervened to improve their overall psychological well-being.
given the interrelations of multiple mental health risks. Furthermore, children living in a disadvantaged environment can be intervened to increase positive emotion expressions and effectively regulate negative emotion expressions. This may encourage individuals around those children to provide appropriate social interactions, which in turn promotes the development of children’s EF skills. Finally, the holistic approach will contribute to the promotion of children at risk for developing EF skills.
Table 2.1. Descriptive Statistics and Bivariate Correlations

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
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<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Maternal education</td>
<td></td>
<td>.52**</td>
<td>-.22*</td>
<td>-.16†</td>
<td>.05</td>
<td>.07</td>
<td>.11</td>
<td>.05</td>
<td>.17†</td>
<td>.11</td>
<td>-.02</td>
</tr>
<tr>
<td>2. Income-to-needs ratio</td>
<td></td>
<td>-.22*</td>
<td>-.24**</td>
<td>-.06</td>
<td>.06</td>
<td>.36**</td>
<td>.23*</td>
<td>.13</td>
<td>.12</td>
<td>-.11</td>
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<td>3. Maternal depressive symptoms</td>
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<td>.88**</td>
<td>.53**</td>
<td>-.02</td>
<td>-.17†</td>
<td>-.06</td>
<td>-.15</td>
<td>-.22*</td>
<td>.16†</td>
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<tr>
<td>4. Maternal anxiety</td>
<td></td>
<td></td>
<td>.51**</td>
<td>-.03</td>
<td>-.18†</td>
<td>-.06</td>
<td>-.08</td>
<td>-.18*</td>
<td>.15†</td>
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<td>5. Maternal stress</td>
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<td>.02</td>
<td>-.10</td>
<td>-.01</td>
<td>-.00</td>
<td>-.15†</td>
<td></td>
<td>.38**</td>
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<tr>
<td>6. Child inhibitory control (T1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.28**</td>
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<td>-.04</td>
<td>.15</td>
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<td>7. Child inhibitory control (T2)</td>
<td></td>
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<td></td>
<td></td>
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<td>.21*</td>
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<td>8. Child attention flexibility (T1)</td>
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<td>.24*</td>
<td>.03</td>
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<td>.18*</td>
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<td>9. Child attention flexibility (T2)</td>
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<tr>
<td>10. Child positive emotionality</td>
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<td>11. Child negative emotionality</td>
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<td>15.56</td>
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<td>.02</td>
<td>.00</td>
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<td>8.75</td>
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<td>12.87</td>
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<td>4.77</td>
<td>.80</td>
<td>.77</td>
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<td>3.05</td>
<td>.82</td>
<td>2.19</td>
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<td>10.50</td>
<td>-.01</td>
<td>-2.03</td>
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<td>.00</td>
<td>.00</td>
<td>3.33</td>
<td>5.33</td>
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<tr>
<td>Max.</td>
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<td>54.00</td>
<td>38.00</td>
<td>1.91</td>
<td>1.52</td>
<td>.80</td>
<td>11.13</td>
<td>11.26</td>
<td>7.00</td>
<td>18.07</td>
</tr>
</tbody>
</table>

*Note.* T1 = age 3; T2 = age 4.

†p < .10, *p < .05, ** < .01.
Table 2.2. Fit Statistics for LPA Models with 1- to 6-class Models based on the Five Familial Risks

<table>
<thead>
<tr>
<th>LPA models</th>
<th>BIC</th>
<th>VLMR p value</th>
<th>LMR p value</th>
<th>BLRT p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-class</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>2-class</td>
<td>1693.317</td>
<td>.004</td>
<td>.005</td>
<td>.000</td>
</tr>
<tr>
<td>3-class</td>
<td>1614.481</td>
<td>.001</td>
<td>.001</td>
<td>.000</td>
</tr>
<tr>
<td>4-class</td>
<td>1609.486</td>
<td>.175</td>
<td>.185</td>
<td>.000</td>
</tr>
<tr>
<td>5-class</td>
<td>1609.828</td>
<td>.085</td>
<td>.092</td>
<td>.000</td>
</tr>
<tr>
<td>6-class</td>
<td>1602.261</td>
<td>.370</td>
<td>.381</td>
<td>.000</td>
</tr>
</tbody>
</table>

Note. BIC = Bayesian Information Criteria; VLMR = Vuong-Lo-Mendell-Rubin; LMR = Lo-Mendell-RUBIN; BLRT = Bootstrapped Likelihood Ratio Test; LPA = Latent Profile Analysis.
Table 2. Mean Comparisons of Risk Factors between Subgroups

<table>
<thead>
<tr>
<th></th>
<th>Higher SES-healthy (N = 17)</th>
<th>Lower SES-Healthy (N = 45)</th>
<th>Lower SES-average mental health (N = 41)</th>
<th>Lower SES-poor mental health (N = 23)</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td>M (SD)</td>
<td></td>
</tr>
<tr>
<td>Maternal education</td>
<td>.96 (.31) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.17 (1.1) &lt;sup&gt;b&lt;/sup&gt;</td>
<td>.04 (.93) &lt;sup&gt;b&lt;/sup&gt;</td>
<td>-.42 (.90) &lt;sup&gt;b&lt;/sup&gt;</td>
<td>8.28</td>
</tr>
<tr>
<td>Income-to-needs ratio</td>
<td>1.81 (.76) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.24 (.58) &lt;sup&gt;b&lt;/sup&gt;</td>
<td>-.38 (.68) &lt;sup&gt;b&lt;/sup&gt;</td>
<td>-.18 (.91) &lt;sup&gt;b&lt;/sup&gt;</td>
<td>43.39</td>
</tr>
<tr>
<td>Depressive symptoms</td>
<td>-.64 (.31) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.79 (.31) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>.16 (.39) &lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.76 (.54) &lt;sup&gt;c&lt;/sup&gt;</td>
<td>238.27</td>
</tr>
<tr>
<td>Anxiety</td>
<td>-.74 (.50) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.91 (.38) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>.48 (.39) &lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.42 (.52) &lt;sup&gt;c&lt;/sup&gt;</td>
<td>185.32</td>
</tr>
<tr>
<td>Stress</td>
<td>-.21 (.67) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>-.66 (.55) &lt;sup&gt;a&lt;/sup&gt;</td>
<td>.32 (1.10) &lt;sup&gt;b&lt;/sup&gt;</td>
<td>.86 (.83) &lt;sup&gt;c&lt;/sup&gt;</td>
<td>20.256</td>
</tr>
</tbody>
</table>

Note. Differing subscripts within rows indicate significantly different means at p < 0.05.
Table 2.4. The Associations between Child Emotionality and Child EF in Different Subgroups

<table>
<thead>
<tr>
<th>Interaction model</th>
<th>Higher SES-healthy (N = 17)</th>
<th>Lower SES-healthy (N = 45)</th>
<th>Lower SES-average mental health (N = 41)</th>
<th>Lower SES-poor mental health (N = 23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC T2 B (SE)</td>
<td>0.101 (.152)</td>
<td>0.307* (.143)</td>
<td>0.678* (.342)</td>
<td>-0.052 (.143)</td>
</tr>
<tr>
<td>PE</td>
<td>0.296 (.264)</td>
<td>0.038 (.186)</td>
<td>-0.183 (.625)</td>
<td>0.458** (.151)</td>
</tr>
<tr>
<td>IC T1 B (SE)</td>
<td>0.068 (.140)</td>
<td>0.296* (.117)</td>
<td>0.254† (.145)</td>
<td>0.384† (.207)</td>
</tr>
<tr>
<td>NE</td>
<td>-0.033 (.104)</td>
<td>0.303 (.058)</td>
<td>0.093 (.065)</td>
<td>0.023 (.080)</td>
</tr>
<tr>
<td>AF T2 B (SE)</td>
<td>0.019 (.122)</td>
<td>0.230† (.138)</td>
<td>0.045 (.110)</td>
<td>0.197 (.246)</td>
</tr>
<tr>
<td>PE</td>
<td>-3.058 (3.761)</td>
<td>0.112 (.554)</td>
<td>0.368 (.544)</td>
<td>-1.963** (.700)</td>
</tr>
<tr>
<td>AF T1 B (SE)</td>
<td>0.569 (.720)</td>
<td>0.253 (.191)</td>
<td>0.028 (.111)</td>
<td>0.166 (.250)</td>
</tr>
<tr>
<td>NE</td>
<td>0.044 (.570)</td>
<td>-0.094 (.356)</td>
<td>-0.183 (.158)</td>
<td>-0.879† (.474)</td>
</tr>
</tbody>
</table>

Note. IC = inhibitory control; AT = attention flexibility; PE = positive emotionality; NE = negative emotionality; T1 = age 3; T2 = age 4.

†p < .10, *p < .05, **p < .01.
Figure 2.1. Means of the familial risk indicators of each identified profile.

Note. The five risks were standardized; the y-axis indicates the mean scores of the indicators shown on the x-axis; G1 = group 1; G2 = group 2; G3 = group 3, G4 = group 4.
Chapter 3: Maternal Depressive Symptoms and the Growth of Child Executive Function: Mediation by Maternal Sensitivity

Executive function (EF) refers to a set of higher cognitive processes that allow individuals to execute goal directed behavior in a novel context (Welsh, Friedman, & Slieker, 2006). EF in early childhood plays an important role in children’s development across various domains. Children with better EF skills tend to show more positive developmental outcomes, such as higher socio-emotional competence and academic achievement, compared to their counterparts with poorer EF skills (Becker, Miao, Duncan, & McClelland, 2014; Fitzpatrick, McKinnon, Blair, & Willoughby, 2014). With the growing recognition of the role of EF in child development, empirical studies have shown that EF emerges in infancy and improves through adolescence, with substantial individual variation in its developmental course. Such individual differences in developmental trajectories of child EF skills may be associated with different child-rearing environments (Lewis & Carpendale, 2009). One of the well-established risks for children’s cognitive development is maternal depression (Cumming & Davis, 1994); however, few studies have examined the specific link between maternal depressive symptoms and children’s EF development (Hughes, Roman, Hart, & Ensor, 2013).

Although it has long been documented that maternal depression negatively impacts children’s cognitive development, little is known about the mechanisms linking maternal depression and child maladaptive cognitive functioning. The Integrative Model for the
Transmission of Risk to Children of Depressed Mothers (Goodman, 2007; Goodman & Gotlib, 1999) proposes several mechanisms through which maternal depression leads to adverse child outcomes. One mechanism that is relevant to children’s cognitive malfunctioning pertains to mothers’ inadequate parenting. Depressed mothers are often characterized as disengaged in interactions with the child, unresponsive to child’s needs, and exhibiting criticism or rejection to the child (McLearn, Minkovitz, Strobino, Marks, & Hou, 2006), all of which indicates lack of sensitivity. Insensitive mothers may be unable to follow children’s lead during mother-child interactions and fail to provide appropriate support to children (Lovejoy, Graczyk, O'Hare, & Neuman, 2000), which in turn may undermine children’s EF development (Bernier, Carlson, & Whipple, 2010). However, little empirical research has focused on the mechanisms linking maternal depression and children’s poor EF skills. In the current study we examined the role of a potential mechanism, maternal sensitivity, in mediating the relation between maternal depressive symptoms and child EF development. Another limitation of prior work is that although parental characteristics, such as maternal depressive symptoms and sensitivity, change as children grow, how the relations among such familial characteristics and child EF evolve over time is not well understood. To fill this gap, in this study we aimed to examine how the long-term associations among the trajectories of maternal depressive symptoms, maternal sensitivity, and child EF spanned across early and middle childhood.

The Developmental Trajectory of Child EF during Middle Childhood

Over the past several decades there has been considerable attention directed to the development of child EF, including its conceptualization and measurement (Lee, Bull, & Ho, 2013; Welsh et al., 2006), its emergence and development (Diamond, Carlson, & Beck, 2005;
Zelazo, Muller, Frye, & Marcovitch, 2003), its developmental antecedents (Conway & Stifer, 2012; Cuevas et al., 2014), and its consequences (Clark, Pritchard, & Woodward, 2010; Jerman, Reynolds, & Swanson, 2012). In regard to its conceptualization, EF consists of several interrelated components: 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 pieces of information (Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003; Miyake et al., 2000). While these three are basic components of EF, planning skills are considered a higher level of EF functioning, as they require the basic EF components to work together simultaneously (Scholnick & Friedman, 1993). Overall, EF skills emerge during infancy and mature through early childhood to adolescence, with certain components developing at varying rates during different developmental stages (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). Despite the clear evidence of age-related changes in EF skills in childhood and adolescence, less is known about the developmental trajectories of individual children’s EF over a long developmental period.

Prior work has focused on normative developmental levels of EF in different age groups (e.g., Huizinga, Dolan, & van der Molen, 2006) using cross-sectional data, whereas only a few studies examined trajectories of EF using longitudinal data (e.g., Jerman et al., 2012). Among these few studies, most tracked growth in working memory and inhibitory control separately over a relatively short period of time (e.g., 2-3 years). For example, children showed a linear increase in working memory from grade 1 to 3 (Swanson, Jerman, & Zheng, 2008). Likewise,
children’s working memory and inhibitory control showed linear growth from 4 to 6 years of age (Hughes & Ensor, 2011). Relatively less work has focused on the development of planning skills. Empirical studies have generally reported that older children perform better than younger ones (Luciana & Nelson, 1998). For example, when four groups of children of different ages were administered the Tower of London task, a measure which taps into planning skills, children at ages between 12-14 showed better planning skills than those at ages between 9-11 but worse than adolescents at ages between 15-17 (Luciana, Collins, Olson, & Schissel, 2009). These studies, although they used cross-sectional data, may hint the developmental trajectories of planning skills through middle childhood. In this study we aimed to expand previous research and examine the developmental trajectory of planning skills in middle childhood.

**Maternal Depressive Symptoms and Child EF Development**

EF development is susceptible to contextual influences (Lewis & Carpendale, 2009; Noble, Norman, & Farah, 2005). In general, supportive familial environment (e.g., caregiver’s support) may facilitate the development of child EF skills, whereas unsupportive familial environment (e.g., family financial strain) may undermine the development of child EF (Bibok, Carpendale, & Müller, 2009; De Bellis, 2001). Specifically, it has been found that caregivers’ psychological problems such as depression and anxiety (Buss, Davis, Hobel, & Sandman, 2011), insecure caregiver-child attachment (Bernier, Beauchamp, Carlson, & Lalonde, 2015), and low family socioeconomic status (Sarsour et al., 2011) are associated with poor child EF. Considering that typically mothers are the primary socialization agents of children throughout early and middle childhood, maternal characteristics and behavior may serve an important role in the development of child EF (Fay-Stammbach, Hawes, & Meredith, 2014). It has been well
documented that children of depressed mothers are at risk for maladaptive development in many aspects, including cognitive development (Cummings & Davies, 1994; Kiernan, & Huerta, 2008). It is estimated that a great portion of new mothers, approximately up to 80%, may experience post-partum depressive symptoms with 1 out of 10 showing clinical depression (Ertel, Rich-Edwards, & Koenen, 2011; Payne, 2003; Wang, Wu, Anderson, & Florence, 2011). Children’s early exposure to maternal depression is associated with current or later maladaptive cognitive functioning (Liu et al., 2017; McManus & Poehlmann, 2012). Whereas much of the research on children’s early exposure to maternal depression focuses on children’s general mental maturity (e.g., Galler, Harrison, Ramsey, Forde, & Butler, 2000; Kiernan & Huerta, 2008), little is known about how the maternal depression is associated with child EF development specifically.

In addition to early exposure to maternal depression, the patterns of change in maternal depression may also have an impact on child EF development, as there has been evidence suggesting the association between trajectories of maternal depressive symptoms and child cognitive development (e.g., Campbell, Matestic, von Stauffenberg, Mohan, & Kirchner, 2007; Dawson et al., 2003). Studies have shown that overall mothers declined in their depressive symptoms from child’s birth through early childhood (Wu, Selig, Roberts, & Steele, 2011); however, some mothers maintained elevated or even increasing patterns of depressive symptoms over time (Campbell, 1995; Luoma, Korhonen, Salmelin, Helminen, & Tamminen, 2015). When mothers are chronically depressed over the course of the offspring’s childhood, children are at a greater risk of cognitive deficits than those of non-depressed mothers or mothers with remitted depression (Brennan et al., 2000; NICHD ECCRN, 1999a). For example, Campbell et al. (2007)
found that children whose mothers displayed increased or chronic depressive symptoms from 6 months to grade 1 showed poorer cognitive skills (e.g., poor memory and vocabulary skills), compared to those whose mothers showed consistently low or moderate levels of depressive symptoms. More related to the current study, Hughes and colleagues (2013) found that a faster decline in maternal depressive symptoms from age 2 to 6 predicted better child EF at age 6, compared to mothers who showed a slower drop. This line of studies suggests that trajectories of maternal depressive symptoms play a critical role in the development of child EF. It is unclear, however, if trajectories of maternal depression beyond early childhood years may still exert an impact on child EF. Another limitation of this line of research is that child EF, as the outcome of trajectories of maternal depressive symptoms, is only assessed at one point in time. This approach may overlook the longitudinal process of children’s EF growth. Responding to the gap, in this study we investigated the associations between trajectories of maternal depressive symptoms from infancy through middle childhood and developmental trajectories of child EF during middle childhood.

**Maternal Sensitivity as a Mediator in the Association between Maternal Depressive Symptoms and Child EF**

Maternal sensitivity can be defined as a mother’s ability to recognize her child’s signals accurately and to respond to them in a warm, prompt, and appropriate manner (Ainsworth, 1979). According to Goodman and Gotlib’s (1999) Integrative Model for the Transmission of Risk to Children of Depressed Mothers, inadequate parenting, such as lack of maternal sensitivity, can serve as a mechanism in the association between maternal depressive symptoms and child maladaptive cognitive functioning. Empirical studies that have tested the mediating
role of maternal sensitivity have mostly focused on children’s socio-emotional outcomes such as internalizing/externalizing problems and emotion regulation skills (e.g., Harnish, Dodge, Valente, & Conduct Problems Prevention Research Group, 1995; van Doorn et al., 2016). Only a few studies have investigated the mediation model with child cognitive development as the outcome. For example, Murray and colleagues (1993) found that mothers’ negative affect expression, one of the indicators of low maternal sensitivity, at 2 months mediated the association between maternal depressive symptoms at 2 months and children’s poor cognitive functioning at 18 months. Although it seems plausible, the mediating role of maternal sensitivity has not been tested in the development of EF, particularly within a wider timeframe that goes beyond infancy and early childhood. Applying the Integrative Model for the Transmission of Risk to Children of Depressed Mothers (Goodman & Gotlib, 1999) to school age children’s EF development may extend our knowledge about the processes by which early childhood exposure to maternal depression contributes to the development of child EF across a wide developmental period.

Another limitation of the prior research is insufficient attention to change in maternal sensitivity and its impact on child outcomes. Levels of individual mothers’ sensitivity may change as children grow up, and different patterns of the change may be associated with differences in children’s development (e.g., Mills-Koonce, Gariepy, Sutton, & Cox. 2008). For example, Wang and colleagues (2013) found that maternal sensitivity decreased slightly between 3 and 11 years of children’s age, and that a faster decrease in sensitivity predicted a greater increase in externalizing problems from ages 4 to 12. Much of this line of work focused primarily on children’s problem behaviors or general cognitive comprehension (e.g., Campbell et
al., 2007); however, little is known about how the trajectories of maternal sensitivity predict child EF development. To address the limitation, the current study examined the association between changes in maternal sensitivity and developmental trajectories of child EF. Further, we tested whether changes in maternal sensitivity mediated the relations between the changes in maternal depressive symptoms and the developmental trajectories of child EF skills. Currently, no studies have tested this mediational pathway; however, there has been some empirical evidence partially supporting the mediational model. First, Campbell and colleagues (2007) reported that higher levels or increasing patterns of maternal depressive symptoms were associated with lower levels and decreases in their sensitivity during early childhood. Additionally, Wang et al. (2013) found that across early and middle childhood a faster decrease in maternal sensitivity predicted a greater increase in children’s externalizing problems, of which EF skills are developmental antecedents (Hughes & Ensor 2011; Sulik et al., 2015).

**The Present Study**

In the current study, the associations among the trajectories of maternal depressive symptoms from 6 months to grade 5, maternal sensitivity from 36 months to grade 5, and children’s EF, in particular planning skills, from grade 1 through grade 5, were examined using the National Institute of Child Health and Human Development (NICHD) Study of Early Child Care and Youth Development (SECCYD). Furthermore, we examined whether changes in maternal sensitivity would mediate the associations between changes in maternal depressive symptoms and growth in child EF skills. It was hypothesized that first mothers would show a decrease in depressive symptoms and sensitivity over time, while children would show an increase in EF skills. Second, in regards to direct associations, lower levels of maternal
depressive symptoms in infancy and a faster decrease in maternal depressive symptoms over
time would be associated with a) higher levels of and a slower decrease in maternal sensitivity
during preschool and elementary school periods, and b) higher levels of child EF in grade 1 and
faster growth in EF during middle childhood. Higher levels and a slower drop in maternal
sensitivity would predict higher initial levels of as well as a faster growth in child EF. Finally, in
regards to the mediation effect, it was predicted that lower levels of maternal depressive
symptoms in infancy and a slower drop of depressive symptoms would predict higher levels of
maternal sensitivity at 36 months and a slower decrease in maternal sensitivity, which in turn
would predict higher levels of children’s EF in grade 1 and faster growth in EF during
elementary school years.

Method

Participants

The sample of this study was drawn from the NICHD Study of Early Child Care and
Youth Development (SECCYD), including 1,364 primary mother-child dyads across 8 different
time points, from the focal child’s age of 6 month to 5th grade (boys = 705; girls = 659). Trained
staff conducted home visits to administer the surveys and observations at 1, 15, and 24 months,
while the families visited the laboratory at 36 and 54 months, and grade 1, 3, and 5. For a
detailed description of the sample selection and recruitment procedures, see NICHD Early Child
Care Research Network (1999b). 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%), 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 had less than college education and 35.3% had a bachelor’s degree or above. At the
time of focal child’s age of 1 month, most of the mothers were living with their spouse or partner
(85.4%) and 14.6% were living alone. IRB approval was obtained for the analyses of the data
from the Ohio State University.

Overall, the retention rate from 6 months to grade 5 was 68.16%. Among 1,364 mother-
child dyads, 6.31% of the responses at 6 months were missing, 9.01% at 15 months, 17.96% at
24 months, 13.38% at 36 months, 22.40% at 54 months, 26.42% in grade 1, 26.22% in grade 3,
and 27.91% in grade 5. Data were missing at random, as Little’s MCAR (missing completely at
random) test was not significant (normed $\chi^2 = 2618.89, p = 1.00$). The full information maximum
likelihood method was used for the missing data.

Measures

Child EF. Child EF, in particular, planning skills, was assessed using 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 pegs. 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 were asked to make the minimum number of
moves, which was considered a perfect solution. The number of attempts the child made to reach
the perfect solution was scored and then reversed. Children were given 6 trials. Those who
successfully performed the first two trials were allowed to complete the rest of the 4 trials. Each
trial was scored, and the possible score range for each trial was 0 to 6. When a child gave up or
refused to continue, s/he received a failing score and the procedure ended. Children who received a failing score at any time point during the procedure finally received a total score for the trials that they had performed. The higher total scores indicated better planning skills.

**Maternal depressive symptoms.** Mothers’ depressive symptoms were assessed with the *Center for Epidemiological Studies Depression Scale* (CES-D; Radloff, 1977) at 6, 15, 24, 36, and 54 months of the child’s age, and in 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). Across time points, on average Cronbach’s alpha was .89, ranging from .86 to .91.

**Maternal sensitivity.** Maternal sensitivity was measured with semi-structured observation of mother-child interactions in a laboratory context (NICHD ECCRN, 1999b) at 36 and 54 months, and in grade 1, 3 and 5. Mother-child interactions were observed in two different contexts, free-play and challenging contexts (e.g., a mother was asked to assist her child while a child was completing a difficult maze). Three subscales, *supportive presence, respect for child’s autonomy,* and *hostility,* were assessed on a 1 to 7 point-scale (1 = very low; 7 = very high). A composite score of maternal sensitivity was created by combining *supportive presence, respect for child’s autonomy,* and reversed *hostility* (NICHD ECCRN, 1999b). Cronbach’s alpha showed good internal consistency, ranging from .80 to .85. Inter-coder reliability was estimated, according to Winter’s (1971) method. Inter-coder reliability for the maternal sensitivity composite ranged from .84 to .91 (NICHD ECCRN, 2003; Wang et al., 2013).
**Covariates.** Child sex, maternal education, and family income-to-needs ratio were included as covariates. 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, mothers self-reported their education level and family income. 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**

Data were analyzed using the Mplus 7.4 (Muthén & Muthén, 1998–2015). For the first research question, unconditional latent growth curve models for maternal depressive symptoms, maternal sensitivity, and child EF were examined separately. Linear and quadratic growth models were estimated for maternal depressive symptoms and sensitivity, which means that the intercept (initial level), the linear slope (rate of change), and the quadratic slope (rate of non-linear change) of each variable were estimated. After the comparison of the linear and quadratic growth models, either linear or quadratic model was chosen for the further analysis. Regarding child EF, however, only linear change was modeled, estimating the intercept and the linear slope, because the three waves of child EF assessment did not allow for non-linear change modeling. In regard to the second research question, a longitudinal mediation was tested in the latent growth curve modeling framework, with the initial level (the intercept) and the rate of change (the slope) in maternal depressive symptoms as the predictors, the intercept and slope of maternal sensitivity as the mediators, and the initial level and the rate of change in child EF as the dependent variables. The mediation effects of changes in maternal depressive symptoms (both intercept and slope) on child EF growth (both intercept and slope) through changes in maternal sensitivity
(both intercept and slope) were estimated using the bootstrapping method (Preacher & Hayes, 2008). Bootstrapped standard errors were computed using 3000 draws in order to obtain bootstrap confidence intervals for the indirect effects. For the direct and indirect paths, child sex, maternal education, and family income-to-needs ratio were included in the analyses as covariates.

Results

First, descriptive statistics of maternal depressive symptoms, maternal sensitivity, and child EF are provided in Table 3.1. As presented in Table 3.2, maternal depressive symptoms and maternal sensitivity across multiple time points showed moderate levels of negative correlations. Overall, maternal depressive symptoms were negatively correlated with child EF, whereas maternal sensitivity was positively correlated with child EF over time.

Developmental Trajectories of Maternal Depressive Symptoms, Maternal Sensitivity, and Child EF

Trajectories of maternal depressive symptoms. The linear growth model best represented the changes in maternal depressive symptoms. The intercept was the mean score of depressive symptoms assessed at 6 months, and the slope was the rate of change in depressive symptoms from 6 months to grade 5. The latent growth curve model fit the changes in maternal depressive symptoms, \( \chi^2(31) = 102.002, p < .001; \) CFI = .963; RMSEA = .042, 90% CI [.033, .051]. Maternal depressive symptoms declined over time in a linear fashion (Figure 3.1), as the mean of the slope was significantly different from zero (Table 3.3). Also, as presented in Table 3, there were significant variances around the slope of maternal depressive symptoms. The intercept of maternal depressive symptoms was significantly different from zero, and there were
significant individual variances in the intercept. The intercept of maternal depressive symptoms was negatively correlated with the slope of depressive symptoms ($r = -0.332, p < .001$), meaning that high levels of maternal depressive symptoms at 6 months were associated with a slower decrease in depressive symptoms from 6 months through grade 5.

**Trajectories of maternal sensitivity.** The linear change in maternal sensitivity best described the trajectories of maternal sensitivity, which fit the data reasonably well, $\chi^2(10) = 50.481, p < .001$; CFI = .961; RMSEA = .057, 90% CI [.042, .074]. Mothers showed a linear drop in sensitivity levels over time (Figure 3.1). The intercept was the mean score of sensitivity measured at 36 months, and the slope was the rate of change in sensitivity from 36 months to grade 5. Both the mean of maternal sensitivity intercept and slope were significantly different from zero (Table 3.3). There were significant individual differences in both the intercept and slope of sensitivity among the mothers. The intercept of maternal sensitivity was negatively correlated with the slope of maternal sensitivity ($r = -0.592, p < .001$), indicating that mothers starting out with higher levels of sensitivity tended to show a slower decrease in their sensitivity over time.

**Growth in child EF.** The unconditional growth model of child EF was estimated, with the initial levels of child EF, and the rate of change from grade 1 through grade 5. The initial estimation of the latent growth in child EF indicated that EF growth was not linear. However, the three waves of child EF assessment did not allow for the estimation of a non-linear growth pattern. To address this issue, the correlation between the intercept and slope, which was nonsignificant, was set to zero and the time score for the second wave was freely estimated. The latent growth model fit the changes in child EF, $\chi^2(1) = .466, p = .495$; CFI = 1.000; RMSEA <
.001, 90% CI [.000, .069], and children showed an increase in EF over time (Figure 3.1). The intercept and the slope of EF were significantly different from zero (Table 3.3). The variances of the intercept and the slope were significant.

The Mediation Model

Regarding the second research question, a structural equation model was estimated with maternal depressive symptoms intercept and slope as the predictors, child EF intercept and slope as the outcomes, and maternal sensitivity intercept and slope as the mediators (Figure 3.2). The mediation model, with the significant covariates, fit the data reasonably well: $\chi^2(154) = 495.347$, $p < .001$; CFI = .926; RMSEA = .046, 90% CI [.042, .050]. There were three significant direct associations (Figure 3.2): high levels of maternal depressive symptoms at 6 months predicted low levels of maternal sensitivity at 36 months. Higher levels of maternal sensitivity at 36 months were predictive of better child EF skills at grade 1 as well as a faster increase from grade 1 through grade 5. Further, two indirect associations were found to be significant. First, low levels of maternal depressive symptoms at 6 months predicted high levels of child EF at grade 1 through high levels of maternal sensitivity at 36 months ($\beta = -.091, p < .001$). Second, low levels of the maternal depressive symptoms at 6 months were predictive of a greater increase in child EF through high levels of maternal sensitivity at 36 months ($\beta = -.057, p = .014$).

In regard to the covariates, maternal education, family income-to-needs ratio, and child gender were significant predictors of child EF skills in grade 1. Specifically, children with more highly educated mothers ($\beta = .483, p = <.001$), higher family income-to-needs ratio ($\beta = .164, p < .001$), and girls ($\beta = .103, p = .009$) showed greater EF scores in grade 1. Higher levels of
maternal education were also associated with slower growth rates of child EF from grade 1 to 5 ($\beta = -0.372, p = .028$).

**Discussion**

The goal of this study was to examine whether the trajectories of maternal depressive symptoms through early and middle childhood were associated with the trajectories of child EF during elementary school years, and whether maternal sensitivity trajectories mediated the association between the trajectories of maternal depressive symptoms and child EF. We found two mediational pathways through maternal sensitivity: high levels of maternal depressive symptoms during infancy predicted low levels of maternal sensitivity at age 3, which in turn was predictive of both low levels of child EF at grade 1 and a slower increase in EF from grade 1 to 5. Our findings support the Integrative Model for the Transmission of Risk to Children of Depressed Mothers (Goodman & Gotlib, 1999) which suggests that deficits in parenting skills, in particular lack of maternal sensitivity, serve as a mechanism in the long-term processes by which children’s early exposure to maternal depressive symptoms is associated with their EF development during middle childhood. Furthermore, our findings revealed that the contextual factors associated with the development of child EF, such as maternal depressive symptoms and maternal sensitivity, also change as children get older.

Overall, mothers showed a decline in their depressive symptoms from 6 months through grade 5, as expected. Our finding is in line with previous studies (Horowitz & Goodman, 2004; Luoma et al., 2001; Wu et al., 2011), which suggested a decreasing pattern in maternal depressive symptoms during early childhood, and extended previous findings to middle childhood period. Contrary to our hypotheses, the rate of change in maternal depressive
symptoms was associated with neither initial levels nor growth rates of child EF. This is inconsistent with previous results that suggested a slower decrease in maternal depressive symptoms from age 2 to 4 predicted higher levels of child EF at age 6 (Hughes et al., 2013). It is possible that when examining trajectories of maternal depressive symptoms within a wider timeframe, change in maternal depressive symptoms may not be directly related to the development of school age children’s EF.

Similar to maternal depressive symptoms, maternal sensitivity also decreased from age 3 to grade 5. This replicated previous findings in which maternal sensitivity declined from preschool periods to preadolescence (Feldman, 2010; Wang et al., 2013). Maternal sensitivity may play an important role in early childhood development; however, as children make the transition to school, other dimensions of parenting, such as scaffolding (adult’s support for a child to face challenges and persist with their work), may become more salient, particularly with regard to cognitive development. Furthermore, mothers may be more likely to show sensitivity in a challenging context than in a free-play setting. Ciciolla and colleagues (2013) found that mothers showed increasing patterns of sensitivity from age 3 to 5 in a challenging context, whereas sensitivity in a free-play context declined over the same assessment window. In the NICHD SECCYD study, maternal sensitivity was assessed from both free-play and challenging situations and the final sensitivity score combined the assessment across situations, and thus we were unable to differentiate between challenging and free-play situations. Future studies should examine trajectories of maternal sensitivity assessed separately in challenging and free-play situations during early and middle childhood.
Maternal sensitivity at 36 months was predicted by low levels of maternal depressive symptoms at 6 months. This finding suggests that maternal depressive symptoms in infancy have enduring consequences on mothers’ sensitivity in early preschool periods. This finding also supports prior work in which mothers with severe and chronic depressive symptoms were found to show low levels of sensitivity when interacting with their child (Campbell et al., 2004, 2007; NICHD ECCRN, 1999a). Compared to mothers with low levels of depressive symptoms, those with elevated depressive symptoms may have less emotional availability to promptly respond to child’s cues (Reck et al., 2004), thus failing to be appropriately attuned to child’s cognitive needs (Murray, Fiori-Cowley, Hooper, & Cooper, 1996). Whereas some researchers argued that maternal depressive symptoms may covary with lack of sensitivity (Murray et al., 1996), others suggested that early severity or chronicity of maternal depressive symptoms may undermine their sensitivity later on (Kluczniok et al., 2016; van Doorn et al., 2016). Our findings support that earlier maternal depressive symptoms predict later their sensitivity.

When mothers showed higher levels of sensitivity at 36 months, children showed higher levels of EF skills in grade 1 as well as faster growth in their EF during elementary school years. These findings highlight the important role of maternal sensitivity in preschool periods in relation to later child EF development. To some extent, our results are also consistent with previous work in which maternal sensitivity in preschool periods predicted child externalizing problems in school ages (e.g., Bradley & Corwyn, 2007), considering deficits in EF is a core precedent of externalizing behavior (Schoemaker, Mulder, Deković, & Matthys, 2013). Moreover, Wang and colleagues (2013) reported that higher levels of maternal sensitivity at age 3 predicted a faster drop in child externalizing problems. It can be argued that when mothers are
responsive to and attuned with child’s cues, their child’s later development of EF may be facilitated over the course of middle childhood.

Unexpectedly, changes in maternal sensitivity were a significant predictor for neither the intercept nor the rate of change in child EF skills, which is inconsistent with previous findings. Most of the studies reporting the association between the changes in maternal sensitivity and child cognitive functioning utilized a person-centered approach by assigning mothers into different groups, based on the patterns of their sensitivity trajectories. For example, children of the mothers who showed high and stable sensitivity from 6 months through 54 months showed better academic achievement, of which EF is one of key antecedents, compared to their counterparts whose mothers showed low sensitivity over time (Hirsh-Pasek & Burchinal, 2006). It is possible that the association between changes in maternal sensitivity and child EF only existed in certain sub-groups of mothers and children who showed specific patterns of change, as previous work using a person-centered approach may suggest (e.g., Campbell et al., 2007).

As expected, child EF skills, in particular planning skills, increased over the course of elementary school grades. Considering that much of the prior research investigated age-related changes in child EF at different age groups using cross-sectional data (e.g., Huizinga et al., 2006), this study adds empirical evidence that EF improves during middle childhood. The tower of Hanoi task used in this study involves multiple cognitive processes such as representing a problem, setting a goal, coming up with and carrying out strategies, and monitoring the whole problem-solving processes (Scholnick & Frieman, 1993). Children older than age 5 may have the ability to successfully perform such tasks by utilizing problem-solving and reasoning skills (Luiziana & Nelson, 1998). Our finding indicates that children consistently improve planning
skills during middle childhood, as they acquire the ability to coordinate multiple components of EF.

Higher levels of maternal sensitivity at 36 months predicted both children’s better EF skills in grade 1 and the faster growth of EF from grade 1 to 5. Considering the components of maternal sensitivity in our study including maternal supportive presence, respect for child’s autonomy, and hostility, mothers who tend to offer comfort at the time of child’s distress, who encourage their child to lead the task, and who are less critical may help facilitate children’s development of problem-solving skills. In regards to growth of child EF, maternal education, which was included as a covariate, was related to slower growth of child EF from grade 1 to 5. Children of mothers who received higher education tend to show better cognitive functioning (Duncan & Magnuson, 2012). Thus, children of highly educated mothers may start out with higher EF scores in grade 1 and may show slower growth during elementary years, compared to those whose mothers with lower education.

Finally, high levels of maternal sensitivity at 36 months served as a mediator between the associations between low levels of initial maternal depressive symptoms and child EF skills in grade 1, and between initial maternal depressive symptoms and a greater increase in child EF from grade 1 to 5. These findings extend previous studies, which examined the association between maternal depressive symptoms and children’s early cognitive functioning (e.g., age 2) within a relatively short period of time (e.g., Murray et al., 1993). Furthermore, the research design of the current study helps us understand the long-lasting impact of early maternal psychological health on school age children’s EF development through their sensitivity parenting. Such a mediational role of maternal sensitivity may have implications for
interventions on children who are exposed to maternal depression in early childhood and may struggle developing appropriate levels of EF skills; indeed, if their mothers are intervened and instructed on how to increase their sensitivity, those children may be stimulated to develop EF faster, compared to those whose mothers did not receive such intervention.

The current study has several limitations and suggests several future directions. First of all, three waves of assessing child EF skills did not allow for the investigation of non-linear growth trajectories of child EF. Future research may add more time points of EF assessment which would enable researchers to examine the possible nonlinear trend in the development of EF in middle childhood. Second, we examined one parenting variable, maternal sensitivity, as a mechanism linking maternal depressive symptoms to child EF growth; however, there is a need for exploring other mechanisms underlying the association between trajectories of maternal depressive symptoms and child EF growth. For example, depressed mothers may lack scaffolding behavior, as they often have difficulty engaging with their child or providing constructive instructions during a challenging task (Klucznik et al., 2016). Third, we examined only the maternal role in the development of child EF, whereas other family members, such as fathers, may have impact on child EF development. For example, paternal support for child’s autonomy predicted 3-year-olds’ EF skills (Meuwissen & Carlson, 2015). Fourth, child EF development during school years may be susceptible to school environment (Bagby, Barnard-Brak, Sulak, Jones, & Walter, 2012; Chien et al., 2010). The inclusion of teacher or classroom characteristics may extend our knowledge of how school and family environments jointly affect child EF development. Fifth, maternal sensitivity may reflect bidirectional nature between a mother and a child. Measuring for maternal sensitivity should possibly 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). Lastly, this study was correlational in nature, thus causal inferences between variables were not allowed. Despite the fact that we found longitudinal associations between maternal depressive symptoms and sensitivity and child EF, they should not be interpreted as evidence that one variable causes another.

Despite the limitations, this study has several strengths. First, multiple waves of data were included in terms of the assessment of maternal depressive symptoms and sensitivity and child EF. The research design enabled us to look into changes in both maternal depressive symptoms and sensitivity in relation to child EF development for a relatively wider timeframe, from infancy through preadolescence. Second, maternal sensitivity was assessed using an observational method during mother-child interactions. Thus, the assessment of maternal sensitivity may be less biased, compared to self-report based methods. This is due to the tendency of depressed mothers that they may give biased responses on their own parenting behavior (Parent et al., 2014). Third, the multi-method approach in the assessment of study variables (i.e., self-report on maternal depressive symptoms, observation of maternal sensitivity, and laboratory assessment of EF) reduced possible shared method variance, and thus increased the validity of the findings. Lastly, we investigated growth of child EF, especially planning skills, which involves multiple components of EF skills, such as working memory, inhibitory control, and attention shifting. The investigation of developmental trajectories of planning skills may fill the gap in the previous literature, most of which has focused on trajectories of only one
or two components of child EF (e.g., Swanson et al., 2008). This may provide a more complete picture of the developmental course of EF skills during middle childhood.

In conclusion, the current study indicates that early maternal depressive symptoms may not directly predict school age children’s EF development; however it may affect children’s EF growth indirectly through the mechanism of maternal sensitivity. This finding implies that child EF development involves a dynamic of multiple maternal characteristics, especially maternal psychological health and parenting behavior, that consistently change throughout early and middle childhood.
Table 3. 1. Descriptive Statistics of Maternal Depressive Symptoms and Sensitivity, and Child EF

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean (SD)</th>
<th>Range</th>
<th>Skewness</th>
<th>Kurtosis</th>
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<tr>
<td>6 month</td>
<td>1278</td>
<td>8.95 (8.34)</td>
<td>0 – 52</td>
<td>1.72</td>
<td>3.62</td>
</tr>
<tr>
<td>15 month</td>
<td>1241</td>
<td>9.08 (8.18)</td>
<td>0 – 54</td>
<td>1.55</td>
<td>2.80</td>
</tr>
<tr>
<td>24 month</td>
<td>1119</td>
<td>9.40 (8.63)</td>
<td>0 – 51</td>
<td>1.59</td>
<td>2.80</td>
</tr>
<tr>
<td>36 month</td>
<td>1202</td>
<td>8.98 (8.31)</td>
<td>0 – 57</td>
<td>1.50</td>
<td>2.63</td>
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<td>9.83 (8.70)</td>
<td>0 – 55</td>
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<td>0 – 50</td>
<td>1.55</td>
<td>2.51</td>
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<tr>
<td>Grade 3</td>
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<td>0 – 55</td>
<td>1.52</td>
<td>2.59</td>
</tr>
<tr>
<td>Grade 5</td>
<td>1019</td>
<td>8.73 (8.62)</td>
<td>0 – 49</td>
<td>1.70</td>
<td>3.41</td>
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<td>Maternal sensitivity</td>
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<tr>
<td>36 month</td>
<td>1161</td>
<td>17.19 (2.78)</td>
<td>4 – 21</td>
<td>-1.37</td>
<td>2.77</td>
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<td>54 month</td>
<td>1040</td>
<td>16.95 (2.91)</td>
<td>4 – 21</td>
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<td>2.50</td>
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<tr>
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<td>1.19</td>
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<td>929</td>
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<td>7 – 21</td>
<td>-.84</td>
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<td>Child EF</td>
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<td>22.87 (58.17)</td>
<td>0 – 36</td>
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Notes: SD = Standard Deviation
Table 3. Correlations among Maternal Depressive Symptoms and Sensitivity, and Child EF

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***p < .001; **p < .01; *p < .05.
Table 3. Unconditional Growth Curve Models for Maternal Depressive Symptoms and Sensitivity, and Child EF

<table>
<thead>
<tr>
<th></th>
<th>Unstandardized</th>
<th>p</th>
<th>Variance (SE)</th>
<th>p</th>
</tr>
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<tr>
<td></td>
<td>Unstandardized</td>
<td></td>
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<tr>
<td>Maternal depressive symptoms</td>
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</tr>
<tr>
<td>Mean (SE)</td>
<td>p</td>
<td>Variance (SE)</td>
<td>p</td>
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</tr>
<tr>
<td>Intercept</td>
<td>9.293 (.198)</td>
<td>&lt; .001</td>
<td>39.042 (2.389)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>slope</td>
<td>-1.114 (.058)</td>
<td>.049</td>
<td>1.533 (.223)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>I with S</td>
<td>-2.566 (SE = .624), p &lt; .001</td>
<td></td>
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<tr>
<td>Maternal sensitivity</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>17.111 (.077)</td>
<td>&lt; .001</td>
<td>4.824 (.440)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Slope</td>
<td>-.513 (.054)</td>
<td>&lt; .001</td>
<td>.865 (.193)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>I with S</td>
<td>-1.210 (SE = .247), p &lt; .001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child EF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>14.239 (.213)</td>
<td>&lt; .001</td>
<td>19.487 (1.602)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Slope</td>
<td>8.616 (.260)</td>
<td>&lt; .001</td>
<td>29.815 (6.418)</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>I with S</td>
<td>.000 (SE = .000), p = N/A</td>
<td></td>
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</tr>
</tbody>
</table>

Note. SE = Standard Error; I = intercept; S = slope.
Figure 3. 1. Developmental trajectories of maternal depressive symptoms and sensitivity, and child EF.

Notes: Solid line = estimated means; dotted line = sample means.
Figure 3.2. Changes in maternal depressive symptoms and growth in child EF: Changes in maternal sensitivity as a mediator.
Notes. 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; maternal education and family income-to-needs ratio, and child gender were included in the analyses as covariates but not shown in the figure.

***p < .001; **p < .01; *p < .05.
Chapter 4: The Transactional Relations between Maternal Parenting and Child Executive Function

Executive function (EF) refers to a set of higher cognitive processes that allow goal-directed behavior to occur in a novel, problem-solving context (Welsh, Friedman, & Slieker, 2006). The development of children’s EF is susceptible to contextual influences (De Bellis, 2001), in particular, familial influences (Bibok, Carpendale, & Müller, 2009). Multiple familial factors, such as stable family structure (Rhoades, Greenberg, Lanza, & Blair, 2011), high family socio-economic status (Mackay, 2005) and good maternal mental health (Hughes, Roman, Hart, & Ensor, 2013) have been identified to familial factors that can facilitate the development of EF skills. In recent years, parenting behavior has received scholarly attention as a predictor of children’s EF (Fahie & Symons, 2003). Prior work has provided evidence that maternal sensitivity and scaffolding may facilitate the development of EF (Bernier et al., 2012; Lewis & Carpendable, 2009). One limitation of previous work is that researchers tended to assume that the association between parenting and children’s EF development is unidirectional (Fay-Stammbach et al., 2014). Relatively less is known about children’s influences on parenting behavior. The transactional model of child development (Sameroff, 2009) posits that maternal parenting behavior and child EF development mutually affect each other, as children play an active role in eliciting certain types of maternal parenting behavior. Thus, the goal of current
study was to examine whether maternal sensitivity and scaffolding have mutual relations with children’s EF development.

The Development of EF in the Preschool Period

EF is thought to consist of several components including inhibitory control, attention flexibility, and working memory and those components have been suggested to be interrelated with each other but dissociable (Miyake et al., 2000). Inhibitory control refers to the ability to withhold a prepotent response but activate a non-dominant response; attention flexibility is the ability to shift attention between two- or multiple-dimensions; and working memory involves updating, monitoring, and manipulating information. Preschool years are a critical period in which children’s EF skills rapidly increase (Anderson, 2002; Carlson & Moses, 2001). For example, 4-year-olds tend to show higher levels of inhibitory control than 3-year-olds, while 5-year-olds may outperform 4-year-olds (Gerstadt, Hong, & Diamond, 1994). Similarly, the majority of 3-year-olds may have difficulty shifting attention between two dimensions, whereas 4-year-olds may better understand the rule and more successfully complete attention shifting tasks. Although there is normative increasing pattern of inhibitory control and attention skills during the preschool period, preschool age children show individual differences in their EF skills. These differences have implications on future outcomes (Fitzpatrick, McKinnon, Blair, & Willoughby, 2014). For example, children with better EF skills tend to show higher academic achievement in math and reading abilities (Blair & Razza, 2007). Given the important role of early childhood EF in long term outcomes, there is a need to examine what factors facilitate or compromise the development of EF in the preschool period.

Maternal Parenting and Children’s EF Development
A supportive environment may facilitate the development of children’s EF skills, while an unfavorable environment may undermine the development of children’s EF (Noble, Norman, & Farah, 2005). Considering that young children tend to spend a significant amount of time with their primary caregivers and most of the primary caregivers are their mothers, maternal behavior may be an important factor that shapes children’s rearing environment. Attachment theory posits that maternal sensitive parenting is associated with children’s later adaptations such as self-regulation skills (Bowlby, 1982; Dallaire & Weinraub, 2005; Kivijärvi, Räähä, Virtanen, Lertola, & Piha, 2004). Maternal sensitivity refers to a mother’s ability to recognize a child’s cues and respond to them in a warm and prompt manner (Ainsworth, 1979). At early ages children are primarily regulated by external sources, most of which are primary caregivers (Kopp, 1982). When a child displays a socially inappropriate response towards certain stimuli, a sensitive mother may support a child to show a socially appropriate response. As a child is repeatedly exposed to such maternal support, a child may gradually obtain appropriate regulation skills. A theoretical framework for self-regulation development suggests that EF skills are control processes embedded within a broader construct of self-regulation (Calkins & Bell, 2010). Thus, maternal sensitivity may also facilitate the development of children’s EF skills as part of self-regulation skills. Empirical research has provided evidence for the link between maternal sensitivity and children’s EF development (e.g., Bernier, Carlson, Deschênes, & Matte-Gagne, 2012; Kok et al., 2014; Mileva-Seitz, 2015). Indeed, when a mother tends to be attuned to child’s needs and be less intrusive during mother-child interactions, children exhibit high EF skills (Cuevas et al., 2014).
In addition, children may develop EF skills from social interactions. According to the social interaction framework (Vygotsky, 1978), children may develop their mental ability through interactions with competent individuals, such as mothers or peers. One of the important aspects of social interactions is scaffolding, which is characterized as competent individuals’ assistance when individuals face and perform challenging tasks (Lewis & Carpendable, 2009). A competent individual may encourage a child to be engaged in challenging activities and help a child to persistently work on resolving the problems. Through these processes, a child gradually obtains the skills necessary to regulate their thought and behavior. There has been empirical evidence for the link between maternal scaffolding and children’s EF development (Bibok, Carpendale, & Müller, 2009; 2012; Hammond, Müller, Carpendale, Bibok, & Liebermann-Finestone, 2012; Hughes & Ensor, 2009). For example, during a challenging task when mothers intervened in accordance with children’s needs by taking their children’s perspective and supporting children’s autonomy, children showed high levels of EF skills later (Bernier et al., 2010).

**Transactional Relations between Maternal Parenting and Child EF**

Current literature provides a framework explaining how maternal behavior plays a role in the development of children’s EF, but what is less clear is whether the association between maternal parenting and children’s EF development is bidirectional. The transactional model of child development (Sameroff, 2009) indicates that the environment created by maternal parenting may affect children’s development, and at the same time children’s characteristics/behavior may also have an impact on parenting behavior. This perspective implies that individual differences in maternal sensitivity and scaffolding may be accounted for by
children’s different levels of EF skills (Fay-Stammbach et al., 2014). Children with poor EF skills may have difficulty maintaining focus on a given task, thus demanding more attention from their mothers (Belsky, Pasco Fearon, & Bell, 2007). The burden to engage such children in certain tasks may lead to intense parenting stress, and in turn may reduce mothers’ ability to provide high quality parenting, such as high levels of sensitivity or scaffolding. In contrast, children with better EF skills may elicit less parenting stress. Mothers experiencing low levels of stress could be more responsive to their child’s cues and supportive of the child’s autonomy. In turn, those children may develop better EF skills, and the increased EF skills may lead to better quality of parenting. Despite the theoretical support, the processes by which child EF and parenting mutually affect one another have rarely been explored. Only a few empirical studies have examined the transactional relations between maternal parenting, focusing on a sensitivity aspect of parenting, and children’s EF (e.g., Blair, 2013). Extending the prior work, in this study we aimed to examine whether maternal parenting quality including sensitivity and scaffolding and children’s EF are reciprocally related to each other across three time points during preschool years.

The current study

We examined the transactional relations between maternal parenting (i.e., maternal sensitivity and scaffolding) and children’s EF (i.e., inhibitory control and attention flexibility) during preschool years, from age 3 to 5. Two transactional models for inhibitory control and attention flexibility were estimated separately, as there have been findings supporting that inhibitory control and attention flexibility were distinct, separable components of EF (Willoughby, Holochwost, Blanton, & Blair, 2014). Across three time points, maternal
sensitivity, maternal scaffolding, child inhibitory control, and child attention flexibility were assessed. We hypothesized that there would be a lagged reciprocal relation between maternal parenting and child EF such that: 1) higher levels of maternal sensitivity and scaffolding would predict higher levels of subsequent child attention flexibility or inhibitory control; and 2) higher levels of child attention flexibility or inhibitory control would predict higher levels of subsequent maternal sensitivity and scaffolding.

Method

Participants

The sample was composed of 126 children (65 girls) and their mothers who participated in a longitudinal study that was designed to investigate how children develop cognitive and emotional regulation in the familial context. Participants were recruited in a large Midwestern city. For screening purposes, the Centers for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977) was administered to the mothers via phone in order to assess maternal depressive symptoms. Mothers were eligible if they a) were at or above 21 years; b) had a biological child at ages between 3 and 3.5 years; and c) had not been diagnosed with any psychiatric disorders other than depression, either with or without co-occurring anxiety. Children with any disorders or developmental delay were not eligible. Data were collected at three waves, when children were 3 (T1), 4 (T2), and 5 years old (T3). At T2 109 mother-child dyads (86.51% retention) were remained in the study and 85 (67.46% retention) at T3. At T1, children were 3.23 years ($SD = .19$). Most of the mothers were White (65.4%), 30.7% were Black, and 3.9% were other ethnicity. At the time of enrollment, mothers’ age ranged from 21 to 47 years ($M = 31.02$; $SD =$
5.39) and 51.6% had a Bachelor’s or graduate degree. At T1, 45.31% of the mothers showed elevated depressive symptoms, as they received a score of 16 or above.

Among 126 mother-child dyads, 5.26% of the responses at T1 were missing, 18.92% at T2, and 34.44% at T3. Data were missing completely at random, Little’s MCAR ($\chi^2 = 341.97, p = .20$). Full information maximum likelihood was used to handle missing data.

**Procedures and Measures**

The mother-child dyads participated in a 2.5 to 3.5 hours of a laboratory visit at T1, T2, and T3. The mother-child dyads were asked to complete multiple mother-child interaction tasks at each time point. In addition, children were administered a set of EF tasks measuring two components of EF, inhibitory control and attention flexibility, during the laboratory visit at all the three waves.

**Maternal sensitivity.** The Block task (Egeland & Hiester, 1995) was used to measure maternal sensitivity. The child was asked to build models to replicate a 3-dimensional shape for five minutes, while the mother was instructed to assist the child in completing the task but not to complete the task for the child. Maternal behavior was video-recorded for the coding process. Maternal sensitivity was coded using a coding system adopted from NICHD Early Child Care Research (NICHD Early Child Care Research Network protocol, 1999b). Multiple indicators of maternal sensitivity were observed, including supportive presence, over-control (reversed), negative emotion arousal (reversed) and critical (reversed). Supportive presence indicated mother’s expression of positive regard and/or emotional support to the child. Over-control was assessed by the degree to which the mother executed control over the child’s efforts to complete the task in an intrusive manner. Negative emotion arousal indicated the mother’s verbal or
nonverbal expressions of negative emotion towards the child. *Critical* included the mother’s verbal or nonverbal disapproval towards the child. The duration of which the mother appeared *Critical* was coded. *Supportive presence, over-control, and negative emotion arousal* were scored on a 7-point scale, “1 = the mother completely failed to show the behavior” to “7 = the mother showed the behavior consistently during the whole session in a skillful manner.” For each behavior, approximately 25% of the mothers were double-coded and inter-coder reliability for each behavior ranged from .92 to .98. Based on the high correlations ($r_s = .44 \sim .72, ps < .01$ across T1, T2, and T3) between *critical* and *negative emotion arousal*, scores of these two variables were standardized and summed into one variable, *critical/negative emotion arousal*. Finally, the three behaviors, *supportive presence, over-control* (reversed), and *critical-negative emotion arousal* (reversed) were $z$-scored and combined into a composite of maternal sensitivity. Internal consistency among the three behavioral indicators was good, ranging from .72 to .77 across T1, T2, and T3.

**Maternal scaffolding.** The same Block task was used to assess maternal scaffolding. Several indicators of maternal scaffolding were observed, including *approval* (e.g., the mother praised the child), *problem-solving* (e.g., the mother explained how the activity would work), *engagement* (e.g., the mother’s effort to engage the child in the task), and *quality of instruction* (e.g., the mother broke a task into several parts and gave step-by-step instructions). Maternal scaffolding was coded based on a coding system adapted from Hammond et al.’s (2012) and NICHD Early Child Care Research (NICHD Early Child Care Research Network protocol, 1999b). For *approval* and *problem-solving*, the duration of the behavior displayed were coded. For *quality of instruction* and *engagement*, overall evaluation of each behavior was coded on a 7-
point scale, “1 = the mother never showed the behavior throughout the session” to “7 = the mother displayed the behavior throughout the whole session in an appropriate manner.” One fourth of the mothers were double-coded and inter-coder reliability for the behaviors ranged from .72 to .97. Based on the bivariate correlations ($r = .26 \sim .60, ps < .01$ across T1, T2, and T3) and conceptual similarities between quality of instruction and problem-solving, $z$-scores of these two behaviors were combined into one variable “quality of instruction/problem-solving.” For further analysis, three behavioral indicators, approval, engagement and quality of instruction/problem-solving, were standardized and summed into a composite of maternal scaffolding for each time point. Internal consistency among the three indicators ranged from .71 to .77 across T1, T2, and T3.

**Child inhibitory control.** At T1, the *Day/night task* (Gerstadt, Hong, & Diamond, 1994) and the *Bear and Dragon task* (Murray & Kochanska, 2002) were administered to measure children’s inhibitory control. In the *Day/night task*, the child was instructed to point at the picture of the day sky when the experimenter said “night,” and the picture of night sky when the experimenter said “day.” The child’s performance was scored “0 = incorrect,” “1 = incorrect on the first attempt but self-corrected,” and “2 = correct on the first attempt.” Accuracy scores were created by summing scores of each trial. For the *Bear and Dragon task*, the child was instructed to follow the Bear puppet’s commands (e.g., “Touch your nose”), but not those of Dragon puppet. Each trial was scored as “0 = fails to move/wrong movement,” “1 = performs a partial movement,” and “2 = performs full, correct movement.” Scores were calculated only for the trials that were commanded by the dragon puppet. A total score of each child was created by summing the scores of the Dragon command trials.
When children were 4 years old (T2), the Day/night and the Shape tasks (Kochanska, Murry, & Coy, 1997) were administered. The Day/night was conducted and scored in the same way the task was done at T1. The Shape task consisted of 24 pictures on which geometric shapes or animals were presented. In each picture, there were smaller shapes inside of a larger shape (e.g., a drawing of a large dog that contained smaller cats inside). The child was first primed to name the large shapes, and then instructed to name the small shapes when each picture was presented. For a set of 12 pictures, a large shape was consistent with smaller shapes (e.g., Small stars inside of a large star) and another 12 pictures contained large shapes that were inconsistent with smaller shapes (e.g., small stars in a large moon). Each trial was scored as “0 = incorrect response,” “1 = self-corrected response,” and “2 = correct response.” The scores from inconsistent trials were summed into to a total score of each child.

At T3, the Day/Night/Snow/Grass task (Kochanska et al., 2007), an advanced version of Day/night, was administered. Another rule was added to the Day/night task. The child was asked to point to the picture of grass when the experimenter said “snow” but the picture of grass when told “snow.” The full performance was scored as “0 = incorrect,” “1 = incorrect on the first attempt but self-corrected,” and “2 = correct on the first attempt.” Total scores were created by summing the score of each trial. A total score of each child was created by summing scores of inconsistent trials.

**Child attention flexibility.** The Happy faces version of the Dimensional Changing Card Sort task: Emotional Faces version (Qu & Zelazo, 2007) was used to assess children’s attention flexibility at T1. This task consisted of two sets of cards: One set with child’s emotional faces, either a happy or neutral face (e.g., girl’s happy face, boy’s neutral face) and another set with
child’s and adult’ happy faces (e.g., girl’s or boy’s happy face, female or male adult’s happy face). The child was asked to sort the first set of cards by gender (girls versus boys). After the trials with a “gender” dimension, the child was asked to sort the second set of cards by ages (children versus grow-ups). The task consisted of three sets: two demonstration, 6 pre-switch (sorting by child’s gender) and 6 post-switch trials (sorting by ages). Each trial was scored “0 = incorrect response” and “1 = correct response.” Accuracy scores were calculated by adding the number of correct responses on the post-switch trial. For each post-switch trial, reaction time was recorded. Reaction time scores were reveral thus, higher scores on reaction time indicated a better ability. A total score of each child was created based on accuracy and reaction time scores (Zelazo et al., 2013). One purpose of adding reaction time scores to accuracy scores is that the distribution of the accuracy scores was negatively skewed. To correct the skewness, for those who were 100% accurate on all the post-switch trials, a reaction time score was added based on each child’s median reaction time. Both accuracy and reaction time scores were standardized before they were combined into a composite score.

At T2, the Dimensional Changing Card Sort task: Border version (DCCS: Border, Zelazo, 2006) was used to measure children’s attention flexibility. This is an advanced version of the Standardized DCCS (Zelazo et al., 2003) in which children were asked to sort a set of cards by color and then shape. In the Border version, another dimension, “border,” was added. The DCCS Border was composed of a set of cards on which a drawing of a boat and rabbit was presented. The color of a boat and a rabbit is either blue or red (e.g., blue rabbit and red boat). A border was shown on half of the cards (e.g., blue rabbit with a border and red boat without a border). The child was asked to sort the cards by color when the border was presented on the
card. In contrast, the child was instructed to sort the cards by shape when there was no border on the card. The child was administered 2 demonstration trials and 12 scored trials. Each trial was scored “0 = incorrect response” and “1 = correct response”. A total score of each child was calculated from scores of the post-switch trials. The distribution of total scores showed a normal distribution, thus not requiring to create adjusted scores based on a reaction time.

At T3, children were administered the computerized Dimensional Changing Card Sort task (Zelazo et al., 2013). This measure consisted of 4 sets: 4 practice, 5 pre-switch, 5 post-switch, and 30 mixed trials. A set of cards were presented on the computer screen, and the child was asked to sort the card by one of the dimensions, either color or shape. A total score was calculated based on the number of correct responses and a reaction time. The total score was adjusted based on children’s age, and this score was used as a final score.

Covariates. Maternal depressive symptoms and education, and child sex were included as covariates. As mothers with elevated depressive symptoms were over-sampled, maternal depressive symptoms were included as time-varying covariates. This is based on prior work in which mothers tend to show changes in their depressive symptoms over time (Campbell, Masteic, von Stauffenberg, Mohan, & Kirchner, 2007). Maternal depressive symptoms were self-reported on the Beck Depression Inventory (BDI-II; Beck, Steer, Ball, & Ranieri, 1996) across three waves. Maternal depressive symptoms was controlled for maternal sensitivity and scaffolding at each time point. Maternal education and child sex assessed at T1 were included as time-invariant covariates, as maternal education levels were likely to remain stable over time. For maternal education, the highest level of education mothers received was self-reported by
mothers. It was coded “1 = less than grade school” to “8 = graduate degree.” Child sex was
coded “Female = 0” and “Male = 1.”

Analytic plans

Data were analyzed using the Mplus 7.4 (Muthén & Muthén, 1998–2015). Two
autoregressive and cross-lagged models were estimated for children’s inhibitory and attention
flexibility control, respectively. As presented in Figure 4.1, the first transactional model of
parenting and children’s inhibitory control included three repeated measured variables, maternal
sensitivity, maternal scaffolding, and child inhibitory control, across three time points. In the
second transactional model, maternal sensitivity, three repeated constructs of maternal
scaffolding, and child attention flexibility were included across three waves. Residuals of
dependent variables assessed at the same time point were allowed to be correlated. After the
whole model was estimated, insignificant paths and correlations were removed. Bootstrapped
standard errors were computed using 5000 draws in order to obtain confidence intervals for each
path coefficient. For each path predicting child EF skills from maternal parenting, child sex and
maternal education were included as covariates across three waves. Maternal depressive
symptoms assessed at each wave were regressed on maternal sensitivity and scaffolding at each
wave. Maternal depressive symptoms were used as time-varying covariates, because level of
depressive symptoms may change over time.

Results

Descriptive statistics and bivariate correlations

Descriptive statistics and bivariate correlations of study variables are presented in Table
4.1. Overall, maternal sensitivity was positively correlated with maternal scaffolding across three
waves. In general, higher maternal sensitivity and scaffolding were correlated with lower maternal depressive symptoms. Maternal sensitivity at T1, T2, and T3 tended to show positive correlations with children’s inhibitory control, especially assessed at T2 and T3. Maternal sensitivity scores at T1 and T3 had positive correlations with attention flexibility at T3. Maternal scaffolding at T1 and T2 showed positive correlations with attention flexibility at T3. At each time point, child inhibitory control was not correlated with attention flexibility.

**Transactional Relations of Maternal Sensitivity and Scaffolding with Child Inhibitory Control across Age 3, 4, and 5**

The final model is shown in Figure 4.2. Model fit was acceptable, $\chi^2(19) = 30.43$, $p = .05$; CFI = 0.89; RMSEA = 0.08, 90% CI [.01, .13]. Maternal sensitivity at T1 predicted child inhibitory control at T2 ($B = .12$, $SE = .05$, 95% CI [.03, .20]). Maternal sensitivity at T2 was a significant predictive of child inhibitory control at T3 ($B = .11$, $SE = .70$, 95% CI [.00, .23]), while child inhibitory control at T2 was positively associated with maternal sensitivity at age T3 ($B = .87$, $SE = .31$, 95% CI [.35, 1.38]). Transactional relations were found for maternal sensitivity and inhibitory control. Regarding the covariates, among three maternal depressive symptoms variables, only maternal depressive symptoms at T2 was a significant predictor for maternal sensitivity at T2 ($B = .03$, $SE = .02$, 95% CI [.01, .06], $\beta = .16$, $p = .03$).

**Transactional Relations of Maternal Sensitivity and Scaffolding with Child Attention Flexibility across Age 3, 4, and 5**

Model fit for the final model (Figure 4.3) was acceptable, $\chi^2(19) = 24.61$, $p = .04$; CFI = 0.915; RMSEA = 0.08, 90% CI [.02, .14]. The adjusted model presents that maternal scaffolding at T2 predicted children’s attention flexibility at T3 ($B = 2.28$, $SE = 1.35$, 95% CI [.60, 4.49]),
while children’s attention flexibility at T2 was associated with maternal scaffolding at T3 (B = .46, SE = .17, 95% CI [.18, .75]). Therefore, maternal scaffolding and children’s attention flexibility are mutually associated with each other across children’s age 4 and 5. For the covariates, high levels of maternal education were associated with high levels of maternal sensitivity at T2 ((B = .55, SE = .23, 95% CI [.18, .93], β = .35) and T3 ((B = .25, SE = .15, 95% CI [.01, .50], β = .25), respectively.

Discussion

The goal of the current study was to examine the transactional relations between maternal parenting (sensitivity and scaffolding) and children’s EF development (inhibitory control and attention flexibility) during preschool years. We found the transactional relations between maternal sensitivity and children’s inhibitory control during the preschool period. In addition, maternal scaffolding exhibited transactional relations with children’s attention flexibility over time. Our findings support the transactional model of child development in EF. The bidirectional patterns were significant only between ages 4 and 5, not between ages 3 and 4. These findings increase our understanding of how maternal parenting and children’s EF are reciprocally related over time. Furthermore, our findings suggest that maternal sensitivity and scaffolding have distinctive roles in the development of children’s EF during early childhood.

Maternal sensitivity at age 3 was predictive of children’s inhibitory control at age 4, after controlling for stability in maternal sensitivity and child inhibitory control over time. This association between earlier maternal sensitivity and later child inhibitory control still existed a year later. Therefore, these findings support our hypothesis. Our findings also support prior evidence for the central role of maternal sensitivity in the development of children’s EF (Bernier
et al., 2010; Hughes & Ensor, 2009; Kok et al., 2004). The result could suggest that sensitive mothers are available to their children at the time of distress, supportive for their children’s autonomy, and less critical about their children’s performance (Lovejoy, Graczyk, O'Hare, & Neuman, 2000; Reck et al., 2004). Such maternal behavior may create an environment where children freely learn to suppress undesirable, involuntary responses and activate desirable, voluntary ones, when they face circumstances in which these skills are required. It is also important to note that even after controlling for maternal education and depressive symptoms, maternal sensitivity was still a significant predictor for children’s inhibitory control over time. Thus, maternal sensitive parenting may serve as a more important role in children’s EF development, compared to maternal demographic characteristics, a finding that is consistent with previous studies (e.g., Cuevas et al., 2014).

Children’s inhibitory control at age 4 predicted maternal sensitivity at age 5, after controlling for the stability of maternal sensitivity and child inhibitory control constructs over time. Thus, our hypothesis of the bidirectional association between maternal sensitivity and inhibitory control was supported. The bidirectional associations are consistent with prior work in which higher maternal sensitivity at age 3 was associated with higher children’s EF at age 5 and vice versa (Blair et al., 2013). Children with low inhibitory skills may have difficulty holding undesirable, dominant responses and activating desirable, non-dominant responses. Mothers of those children may experience stress and frustration during mother-child interactions, when children cannot exercise appropriate impulse control. This stressful interaction may reduce maternal emotional availability that can be attuned to children’s needs. In contrast, children who are able to control their attention may enhance the quality of mother-child interactions (Belsky et
Mothers of children with high inhibitory control may face relatively less stressors related to parenting, as taking care of such children requires less maternal intervention. The positive dynamic between children and mothers may facilitate mothers to maintain high levels of sensitivity to their children over time, which in turn contributes to the development of children’s inhibitory control.

Maternal scaffolding at age 4 predicted children’s attention flexibility at age 5. This finding is in line with prior work showing that maternal scaffolding has prospective associations with children’s EF (Matte-Gagné & Bernier 2011; Hughes & Ensor, 2009). The link between maternal scaffolding and attention flexibility can be explained in light of the context of attention flexibility tasks. Two important aspects of attention flexibility are goal setting and overcoming a previously relevant rule (Cragg & Chevalier, 2012). In order for children to successfully complete attention flexibility tasks, they need to develop a hierarchical rule structure that incorporates the relevant rules (Zelazo et al., 2003). After the goal setting, children have to persist against proactive interference from the previous two dimensions, color and shape, in order to sort cards by border. Our result reveals that mothers who provide effective instructions and keep the child engaged in a problem-solving context, enable children to develop organizing skills to set a higher order rule integrating multiple rules and persistently overcome interferences.

Children’s higher attention flexibility at age 4 predicted higher maternal scaffolding at 5. Thus there was a transactional relation between maternal scaffolding and children’s attention flexibility, which supports our hypothesis. The findings mirror previous work suggesting that mothers may modify their behavior in accordance with children’s developmental outcomes. For example, Lugo-gil et al. (2008) found that when children displayed higher cognitive abilities,
mothers responded to them with higher quality of maternal teaching. Our finding reveals that children who can overcome interferences and keep their attention on a current task may elicit mothers’ frequent approval of children’s achievement and promote the quality of their problem-solving instructions. Moreover, those children may keep mothers to be consistently engaged with them in order to complete a problem-solving task. It is important to note that in the present study, the transactional relations appeared only between ages 4 and 5, but not between ages 3 and 4. This implies that the bidirectional association between maternal scaffolding and children’s attention flexibility are gradually manifested during the late preschool period, rather than the early preschool period when attention flexibility has just emerged.

Findings of the current study should be interpreted in light of several limitations. Our sample included relatively highly educated mothers. Additionally, approximately 43% of the mothers showed elevated depressive symptoms, as mothers with moderate to severe depressive symptoms were over-sampled. The use of samples from a more diverse background in terms of family socio-economic status may increase the generalizability of research findings. Another potential limitation of our study is that our measures of children’s EF did not tap into children’s working memory. Working memory is a separate component of EF but at the same time it is closely related with inhibitory control and attention flexibility (Lehto Juujärvi, Kooistra, & Pulkkine, 2003; Lerner & Lonigan, 2014). Given the interrelations among working memory, inhibitory control, and attention flexibility, future studies may examine whether maternal parenting (maternal sensitivity and scaffolding) and children’s working memory reciprocally predict each other. In addition, we examined maternal parenting behaviors in relation to children’s EF. However, other family members’ behavior such as paternal parenting may also
predict children’s EF development (e.g., Meuwissen & Carlson, 2015). Lastly, maternal
sensitivity and scaffolding were measured in the same context where children were asked to
complete a challenging task. There may be possible shared method variance between maternal
sensitivity and scaffolding. In regards to the context of the parenting measure, a challenging
context is considered appropriate to elicit maternal scaffolding, according to the definition of
scaffolding from early Vygotsky’s work (1978). However, mothers may exhibit different levels
of sensitivity in a free-play and a challenging context (Ciciolla et al., 2013).

Although the present study has several limitations, there are also strengths. One strength
is that we examined the relative contributions of maternal sensitivity and scaffolding to the
development of children’s EF by considering the two maternal parenting behaviors in one model.
The majority of previous work tended to include either sensitivity or scaffolding (e.g., Kok et al.,
2014). Our study design allowed us to investigate a unique role of maternal sensitivity and
scaffolding in the development of children’s EF. Moreover, we included inhibitory control and
attention flexibility in separate models. It enabled us to examine how maternal sensitivity and
scaffolding were associated with different EF components. Although EF as a composite has been
studied in relation to contextual influences, less has been known about contextual predictors of
each component. Our study extends our current knowledge by showing that different
components of children’s EF skills are facilitated by different parenting behaviors.

Another strength of the present study is that the data is rich, including observational
measures across three time points. Maternal sensitivity and scaffolding were assessed from
observations on mother-child interactions. Given that depressed mothers may report their
parenting behavior with bias (Parent et al., 2014), the use of an observational method may have
reduced a possible bias from those mothers. In addition, we used both micro and global coding systems. A micro coding system allowed us to focus on the duration of a certain maternal behavior, while with a global coding system we were able to capture the quality of a certain behavior. The current study is a longitudinal study including three waves. The inclusion of more than two waves enabled us to capture the different patterns of the bidirectional relations of maternal parenting and children’s EF in the earlier preschool period and later.

Our study also has implications for intervention researchers, practitioners, and parents. Children who were exposed to early adverse environment, such as lack of maternal sensitivity and scaffolding, may be at risk for developing inadequate levels of EF skills. Intervention programs designed to increase children’s EF skills may need to consider both maternal sensitivity and scaffolding. The facilitation of maternal sensitivity and scaffolding towards young children may help children develop different components of EF. As our findings reveal the bidirectional associations between maternal parenting and child EF, the facilitation of children’s EF skills may in turn elicit positive maternal parenting, such as high sensitivity and scaffolding.

In conclusion, the current study found that maternal sensitivity and scaffolding make unique contributions to the development of child EF during early childhood. More importantly, differing levels of children’s EF skills elicit individual differences in maternal sensitivity and scaffolding. Children may play an active role constructing their environment, especially maternal parenting behavior, and their active role may gradually become salient, as they enter the later preschool period.
### Table 4.1: Descriptive Statistics and Bivariate Correlations

|                  | 1.     | 2.   | 3.   | 4.   | 5.   | 6.   | 7.   | 8.   | 9.   | 10.  | 11.  | 12.  | 13.  | 14.  | 15.  |
|------------------|--------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 1. M Sensitivity T1 |        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 2. M Sensitivity T2 |        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 3. M Sensitivity T3 |        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 4. M Scaffolding T1 |        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 5. M Scaffolding T2 |        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 6. M Scaffolding T3 |        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 7. M Depressive T1 |        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 8. M Depressive T2 |        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 9. M Depressive T3 |        |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 10. C Inhibitory Control T1 | |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 11. C Inhibitory Control T2 | |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 12. C Inhibitory Control T3 | |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 13. C Attention Flexibility T1 | |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

*Note: The table includes bivariate correlations between different variables at various time points. The values indicate the strength and direction of the relationship. The symbols * and ** denote statistical significance at the 0.05 and 0.01 levels, respectively. The symbol † denotes a trend towards significance. The values in the table range from -.74 to .88.*
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| N                | 123   | 107   | 84    | 123   | 107   | 84    | 126   | 109   | 126   | 108   | 98    | 84    | 119   | 94    | 76    |
| Mean             | 0.05  | 0.02  | 0.05  | -0.01 | 0.01  | 15.56 | 11.30 | 10.24 | -0.01 | 0.00  | 0.00  | 6.78  | 6.82  | 106.09|
| SD               | 2.47  | 2.37  | 2.39  | 2.39  | 2.46  | 12.87 | 10.32 | 8.78  | 0.75  | 0.77  | 1.00  | 3.90  | 1.97  | 23.06 |
| Min.             | -10.85| -8.85 | -7.56 | -7.15 | -8.07 | -6.63 | 0.00  | 0.00  | 0.00  | -1.7  | -2.76 | -4.10 | 0.00  | 0.00  | 75.05 |
| Max.             | 8.00  | 2.32  | 2.31  | 6.03  | 4.60  | 5.06  | 54.00 | 52.00 | 34.00 | 1.43  | 0.80  | 0.75  | 11.07 | 12.00 | 144.13|

**Note.** T1 = 3 years of child’s age; T2 = age 4; T3 = age 5; M = mother; C = child; Depressive = maternal Depressive symptoms.

**p < .01; *p < .05; †p < .10
Figure 4. 1. Autoregressive and cross-lagged models for maternal sensitivity, maternal scaffolding, child inhibitory control, and child attention flexibility.

Note. For each regressive path predicting children’s EF from maternal sensitivity and scaffolding, child sex and maternal education were included in the analysis as covariates but not presented in Figure 1. Child inhibitory control and attention flexibility were included in the model separately. The model included within-time correlations between residuals of dependent variables but the correlations are not presented in the figure.
Figure 4. 2. Adjusted Model 1: Standardized path coefficients for significant paths of the child inhibitory control model.

Note. Only significant autoregressive and cross-lagged paths were included in the model; a significant covariate was included in the model; correlations between residuals of dependent variables were not presented in the figure; MSEN = maternal sensitivity; MSCF = maternal scaffolding; IC = child inhibitory control; MDEP = maternal depressive symptoms.

**p < .01; *p < .05; †p < .10.
Figure 4. 3. Adjusted Model 2: Standardized path coefficients for significant paths of the child attention flexibility model.

Note. Only significant autoregressive and cross-lagged paths were included in the model; a significant covariate was included in the model; correlations between residuals of dependent variables were not presented in the figure; MSEN = maternal sensitivity; MSCF = maternal scaffolding; AF = child attention flexibility.

**p < .01; *p < .05; †p < .10.
Chapter 5: Conclusions

Findings presented in the current dissertation enhance our understanding of the processes by which children develop EF within a familial context during early and middle childhood. The examination of the processes is important because early adaptive EF promotes future functioning such as socio-emotional and academic outcomes (Becker et al., 2014; Fitzpatrick et al., 2014). Recognizing the critical role of a familial context to the development of EF, the present dissertation reveals how multiple familial factors work together to predict child EF outcomes and the mechanisms linking a familial factor to EF outcomes. Furthermore, it suggests how children act as an agent to create their rearing environment.

Considering all the three studies collectively, findings of the studies support a theoretical framework that children’s EF development is susceptible to the influence of a familial environment. The results indicate that overall, an adverse rearing environment with low family SES, maternal severe depressive symptoms, and the lack of maternal sensitivity or scaffolding may predict poor EF outcomes, specifically in regard to inhibitory control and attention flexibility. Study 1 and 2 suggest the contributions of maternal characteristics, especially maternal mental health. Study 1 identified maternal poor mental health as a risk factor. In line with this finding, Study 2 also revealed the role of maternal mental health, in particular maternal depressive symptoms early in child’s
life, as a risk for maladaptive EF skills. Although there was not a direct association between maternal depressive symptoms in infancy and school age children’s EF, there was an indirect association via low maternal sensitivity in the preschool period.

Studies 2 and 3 consistently suggest the important role of maternal parenting in the preschool period in EF outcomes. Maternal sensitivity was a significant predictor for the development of EF. More importantly, lack of maternal sensitivity was found to serve as a mechanism linking early maternal depressive symptoms and poor child EF outcomes. The importance of maternal sensitivity is in accordance with findings of Study 3. Study 3 presented the unique role of maternal sensitivity and scaffolding in predicting EF skills. One significant implication is that prospective associations between maternal sensitivity and child inhibitory control provide additional empirical evidence for the attachment theory that emphasizes mothers’ warm and supportive attitudes towards children. Moreover, the social interaction perspective of child mental development is supported by a finding of the relation between maternal scaffolding and child attention flexibility.

In addition to maternal contributions of child EF development, Study 1 and 3 revealed children’s own role in developing their EF skills. Children may directly or indirectly contribute to the development of their EF. Study 3 supported a theoretical framework for the transactional relations between maternal parenting and child EF development. Children’s differing EF skills elicited individual differences in maternal parenting both in terms of sensitivity and scaffolding. At the same time, mothers of children with better EF may flexibly adjust their parenting behavior to become more
supportive for children’s EF development with increasing levels of sensitivity or scaffolding. In this way children may directly contribute to shaping their rearing environment. Results of Study 1 revealed that children’s disposition to exhibit positive or negative emotion might be associated with their EF development in a certain context. When children frequently display joy or excitement, this may buffer the adverse effect of the environment, in particular for children who are exposed to multiple familial risks. Similarly, children who are not emotionally reactive can develop adaptive EF when they live in an unsupportive environment. Although children’s emotionality predicted EF only in a certain condition, it may be still meaningful to add an emotionality component to pre/interventions designed to enhance children’s EF. The consideration of the protective role of emotionality may be informative when identifying a highest risk group for exhibiting poor EF skills. Broadly, findings of the interactions between maternal parenting and children’s emotionality are in line with the bioecological model that explains the interplay of children’s individual characteristics and their developmental outcomes.

**Limitations and Strengths**

The three studies presented in this dissertation need to be interpreted in light of certain limitations. First, for the sample of Study 1 and 3, participants were relatively highly educated mothers and only a few of them were below the federal poverty line. In addition, approximately 40% of the mothers exhibited elevated depressive symptoms at the time of enrollment. These characteristics may limit the generalizability of the results of Study 1 and 3. Second, working memory was not included in our measurement of
child EF in Study 1 and 3. Working memory is one of the EF components and is related to other components of EF, such as inhibitory control and attention flexibility (Lehto Juujärvi, Kooistra, & Pulkkine, 2003; Lerner & Lonigan, 2014). The inclusion of working memory may provide a more comprehensive picture of how ecological factors are differently associated with each EF component. However, Study 2 reduces this concern by including planning skills that need the other three basic components to function together. Third, in regard to measures of maternal mental health (e.g., depressive symptoms). Across three papers, maternal characteristics and behaviors were considered as contributing factors to the development of child EF. However, other family members’ characteristics or behavior (e.g., paternal parenting) may also influence child EF outcomes (Meuwissen & Carlson, 2015).

The three studies presented in the current dissertation also have strengths that increased the significance of findings. The observational method used to measure maternal parenting behavior reduces bias associated with self-ratings of maternal parenting behavior. In addition, all three studies utilized a multi-method and multi-informant assessment approach. The reliance on multiple data sources help reduce possible shared method variance and increase validity of the studies. Next, children’s EF development was considered within a relatively wide timeframe, from preschool to elementary school years. A number of prior work has focused on EF development at earlier ages in relation to familial environmental influences. The examination of EF development during elementary school years may add empirical evidence for how a familial context interferes with or facilitates EF development through middle childhood.
Another benefit of using longitudinal data, in which EF was assessed across multiple waves, is that findings from such data may strengthen a theoretical framework for changes in EF skills with ages.

**Implications and Future Directions**

Studies presented in the current dissertation have implications for prevention and intervention programs. Overall findings across the three studies suggest the importance of creating a supportive rearing environment to facilitate the development of child EF. One important implication is that maternal parenting behavior can be intervened with to promote child EF development, especially among mothers with poor mental health. Furthermore, the current dissertation emphasizes that child characteristics (e.g., expression of a large amount of positive emotion) can play a role as a protective factor, thus these can be considered when designing pre/interventions aimed at enhancing child EF skills.

There are several suggests for future studies. Studies of the present dissertation focused mainly on maternal factors in relation to child EF development. Since fathers play a unique role in child development, paternal characteristics need to be considered a predictor for child EF development. Given that children spend a significant amount of time in childcare or school, it is possible that childcare or school environments are related to children’s EF development as well as a familial environment. Moreover, communities or neighborhood are another context that may affect child development. Consideration of how a familial environment, a childcare/school setting, and neighborhood/community would jointly affect children’s EF development can provide a more complete picture of
how children develop under interactions of multiple rearing environments. Lastly, it is recent that children’s cognitive or socio-emotional abilities have been regarded to elicit certain parenting behavior. Extending findings of the current dissertation, there is a need to investigate whether children’s EF skills would contribute to eliciting other caregivers’ behavior, such as fathers and teachers.
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