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Associations between parenting behavior and executive function among preschool-aged children born very preterm

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Abstract

The objective of the current study was to determine whether three domains of observed parenting behavior were associated with executive function in preschool-aged children born very preterm (<30 completed weeks' gestation). Executive function of 41 preschool-aged (3.5 to 4.5 years) children was assessed using a standardized protocol (gift delay) and by parent-report (Behavior Rating Inventory of Executive Function-Preschool, BRIEF-P). Observational protocols were used to determine parental sensitivity, harsh intrusiveness, and dyadic mutuality in a semi-structured play task. Parental sensitivity and mutuality were rated as higher, and harsh intrusiveness was rated as lower for children high in executive function on the gift delay task. Similarly, correlations between the three parenting scales and the BRIEF-P Global Executive Composite t-score were in the expected direction though not always statistically significant. Findings suggest that very preterm children who experienced sensitive parenting and were rated as having greater mutuality in their interactions with their caregivers scored higher on executive function tasks. These findings add to the growing literature on the key role that sensitive parenting and mutually responsive, harmonious interactions between caregivers and children may play in the development of executive function in very preterm children.

Keywords

very preterm children; executive function; parenting behavior

Recent improvements in the survival rates of children born very and extremely preterm have been accompanied by growing concerns regarding their long-term developmental outcomes. Children born very preterm are at increased risk for neurodevelopmental deficits, including poor executive function (Anderson & Doyle, 2004; Garon, Bryson, & Smith, 2008; Taylor & Clark, 2017). Executive function (EF) refers to a set of neurocognitive processes that underlie goal-directed behaviors, including inhibition, working memory, self-regulation, planning, and organization (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000). These higher-order mental processes are needed by young children to meet new

challenges, resist temptation and distractions, and to reason and solve problems (Diamond, 2013).

As early as infancy and toddlerhood, children born preterm show impairments in EF including inhibition, spatial working memory, and emotional regulation (DeLuca & Leventer, 2008; Clark, Woodward, Horwood, & Moor, 2008; Rose, Feldman, Jankowski, & Van Rossem, 2011; Ritter, Nelle, Perrig, Steinlin, & Everts, 2013). By school-age, very preterm children are characterized by a range of deficits in EF, including difficulties in reasoning ability, working memory, planning and problem solving (Anderson & Doyle, 2004). The preschool years are a period of rapid growth in EF ability (for a review, see Garon et al., 2008). Between the ages of 3-5, children make significant progress in their understanding of self and the development of goal-directed behaviors (Garon et al., 2008). In addition, there is evidence of individual differences in EF that arise among preschool-aged children that have implications for child functioning across multiple domains (Müller, Liebermann-Finestone, Carpendale, Hammond, & Bibok, 2012). Identifying factors in the preschool period related to supporting children's EF allows for the development of targeted interventions before children transition to formal schooling given the significant literature demonstrating that EF and academic achievement are closely intertwined (Best, Miller, & Naglieri, 2011).

Across studies, social and environmental factors are linked to EF with extensive evidence demonstrating that childhood experience has a substantial impact on brain development (Shonkoff et al., 2011). A number of recent reports document that children's EF is associated with families' socioeconomic status (SES), including parental education and income (Hackman, Gallop, Evans, & Farah, 2015), such that differences were noted in children as young as 6-14 months of age (Lipina, Martelli, Vuelta, & Colombo, 2005) and as a function of family SES (Raver, Blair, & Willoughby, 2013). Emerging research highlights the importance of social interactions in the development of EF among preterm children, such that favorable environmental experiences, especially those embedded within early caregiving relationships, have a positive impact on the development of prefrontal brain systems linked with executive function (e.g., Smith et al., 1996; Landry, Smith, Swank, Assel, & Vellet, 2001; Assel, Landry, Swank, Smith, & Steelman, 2003; Clark, Woodward, Horwood, & Moor 2008; Lowe, Erickson, MacLean, Duvall, Ohls, & Duncan, 2014; Camerota, Willoughby, Cox, & Greenberg, 2015; Treyvaud et al., 2015). Taken together, these studies suggest that parenting and the quality of the parent-child relationship are important for children's EF among preterm children.

Much of this early research focusing on the relations between EF and parenting on preterm children were with heterogeneous samples of children born preterm (< 36 weeks gestation), many of whom have very modest cognitive deficits. Less research has examined the role of parenting to EF in children born very preterm who are much more likely to have developmental impairment (e.g., Clark et al., 2008; Treyvaud et al., 2015). Whether early parenting behavior operates similarly for children who are biologically at-risk for adverse outcomes due to very and extremely preterm birth is not well understood (Tully, Arseneault, Caspi, Moffitt, & Morgan, 2004). As neonatal care improves and the boundaries of viability

expand to include extremely low gestational ages (< 28 weeks), it is important to identify factors that promote and support the early development of very preterm children.

Parenting behavior may play a particularly important role in the neurodevelopmental outcomes of children born very preterm given their increased risk for neurodevelopmental deficits (Landry et al., 2001; Poehlmann et al., 2012). Studies examining the associations between parenting and EF suggest that the sensitive caregiving behaviors may be related to higher levels of goal-directed behavior at age 4 years for children born very preterm (Assel et al., 2003) and better EF outcomes at school age (Treyvaud et al., 2015). Landry and colleagues (2001) reported that maternal responsiveness was an important contributor to the cognitive development of children born preterm, whereas others have found that sensitive and responsive mother-child interactions are associated with better self-regulation, improved joint attention, and fewer behavior problems in children born preterm (Clark et al., 2008). In contrast, parents characterized as harsh and controlling emphasize children's compliance and the achievement of particular goals. Clark & Woodward (2008) reported that higher levels of intrusive parenting were related to lower EF at school age for children born very preterm. Although limited, the existing literature demonstrates the buffering potential of sensitive parenting for children with biological risk (Kok et al., 2014).

Furthermore, much of the current literature examining the relations between parenting and EF has focused on two pivotal aspects of parenting: parental sensitivity and harsh intrusiveness (Cox & Harter, 2003; Grolnick, Gurland, DeCoursey, & Jacob, 2002). Parent sensitivity is the ability to recognize and respond both effectively and promptly to the distress and needs of one's child (Cox & Harter, 2003). In so doing, the parent or caregiver helps the child develop his or her own self-regulation by responding to the child's distress with support and sensitivity (Cassidy, 2008). These studies, however, focused on the role of the caregiver to child functioning. Research on parenting has placed an increasing emphasis on bidirectional processes of parent-child interactions to more fully describe the dyadic quality of their interactions (Kim, Boldt, & Kochanska, 2015). Parent-child mutuality, a bidirectional, responsive quality of the parent-child interaction, has emerged as an important behavioral indicator of the quality of the parent-child relationship (Kochanska & Aksan, 2004; Maccoby, 1992), and child adjustment (Deater-Deckard & Petrill, 2004; Mize & Petit, 1997). Distinct from other domains of parenting, parent-child mutuality encompasses both the mother's and the child's responsivity to each other, their joint attention, and shared affect (Harrist & Waugh, 2002; Kochanska, 2002). Only one study to date has examined EF and the dyadic quality of parent-child interactions and found that a synchronous nature of interactions was related to optimal cognitive development of toddlers born very preterm (Treyvaud et al., 2009).

Despite these earlier findings, the aforementioned research examined parenting at early stages of development between infancy and toddlerhood (e.g., Camerota et al., 2015) or used limited definitions of sensitive parenting behaviors such as maternal scaffolding (e.g., Lowe et al., 2015) as compared to a more comprehensive estimation of parenting behavior. For example, although there is empirical and theoretical work supporting the key role of parenting during infancy and toddlerhood in laying the foundation for the development of executive function (Swingler, Perry, & Calkins, 2015), it is not yet well understood if

caregiving behavior during the preschool period has implications for children with heightened risk for EF impairments. Given that preschool age has been identified as a period of rapid growth in EF ability (Garon et al. 2008), supportive environments including sensitive and mutually responsive caregiving during this key developmental stage may be particularly salient for children born very preterm.

The Current Study

The present study extends the current literature in three key ways. First, we use observational assessments of multiple domains of parenting behavior (i.e., sensitivity, intrusiveness and dyadic mutuality) to develop a more comprehensive picture of the overall strategies employed by parents in their caregiving practices with very preterm children. Although previous studies provide evidence for an association between parenting and the development of EF, less is known about the role of mutual responsiveness and shared affect during parent-child interactions to the development of EF. Understanding aspects of parenting behavior that may be related to neurocognitive development in children born very preterm will further our understanding of which parenting behaviors could be the emphasis of early intervention. In the current study, we hypothesized that lower levels of observed caregiver sensitivity, higher caregiver intrusiveness and lower levels of parent-child mutuality would be related to deficits in EF. Second, as previously recommended (Isquith, Crawford, Espy, & Gioia, 2005), we use both performance-based measures and parents' ratings of EF. There are findings suggesting that parent-report alone may not be sufficient to develop a comprehensive picture of a child's EF; in the current study, we use both behavior rating scales and experimental measures of executive function (Ten Eycke & Dewey, 2016). Parents' interpretation of their child's behavior may vary depending on their own understanding of developmentally appropriate child behavior. In addition, there are findings suggesting performance-based and parent-rated measures of EF may assess different underlying mental constructs. A meta-analysis of 20 studies comparing performance based and parent-report measures of EF found that only 24% of the reported correlations were statistically significant (Tolpak et al., 2013). In the current study, we use the gift delay task to assess effortful control, which is posited as essential to children's EF because it reflects the child's ability to inhibit a prepotent behavioral response and to respond with a more appropriate, subdominant behavior (Cipriano & Stifter, 2010). Third, given previous findings suggesting that there may be key developmental stages during which vulnerable children may especially benefit from supportive environments (Camerota et al., 2015), we examine the role of parenting at preschool age when children experience a period of rapid growth in EF ability (Garon et al. 2008).

Methods

Participants

The sample consisted of 41 preschool-aged children who were born at <30 weeks' gestation and a parent. The participants were recruited from a roster of children who were neonatal intensive care unit (NICU) patients as singleton neonates in a large midwestern U.S. city and surrounding area. This was a cross-sectional pilot and feasibility study for a larger project

and did not include a term-born comparison group. Study eligibility requirements included the parent indicating that they “participated in the child’s mealtime activities” and lived in a household in which English was the primary language; children had to be between 3.5 and 4.5 years of age and able to engage in and communicate during play and eat snacks. Children who were blind, deaf, or tube fed were ineligible. More than 80% of contacted families with an eligible child participated in the study. The study was approved by the Nationwide Children’s Hospital institutional review board, and parents provided written informed consent.

Procedure and Measures

The study involved one three-hour visit during which children participated in standardized developmental assessments, and a parent (93% were the biological mother) completed questionnaires regarding family demographics and their child’s social-emotional development. Assessments took place between July 2013 and April 2014 in research space with capability for monitoring and digital recording. Information on the child’s date of birth, gestational age (weeks’ completed gestation), birthweight, and length of stay in the NICU were abstracted from the medical record. Executive function of the preschool-aged children was assessed, as described in the next section, using a standardized and well validated protocol (Gift Delay Task) and by parent-report (Behavior Rating Inventory of Executive Function-Preschool). In addition, parents and children were video recorded in a dyadic play activity. Parent-child interaction was assessed using a standard set of developmentally appropriate toys. A trained coder scored the recordings for caregiver behavior as further described in the methods.

Gift Delay Task.—The Gift Delay task assessed children’s performance in a situation requiring effortful control, an aspect of executive function (Kochanska, Murray, Jacques, Koenig, & Vandegest, 1996). For this task, the child was presented with a brightly colored gift bag that concealed a small gift for the child. The research assistant (RA) indicated that she “forgot the bow” and requested that the child wait and not touch the gift bag until she returned. After 3 minutes, the RA came back with the bow and the child was given the gift. The procedure was video recorded and scored by trained coders for whether the child could refrain from touching the gift bag (1=child opened gift, 2=child picks up gift bag, but doesn’t open, 3=child touches gift bag, 4=child doesn’t touch gift bag) and the number of seconds that elapsed until the child got out of his/her seat, if they did so. Consistent with prior reports (Kochanska, Coy, & Murray, 2001; Anderson, McNamara, Andridge, & Keim, 2015), we defined children as having “good executive function” if both raters indicated that the child stayed seated for at least 2 minutes and did not touch the gift bag at all during the full 3 minutes of the task. Children who did not meet this threshold served as the comparison. Two RAs demonstrated reliability in coding (intra-class correlation coefficients for touch score and latency to leaving seat were 0.90 and 0.99, respectively). Detailed information on the psychometric properties of the gift delay task have been previously published (Mulder, Hoofs, Verhagen, van der Veen, & Leseman, 2014).

Behavior Rating Inventory of Executive Functioning-Preschool Version (BRIEF-P).—The BRIEF-P was used as a parent report measure of children’s overall level

of executive function. The BRIEF-P (Isquith, Gioia, & Espy, 2004) is a standardized rating scale designed to measure the range of executive function in preschool-aged children and has demonstrated reliability and validity to detect EF deficits in children with risk factors or developmental disorder (Gioia, Isquith, Retzlaff, & Espy, 2002). The BRIEF-P consists of 63 statements about behaviors that may be problematic for some preschool-aged children (e.g., “Small events trigger big reactions”). For each statement, parents indicated if during the past 6 months the behavior was never, sometimes, or often a problem for their child. We calculated the global executive composite t-score (mean=50, standard deviation=10) which is age and sex-standardized. Higher scores indicate more difficulties with executive functioning and scores at or above 65 may indicate clinically significant difficulties (Gioia, Isquith, Guy, & Kenworthy, 2000). The BRIEF-P global executive composite score had excellent internal consistency in our sample (Cronbach’s alpha=.97). As recommended, we used chronologic age, rather than age corrected for prematurity, because all children were over the age of 3 years (Engle, 2004).

Parenting Behavior.—Observational protocols were used to determine parent sensitivity, harsh intrusiveness, and dyadic mutuality (Cox & Crnic, 2002) in a semi-structured play task. Caregivers were instructed to play with their child for 10 minutes using the contents of 2 boxes; one box contained a children’s story book (Cordoroy; Freeman, 1968) and the other contained Play-doh and craft tools (i.e., shapes, rollers). These interactions were recorded and later coded by a trained and reliable coder (first author) blind to other information about the families. Each parenting behavior was rated on a 7-point scale (where 1 = not at all characteristic and 7 = very characteristic). Behaviors assessed included the level of caregiver’s supportive presence, detachment, cognitive stimulation, intrusiveness, positive regard, and negative regard while interacting with the child. Sensitive parenting consisted of the mean of the reverse score for the detachment/disengagement scale and the scores for sensitivity/responsiveness, positive regard, and stimulation of cognitive development scales. Accordingly, higher scores on the sensitivity subscale reflect parenting behaviors that are child-centered, engaged, warm, and stimulating. Harsh intrusive parenting behavior consisted of the mean of the intrusiveness and negative regard scales. Accordingly, higher scores on the harsh intrusiveness subscale reflect parenting behaviors that are parent-centered, hostile and affectively negative. A number of published reports have used these observational parent-child interaction procedures to predict child outcomes including socioemotional and cognitive development (see, for example, Zvara et al., 2014; Mills-Koonce et al., 2015).

We also scored one dyadic scale, mutuality, to assess the synchrony of the interaction and the degree of shared experience between parent and child. Dyadic mutuality may be reflected by reciprocal play, reciprocal communication and shared enjoyment. At the low end, lack of mutuality is reflected by an interaction that is stifled, conflictual, or non-reciprocal. At the high-end, dyadic mutuality manifests behaviors that reflect reciprocal play, communication and shared enjoyment with clear evidence of shared positive affect from both parent and child (Cox & Crnic, 2002).

Covariates.—Household demographic variables including household income and maternal education have each been identified as important correlates of parenting (see Conger et al., 2010, for a review) and child EF (Hackman, Gallop, Evans, & Farah, 2015), and thus the family's income and parental education were included as covariates in this model. Child sex was controlled given previous research showing that boys tend to do less well on tasks of EF compared to girls (Willoughby & Blair, 2016).

Statistical Analysis

Relationships between sociodemographic characteristics, executive function (gift delay, BRIEF-P), and parent-child interaction (sensitivity, mutuality, and harsh intrusiveness) were examined using independent samples t-tests (unequal variances assumed), analysis of variance, chi-square and Fisher's exact tests, and Spearman correlation coefficients. Generalized linear models were used to estimate the impact of parenting on child executive function adjusting for child and family characteristics. The following characteristics were considered as potential confounding factors during model building: child age, sex, birth weight, gestational age, length of stay in the NICU, parent age, and parent education. Models were built in a stepwise fashion and variables retained that were independent predictors of child executive function or that impacted the effect estimate for the association between parenting and child executive function by more than 15%. Statistical significance was based on two-tailed alpha level <0.05 . All analyses were conducted using SAS 9.3 (SAS Institute Inc, Cary NC).

Results

Sample characteristics

The study included 41 children (mean age=47 months; 61% male) who had been born at 24-29 (mean=27.3) weeks' gestation. Descriptive characteristics are presented in Table 1. Children's weight at birth ranged from 430 to 1609 grams, and 54% weighed <1000 grams. The median length of stay in the NICU was 74 days but ranged from 39 to 254 days. The parent respondent (mean age=33 years) was the biological mother ($n=38$), biological father ($n=2$), or adoptive mother ($n=1$); the sample was diverse relative to parent education and household income (Table 1).

Executive function

Ten children (24%) refrained from touching the gift bag and stayed seated for at least 120 seconds (2 minutes); these children were classified as having 'good' executive function and were compared to the other children in the study ($n=31$). Girls were more likely than boys to have good executive function on the gift bag (44% of girls vs 12% of boys, $p=0.03$). Children with good executive function also spent less time in the NICU as infants (mean (SD) 68 (19) days for the 10 children with good executive function on the gift bag vs 91 (47) days for the remaining 31 children, $p=0.03$). Children's age, birth weight, gestational age, parent age and education were not statistically significantly related to performance on the gift delay assessment. The mean and standard deviation (SD) for the BRIEF-P global executive composite t-score was 53.5 (SD=15.7), and 8 children (20%) had scores ≥ 65 . Children demonstrating good executive function in the gift delay assessment were rated as

having fewer difficulties with executive function on the BRIEF-P than children who did not meet this performance threshold (45.4 vs 56.2, $p=.01$), and none of the 10 children who scored well on the gift delay task had BRIEF-P scores ≥ 65 . Mean score on the BRIEF-P was not related to child sex, age, birth weight, weeks' gestation, or length of NICU stay, but children of older and more-educated parents were rated as having fewer difficulties with executive function on the BRIEF-P: Pearson correlation (r) between parent age (years) and BRIEF-P score was -0.31 , $p=0.05$; mean BRIEF-P score for children of parents with a college degree compared to those who had not completed a college degree was 47.6 vs. 57.4, $p=0.02$.

Parenting behavior

Parenting sensitivity and dyadic mutuality were strongly correlated, and both of these parenting behaviors were negatively correlated with harsh intrusiveness (Table 2). Parenting behaviors were not related to child sex, chronological age, or gestational age (Tables 2 and 3); however, parental sensitivity and dyadic mutuality were positively related to birth weight (children of higher birth weight experienced more sensitive parenting and greater dyadic mutuality) and inversely related to length of stay in the NICU. Parents who were older were observed to be more sensitive; however, parent age was not associated with levels of harsh intrusiveness or dyadic mutuality. Parents who had completed a college degree displayed more sensitivity, less harsh intrusiveness, and greater dyadic mutuality compared to parents who had completed some college or a high school degree (Tables 2 and 3).

Association between child executive function and parenting behavior

Each of the three parenting behaviors were examined in separate analyses. In unadjusted logistic regression models, sensitivity, dyadic mutuality and harsh intrusiveness were each associated with whether the child showed good executive function in the gift delay task. Adjusting for child sex, parental education, and days spent in the NICU, a 1 unit increase in parenting sensitivity was associated with a higher odds of showing good EF in the gift delay task (adjusted OR=3.33, 95% CI: 1.00, 11.05). Similarly, dyadic mutuality was associated with good EF (adjusted OR=2.69, CI: 1.09, 6.62; Table 4). Harsh intrusiveness was associated with lower odds of good EF in unadjusted models (OR=0.54, .29, 1.00; $p=0.048$), and adjustment for covariates did not attenuate this association. In adjusted models each 1 unit increase in rating of harsh intrusiveness was associated with lower odds of good EF (adjusted OR=0.51, CI: 0.26, 1.03; Table 4); however, this estimate was not statistically significant at the traditional alpha level ($p=0.058$). With regard to parent-report of EF, higher ratings of sensitivity and dyadic mutuality were associated with lower scores on the BRIEF-P (indicative of fewer difficulties with executive function), but estimates did not reach statistical significance in unadjusted linear models ($p=0.10$ for sensitivity and $p=0.07$ for mutuality). Furthermore, these associations were substantially attenuated by adjustment for covariates (Table 4). For harsh intrusiveness the unadjusted association was statistically significant; each 1 unit increase in harsh intrusive parental behavior was associated with higher BRIEF-P scores of 3.21 (CI: 0.42, 6.00) units, but as with sensitivity and mutuality, the association was attenuated in adjusted models (Table 4).

Discussion

This study examined the relations between three domains of parenting behavior (i.e., sensitivity, harsh intrusiveness, and dyadic mutuality) and EF in preschoolers born very preterm. The findings from this study add to the growing literature (Clark et al., 2008; Treyvaud et al., 2009; Treyvaud et al., 2015) on the quality of the parent-child relationship to EF among children born very preterm. Despite the current body of research suggesting that parenting may be associated with better EF among children born preterm, it is less well understood whether early parenting behavior operates similarly for children who are biologically at-risk for adverse outcomes due to very preterm birth (Clark et al., 2008; Treyvaud et al., 2015).

Briefly, the findings from this study support and extend previous findings on factors related to EF in preschoolers born very preterm. In support of previous studies, our findings suggest that sensitive parenting was related to better EF. Our results further suggest that parent-child interactions that are characterized as mutually responsive are related to better EF. In addition, although earlier research provides evidence that caregiving behaviors in infancy and toddlerhood play a key role in supporting the emergence of the executive function, our findings indicate that sensitive and responsive caregiving during preschool age when EF abilities are rapidly developing may be important for children with heightened risk for EF impairments. Furthermore, in keeping with previous research, we found that performance-based and parent-report measures of EF may assess different underlying mental constructs for children born very preterm.

It was expected that greater sensitive parenting and caregiver-child mutuality, and less harsh-intrusive parenting would predict better child EF. The results from this study lend support to this hypothesis. We found that all three domains of parenting behavior, examined in the current study (sensitivity, harsh intrusiveness, and dyadic mutuality) were related to children's performance on EF assessments. These findings are consistent with previous research using observational assessments of parenting behavior (Treyvaud et al., 2016; Landry et al., 2001). Our findings suggest that children who performed better on EF tasks had caregivers who were independently rated as more warm and responsive in their interactions with their children. In addition, children whose interactions with their parents were characterized as having greater mutuality as evidenced by their mutually responsive, cooperative, and well-synchronized interactions were also found to have high EF. Furthermore, parents of children who performed well in the EF tasks were rated as less intrusive in their caregiving behavior.

Consistent with previous studies (e.g., Landry et al., 2001; Assel et al., 2003; Treyvaud et al., 2015), these findings suggest that very preterm children may benefit from parental support across early childhood when EF is rapidly developing, and that warm, supportive, mutually responsive parent-child interactions may protect children born very preterm from enduring deficits in EF. The cross-sectional design of this study, however, does not allow for direction of causality to be inferred and it may be that children with better EF elicit more responsive parenting. The importance of sensitive parenting to EF suggests that it may play a role both in promoting children's foundational brain development, as well as supporting

their later attempts at inhibition and self-regulation. A wealth of evidence suggests that early environmental experiences shape brain development (e.g., Chugani et al., 2001; Debellis, 2001; Loman & Gunnar, 2010), and that early caregiver interactions impact the development of prefrontal brain systems linked with executive functions. The prefrontal cortex is a slow-developing area with neural density of the frontal lobes beginning to decline at approximately 7 years of age (Loman & Gunnar, 2010), providing a large window of plasticity during which early environmental experiences, including early parent-child relationships, help shape development (Noble, Norman, & Farah, 2005). Parents who are attentive and skilled at reading their children's cues create an environment characterized by responsiveness, emotional involvement, cognitive stimulation, and encouragement in the face of challenge and may thus set the foundation for the physiological and behavioral regulatory skills needed for executive function (Bernier et al, 2012). Prior research supports this view with findings linking quality of parent-child interactions with stress-response system functioning (Gunnar et al., 2006), which in turn may alter the development of prefrontal brain regions linked with executive function (Blair et al., 2011).

Our findings also attest to the importance of examining dyadic mutuality in relation to executive function among preschool children. Dyadic mutuality, unlike parental sensitivity, encompasses both the caregiver's and the child's responsivity, and their emotional availability to each other. Earlier research on the role of dyadic mutuality to child adjustment provides support for these findings such that synchronous and harmonious interactions between caregivers and children are related to more optimal outcomes in young children (Kochanska & Aksan, 2004; Deater-Deckard & Petrill, 2004). Further, much of the literature on the role of parenting behavior to executive function has been focused on the parenting dimension of sensitivity (Gardner, Ward, Burton, & Wilson, 2003). To our knowledge, this is the first study to provide evidence that dyadic mutuality may be important to the development of EF among preschool children born very preterm. Looking ahead, future research should examine how dyadic mutuality may be implicated in the development of EF using larger samples and a comparison sample of children born at term.

Using two measures of children's EF at preschool-age is a strength of our study, and the finding that associations between parenting behaviors and parent-reported EF on the BRIEF-P were attenuated controlling for child sex, household income, parent education, and children's days spent in the NICU after their very preterm birth is of note. The impact of covariate adjustment between the gift delay task and parent report of EF may be explained from two different perspectives. There have been reports suggesting that parent-report and performance-based measures of executive function may assess different constructs (see for example, Ten Eycke & Dewey, 2016). Although the BRIEF-P provides a convenient, well validated means of tapping into complex, real-world manifestations of executive functions, it is, however, a global view of executive function as compared to tests that measure the specific executive function processes (Toplak, West, & Stanovich, 2013). Secondly, parenting literature provides evidence that knowledge of child development is related to parents' more accurate interpretations of their children's behaviors (Benasich & Brooks-Gunn, 1996; Bugental & Happaney, 2002).

Our findings provide support that knowledge of child development may be related to parental reports of child behavior. Whereas in unadjusted models each 1 unit increase in harsh intrusive parental behavior was associated with higher BRIEF-P scores, this association was no longer significant at $p < .05$, after covariates such as maternal education were included in the models. This provides suggestive evidence that parent report of child behavior may be closely tied to parental factors such as education (Benasich & Brooks-Gunn, 1996). Findings by McAuley et al. (2010) provide additional support. In a sample of older children (ages 6-15 years) using a multi-informant design, they found that, although parent and teacher report of child behavior (BRIEF) were strongly related to each other, neither was associated with scores on the performance-based tasks of executive function (McAuley, Chen, Goos, Schachar, & Crosbie, 2010). Future research is needed to compare the impact of each type of EF measure across a wider age range of children born very preterm to detect developmental differences.

In keeping with developmental theories on parent-child relationships, a novel finding from this study suggests that harsh, intrusive parenting may be related to poor EF outcomes in children born very prematurely. Harsh, intrusive parenting characterized by controlling behaviors and negative affect towards the child may have particularly harmful and long-lasting consequences for very preterm children, as these forms of parent-child interactions interfere with children's attempts to establish autonomy in the context of the parent-child dyad.

Limitations

Our findings should be interpreted in the context of the limitations of this study. This is a small cross-sectional study of 41 preschool-aged children who had been born very preterm. Whether the findings of our research are generalizable is a question that invites replication of this research. We did not assess maternal depression or children's overall level of cognitive function and these or other unmeasured variables could potentially confound our results. Given the cross-sectional nature of the data, our conclusions are necessarily preliminary.

In our study, we used one measure of observed EF, the gift bag delay task. Given that EF is an umbrella term that refers to a wide range of cognitive abilities, its assessment may require tasks representing other components including working memory, inhibitory control, and mental flexibility. As previously reported by Ten Eycke & Dewey (2016), the varying results we found between the performance-based measure of EF and parent rating of EF may be due to global measures of EF from the Brief-P and the gift delay task targeting different EF components. Future research would benefit from using a more broad range of performance based EF measures.

Although our models and hypotheses use child executive function as an outcome that is predicted from the quality of parent-child interaction, our data were collected at one time point. Longitudinal studies, in which parent-child interaction was measured years before child outcomes (Treyvaud et al., 2016), establish temporal ordering and our cross-sectional results are not inconsistent with findings that the emergence of children's EF is optimally supported when experiencing interactions with sensitive, responsive caregivers, whereby the

impact of early adversity may be attenuated by later experiences with positive, supportive parenting. However, it is also possible that parents behave differently as a consequence of differences in children's levels of EF. In addition, we did not have information on early childhood education experiences of the children as these may be related to EF (Diamond, Barnett, Thomas, & Munro, 2007).

Despite these limitations, strengths of this study include the use of observational protocols for independent assessment of parenting behavior. Parenting was qualitatively coded from video recorded observations, and our final composite scores captured the multiple dimensions of parental sensitivity and intrusiveness, offering the advantage of recording overt behavior, which may be less open to differing interpretations than are items on a self-report (Gardner, 2000). In addition, we utilized multiple methods, both observational and parent-reported, to assess EF adding further rigor to our methodology.

Implications and future research

Children born very preterm are at higher risk than their full-term peers for executive functioning (EF) difficulties by school-age (Anderson & Doyle, 2004). Our findings provide evidence that, among children born very preterm, EF is supported when children experience interactions with caregivers that are characterized as sensitive and mutually responsive (Hofer, 1994; Schore, 2001; Sroufe, 1996; Thompson, Lewis, & Calkins, 2008). Targeted interventions focused on caregiver training to enhance parent responsiveness and parent-child interactions may be particularly fruitful for families with children born very preterm. Looking ahead, using a comparison group of children born at term would provide useful information for points of entry for interventions. Further, given the varying results between performance-based measure of EF and parent rating measure suggests that the use of subjective measures alone may not sufficiently identify children experiencing problems. Professionals should, therefore, be cautioned when using subjective measures alone to measure children's EF and, when possible, both performance-based and subjective measures should be used to obtain a more accurate depiction of children's true EF abilities.

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Table 1

Descriptive characteristics of participants (n=41 children and a parent).

Child/ Family Characteristics, n (%) unless specified		
Child age		
Mean (SD)	46.8 (3.1)	months
Child sex		
male	26 (61%)	
female	15 (39%)	
Weeks' completed gestation		
24-25	6 (15%)	
26-27	14 (34%)	
28	11 (27%)	
29	10 (24%)	
Birth weight		
Mean (SD)	1033 (306)	g
Days spent in NICU		
<50	6 (15%)	
50-74	15 (37%)	
75-99	11 (27%)	
100	9 (22%)	
Child race/ethnicity		
Hispanic, any race	2 (5%)	
Non-Hispanic white	23 (56%)	
Non-Hispanic black	14 (34%)	
Other race, non-Hispanic	2 (5%)	
Age of parent respondent *		
Mean (SD)	33.3 (6.1)	years
Range	21-45	years
Education level of respondent *		
High school	6 (15%)	
Some college	19 (46%)	
Bachelor's degree	8 (20%)	
Post graduate degree	8 (20%)	
Annual household income		
<\$20,000	6 (15%)	
\$20,000 - <\$35,000	16 (39%)	
\$35,000 - \$45,500	5 (12%)	
>\$45,500	14 (34%)	

Note.

* Respondent was biological mother (n=38); biological father (n=2); adoptive mother (n=1)

Table 2

Spearman Correlations of parenting behaviors and sociodemographic characteristics (N=41)

	Sensitivity	Dyadic Mutuality	Harsh Intrusiveness
Sensitivity	--	0.93 *	-0.79 *
Dyadic Mutuality	--	--	-0.86 *
Child age	-0.01	0.01	-0.13
Gestational age	0.19	0.26	-0.15
Birth weight	0.32 *	0.33 *	-0.26
Length of stay in NICU	-0.39 *	-0.36 *	0.27
Parent age	0.40 *	0.29	-0.09

Note.

*
p < 0.05

Table 3

Parenting behaviors in relation to child sex and parent education

		Parenting behaviors		
		Sensitivity	Dyadic Mutuality	Harsh Intrusiveness
		Mean (SD)		
Child Sex				
	Boys	3.7 (1.2)	3.7 (1.6)	3.2 (1.6)
	Girls	3.8 (1.2)	3.8 (1.6)	3.1 (2.0)
	P value ^a	.75	.86	.90
Parent has college degree				
	Yes	4.5 (1.1)	4.5 (1.4)	2.5 (1.7)
	No	3.3 (1.0)	3.3 (1.5)	3.6 (1.6)
	P value [*]	.001	.01	.04

Note.

^{*}
 $p < 0.05$ ^{**}
 $p < 0.01$ ^{** *}
 $p < 0.001$

P value from 2 sample t-test (unequal variances assumed).

Table 4

Associations between parenting behaviors and child executive function (N=41)

Parenting behavior	Good executive function on gift delay ^a		BRIEF-P Global executive composite t-score – continuous measure ^b	
	Unadjusted	Adjusted ^c	Unadjusted	Adjusted ^c
	Odds ratio (95% CI)		β (95% CI)	
Sensitivity	2.04 (1.02, 4.07)	3.33 (1.00, 11.05)	-3.48 (-7.67, 0.70)	0.64 (-5.17, 5.30)
Dyadic Mutuality	1.92 (1.09, 3.39)	2.69 (1.09, 6.62)	-2.88 (-5.95, 0.20)	-0.98 (-4.50, 2.55)
Harsh Intrusiveness	0.54 (0.29, 1.00)	0.51 (0.26, 1.03)	3.21 (0.42, 6.00)	1.49 (-1.51, 4.49)

Note.

^aOdds ratio (95% CI) from logistic regression model predicting good executive function (children had to not touch the gift bag for 3 minutes and remain seated for >120 seconds) associated with 1 unit increase in rating of parenting behavior.

^bEstimate (95% CI) for difference in score on BRIEF-P associated with 1 unit increase in rating of parenting behavior. Higher scores on the BRIEF-P indicate poorer executive function.

^cAdjusted models control for child sex, parent education, and days spent in the NICU.