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The Development of Effortful Control in Children Born Preterm

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Abstract

This prospective longitudinal study examined emerging effortful control skills at 24- and 36-months postterm in 172 children born preterm (<36 weeks gestation). Infant (neonatal health risks), family (sociodemographic risks) and maternal risk factors (depressive symptoms, anger expressions during play interactions) were assessed at six timepoints across 3 years. Additionally, children's emerging effortful control skills, cognitive development, and mother-reported behavior and attention problems were assessed at 24- and 36-months. Analyses documented links between effortful control skills, cognitive skills, and concurrent attention problems in children born preterm. The study also found that preterm children's effortful control skills improved over time. In addition, neonatal health risks, family sociodemographic risks, and angry parenting interactions were associated with less optimal effortful control skills.

Keywords

ADHD; attention; effortful control; parenting; preterm; risk

It is estimated that 50 to 70% of infants born preterm (<36 weeks gestation) develop behavior problems, including internalizing and externalizing problems and symptoms of Attention-Deficit/Hyperactivity Disorder (ADHD) (Aylward, 2005; Bhutta, Cleves, Casey, Craddock, & Anand, 2002; Pinto-Martin et al., 2004; Taylor, Klein, & Hack, 2000). Many behavioral disturbances in preterm infants, including attention problems, are believed to originate from impairments in self-regulation (Davis & Burns, 2001). Self-regulation, broadly defined, is the ability to act in accord with social standards and to adjust one's attention, behaviors, and emotional expressions to meet such external standards (Kopp, 1982).

Effortful control, a component of self-regulation, involves suppression of a dominant response to express a subdominant response (Rothbart & Bates, 2006). Effortful control includes skills such as delaying gratification, slowing motor activity, lowering one's voice, suppressing and initiating an activity upon signal, and effortful attention (Kochanska, Coy,

& Murray, 2001). Effortful control has been linked with attention regulation (Harris, Robinson, Chang, & Burns, 2007), ADHD symptoms (Goldsmith, Lemery-Chalfant, Schmidt, Arneson, & Schmidt, 2007; Nigg, Goldsmith, & Sachek, 2004), and academic achievement (Blair & Razza, 2007).

Despite these findings and the aforementioned links between prematurity and ADHD, only one study to date has examined associations between an effortful control skill (delay) and attention difficulties and cognitive abilities in children born preterm (Feldman, 2009). Thus, the present study sought to elucidate the processes involved in the development of effortful control skills in young children born preterm. This study had two objectives: (1) to examine change in effortful control skills between 24- and 36-months in preterm children, and (2) to examine the relations among early and concurrent effortful control and attention problems, ADHD symptoms, cognitive skills, and broadband behavior problems in the context of prematurity.

Theoretical Model

Ecologically-based theories of development and a growing body of empirical research point to the importance of dynamic interactions between children's biologically-based characteristics, parenting, and the larger social context in predicting children's outcomes (Bronfenbrenner & Ceci, 1994). Ecological theories recognize that children's proximal environments are multidimensional and that multiple risk factors, rather than any single risk, lead to increased likelihood of problematic outcomes (Sameroff & Fiese, 2000).

It is particularly important to examine risks and proximal environments as predictors of outcomes in children born preterm because they exhibit elevated rates of behavior problems and cognitive difficulties during the preschool period and at school age compared to healthy term infants (Goldberg, Corter, Lojkasek, & Minde, 1990; Gray, Indurkhya, & McCormick, 2004). In a recent meta-analysis, 81% of the studies reviewed found elevations in internalizing or externalizing behaviors, including ADHD symptoms, in preterm children (Bhutta et al., 2002). Estimates suggest ADHD prevalence rates of 23% in preterm children compared to 6% in full-term children (Botting, Powls, Cooke, & Marlow, 1997).

The Development of Effortful Control in Full-Term Children

Studies focusing on children born healthy and full-term have found that effortful control skills begin to emerge at the end of the first year of life, become more consistent during the second year, and develop into a more integrated skill set in the early preschool years (Kochanska, Murray, & Harlan, 2000). Effortful control is seen as a salient and relatively stable component of personality by age 4 (Kochanska & Knaack, 2003). Demonstration of effortful control skills requires the capacity to initiate, cease, or modulate one's behavior in accord with external standards and expectations (Kochanska et al., 2001). The child's capacity to modulate his impulses is most salient when external expectations differ from his own wishes or current behaviors (e.g., when a child is asked to refrain from touching an enticing object, even though he wants to play with it, or when a child is asked to refocus his attention).

Previous research has found that the development of effortful control in full-term children is influenced by parental behaviors and has implications for children's later social development. Children whose mothers are more responsive, emotionally available, supportive, sensitive, and accepting show better effortful control skills at 22- and 33-months compared to children who experienced less optimal parenting (Kochanska et al., 2000). In addition, children with better effortful control skills demonstrate more advanced conscience formation at 52-months and less disruptive behavior at 67-months (Kochanska, Barry, Aksan, & Boldt, 2008). Previous research has also examined gender differences in effortful control skills (Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006), and relations between effortful control and attention problems in healthy children born at term. However, research focusing on effortful control skills in preterm infants is limited. Feldman (2009) examined delay, one component of effortful control, at 12- and 24-months in a sample of preterm infants. She found that delay at 24-months was associated with children's behavior problems at 5 years. However, the parenting context was not examined.

Effortful Control, Brain Development and Preterm Infants

The neurological structures involved in the development of effortful control appear to include the prefrontal cortex (PFC) and anterior cingulate cortex (ACC), which mediate voluntary executive control mechanisms (Thompson, Lewis, & Calkins, 2008). There is evidence to suggest that the emergence of effortful control coincides with the development of this part of the brain. Preterm infants may be particularly likely to exhibit vulnerabilities in behaviors that rely heavily on the prefrontal cortex, as the prefrontal cortex develops rapidly late in gestation (Sun, Mohay, & O'Callaghan, 2009). Many higher order functions regulated by the cerebral cortex, such as the development of executive function, are immature in preterms (Damus, 2008).

More specifically, when considering the development of effortful control skills in preterm infants, it is important to consider these developmental processes in light of children's brain development. Although neuronal proliferation and migration to the cerebral cortex are typically completed by 24 weeks gestation, the maturation of these tissues is incomplete in preterm infants. Quantitative MRI data have shown the brain volume increases linearly with advancing gestational age, and the relative percentage of both gray and myelinated white matter increases exponentially between 36- and 40-weeks gestation (Adams-Chapman, 2006). Thus, brain structure, morphology, and presumably function may differ between preterm and full-term infants, raising the possibility that the processes leading to the development of effortful control may not be equivalent for full-term and preterm infants.

Given these issues, the present study used a within-group design (i.e., no full-term comparison group). Because the study focuses on processes associated with cognitive skills and effortful control in preterm infants of varying medical risk, it goes beyond research that documents group differences (typically deficits) resulting from infants' term status or birthweight grouping. Rather, it extends previous research by examining within-group predictors that are suggested by ecological models and research with full-term infants.

Using a within-group approach with a high risk sample is also one way to elucidate processes associated with resilience, or successful adaptation in the face of significant adversity (e.g., Luthar, Cicchetti, & Becker, 2000; Masten, 2001, 2007). Although previous research has documented associations between preterm birth and less optimal cognitive and behavioral development (e.g., Bhutta et al., 2002), all children do not exhibit uniformly poor outcomes in the face of risk (e.g., Werner, 2000; Cicchetti, Rogosch, & Toth, 1998), including risks associated with prematurity. Further study of children who develop positive effortful control and cognitive skills, despite preterm birth, can potentially reveal processes associated with resilience.

Biological and Environmental Predictors of Preterm Infant Outcomes

Several risks should be considered when examining the development of effortful control in children born preterm, including neonatal health risks. It is well-known that less optimal cognitive outcomes in preterm infants are related to the neonatal health, such as lower birthweights and respiratory complications (Aylward, 2005; Bhutta et. al., 2002; Hack, 2002; Ment et. al., 1996). In addition, emerging evidence suggests that neonatal health risks may also influence the emotional and behavioral outcomes of preterm infants through the development of self-regulatory capacities (Carmody et al., 2006), with greater impairments seen in infants born extremely premature (<28 weeks), extremely low birthweight (<1000g), or with more neonatal illnesses (Clark, Woodward, Horwood, & Moor, 2008; Hack et. al., 2004; McGrath et. al., 2005). In addition, preterm infants with a history of neurologic involvement demonstrate less optimal self-regulation and attention compared with preterm infants without such a history (Clark et al., 2008), suggesting a biologic pathway (Wolke, 1998).

However, a biological model only partially explains why preterm infants experience increased risk for self-regulatory disturbances and attention problems. There is growing evidence that the capacity for self-regulation is influenced by biological *and* environmental factors. Specifically, the quality of early caregiving appears to play an important part in the development of early regulatory competencies (Eisenberg et al., 2005). Extensive evidence suggests that preterm infants are especially vulnerable to difficulties in maternal social interactions (Forcada-Guex, Pierrehumbert, Borghini, Moessinger, Muller-Nix, 2006; Muller-Nix et al., 2004). Maternal expressions of anger during interactions may be particularly dysregulating for infants and young children (Field et al., 2005). These effects may be even more striking in maternal interactions with infants with biological vulnerabilities (Feldman & Eidelman, 2004). Moreover, risks in the parenting environment, such as maternal depression, may contribute to negative dyadic interactions and to less optimal self-regulation. Compared to nondepressed parents, depressed parents show decreased responsiveness and involvement (Downey & Coyne, 1990), deficits in parenting skills (Teti, Gelfand, Messinger, & Isabella, 1995), more negative affect expression, less positive engagement (Field, 1992), and less sensitive maternal care (Lyons-Ruth, Zoll, Connell, Grunebaum, & Botein, 1990). Further, children who interact with chronically depressed mothers experience the greatest risk (Cornish et al., 2005; Trapolini, McMahon, & Ungerer, 2007).

Little research with infants and young children has examined interactions between biologically-based and relationship-based processes in emerging self-regulation (e.g., Calkins & Fox, 2002). This is especially true in research focusing on preterm infants, although Clark et al.'s (2008) study is an exception. Clark et al. examined child regulatory behaviors exhibited during cognitive assessment and persistence during problem solving, which possibly reflect a wide range of skills, including co-regulation with an examiner, emotion regulation, and/or effortful control. In contrast, the present study examined children's effortful control skills using a standard laboratory battery (Kochanska et al., 2000).

Previous studies have also documented effects of family sociodemographic (SES) risks on child outcomes, including children born preterm (e.g., Brooks-Gunn & Duncan, 1997; Linver, Brooks-Gunn, & Kohen, 2002). Given these findings, we examined biological and environmental risks as covariates, including neonatal health risks, maternal depressive symptoms, anger during maternal interactions, and family SES risks, as well as infant gender.

Current Study

Based on this background research, the current study addressed the following questions:

1. How do effortful control skills change between 24- and 36-months postterm in children born preterm? Do preterm infants born with the lower and higher birthweights showed gains in effortful control skills over time? Do individual

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preterm children maintain their relative ranking in effortful control skills across time? (Relative ranking refers to the position of a child's scores in comparison to the scores of other children at the same timepoint.)

2. Do preterm children who demonstrate more optimal effortful control skills exhibit fewer attention problems, ADHD symptoms, internalizing and externalizing behavior problems (as indexed by the Child Behavior Checklist) and more optimal cognitive development at 36-months compared to preterm children who demonstrate less optimal effortful control skills?

Method

Participants

For this report, 172 preterm infants (gestational age < 36 weeks) were included. A total of 181 mothers and their infants were initially recruited from three neonatal intensive care units (NICUs) in southeastern Wisconsin between 2002 and 2005 as part of a larger longitudinal study focusing on the infants born preterm or low birthweight (Poehlmann, Schwichtenberg, Bolt, & Dilworth-Bart, 2010). A research nurse from each hospital invited families to participate in the study, if they met the following criteria: (a) infants were born ≤ 35 weeks gestation or weighing < 2500 grams, (b) infants had no known congenital problems, major neurological problems (e.g., Down Syndrome, periventricular leukomalacia), or prenatal drug exposures, (c) mothers were at least 17 years of age, (c) mothers could read English, and (d) mothers self-identified as the child's primary caregiver. For multiple births, one infant was randomly selected to participate. Because the hospitals would not allow us to be "first contact" for families and they only provided us with information about families who signed consent forms for the study, we were unable to calculate a participation rate. However, of the 186 mothers who signed consent forms, 181 (97%) participated in data collection. The data from four of the 181 families were removed because we later discovered that a grade IV intraventricular hemorrhage had occurred prior to NICU discharge and/or the child was diagnosed with cerebral palsy by three years of age. Because we were interested in exploring the outcomes of preterm infants in the present study, five additional cases were removed because the infants were born ≥ 36 weeks, despite having low birthweights.

Participating family characteristics paralleled the population of Wisconsin during the years of data collection. For example, 77% of mothers who gave birth in 2005 in Wisconsin were White, 9% were Black, and 9% were Latina (Martin et al., 2007), although the rate of preterm birth is higher for Black (18.4%) than White (11.7%) infants (Hamilton, Martin, & Ventura, 2007). Our sample consisted of 66% White, 14% Black, 2% Latino, and 17% multiracial infants. In Wisconsin, 89% of mothers who gave birth were between 20 and 39 years of age, and an average of 16% of children lived in poverty in Wisconsin between 2003 and 2005 (U.S. Bureau of Census, 2003–2005). Approximately 87% (n = 149) of the mothers in our sample were between 20 and 39 years of age, and 22% (n = 38) were living in poverty.

Of the 172 infants included in our analyses, infant birthweights ranged from 490g to 3328g (M = 1711g, SD = 579), gestational ages ranged from 23.7 to 35.9 weeks (M = 31.3, SD = 3.0), and infants spent an average of 33 days (SD = 28) in the NICU. Thirty-three (19%) of the infants were part of a multiple birth (three were triplets) and just over half of the infants (n = 91, 53%) were boys. At hospital discharge, mothers were an average of 29.6 years old (SD = 6.3), had obtained an average of 14.2 years of education (SD = 2.7), and most (n = 118, 69%) reported that they were married. The average household income was $59,124 ($SD$ = $52,989).

Infants and their families were assessed at six time points: just prior to the infant's hospital discharge (Time 1) and again at 4- (Time 2), 9- (Time 3), 16- (Time 4), 24- (Time 5), and 36-months (Time 6), corrected for prematurity. Corrected age was calculated on the basis of the infant's due date; this method is commonly used for assessments of preterm infants (DiPietro & Allen, 1991). At Time 6, 142 (83%) families continued to participate in the study.

Multivariate analysis of variance (MANOVA) was used to examine potential differences between families who continued in the study for three years and families lost to attrition. The MANOVA examining differences in participation at the three year assessment for infant health variables revealed no significant differences, *multivariate* F (6, 165) = 0.96, $p = .45$, for infant gestational age, birthweight, 1- and 5-minute Apgar scores, days hospitalized, or the neonatal health risk index. The MANOVA conducted on family SES variables (measured at Time 1) revealed significant differences between families who participated in the study for three years and families lost to attrition, *multivariate* F (7, 164) = 5.06, $p < .05$. Follow-up univariate tests indicated that mothers lost to attrition were younger, F (1, 170) = 7.24, $p < .05$, and had completed fewer years of education, F (1, 170) = 13.19, $p < .05$. In addition, families were more likely to be lost to attrition when the fathers had completed fewer years of education, F (1, 170) = 8.24, $p < .05$, and when the families had more SES risks, F (1, 170) = 8.28, $p < .05$. However, there were no differences in mothers who participated in the study for three years and mothers lost to attrition on the number of children in the family, the father's age, or family income. Chi-square analyses revealed that mothers lost to attrition were more likely to be single, $\chi^2(1) = 8.12$, $p < .05$. However, there was no difference between attrition groups on maternal race. Additionally, a one-way ANOVA revealed that Time 1 depressive symptoms did not differ between mothers who continued to participate in the study and mothers lost to attrition. Our attrition rate is similar to, or less than, other longitudinal studies of preterm infants. For example, Miles, Holditch-Davis, Schwartz, and Scher (2007) had 27% attrition across 27 months in their study of preterms, and Feldman (2009) had a 20% attrition rate across 5 years.

Measures

Neonatal health risks—Neonatal health risks during the infant's NICU stay were documented through review of infant medical records. Because infant birthweight and gestational age were highly correlated ($r = .88$, $p < .001$), we standardized and combined them, and then reverse scored the composite so that higher scores reflected more prematurity. Next, we summed ten neonatal medical risk variables, each dichotomized into *1* if present, *0* if absent: diagnosis of apnea (n = 119, 69%), respiratory distress (n = 91, 53%), chronic lung disease (n = 18, 11%), gastroesophageal reflux (n = 16, 9%), multiple birth (n = 33, 19%), supplementary oxygen at NICU discharge (n = 17, 10%), apnea monitor at NICU discharge (n = 79, 46%), 5-minute Apgar score less than 6 (n = 5, 3%), ventilation during NICU stay (n = 92, 54%), and NICU stay of more than 30 days (n = 69, 40%).

The reverse-scored, standardized prematurity composite was then summed with the standardized dichotomous medical risk score, resulting in a neonatal health risk index with a Cronbach's α of .70, with higher scores reflecting more prematurity and neonatal health risks. The neonatal health risk index was used as a covariate in the majority of our analyses. For our repeated measures multivariate analysis focusing on change in effortful control skills over time, we dichotomized infant birthweight into lower (<1500g, n = 65) and higher (≥1500g, n = 107) groups. This dichotomization was used to assess if preterms born with lower and higher birthweights showed gains in effortful control skills over time.

Family sociodemographic risks—Mothers completed a demographic questionnaire while their infants were in the NICU (Time 1). On the basis of previous research with children using a multiple risk model (e.g., Burchinal, Roberts, Hooper, & Zeisel, 2000), one point was given for each of the following risks: the family's income was below the federal poverty guidelines (adjusted for family size), both parents were unemployed, the mother was single, the mother gave birth to the target child as a teen, the family had four or more dependent children in the home, the mother had less than a high school education, and the father had less than a high school education. This index could range from 0 to 7, with higher scores reflecting more risks. Cronbach's α for the SES index was .75. We assessed family SES risks at all timepoints and found that scores were highly correlated. We used Time 1 information to minimize missing data.

Depressive symptom persistence—The Center for Epidemiologic Studies-Depression Scale (Radloff, 1977; CESD) was used to assess maternal depressive symptoms at each timepoint. The CESD is a 20-item self-report questionnaire that asks respondents to rate their symptoms of depression on a 4-point scale ranging from *rarely/none of the time* (*0*) to *most/all of the time* (*3*) during the past week. Scores of 16 and above are considered in the clinical range. The CESD discriminates between patients and non-patients and has been used extensively in clinical and epidemiological research. Internal consistency ranges from .85 to .90. Alphas for the present study ranged from .85 to .89. For the present report, we calculated a persistent (i.e., chronic) depressive symptom index. Using CESD data from NICU discharge, 4-, 9-, and 16-month postterm assessments, we gave mothers one point for each timepoint that their CESD scores were within the clinical level. Thus, the depression index could range from 0 to 4, with higher scores indicating more persistent symptoms. In our sample, 31% of mothers reported symptoms in the clinical range at NICU discharge. In addition, 21%, 20%, and 13% reported clinically elevated symptoms at the 4-, 9-, and 16-month assessments, respectively.

Parenting interactions—At 24-months postterm (Time 5), infant-mother play interactions took place in our laboratory playroom with a standard set of age-appropriate toys. Interactions were recorded and were later coded using the Parent Child Early Relational Assessment (PCERA; Clark, 1985). The PCERA is a system designed to assess the frequency, duration, and intensity of affect and behavioral characteristics of parents and infants that occur during 5 minutes of face-to-face interactions. On the basis of the 5-minute observation, each variable is coded on a scale ranging from 1 (*negative relational quality*) to 5 (*positive relational quality*). In the present study, we focused on the 29 parent variables. Previous studies of the PCERA have reported an acceptable range of internal consistency ($r = .75$ to .96) and factorial validity (Clark, 1999). Additionally, the PCERA has been used with preterms (Pridham, Lin, & Brown, 2001).

Use of the PCERA often includes identifying subscales or factors (Clark, 1999; Else-Quest, Hyde, & Clark, 2003). For the present study, the 29 PCERA parent items were subjected to an unweighted least squares exploratory factor analysis with a varimax rotation, resulting in a three factor solution. For this report, we focused on the factor labeled Maternal Anger, Hostility, and Criticism (*Anger* factor; 10 items, α = .91) because of its potential dysregulatory function for preterm infants. Examples of items in the *Anger* factor included angry/hostile tone of voice, negative affect, and parental displeasure, disapproval, or criticism. Higher scores reflected more positive parenting interactions (less anger and hostility, less criticism, less displeasure). Ten percent of the sample was independently coded by four trained research assistants (trained by the developer of the PCERA). Interrater reliability ranged from 83% to 97% agreement across codes, with a mean of 88%. Percent agreement is the standard used in research with the PCERA (e.g., Clark, Hyde, Essex, & Klein, 1997; Pridham, Brown, Clark, Sondel, & Green, 2002).

Effortful control—We examined effortful control skills at 24- and 36-months (Times 5 and 6). At 24-months, we used a behavioral battery described in Kochanska et al. (2000). Five components of effortful control were examined: ability to delay (Snack Delay, Gift Bag), suppressing-initiating activity to signal (Towers), effortful attention (Shapes), slowing motor activity (Walk-a-line Slowly), and lowering voice (Whisper). The tasks were administered by a trained graduate student while the child's mother sat behind a screen to complete paperwork, with the exception of Gift Bag, in which the mother and experimenter left the room. If a child became upset at the mother's departure, she was asked to comfort the child and then sit behind the screen during the task (this occurred in 26% of the cases). Following the study protocol, all tasks were administered in the same order for all children (except in cases in which the child refused the task, then the experimenter attempted to administer it again later in the visit).

The Snack Delay task included four trials, with each successive trial requiring the child to wait for longer periods of times (range of 10 to 30 seconds). In this task, the child was asked to wait with his hands on the table until the experimenter rang a bell before retrieving a candy from underneath a clear plastic cup. Delay to touch the cup (in seconds) was coded for each trial and averaged across all four trials. The delay task was independently coded by two trained students, who attained 100% reliability with each other within 1 second of the child's response (the 1-second standard was used because of the short time for each trial). For the Gift Bag task, the child was presented with a brightly colored gift bag filled with tissue paper and a small prize and asked not to touch the bag for 2 minutes (after which the child was allowed to retrieve the prize). The task was rated using mutually exclusive categorical codes ranging from 1 (*child pulls gift from bag*) to 5 (*child does not touch bag*). The Gift Bag task was independently coded by two trained students who attained 100% reliability (kappa = 1.0).

For the Shapes task, we assessed the child's responses to imbedded animal cards following a brief training. The training consisted of presenting the child with two sets of three cards each (one set of large animals and one set of the same animals in smaller sizes) to ensure that the child understood the animal names and the words "big" and "little." For the testing sets, the child was then shown two sets (of three cards each) with a small picture of an animal imbedded within a larger picture of a different animal. Children's answers were scored as 0 (*refusal or pointing to incorrect animal*), 1 (*pointing to large rather than small animal*), 2 (*self-correction*), or 3 (*correctly pointing to small animal*). For the Shapes task, Cronbach's alpha was .83, and coders achieved average kappas of .95.

The Whisper task included raising the child's activity level (i.e., playing a chasing game), and then asking the child to whisper across two trials. The task was coded as 0 (*no response*), 1 (*responds but does not whisper*), or 2 (*whispers*), with a kappa of 1.0. The Whisper task was immediately followed by the Walk-a-line-slowly task, when the child was asked to walk on a line taped to the floor as slowly as possible for two trials. The seconds that it took the child to walk the line was recorded. Two coders were 100% accurate with each other within 1 second of children's walk times (the 1-second standard was used because of the brief times of each trial).

Finally, the Towers task included providing instruction regarding expectations for turn taking, then asking the child to build a block tower with the experimenter across two trials. Twelve blocks were presented per trial. The task was coded as a function of the average number of turns the child allowed the experimenter, with higher scores indicating more turn taking (kappa = 1.0). On average, experimenters took two turns per trial (range of 0 to 5 turns per trial).

At 36-months (Time 6), we again assessed the five components of effortful control. For lowering voice (Whisper), effortful attention (Shapes), and slowing motor activity (Walk-a-line), the tasks and coding systems were identical to the 24-month protocol. To assess delay at 36-months, we presented the child, who was seated at a small table, with an interesting toy (Magic Mountain) and asked him to refrain from touching it until the adults returned to the room. The mother and researcher then left the child in the room alone with the toy for 3 minutes. There were no other toys in the room at the time. Children were coded on the variables *seconds until touch* and *seconds until manipulation of the toy*. Inter-rater reliability ranged from 90–100% agreement within 2 seconds of the child's response (a 2-second standard was used because of the long length of this observation). For the change analysis, the Magic Mountain task was rescaled so that the maximum wait time was 2 minutes (a comparable scale to the 24-month delay task).

At 36-months, we also adapted the Towers task. Instead of using blocks, we used cards with brightly colored characters. Children were instructed to play a game in which they took turns with the researcher when matching the cards on a board. The Cards task was coded as a function of the number of turns the child allowed the experimenter to take.

Because studies with full-term infants have combined these tasks into an effortful control composite (EC composite; Kochanska et al., 2000, 2001), we also used this approach. At 24-months, the EC composite was created by averaging standardized scores from Gift Delay, Snack Delay and each of the two trials of Walk-a-line, Whisper, Shapes, and Towers. The 24-month EC composite had a Cronbach's α of .60 (10 items), with higher scores indicating more effortful control skills. At 36-months, we created an EC composite by averaging the standardized scores from Cards, each of the two trials of Walk-a-line, Whisper, and Shapes, and the two delay variables from the Magic Mountain task (α = .71; 9 items). Again, higher scores reflected more effortful control skills. Internal consistency for the EC composite for Kochanska et al.'s (2000) full-term 22-month-olds was .42, and for 33-month-olds it was .77, similar to our composites.

Children's behavior problems—The problem list of the preschool form of the Child Behavior Checklist (CBCL age 1½ to 5 years; Achenbach & Rescorla, 2000) was used to assess children's behaviors at 24-months (Time 5) and 36-months (Time 6) postterm. The CBCL is a widely-used standardized behavior rating scale that is completed by an adult with whom the child lives. The preschool forms list 99 problem behaviors. Mothers rated each problem behavior on a 3-point scale, *not true* (*0*), *somewhat or sometimes true* (*1*), or *very true or often true* (*2*), in reference to the past 2 months. The CBCL has high internal consistency, with Cronbach's alphas ranging from .78 to .97, and it has been used with preterm infants (e.g., Gray et al., 2004).

Several DSM-IV-oriented scales were derived by creators of the CBCL by collaborating with experienced psychiatrists and psychologists. Professionals were asked to rate behaviors typically associated with the diagnostic categories for each scale (Achenbach & Rescorla, 2000). In the present study, we used the Attention Problems and ADHD Problems scales. Test-retest reliability for the Attention Problems scale was $r = .78$ and for the ADHD Problems scale was $r = .74$ (Achenbach & Rescorla, 2000). The Attention Problems scale is comprised of five items that ask about the child's ability to concentrate, pay attention, and sit still. The ADHD Problems scale contains six items that again assesses the child's ability to concentrate, sit still, and attend to a task. However, it also assesses impulse control, with items focusing on the child's ability to delay, as well as the caregivers' perception of whether the child "gets into everything." In a study of children with otitis media, T-scores for the Attention and ADHD problems subscales of the CBCL were significantly higher among children diagnosed with or being medicated for ADHD compared to children without ADHD at 4 years of age (Loe et al., 2008).

Cognitive development—Child cognitive skills at 24- and 36-months were estimated using the Abbreviated Battery IQ scale (ABIQ) from the Stanford-Binet Intelligence Scales, 5th edition (Roid, 2003a). The ABIQ is comprised of the sum of the Nonverbal Fluid Reasoning ($\alpha = .81$) and Verbal Knowledge ($\alpha = .93$) scaled scores. The ABIQ scale has an α of .90 (Roid, 2003b).

Procedure

The University of Wisconsin-Madison Institutional Review Board (IRB) approved the study. A brochure was distributed to families in each NICU, and a research nurse from each hospital described the study to eligible families by verbally summarizing and giving them a copy of the consent form. Interested mothers returned the signed forms and a researcher met the mother at the NICU just prior to discharge to collect Time 1 data. Each mother was given a list of clinics and agencies that could assist her if she felt distressed. In addition, if a mother reported clinically significant depressive symptoms at any timepoint, the study principal investigator (a licensed psychologist) called the mother to offer follow-up and referral information. Nurses completed a history of hospitalization form by reviewing the infant's medical records shortly after NICU discharge. Home visits were conducted with families when infants were 4- and 9-months corrected age. At the visits, researchers asked mothers to complete questionnaires in addition to videotaping interactions (not used in this report). The visits lasted approximately 1.5 hours and mothers were paid \$25 at the 4-month visit and \$40 at the 9-month visit. When infants were 16- and 24-months postterm, families visited a laboratory playroom with a standard set of age-appropriate toys. Mothers completed self-administered questionnaires while their children participated in assessments. At the 24- and 36-month visits, children participated in free play with their mothers and a series of effortful control tasks. A researcher administered the Stanford-Binet, 5^{th} edition, abbreviated battery. Each of the laboratory visits lasted approximately 1.5 to 2.5 hours. Mothers were paid \$60 at the 16-month visit, \$80 at the 24-month visit, and \$85 at the 36-month visit. Children were given an age-appropriate book or toy at the end of each visit.

Results

Change Over Time

Sample means, standard deviations, and bivariate correlations are provided in Table 1. To compare children's mean scores on the effortful control paradigm at 24- and 36-months corrected age, we conducted a 2 (Age-Within Subjects Factor) × 2 (Birthweight Group-Between Subjects Factor) repeated measures multivariate analysis of variance. For this analysis only, we dichotomized infant birthweight into lower (<1500g) and higher (>1500g) weight groups and used the five separate effortful control tasks rather than the EC composite score.

Our results indicated that Age was a statistically significant factor, $F(5,101) = 35.89$, $p < .001$, although Birthweight Group, $F(5, 101) = 1.39$, $p = .23$, and the Age× Birthweight Group interaction, $F(5,101) = 0.65$, $p = .66$, were not statistically significant. Follow-up univariate tests of the Age factor revealed that children's skills on the effortful attention (24m and 36m Shapes), slowing motor activity (24m and 36m Walk-a-line), suppressing-initiating activity to signal (24m Tower/36m Card turn-taking), and lowering voice (24m and 36m Whisper) tasks improved between 24- and 36-months postterm (p's < .001). However, delay times (24m Gift/36m rescaled Magic Mountain) did not significantly differ at the two timepoints ($p = .14$).

To examine how individual children maintained their relative ranking in effortful control skills across time, rank-order Spearman's rho (ρ) correlations were computed. These analyses revealed consistent individual performance on the EC composite at 24- and 36-months relative to other children's scores ($\rho = .45$, $p < .001$). That is, children who scored high (or low) relative to their peers at 24-months continued to score high (or low) relative to their peers at 36-months.

Links Between Effortful Control and Children's Outcomes

To assess whether effortful control skills at 24- or 36-months postterm were associated with attention problems, ADHD symptoms, cognitive skills, and internalizing or externalizing behavior problems at 36-months, a series of structural equation models (SEM) were specified. One model was specified for each outcome variable (i.e., cognitive development, internalizing problems, externalizing problems, attention problems, and ADHD symptoms).

Each model was specified, identified, and tested for assumption violations prior to model and path estimation and interpretation. Additionally, a full information maximum likelihood (FIML) procedure was used to address missing data when complete data were provided across at least two timepoints. In the Mplus FIML procedure, individual missing data patterns are assessed, and means and covariances for each missing data pattern are calculated to inform the observed information matrix (Arbuckle, 1996; Kaplan, 2009). The observed information matrix is used to generate estimates (Kenward & Molenberghs, 1998). Addressing missing data via FIML assumes that data are missing at random (Little & Rubin, 1989) and is preferable to pair-wise or list-wise deletion (Arbuckle, 1996).

Overall model fit—To assess the overall model fit, three indices were assessed, including chi-square (X^2), root mean square error of approximation (RMSEA), and the comparative fit index (CFI). The X^2 index is a model of misspecification; therefore, a statistically significant X^2 means the model does not fit the sample data. Because the exact fit tested in X^2 may be an unrealistic standard, indices of approximate fit like RMSEA were also assessed (Weston & Gore, 2006). RMSEA tests whether the model fits the population approximately. In RMSEA, .00 is the best possible fit, with higher values indicating poorer fit. Acceptable fit for the RMSEA index is generally .05 (Browne & Cudeck, 1992), although this cutoff is debated. Within this study, the CFI compares the specified model to a null model. The null model posits that there are no associations among the variables. CFI ranges from 0 to 1, with higher values indicating better fit. CFI values above .90 are generally interpreted as acceptable fit (Bagozzi & Yi, 1988).

The models specified for cognitive development ($X^2(df = 13) = 14.89$, *ns*; RMSEA = .03; CFI = 0.99), externalizing problems ($X^2(df = 13) = 12.77$, *ns*; RMSEA = .00; CFI = 1.00), attention problems ($X^2(df = 13) = 14.92$, *ns*; RMSEA = .03; CFI = 0.99), and ADHD symptoms ($X^2(df = 13) = 13.58$, *ns*; RMSEA = .02; CFI = 1.00) had acceptable fit across all three fit indices and were interpreted. The model for internalizing problems ($X^2(df = 13) = 23.57$, $p < .05$; RMSEA = .07; CFI = 0.94) did not have acceptable fit and was not interpreted.

For each interpreted model, the statistically significant paths are depicted in Figure 1 with the standardized path estimate (providing a comparison of path magnitude within each model). Additional path estimates are provided in Table 2. Consistent with the analyses focusing on change over time reported above, within each model there was robust continuity in group performance between 24- and 36-months for the EC composite scores (Figure 1; Table 2).

Assessment of covariates—Neonatal health risks, infant gender, family SES risks, maternal depression, and the maternal interaction (anger) variable were included in each model as covariates. Neonatal health risks significantly related to children's EC composite at 24-months, with lower scores for children who experienced more health risks. In addition, within each interpreted model, family SES risks and maternal interactions significantly predicted the 24-month EC composite. Children from families facing more SES risks and infants whose mothers exhibited angry, hostile, or critical behaviors during play obtained lower scores on the EC composite at 24-months. Infant gender related to children's 24-month EC composite at the trend level, with slightly lower scores for boys than girls. Mothers who reported more persistent depressive symptoms between hospital discharge and 16-months reported that their children exhibited more 24-month externalizing problems (Figure 1b), attention problems (Figure 1c), and ADHD symptoms (Figure 1d), than mothers experiencing less persistent depression. However, depression was not related to 24-month cognitive scores or the EC composite. To confirm that the covariates were correctly specified, post-hoc modification indices were examined, revealing that no substantial associations (i.e., paths) were missing in the model.

Cognitive development—Lower EC composite scores were associated with less optimal cognitive scores concurrently and prospectively. At 24-months, toddlers with lower EC composite scores also had lower Stanford-Binet scores at 24- and 36-months (Figure 1a; Table 2). Likewise, toddlers with lower Stanford-Binet scores at 24-months had lower EC composites at 36-months. However, the concurrent association between cognitive scores and the EC composite decreased over time, as indexed by a reduction in the standardized path estimate from .55 (24-month path) to .30 (36-month path). The time-lagged paths in Figure 1a illustrate that 24-month cognitive ability was a robust predictor of the 36-month EC composite.

Externalizing behaviors—Effortful control was not associated with concurrent or future mother-reported externalizing problems (Figure 1b). In addition, 24-month externalizing problems did not predict the 36-month EC composite.

Attention problems—The associations between effortful control and attention problems varied across time. At 24-months, the EC composite did not predict concurrent or future mother-reported attention problems (Figure 1c; Table 2). Likewise, attention problems at 24-months did not predict the EC composite at 36-months. However, at 36-months there was a statistically significant association between the EC composite and attention problems. As predicted, children with lower effortful control skills exhibited more attention problems at 36-months.

ADHD symptoms—Effortful control at 24-months was not associated with concurrent or future mother-reported ADHD symptoms (Figure 1d), and 24-month ADHD symptoms did not predict 36-month effortful control skills. As with attention problems, the path between effortful control at 36-months and ADHD symptoms at 36-months was significant (Table 2). As expected, children with lower EC composite scores tended to exhibit more ADHD symptoms. The models for attention problems and ADHD symptoms are quite similar; this may reflect the fact that both indices are based on the CBCL or that they tap into similar underlying behaviors (with the exception that ADHD symptoms include hyperactivity and impulsivity).

Discussion

Although infants born preterm are at risk for developing cognitive delays, attention problems, ADHD, and other behavioral difficulties (e.g., Bhutta et al., 2002), developmental and familial processes associated these problems are unclear. This prospective longitudinal investigation investigated the linkage between effortful control skills with concurrent mother-reported attention problems, symptoms of ADHD, and assessments of cognitive development in children born preterm. There was no association between effortful control and preterm children's broadband externalizing or internalizing behavior problems, however, suggesting some specificity in links found between effortful control and children's outcomes. The study also documented improvement in effortful control skills over time and longitudinal associations among infant, maternal, and family risks and effortful control skills in children born preterm.

In our preterm sample, children who exhibited less optimal effortful control skills at 36-months were more likely to be rated as having attention problems and symptoms of ADHD at 36-months compared to children who exhibited more optimal effortful control skills. These findings were specific to attention/ADHD problems and were not found for broadband externalizing problems. In addition, the findings were specific to concurrent (rather than predictive) associations. In other words, we did not find a relation between 24-month effortful control skills and children's 36-month attention or behavior problems. Overall, our findings are consistent with previous research linking children's effortful control with attention regulation (e.g., Harris et al., 2007), ADHD symptoms (e.g., Goldsmith et al., 2007; Nigg et al., 2004), and academic achievement (e.g., Blair & Razza, 2007).

We found that children with less optimal effortful control skills also exhibited lower cognitive abilities at 24- and 36-months. These results support the findings of Feldman (2009), who documented a correlation between 24-month cognitive skills and response to a delay task in a sample of preterm infants. The associations between children's cognitive skills and effortful control competencies found in these studies underscore the idea that self-regulatory skills require complex cognitive control (Posner & Rothbart, 2000; Rothbart & Bates, 2006).

Children's effortful control skills improved significantly between 24- and 36-months for preterms with lower and higher birthweights, with the exception of delay of gratification. Moreover, children's various effortful control skills became more closely associated between 24-and 36-months (i.e., internal consistency increased in the EC composite scores), similar to the developmental process documented in healthy full-term children (Kochanska et al., 2000). Over time, children's effortful control skills appear to become more consistent and stable, suggesting that effortful control may contribute to the development of an individual's emerging personality (Kochanska & Knaack, 2003). Further, as these skills develop, they have important implications for the children's ability to regulate their behaviors, emotions, and attention.

Our investigation also highlighted the importance of both biological and environmental risk factors for preterm children's emerging effortful control skills, consistent with ecological models. We found that children's effortful control skills did not differ on the basis of birthweight categories. However, preterm infants who experienced more neonatal health risks, such as ventilation during the NICU stay, respiratory distress syndrome, and lower birthweight and gestational age, scored less optimally on the effortful control composite at 24-months compared to preterm infants who experienced fewer health risks. These findings suggest that neonatal health risks are important predictors of emerging effortful control skills for infants born preterm, even for those who do not have significant neurological involvement (as the latter were screened out of the study). Children born preterm are at risk for developing attention problems, particularly when born at younger gestational ages and lower birthweights (e.g., Bhutta et al., 2002). Thus, it is possible that differences in attention regulation skills associated with neonatal health begin at a very young age, as reflected in our assessment of toddler effortful control skills. Our findings suggest that future research with the most medically fragile preterm children should explore interventions related to emerging effortful control skills during the toddler period in order to facilitate resilience processes in this population.

In addition to infant health risks, the affective tone of the early parenting environment was associated with children's behavioral and cognitive development. Less maternal anger, negative affect, and hostility during play at 24-months was associated with more optimal effortful control skills and cognitive skills at 24-months and fewer mother-reported externalizing behavior problems, attention problems, and ADHD symptoms. Similarly, in Kochanska et al.'s (2000) sample, children whose mothers were more responsive (e.g., more sensitive, accepting, cooperative, and emotionally available) had children who exhibited better effortful control skills by age three. Positive parenting interactions may facilitate the development of effortful control and other cognitive and behavioral competences in children born preterm and full-term, whereas angry, critical interactions may interfere with this process. These findings suggest that interventions designed to improve the quality of parenting interactions should be explored as a way to positively affect the development of effortful control skills in children born preterm.

Previous studies have found links between maternal depression and children's behavior problems. A meta-analysis of 33 studies that explored the association between maternal depression and externalizing behavior problems in children one year of age and older revealed a moderate association (r = .29) (Beck, 1999). Consistent with these results, we found a relation between persistent maternal depressive symptoms and more mother-reported externalizing behavior problems and attention/ADHD problems. However, we did not find a link between maternal depressive symptoms and children's cognitive development or effortful control skills. These findings underscore the importance of maternal depression for the development of externalizing problems in children born preterm, consistent with Clark et al. (2008).

Family SES risks such as poverty and low parental education also provide a challenging context for child development, as has been discussed in previous research (e.g., Burchinal et al., 2000; Linver et al., 2002). In this sample of children born preterm, SES risks were associated with less optimal 24-month effortful control. Because 24-month effortful control was associated with 36-month effortful control and children's cognitive skills, such environmental risks appear to set the stage for less optimal development for children born preterm. Some of these risk factors (e.g., poverty, maternal depression) are also associated with increased incidence of prematurity (Joseph, Liston, Dodds, Dahlgren, & Allen 2007), suggesting that screening and interventions could begin prior to, or during, pregnancy to increase the likelihood of healthier births and decrease subsequent developmental and parenting challenges.

Limitations

The limitations of our study should be noted when interpreting or applying our findings. Although attrition was relatively low across the 3 years of the study, families that remained in the study were more socioeconomically advantaged than ones who dropped out of the study or could not be located. Thus, appropriate caution should be used in generalizing our findings to more socioeconomically stressed families. In addition, because we focused on infants born preterm, our results are not generalizable to full-term infants. It also should be noted that several measures relied on maternal report, and thus, shared method variance may have led to spurious positive findings (e.g., maternal reports of depressive symptoms and children's behavior problems). However, our use of laboratory-based effortful control assessments, standardized assessment of children's cognitive development, and observer ratings of mother-child interactions were strengths of the study. In addition, we did not determine children's diagnoses of ADHD, but instead relied on maternal report of children's symptoms, as it would be challenging to diagnose ADHD reliably in children this young. Future research is needed to examine links between early effortful control skills and later diagnoses of ADHD in children born preterm, especially in the context of biological and environmental risk factors. We are continuing to follow the children in this sample to school-age to examine such links.

Implications for Research, Policy, and Practice

In sum, our prospective longitudinal study found that effortful control skills in children born preterm improved over time and related to children's concurrent attention problems and early symptoms of ADHD. Because children born preterm are at high risk for developing attention and behavior problems, it is important to identify factors leading to such difficulties in order to facilitate early identification and treatment for this vulnerable population.

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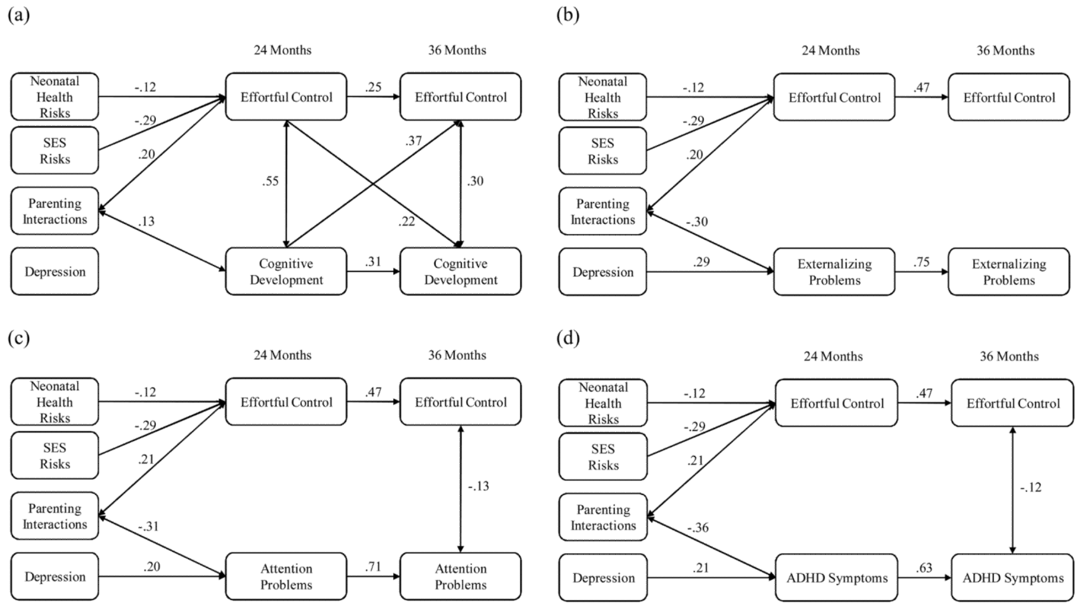

Figure 1.

Statistically Significant Paths for (a) Cognitive Development, (b) Externalizing Problems,(c) Attention Problems, and (d) ADHD Symptoms with Standardized Path Estimates.

Table 1

Bivariate Correlations and Descriptive Statistics for Key Variables (n = 172)

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. SES Risk	-	.11	.37**	−.40**	−.36**	.21*	.24**	.24**	.23**	−.38**	−.33**	.16	.15	.23**	.22**	−.40**
2. Neonatal Health Risk		–	.01	−.10	−.14	−.10	−.04	−.02	−.02	−.13	−.04	−.15	−.15	.07	.07	−.11
3. Persistent Depression			–	−.22	−.17*	.35**	.20*	.28**	.27**	−.19*	−.12	.28**	.22**	.21*	.19*	−.19*
4. 24m Parenting Interactions					.33**	−.34**	−.16*	−.39**	−.36**	.33**	.23**	−.22**	−.08	−.27**	−.28**	.30**
5. 24m EC Composite					-	−.05	−.06	−.12	−.14	.60**	.46**	−.05	−.06	−.10	−.11	.52**
6. 24m CBCL Externalizing						-	.62**	.78**	.67**	−.18*	−.01	.75**	.49**	.52**	.52**	−.17*
7. 24m CBCL Internalizing							-	.45**	.39**	−.26**	−.02	.55**	.75**	.42**	.38**	−.14
8. 24m CBCL ADHD								-	.88**	−.19*	−.03	.59**	.38**	.63**	.65**	−.21*
9. 24m CBCL ADD									-	−.19*	−.01	.56**	.34**	.63**	.70**	−.17
10. 24m Stanford-Binet										-	.51**	−.18*	−.23**	−.22*	−.19*	.58**
11. 36m EC Composite											-	−.07	−.00	−.13	−.12	.54**
12. 36m CBCL Externalizing												-	.63**	.73**	.69**	−.12
13. 36m CBCL Internalizing													-	.48**	.42**	−.03
14. 36m CBCL ADHD														-	.85**	−.19*
15. 36m CBCL ADD															-	−.19*
16. 36m Stanford-Binet																-
M	1.05	0.02	0.77	38.57	−0.03	51.95	49.50	56.21	56.57	79.83	−0.01	51.71	50.71	54.78	56.06	95.99
SD	1.54	2.67	0.99	6.35	0.47	10.15	9.78	6.92	8.05	17.82	0.56	9.48	10.47	5.54	6.71	13.98
Range	0–6	−4.08—6.56	0–4	22–50	−1.07—1.41	28–76	29–71	50–76	50–80	50–121	−1.21—2.08	28–70	29–72	50–71	50–77	52–130
N	172	172	172	146	147	147	147	148	148	145	138	140	140	140	140	134

Note:

** $p < .01$,

* $p < .05$.

CBCL=Child Behavior Checklist (Achenbach & Rescorla, 2000)

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Table 2

Path Estimates for Cognitive Development, Externalizing Problems, Attention Problems, and ADHD Symptoms (n = 172)

	Outcomes							
	Cognitive Development		Externalizing Problems		Attention Problems		ADHD Symptoms	
	Est (SE)	*TS*	*Est (SE)*	*TS*	*Est (SE)*	*TS*	*Est (SE)*	*TS*
Effortful Control (24m) on								
Neonatal Health Risks	−.02 (.01)	−1.78*	−.02 (.01)	−1.76*	−.02 (.01)	−1.77*	−.02 (.01)	−1.77*
Gender	.10 (.07)	1.42+	.10 (.07)	1.39+	.10 (.07)	1.38+	.10 (.07)	1.38+
SES Risks	−.09 (.02)	−4.60**	−.09 (.02)	−4.60**	−.09 (.02)	−4.60**	−.09 (.02)	−4.60**
Parenting Interactions	.02 (.01)	2.72**	.02 (.01)	2.73**	.02 (.01)	2.72**	.02 (.01)	2.73**
Depression	−.00 (.03)	−0.10	−.00 (.03)	−0.12	−.00 (.03)	−0.12	−.00 (.03)	−0.12
Outcome (24m) on								
Effortful Control (24)	20.54 (2.71)	7.58**	1.87 (1.53)	1.22	−.16 (1.20)	−.13	.42 (.99)	.43
Parenting Interactions	.36 (.19)	1.91*	−.48 (.15)	−3.23**	−.39 (.11)	−3.64**	−.39 (.09)	−4.48**
Depression	−1.56 (1.21)	−1.28	3.03 (.81)	3.74**	1.61 (.62)	2.59**	1.44 (.53)	2.74**
Effortful Control (36m) on								
Effortful Control (24m)	.29 (.10)	3.01**	.55 (.09)	6.37**	.56 (.09)	6.43**	.55 (.09)	6.37**
Outcome (24m)	.01 (.00)	4.01**	.00 (.00)	−.08	.00 (.01)	.72	.00 (.01)	.28
Outcome (36m) on								
Outcome (24m)	.25 (.07)	3.78**	.69 (.05)	14.89**	.59 (.06)	10.59**	.51 (.07)	7.58**
Effortful Control (24m)	6.49 (2.61)	2.49**	−.08 (1.36)	−.06	.56 (.98)	.57	.29 (.81)	.36
Effortful Control (36m)	7.56 (1.67)	4.53**	−.94 (1.14)	−.83	−1.54 (.71)	−2.17*	−1.13 (.67)	−1.69*

Note: Est = estimate; SE = standarad error; TS = test statistic; Gender coded as: Boys = 1, Girls = 2; Parenting Interactions = angry, hostile, critical parenting during maternal interactions; Depression = depression chroncitiy from hospital discharge to 16 months postterm;

** $p < .01$,

* $p < .05$,

+ $p < .10$.