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Longitudinal associations between self-regulation and the academic and behavioral adjustment of young children born preterm

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ABSTRACT

Much of the research to date about the structure of self-regulation in early childhood has been conducted with low medical risk samples, with the general conclusion that self-regulation can be separated into overlapping executive function and effortful control factors that differentially predict child outcomes. We examined the factor structure of 36-month self-regulation among children born prematurely ($n = 168$) and the extent to which self-regulation predicted maternal ratings of children's socioemotional and academic competence when they were six years of age. Statistical analyses revealed a single self-regulation factor for this high neonatal risk sample, and this self-regulation factor mediated associations between early sociodemographic risk and mothers' ratings of academic competence and externalizing problems. Our findings suggest that early intervention research with children born preterm should focus on promoting supportive early environments, particularly parental sensitivity to infant cues.

Executive function (EF) and effortful control (EC) originate in different scholarly traditions. Nevertheless, they both refer to the volitional control and inhibition of attention (Vohs & Baumeister, 2004) and other innate behaviors, in addition to being measured in similar ways (Zhou, Chen, & Main, 2012). Recent attention to the conceptual and measurement overlap between the two has led some scholars to call for a unified model of self-regulation in early childhood that incorporates research and theory from both literatures (e.g., Bridgett, Oddi, Laake, Murdock, & Bachmann, 2012; Zhou et al., 2012). Research using confirmatory factor analytic approaches counter this call, indicating that despite their similarities, self-regulation can be meaningfully separated into EC and EF latent variables among children born at term (e.g., Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Willoughby, Kupersmidt, Voegler-Lee, & Bryant, 2011). However, there is limited knowledge about single- or multifactorial models of self-regulation in children born prematurely (≪37 weeks gestation), including how such models relate to subsequent socioemotional and behavioral outcomes in this high-risk group. Such knowledge can provide critical insight into how and when self-regulation develops as well as inform the content and timing of intervention for both typically developing and high-medical risk children.

We examined the extent to which 36-month self-regulation predicted mothers' ratings of socioemotional and academic competence when children were six years old using one- and two-factor models of self-regulation. We focused on children born prematurely due to the potential brain abnormalities associated with being born prior to term, and the relation between these abnormalities and self-regulation deficits. This topic is particularly relevant for preterm children because of their increased risk for developing less-than-optimal behavioral and socioemotional outcomes in infancy and toddlerhood, as well as poorer academic outcomes as they reach school age (Arpi & Ferrari, 2013; Bhutta, Cleves, Casey, Cradock, & Anand, 2002; Scott et al., 2012).

1. Self-regulation among children born prematurely

Scholars who study emerging self-regulation in young children have often done so from either temperament (EC; Rothbart, Ellis, & Posner, 2004) or cognitive processing/neuropsychological (EF; Welsh & Pennington, 1988; Welsh, Pennington, Ozonoff, Rouse, & McCabe, 1990) perspectives. The empirical literature suggests that EF and EC are related skill sets that develop in a manner corresponding to the maturation of the prefrontal cortex (Bechara, Damasio, Damasio, & Anderson, 1994; Bush, Luu, & Posner, 2000; Happaney, Zelazo, & Stuss, 2004). EC is more often associated with self-regulation in emotionally laden contexts in which children are required to control their responses to cues for immediate reward or punishment (Blair & Razza, 2007; Rothbart et al., 2004). EF is more associated with emotionally neutral contexts requiring cognitive control (Blair & Razza, 2007; Zhou et al., 2012).

The EC and EF distinctions provide a means of specifying the diverse

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subsets of skills that fall under the more general self-regulation term (Willoughby et al., 2011). However, these distinctions are not universally accepted and are replete with conceptual and methodological issues, including the use of identical measures to assess both constructs and specifying the relative heat or coolness of a task and individual differences in experiencing a given task as affect-laden or affect-neutral (Welsh & Peterson, 2014; Zhou et al., 2012). Much of the research in this area has also focused on low medical risk children, with less consideration of the extent to which the structure of self-regulation may be different in high medical risk children.

Identifying potential differences between children who experience high versus low medical risks early in life is important because of the possibility that these early experiences shape how self-regulation develops. For example, two separate studies of self-regulation development of high neonatal risk children observed within-group variation in self-regulation development (e.g., Feldman, 2009; Poehlmann et al., 2010). Feldman's (2009) findings from a longitudinal study of 125 infants born preterm suggest that children's ability to regulate their behaviors develops hierarchically across the first five years of life, beginning with physiological regulation during the neonatal period, emotion regulation in year one, attention regulation in year two, and self-regulation (indexed by a global EF score, a latent self-restraint variable, and a latent behavior problems variable) by year five. Feldman (2009) also observed bidirectional associations between EF and behavior problems and a unidirectional relation between EF and self-restraint at five years old. However, this study did not address the extent to which self-regulation predicted child behavior outcomes across time-points, nor did it examine academic outcomes.

Poehlmann et al. (2010) extended this work by examining changes in the emerging self-regulation of children born prematurely over 24- and 36-month time-points. Although they did not observe predictive associations between 24-month EC and 36-month behavior problems, the authors did find that 24- and 36-month EC composites predicted later cognitive ability. They also observed significant improvement in EC abilities across the two time-points.

Together, Feldman's (2009) and Poehlmann et al.'s (2010) findings point to significant developmental changes in self-regulation across the early life-span among children born preterm.

Yet, neither study addressed whether self-regulation is best represented by a unitary factor or a multi-factorial model composed of specific tasks used to construct EC and EF latent variables. This distinction is particularly important when studying children born prematurely because these children are prone to emotion and behavior regulation problems that can negatively impact the quality of early parent-child interactions (Clark, Woodward, Horwood, & Moor, 2008; Poehlmann et al. 2010) which, in turn, has negative implications for social and academic competence (e.g., Boyce, Cook, Simonsmeier, & Hendershot, 2015; Treyvaud et al., 2016).

The timing of premature birth can have significant impacts on brain development, with children born the most premature experiencing the greatest negative impact (Adams-Chapman, 2009; Kinney, 2006). Instead of experiencing the increase in brain volume and myelination that characterizes the last month of gestation in utero (Ball et al., 2012; Kinney, 2006), children born preterm often experience this critical period in development in high stress neonatal intensive care units (NICUs) (Smith et al., 2011; VandenBerg, 2007). Children born preterm are at significant risk for brain deficits associated with exposure to high stress in the NICU, along with the risk for brain injury associated with prematurity. These events may culminate in a potentially different structure of early self-regulation and developmental timing for this subset of children.

Conceptual clarity about the structure of self-regulation is a critical step toward developing effective interventions targeting parent-child interaction quality as a means of enhancing the self-regulation and, thereby, academic and socioemotional outcomes of children born prematurely. Existing research already demonstrates that preterm infants benefit from high quality scaffolding of emerging neurocognitive skills (Landry, Miller-Loncar, Smith, & Swank, 2002). However, the extent to which parent-child interactions are successful in promoting self-regulation depends on the types of behaviors in which parents engage (Dilworth-Bart, Poehlmann, Hilgendorf, Miller, & Lambert, 2010) and child characteristics such as emotionality (Dilworth-Bart, Miller, & Hane, 2012; Poehlmann et al., 2011).

We focus on children born prematurely due to the potential brain abnormalities associated with being born prior to term, and the relation between these abnormalities and self-regulation deficits (Aarnoudse-Moens, Weisglas-Kuperus, van Goudoever, & Oosterlaan, 2009; Baron, Erickson, Ahronovich, Baker, & Litman, 2011; Espy et al., 2002; Orchinik et al., 2011). Our analyses included tasks used by EF and EC researchers to index suppressing or initiating response to signal/inhibitory control, working memory, ability to delay, and effortful attention.

1.1. Suppressing or initiating response to signal/inhibitory control

Suppressing or initiating response to signal, or inhibitory control, refers to the volitional ability to stop an ongoing behavior (Eisenberg, Smith, Sadovsky, & Spinrad, 2004; Garon, Bryson, & Smith, 2008; Miyake et al., 2000). It is associated with both EF and EC (Zhou et al., 2012), further pointing to the conceptual overlap between the two. In this study we include measures of suppressing or initiating response/inhibitory control that were originally conceptualized using EF (i.e., day-night stroop, Gerstadt, Hong, & Diamond, 1994) and EC (i.e., Kochanska & Knaack, 2003; Kochanska, Murray, & Harlan, 2000).

Like other aspects of self-regulation, the skill has developmental precursors in infancy (Garon et al., 2008). Children born prematurely have also been observed to have lower inhibitory control than children born at term (Aarnoudse-Moens, Smidts, Oosterlaan, Duivenvoorden, & Weisglas-Kuperus, 2009; Edgin et al., 2008; Espy et al., 2002). Aarnoudse-Moens, Smidts et al. (2009) and Aarnoudse-Moens, Weisglas-Kuperus et al. (2009) observed that early elementary school students born preterm had lower scores than children born at term on two separate inhibitory control tasks (Go/No Go and Day-Night), even after controlling for processing speed and after excluding preterm children with neurosensory impairments from the sample. However, these effects may be attributable to specific neurological impairments (Edgin et al., 2008). Edgin et al. (2008) found that children born preterm who did not display signs of white matter abnormalities performed similarly to children born full term on inhibitory control tasks, while preterm infants with brain abnormalities had inhibitory control deficits. This suggests that individual differences in inhibitory control impairments among children born preterm may be associated with severity of neonatal risk.

The inhibitory control skills of children born prematurely may reach levels similar to children born at term by elementary school. In a longitudinal study, Aarnoudse-Moens, Duivenvoorden, Weisglas-Kuperus, Van Goudoever, and Oosterlaan (2012) assessed children who were born very preterm and full term controls when they were school aged. They found an interaction effect of age and birth condition on a stop task (which measures inhibitory control), such that the effect of being preterm on inhibitory control declined with time. Four-year-old children born preterm performed 0.70 standard deviations ($p \ll 0.001$) lower than their full-term peers, whereas twelve-year-old children born preterm performed only 0.15 standard deviations ($p \gg > 0.10$) below their full-term peers (Aarnoudse-Moens et al., 2012).

1.2. Executive function

In addition to our measures of inhibitory control, we used a task purported to assess working memory to index EF.