IN-SYNC AND ON-TRACK: SELF-REGULATION IN PRESCHOOLERS BORN VERY /EXTREMELY PREMATURELY

By

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ABSTRACT

INTRODUCTION: Self-regulation (SR) is a major childhood developmental achievement that predicts important preschool academic, adaptive, and psychosocial outcomes. Very or extremely premature (VP/EP) birth impacts cognitive development, however SR and related adaptive outcomes for this group of at-risk children are under-studied despite their importance to optimal outcomes. Consequently, the research goal was to examine the impact of premature birth on preschool SR and related areas and further to identify potential early predictors of risk.

METHODS: This data-driven clinically derived study explored preschool SR outcomes in a convenience sample of 104 Manitoban children born VP/EP at 2 and 4 years of age. A novel SR framework incorporating 'hot' and 'cool' executive function (EF), behavioural, and adaptive components was examined using parent-report measures (Behavior Rating Inventory of Executive Function- preschool, Behavior Assessment System for Children- Parent Report System, Adaptive Behavior Assessment System- second edition) and individually administered cognitive and language measures. Cognitive and language scores were compared at two and four years of age. Scores for participants completing all measures (sample A, n = 60) were compared to participants who did not complete all measures (sample B, n = 44).

FINDINGS: Sample A demonstrated poorer preschool adaptive, 'cool' EF, and atypical behaviour scores relative to test norms, of moderate to strong effect size. Principal Axis Factoring of parent report measures revealed 7 latent factors with Factors 1(Adaptive), 5(Internalizing), 6(Social Communication), and 7(Developmental) predicted by birth weight, brain injury, bronchopulmonary dysplasia, days of hospitalization, and/or chronological age. Cognitive and language scores for 4-year-olds were significantly correlated with preschool adaptive, behavioural and 'cool' EF scores. Sample B demonstrated more complex neonatal histories, greater adaptive

(cognitive, practical, social) and externalizing concerns, and reduced likelihood of 'catch-up' between 2 and 4 years of age.

IMPLICATIONS: The study's In-Sync/On-track framework provides a useful lens to inform research and clinical monitoring of children born VP/EP. Findings revealed limitations to daily function and childhood SR prior to school entry, pointing to practice, policy and research implications, particularly for children with more complex medical histories who demonstrated higher levels of SR impairment but failed to complete testing.

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DEDICATION

This work is dedicated to my partner in life, Dr. F. Meredith Penner, who joined me on this long and winding but so fulfilling road over 40 years ago, typically putting his priorities and responsibilities on hold to support me in ways well beyond reason. This work is also dedicated to my mother Margaret von Hahn who continues to challenge the way I look at life and to my beloved family, the axis of my world. Zarah, Mike, Addoniah, Eden, Rebekkah, Katherine, Michael, Camryn, and Dan - as the refrain goes, "Oh, what a wonderful world!" May we always remain curious...

LIST OF ACCRONYMS

ABAS-II	Adaptive Behaviour Assessment System – Second edition
ADHD	Attention Deficit Hyperactivity Disorder
ASD	Autism Spectrum Disorder
BASC-p	Behavioural Assessment System for Children - Preschool Report
BRIEF-p	Behavioural Rating Inventory of Executive Function - Preschool Report
BSID-II/ III	Bayley Scales of Infant Development- 2nd (or 3rd) edition
EDF	Executive Dysfunction
EF	Executive Function
ELBW	Extremely Low Birth Weight
EP	Extremely Premature
GA	Gestational Age
GDS	Gesell Developmental Schedule
IVH	Intraventricular Hemorrhage
MSEL	Mullen Scales of Early Learning
NICU	Neonatal Intensive Care Unit
PVL	Periventricular Leukomalaica
SR	Self-Regulation
VLBW	Very Low Birth Weight
VP	Very Premature
WM	Working Memory
WMI	White Matter Injury

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CHAPTER 1: SELF-REGULATION IN THE PRESCHOOL YEARS

The rapid expansion of physical, cognitive, psychological, and socio-emotional skills in the preschool years (ages 3 – 5) leads to increased competency, autonomy, independence, and the emergence of self-regulation (SR) (Bassett, Denham, Wyatt, & Warren-Khot, 2012; Daelmans, Black, Lombardi, Lucas, Richter, 2015). Self-regulation (SR) has been defined as a broad and complex construct that refers to a cluster of cognitive, affective, social, and physiological/neurological processes, which in turn modulate attention, emotion, and behaviour (Bassett et al., 2012). More specifically, SR enables regulation of actions, cognition, and emotion of the self by the self, enhancing adaptation and goal achievement (Nigg, 2017). SR has profound significance to the developing child because it is a broad determinant with considerable influence on multiple early and lifelong outcomes (Diamond, 2013; Espy, Sheffield, Wiebe, Clark & Moehr, 2011; Ponitz et al., 2009). Moreover, SR lays a foundation for long-term well being across physical, psychological, behavioural, social, and educational domains (Raver, Jones, Li-Grining, Zhai, Bu, & Pressler, 2011; Shanker, 2013), making it a significant determinant of mental health. For example, SR predicts early school success (Blair & Raver, 2015), development of higher-order problem solving and reasoning skills, general adaptation and lifelong achievement, long-term health, educational and life success, adult outcomes (Moffitt, Arsenault, Belsky, Dickson, Hancox, Harrington et al., 2011; Saigal & Doyle, 2008), and quality of life (Diamond, 2013; Shaheen, 2014). The development of SR is however, influenced by many intrinsic and extrinsic variables impacting early brain development. It has been well studied by a variety of disciplines, being viewed conceptually as a bridge or umbrella construct, but with clear challenges evident integrating the diversity of the literature pertaining to taxonomy, theory, and measurement.

Taxonomical Considerations:

While the concept of SR is widely used, its definition is ambiguous due to lack of consensus on clear signposts of SR and confusing terminology across disciplines (Burman, Green, & Shanker, 2015). To illustrate the problem, Burman and colleagues identified 447 terms associated with SR in contemporary literature. Similarily, Moffitt et al. (2011) suggested that discipline-specific approaches in the study of how children learn to self-regulate have contributed to the emergence of multiple taxonomies where the focus, and consequently, the conceptualizations differ, adding to the noted confusion. For example, neuroscientists emphasize the role of executive function (EF), the brain's frontal cortex, and integrated structures and systems, which plays a critical role in cognitive control. EF researchers have historically focused on thoughts, attention, and action (Diamond, 2013). Behavioural geneticists in contrast discuss genetic and environmental influences; psychologists and neuropsychologists consider how children develop self-control skills across cognitive, behavioural, emotional, and social domains; while health researchers speak of SR as a predictor of morbidity, psychiatric disorders, and unhealthy behaviours (e.g., substance use, overeating, noncompliance, risk-taking behaviours).

Other aspects of SR research contribute to taxonomical confusion and merit brief mention. First, SR is not static but develops in a hierarchical, cascading manner (Nigg, 2017). This results in a diversity of SR clinical signposts that change across the life cycle, with early childhood signposts discussed later in this chapter. Secondly, difficulties differentiating what is being regulated (the target component) from what is regulating (the processes) in any given context may occur (Nigg, 2017). Finally, commonalities and differences exist within key subcomponents of SR, which generally need one another and co-occur, leading to questions as to whether different aspects of SR are indeed clearly dissociable from one another (e.g., self-control and inhibitory control) (Diamond, 2013). In combination, these observations emphasize the need for

development of a clear and consistent theoretical trans-disciplinary framework that disentangles lower and higher order components of SR.

Setting the Research Framework:

The importance of operationalizing a definition of SR for research is widely noted (Burman et al., 2015; Nigg, 2917), requiring precise definition of what is measured, analyzed, and interpreted when studying young children (Cole, Martin, & Dennis, 2004; Wiebe, Espy, & Charak, 2008). As such, key concepts were identified from a review of contemporary SR frameworks, gaps in the literature were noted and a novel 'In Sync'/'On Track' SR framework blending Occupational Therapy and Psychology perspectives was proposed for this study. To begin with, commonalities pertaining to SR theory are considered.

Despite differences in nomenclature, Denham and colleagues (2012) note that "virtually all SR theorists and researchers emphasize, to various degrees, modulating systems of attention, emotion, and behaviour in response to a given situation or stimulus" (page 387). As such, SR traditionally refers to processes that enable the individual to attain and maintain optimal levels of cognitive, emotional, and motivational arousal (Liew, 2011). Further, SR evolves through clear a developmental cascade of hierarchical components that vary in their assembly and functional time course (Nigg, 2017). Thus, SR frameworks include top-down (deliberate) and bottom-up (reactive, automatic) components that modulate and optimize one another. Top-down cognitive control processes are mediated by the prefrontal cortex and are engaged to address novel problems, resolve conflict, and anticipate a goal or challenge. Bottom-up processes in contrast are dependent upon phylogenetically older brain regions. These processes are automatic, sensory (external) stimulus-driven and can be targets of regulation or can be regulatory (e.g. innate responses, reflexes, habits, operant learning, approach-avoidant reactions) (Nigg, 2017).

EF and cognition (in general) are also considered key elements of SR (Ferrier, Bassett, & Denham, 2014), in turn supporting the development of self-control, self-monitoring, learning, and social behaviour (Burman et al., 2015). EF is a critical foundation of SR (discussed later in this chapter) but the constructs are not interchangeable (Miyake et al., 2000; Diamond 2013). Similarities are noted in that both undergird the development of learning, adaptability, goal-directed problem solving and behaviour, and higher order cognitive control, thereby positively impacting social relationships and sense of self (Caughy, Mills, Owen & Hurst, 2013). Differences between how researchers conceptualize SR and EF are also noted.

SR research has traditionally emphasized the impact of attention, emotion, motivation, and behaviour using parent or teacher observations and/or behavioural measures, that latter often generated using emotionally laden test situations (e.g. reward delay or frustrating situations) (Denham et al., 2012; Eisenberg, Valiente, & Eggum, 2010). In contrast, EF researchers have emphasized the importance of higher order cognitive processing. Historically, EF was measured using laboratory tasks that incorporated abstract, decontextualized, emotionally- neutral 'cool' activities, with emotion viewed as distinct and modifiable, in situations "far removed from the real world" (Diamond, 2013, p. 153). Only more recently has the importance of affective-behavioural or emotional components of 'hot' EF and their role in psychosocial adjustment been acknowledged (Cassidy, 2016). While EF skills support SR development, they can also be employed in non-regulatory tasks, such as learning math or how to read (Monette, Bigras, & Guay, 2011).

Similar to EF, the term self-control has also been used interchangeably with SR (Burman et al., 2015) though again the constructs differ (Nigg, 2017). Specifically, self-control reflects a narrower process than SR. It involves deliberate action to overcome an emotionally charged, stimulus driven response and execute a goal-relevant response to promote long-term adaptation (Fujita, 2011). Self control enables the young child to resist temptations or acting impulsively,

with such inhibitory control associated with 'hot' EF (Diamond, 2013). As such self-control is viewed as a subcomponent of SR, that latter also including 'cool' EF and processes regulating action, cognition, and attention. Self-control however enables the child to be 'in sync' across settings and demands, particularly important for affective, behavioural, and social success.

Given many discipline specific approaches exist, often with narrow approaches, this limits broad understanding of the range of outcomes anticipated. Incorporating a multidisciplinary neurodevelopmental viewing lens, blending Occupational Therapy and Psychology perspectives may provide a means to understand and bridge a gap in the SR literature. More specifically, Nigg's (2017) model of SR recognizes the importance of regulation of action, evident in motor, vocal, and ocular adaptive responses. These critical SR outcomes are not typically reflected in contemporary research. Although intact SR enables the child to successfully adapt to changing environments and expectations, solve complex novel problems, and attain developmentally appropriate goals, formal measurement of functional (adaptive) outcomes is limited in SR research. As such, incorporating parent observations of children's daily life participation across naturalistic settings and periods of time, holds promise to provide a direct, ecologically valid means to measure this discrete SR outcome. This both elucidates the impact SR on everyday behaviours and skills and addresses the lack of formal measurement of adaptive outcome in the SR, despite its importance for daily living.

Extending current conceptualizations pertaining to SR and addressing the concern noted above, a novel 'In Sync' (social, behavioural, and emotional regulation) and 'On Track' (cognitive and adaptive attainment) framework with several levels is proposed. This reflects the role of SR as enabling children to be "in sync" socially, emotionally, and behaviourally and "on track" developmentally and adaptively. As depicted in Figure 1 (below), the core of this model reflects extrinsic and intrinsic variables that influence both SR and EF. Extrinsic factors include

environmental adversity, early experience, maternal–child attachment, poverty, and/or stress. Using this approach, pre- and perinatal factors such as being born very or extremely prematurely (VP/EP) are considered extrinsic factors influencing SR outcomes (Eisenberg, Spinrad & Eggum, 2010) (see Chapter 2 for information related to VP/EP populations). Relatedly, intrinsic variables reflect genetic, neurological, and physiological processes and/or temperament (Ponitz, McClelland, Matthews & Morrison, 2009; Rueda, Rothbart, McAndliss, Saccomanno, & Posner, 2005).

As suggested by Figure 1, the second level of this model recognizes the foundational role of EF for higher order, broad SR skills (Hughes, 2011; Diamond 2013). It includes 'cool' EF [or cognitive control skills mediated by the dorsal lateral prefrontal cortex (PFC)] and 'hot' EF (or social/ affective skills mediated by the orbitofrontal prefrontal cortex) (Willoughby, Kupersmidt, Voegler-Lee & Bryant, 2011). As such, a clear distinction is made between those processes necessary for knowledge acquisition ('cool' EF) and those that enable children to conform to social rules and behave appropriately, particularly in emotionally charged situations or when facing fatigue, distraction, or decreased motivation ('hot' EF) (Neuenschwander, Röthlisberger, Cimeli & Roebers, 2012).

In light of the pre-school context, the present study incorporates Garon's EF model (Garon, Bryson, & Smith, 2008), which recognizes that core EF components are organized hierarchically and demonstrate distinct developmental paths (Willoughby, Blair, Wirth, & Greenberg, 2010). Inhibition, WM, and shifting are constructs of particular interest for preschoolers (Hughes, 2011), given that they mutually influence each other, are readily discernable by 5 years of age, and exhibit profound effects on the emergence of school aged EF and SR skills.

A third level in this study's model reflects components of Nigg's framework, which reflects the construct as a triad of regulation for action, cognition, and emotion/behaviour. As depicted in

Theoretical Framework for this Study

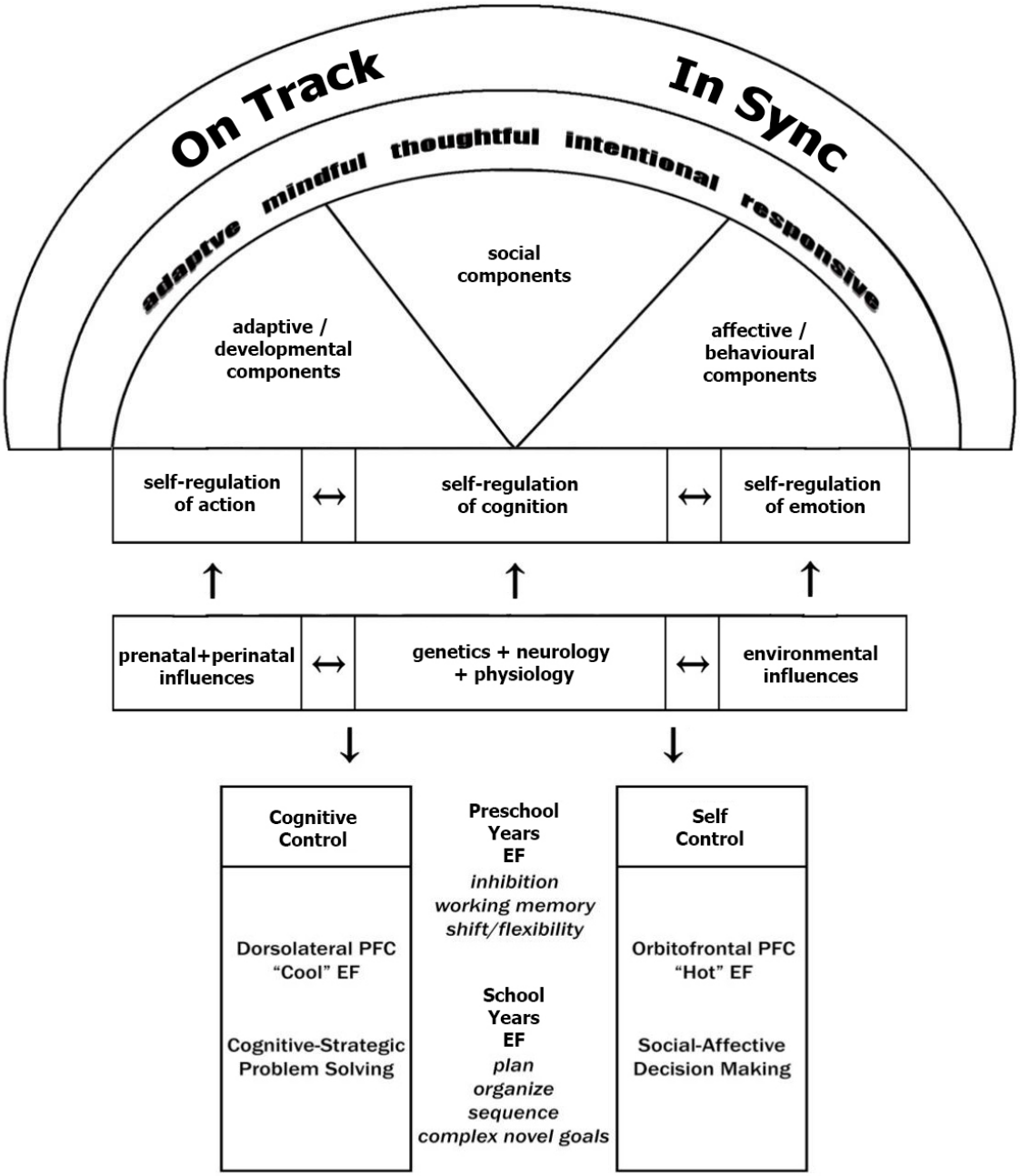

Figure 1: Study Conceptualization of Self-Regulation (S-R). Executive Functions (EF), which support S-R are influenced by intrinsic and extrinsic variables, which similarly influence regulation of action, cognition and emotion. Jointly this supports emergence of adaptive/developmental, social, and affective/behavioural components of SR, evident in the child's functional and cognitive attainment ('On Track') and social, affective, and behavioural skill development ('In Sync').

Figure 1, this SR triad is evident in affective/behavioural, social, and adaptive/developmental subcomponents, each of which may be measured empirically. Preschoolers learn to control their emotions, manage stress, solve increasingly complex interpersonal and academic problems, and interact, learn, and play with others. In doing so, preschoolers become increasingly mindful, intentional, thoughtful, and responsive to the ever-changing world and expectations in which they reside (Bodrova & Leong, 2007), reflected in the upper level of Figure 1. Globally, this is evident in the child's being 'On Track' developmentally and adaptively and 'In Sync' socially, behaviourally, and emotionally.

As noted, "One of the greatest challenges for contemporary investigations of SR involves the definition and measurement of these skills, particularly in young populations" (Denham et al., 2012, p. 667). Adopting this 'In Sync' and 'On Track' viewing lens addresses this concern and holds the potential to provide information applicable to both theoretical and clinical knowledge creation. Consistent with SR literature, the SR framework for this study incorporates key SR components of self-control, social behaviour, and learning (Burman et al., 2015). Moreover, a particular novel and timely aspect of the research framework is the incorporation of adaptive development as a viable, distal marker of goal-directed collective SR processes. This reflects Cramm and colleagues' (2013a) assertion that expression of SR and its related component parts are observed in adaptive daily function and life participation. Further, incorporating adaptive outcomes in this study framework acknowledges that SR impacts competency across the life span (Bronson, 2000; Posner, Rothbart & Rueda, 2008). With this study framework in mind, discussion now shifts to the importance of SR in supporting global (e.g., pediatric mental health) and more specific (e.g., social behavioural adjustment, early learning, and adaptive development) competencies across childhood.

Self-Regulation and Pediatric Mental Health

Pediatric mental health is a significant social concern, predicted in part by SR deficits (Cassidy, 2015; Woodward, Lu, Morris, & Healey, 2017). Community-based epidemiological studies demonstrated that mental health difficulties affect one in five preschoolers, a prevalence rate comparable to that seen in school-aged children (Dougherty et al., 2015; Egger & Angold, 2006). In Canada, one in four children (or teens) experience some sort of mental health problem, many of which involve self-regulation concerns (e.g. Anxiety, ADHD, etc), with 70% of those cases beginning in earlier childhood (Government of Canada, 2006). Of concern, fewer than 20-25% of these children with mental health concerns receive intervention (Dougherty et al., 2015; Kataoka, et al., 2002). When provided, intervention typically begins in the later elementary school years despite parent concerns often originating during the preschool period (Feeney-Kettler, Kratochwall, & Kettler, 2011). Egger and Angold (2006) cautioned that high prevalence rates and negative outcomes for untreated childhood mental health problems represent significant societal concerns, given many children with mental health needs remain unidentified and, therefore, do not receive treatment or support at critical developmental periods (Dougherty, et al., 2015).

While the lack of early intervention services for preschoolers is clearly problematic, this is further complicated by a relative paucity of research relevant to assessment and developmental issues. Preschoolers, overall, are a particularly understudied group--in part because of assessment difficulties associated with the wide range of developmental, environmental, social, and communicative diversity shown even in typically-developing preschoolers, paired with limitations in formal (standardized) tests with predictive validity for this age group. Likewise, these confounds likely impact physician referrals for mental health services for preschooler, given an acknowledged lack of consensus for early clinical markers and limited training regarding

identification of atypical behaviours related to treatment for this age group (Dougherty, et al., 2015).

Despite the challenges of preschool identification of mental health issues, Nigg (2017) advocates SR as "of almost unparalleled importance for mental health" (pg. 361). For example, SR and EF capacity jointly impact pediatric mental health, with stronger SR capacities predicting good mental health outcomes and weak SR capacities poor mental health outcomes (Bierman, et al., 2008; Diamond & Lee, 2011; Raver et al., 2011). As such improved information to facilitate early intervention for problems with SR are critical for timely, effective, mental health interventions.

Self-Regulation and Social Behavioural Adjustment in Preschool Children

By the time children enter preschool, the concept of sharing, taking turns, and waiting for even a highly desired item, as well as the ability to follow increasingly-complex directions, enables more effective learning (Best & Miller, 2010). The ability to stop, think, and then pick a plan emerges, enabling children to respond rather than simply react and solve practical and interpersonal problems with less reliance on adult guidance (Diamond, 2013). Preschoolers learn to play cooperatively, incorporating the themes or rules of others, and can shift perspective to take on the roles of others, such as familiar community workers or imaginary figures or animals (Kochanska, Murray, & Coy, 1997). They begin to label and identify core emotions on themselves and others and learn how to respond when there are conflicts between internal states and what is being said or done (Hughes, 2011). Emergent social communication skills similarly influence early social behavioural adjustment. This is evident as the young child learns to appreciate the cognitive states, beliefs, and knowledge of others and to understand others' thoughts, emotions, and reactions (Beauchamp & Anderson, 2010).

Core components of early social behavioural adjustment, therefore, include the ability to get along and communicate with others, possess a positive self-concept, and adapt to changing social-emotional dynamics and demands (Bassett et al., 2012). Such complex capacities emerge hierarchically (see *Appendix A-Preschool Social Cognitive Milestones*). Self-control emerges as the preschooler increasingly manages, modulates, inhibits, and activates attention, emotions, and/or behaviour to engage successfully with others, both individually and in group settings. This enables the preschooler to regulate emotions, form lasting relationships, and participate fully across a diversity of social life contexts. This enhances early school success, self-esteem and quality of life for both child and family (Beauchamp & Anderson, 2010; Cacioppo, 2002).

Research suggests behavioural adjustment and higher order social skills depend upon efficient, complex neural systems. Age-related improvements in neural connectivity between the frontal cortex, anterior cingulate, and the amygdala beginning during early childhood continue through the adult years (Perlman & Pelphrey, 2011). As newer higher-order social skills emerge, additional frontal region networks are recruited, influenced also by a dynamic interplay between biological, environmental, and cognitive variables, though with unclear developmental pathways (Beauchamp et al., 2010). Given the protracted development of the underlying neural substrates, the developing social brain is vulnerable to early developmental and neurological perturbations (Eslinger, Flaherty-Criag, & Benton, 2004).

Social emotional problems co-occur in high frequency with many neurological and neurodevelopmental disorders and in the presence of chronic medical or psychiatric conditions. They are however, often overlooked in clinical evaluation contexts, where it is difficult to observe social issues, and are often under-reported by parents who may prioritize medical and educational problems over social behavioural concerns during routine child health surveillance visits (Beauchamp et al., 2010). Given that failures in SR contribute to behavioural and emotional

problems, which in turn limit opportunities children have to participate in daily life and interact with parents, adults, and peers (Cassiano, Gaspardo, & Linhares, 2016), identification of those at risk is an important and viable early mental health promotion strategy.

Self-Regulation and Early Learning

In addition to the importance of understanding early SR development for mental health promotion, research indicates social and behavioural development contributes to academic success. As such, SR is critical for early learning. Teachers identify SR skills as the priority for children entering kindergarten (Rimm-Kaufman, Pianta, & Cox, 2000). This is because SR subserves emotional regulation and thereby, directly and significantly influences the child's classroom behaviour, interactions with others, and ability to mediate emotions (McClelland & Cameron, 2011; Waxman, Van Lieshout & Schmidt, 2014). Moreover, SR supports formal academic learning (Wyatt, 2013) and enables the child to meet increasingly complex internal, environmental, social, and emotionally charged demands and situations (Blair & Razza, 2007; Denham et al., 2012), developing competency and a positive sense of self.

SR predicts school success (Denham et al., 2012) by enhancing academic attainment, particularly gains in mathematics and literacy (Rimm-Kaufman, Curby, Grimm, Nathanson, & Brock, 2009). Indeed, SR better predicts early academic success than school entry learning skills (Diamond, 2013), not surprising given SR modulates attention, planning, and reasoning, the generation and implementation of problem-solving strategies, use of feedback, and flexibility of thinking or mental set (Schrieber, Possin, Girard, & Rey-Casserly, 2014). Moreover, SR facilitates positive school engagement, work-habits, and classroom participation by modulating effortful control and on-task behaviour (Blair & Razza, 2007; Liew, 2012).

The development of emotional/behavioural regulation supports not only early learning and academic achievement, but also helps the child navigate change, adjust to school, benefit from diverse learning experiences, and succeed in dynamic social interactions (Ponitz et al., 2009). It is evident in higher-quality relationships with peers and teachers, and low maladjustment, irrespective of gender and background (Eisenberg et al., 2010; Ponitz, et al., 2009; Wyatt, 2013). By facilitating better adjustment, engagement, and interpersonal relationships, the influence of SR on social skills also impacts future life success (Eisenberg et al., 2010). Given such broad impacts across the life cycle, measurement of early SR and cognitive processing may enhance understanding of factors associated with risk and resilience prior to school entry. This is particularly important for at-risk preschoolers including those born very premature (VP) or extremely premature (EP), who have high rates of attention, cognitive processing and emotional difficulties (Sansavini, Guarini, & Caselli, 2011).

In summary, the need to integrate the study of early learning with emotional regulation is critical to advancing current conceptualizations of early child development (Rothbart, 2004). Further, adopting an SR viewing lens recognizes that multiple processes interact to influence early learning, behaviour, and emotional regulation and thereby preschool outcomes (Espy et al., 2011). Such positive outcomes may be expressed by daily living success. As a result, it is important to consider the expression of SR in everyday life activities or early childhood adaptive development.

Self-Regulation and Adaptive Development

Adaptive behaviour is defined as "the collection of conceptual, social, and practical skills that have been learned in order to function in everyday life" (Schalock, Borthwick-Duffy, Bradley, Buntinx, Coulter, Craig et al., 2010, p. 2). Conceptual skills may include functional pre-academics, self-direction, and language/communication; social skills include interpersonal, play,

and leisure abilities; and practical skills are comprised of daily living, health and safety, and community/home living abilities (Oakland & Harrison, 2008). Adaptive skills depend upon a number of neuropsychological foundations including cognition, motor competency, and SR--all necessary for age-appropriate personal and social self-sufficiency and essential to meeting external environmental demands (Killeen, Shiel, Law, Segurado, & O'Donovan, 2015; Milne, McDonald, & Comino, 2012; Sparrow, Cicchetti, & Balla, 2005). For example, even basic self-care skills such as independent toileting, eating, and dressing may influence the successful transition of the child into school or daycare and introduce family specific concerns. In the longer term, adaptive development has been associated with successful employment and independent residential and community living (Woolf, Woolf, & Oakland, 2010), and development of meaningful relationships (Papazoglou, Jacobson, & Zabel, 2013).

While SR skills are evident by successful engagement across a wide range of activities in the world at large (Caughy et al., 2013), the apparent link between SR and practical abilities has been largely ignored. This is concerning given that day to day successfully responding to people, places, and events impacts not only the child's independence, but his or her self-efficacy, sense of competence, and overall quality of life. Variables over and above intelligence influence adaptive development (Papazoglou et al., 2013), which similar to SR, develops within the context of social activity (Moriguchi, 2014. Both SR and adaptive attainment are heavily influenced by cognitive processing and language skills (Bialystok, 2015; Vallotton & Ayoub, 2011), suggesting that directly examining adaptive attainment and concomitant cognitive and language development may advance knowledge of the role of SR as expressed in everyday functional behaviours.

Parent questionnaires sensitive to age, gender, and culture are traditionally used to measure adaptive outcomes (Alton, Taghados, Joffe, Robertson, & Dinu, 2015). Such measures identify strengths and limitations in the child's ability to perform tasks of daily living, an essential

component in follow-up of children with increased biological risk, such as former premature infants (Killeen et al., 2015). Measurement of adaptive skills provide further evidence of achievement of age appropriate goals and behaviours, and the child's ability to appropriately adjust SR across time and settings (Nigg, 2017). Given this information, using parent report measures to examine adaptive behaviour within the proposed SR framework (Figure 1) may clarify both positive and negative relationships between cognitive, behavioural, and EF skills and daily life participation. Further, this approach may facilitate the identification of children who may benefit from timely and more intensive adaptive supports in early childhood.

Executive Function: Making Sense of a Messy Construct

The construct of EF continues to be characterized as "messy" due to its history of divergent theories, definitions, and measurement practices, most notably for young children (Garonet al., 2008). Whereas formal EF research in preschool populations increased exponentially in the 1990s, consensus on conceptualizations remains elusive, despite growing attention across research and clinical practice settings. Research agrees, however, that preschool EF is defined both structurally, based on distinct neuroanatomical substrates, and functionally, and based on age-related phenotypes generated through factor analytic studies (Carlson, 2009; Miyake et al., 2000; Wiebe et al., 2008; Willoughby et al., 2010).

Structurally, development of EF is synchronous with maturation of frontal and striatal networks, a dynamic process controlled by genetic coding, but responsive to environmental, social, and parental stimulation (DeLuca & Leventer, 2008). This system enables the child to respond flexibly to environmental feedback and demands including attending to, reflecting on, revising, and accommodating new information; shifting goals and expectations; and demonstrating social understanding, including 'theory of mind' (Hughes, 2011). As such, emergence of 'theory of mind', or the ability to infer the intentions, desires, thoughts, and beliefs of others in order to

understand and predict behaviour (Premack & Woodruff, 1978), is heavily influenced by early neurobiological factors (Lackner, Bowman, Sabbgah, 2010). Given that structural maturation of the frontal lobes continues in a nonlinear manner through to the third decade of life (Anderson, 2002), EF development is, likewise, highly protracted, progressing from diffuse to specific neural substrates and dependent upon intact functioning of complex neuroanatomical and neurophysiological systems (Hughes, 2011).

Functionally, EF was viewed historically as a relatively unitary construct (Baddeley, 1998; Posner & Fan, 2005; Posner et al., 2008; Zelazo & Frye, 1998; Zelazo & Muller, 2002). Miyake and colleagues (2000) proposed a common attentional mechanism interacting with three partially dissociable core EF components. This model, which conceptualizes EF as a collection of overlapping yet somewhat distinct and hierarchical abilities, is well supported (Carlson, 2005; Espy, Kaufman, Glisky & McDiarmid, 2001; Garon et al., 2008; Miyake et al., 2001) and includes the core EF components of inhibition, working memory (WM) and cognitive flexibility/shifting as reflected in Figure 1. The assumption that discrete components of EF can be examined in isolation however, remains controversial (Bernstein, & Waber, 2007) given different sets of skills may underpin performance on the same task for children of different ages (Hughes, Ensor, Wilson, & Graham, 2009). This contributes to continuities and contrasts in the study of age-related expression of individual EF substrates (Hughes, 2011), necessitating a developmental viewing lens for EF research.

In current conceptualizations, EF tracks meaningfully and in expected directions with early learning, and emotional and behavioural adjustment (Zelazo, Qu & Kesek, 2010) and is highly interrelated to the emergence of SR capacities (Cassidy, 2016). Typical developmental trajectories across EF substrates have been identified (Huizinga, Dolan, & Van der Molen, 2006). More specifically, Garon et al., (2008) augmented Miyake's model by adding critical age and stage

components and identifying separate developmental paths for each core EF component that interact and are heavily influenced by attention. As such, the expression of EF is not linear across childhood, with clear developmental spurts evident between ages 0–2, 3–5, 7–9, and again in late adolescence (Garon et al., 2008). Rapid gains evident between 3 – 5 years of age suggest even a few months difference in age may impact expression of EF skill (Carlson, 2005). This suggests the child's chronological age in months may be important in differentiating typical vs. atypical EF development in preschoolers.

For three to four year old children, inhibition and WM are of particular importance, given that cognitive flexibility/shifting emerges more definitively after 4 ½ to 5 years of age (Carlson, 2005; Diamond, 2006; Diamond, 2013; Garon et al., 2008). Higher-order EF components include sequencing, planning/ organization, and complex problem solving and emerge from the three core EFs during the school years (see Figure 1) and are essential to adult cognitive, social, and psychological development (Diamond, 2016; Shanmugan & Satterthwaite, 2016). Further, attention influences the development and expression of all core EF capacities across ages (Best & Miller, 2010; Hughes, 2011), suggesting it is a potential mediator of outcome.

Inhibition enables the child to delay gratification, stop in the moment to consider intrinsic or extrinsic variables (e.g., alternatives, rules or expectations, motivation) prior to initiating a response, or to change a behavioural set that is no longer working or meeting ever-changing cognitive and social demands. Attentional inhibition enables effortful or conscious suppression of goal irrelevant information and the ability to sustain focus amidst nonsalient intrinsic or extrinsic stimuli. Behavioural inhibition enables cessation of habitual responses so the child acts by choice rather than automatically, can resist temptations, and can exercise self-control, particularly in more emotionally laden situations. Children with too little inhibitory control may present as restless,

impulsive, intrusive, rude, or hyperactive; those with too much may present as withdrawn or disengaged.

WM enables the child to hold in mind and mentally update or use information in memory (Baddeley & Hitch, 1994). It enables the child to retain, manipulate, and use increasingly larger amounts of information for short periods of time, such as when needed to follow longer instructions or retain new school readiness content. WM emerges in the first year of life as the infant searches for hidden objects, expanding to support problem solving and new learning, behaviour, and social engagement. WM is evident when the child applies appropriate social or situational rules and adjusts his/her behaviour in anticipation of the situation or outcome (e.g., playground vs. in class voice volume). In contrast, children with WM difficulties may present as inconsistent, inappropriate, slow to learn, or forgetful.

Finally, shifting (or cognitive flexibility) enables the child to consider different roles, rules, and/or expectations relative to current situational demands and consider stimuli, thoughts, or events from differing perspectives or features. Cognitive shifting enables the child to respond quickly and adaptively to varying circumstances, in part by altering initial cognitive strategies to think "outside the box" (Diamond, 2012). Children with poor shifting may present as perseverative, rigid, intransigent, slow to respond, or overly anxious when change is required.

Cool vs. Hot Executive Function

As reflected in Figure 1, functional and structural EF distinctions differentiate 'hot' (social affective) and 'cool' (cognitive strategic) components (Hongwanishkul, Happaney, Lee, & Zelazo, 2005). 'Cool' EF components, mediated by the dorso-lateral prefrontal cortex, are elicited in tasks that are essentially cognitive, relatively emotionally neutral, or abstract, or tasks that require decontextualized or complex problem solving and/or WM (Anderson & Dewey, 2011; Metcalfe & Mischel, 1999; Zelazo et al., 2005). 'Cool' EF is slower acting with later emergence than 'hot' EF

(Willoughby et al., 2011). 'Cool' EF is activated by task demands rather than by emotional valence and is, therefore, typically measured by planning, strategy selection, or organizational tasks (Todd & Lewis, 2008). It is associated with "top-down" cognitive control, and has received much greater research attention to date than its behavioural 'hot' EF counterpart (Bassett et al., 2012). Within the classroom setting, 'cool' EF enables the preschooler to purposefully shift and then maintain their focus, stay on task, respond more flexibly to new stimuli, situations, people, or rules, and engage in pre- and early academic activities. As such, young children's pre-academic competencies may serve as proximal markers of 'cool' EF (Denham et al., 2011).

In contrast to 'cool' EF, the emotional valence or motivational processes of a task activate 'hot' EF. 'Hot' EF is more reflexive, fast acting, early developing, and stimulus controlled, but takes longer to mature functionally (Willoughby et al., 2011). 'Hot' EF is mediated by the orbito-frontal prefrontal cortex, posterior anterior cingulated cortex, and limbic system--brain regions closely associated with emotional processing, implicit evaluations of stimuli, social understanding and regulation of responses associated with reward and punishment (Todd et al., 2008). Activation of this network enables cortical "braking" so children can regulate strong emotions, both positive and negative, and respond purposefully when emotionally aroused (Denham et al., 2012).

'Hot' EF impacts childhood memory and behaviour (Zelazo et al., 2002), behavioural inhibition (Wallis, Dias, Robbins, & Roberts, 2001), reward delay (Winstanley, Theobald, Dalley, Cardinal, & Robbins, 2006), emotional suppression (Ohira, Nomura, Ichikawa, Isowa, Iidaka, Sato et al., 2006), and social competence (Carlson, 2009). It plays an important role in enabling assessment of and adaptation to the emotional relevance of objects, faces, or social interactions (Gioia, Isquith, & Kenealy, 2008), suppression or redirection of prepotent responses or emotions, and the ability to stop and respond rather than automatically react (Roesch, Taylor, & Schoenbaum, 2006; Zelazo et al., 2005). In school, behavioural inhibition may be noted, for

example, when children learn to request and not grab a desired object; keep their hands to themselves and not hit someone who has irritated or upset them; remain quiet rather than blurting out an inappropriate response; or wait for their turn even when it is difficult. The child becomes able to stay "In Sync" with peers socially, emotionally, and behaviourally as inhibition, WM, emergent theory of mind, and new emotional understandings combine, in turn enabling and predicting future development (Lane, Wellman, Olson, LaBounty & Kerr, 2010).

Researchers cautions that 'hot' and 'cool' EF networks reflect a continuum rather than truly dichotomous constructs (Beck, Schaefer, Pang, & Carlson, 2011). From a research perspective, it is not so much a question of "is the behaviour/task/event hot or cool", but rather, do 'hot' and 'cool' EF components interact to influence performance in this population? Differences in "temperature" (i.e., emotional or affective valance) for example, may explain in part why parent and teacher reports of a child's EF in daily life may differ and why, for some children, the nature of the risk, reward, or setting has considerable influence on outcome. Further, adopting a 'hot' and 'cool' viewing lens may elucidate the intersection of emotion and cognition, identified as pivotal to enhancing child health promotion (Calkins & Bell, 2010), and recognizing the importance of investigating 'cool' (cognitive) and 'hot' (behavioural) EF concurrently in young populations (Neuenschwander et al., 2012).

Executive Dysfunction

The developing brain is particularly susceptible to neurological perturbations (Hughes & Graham, 2008). As such, it is not surprising that executive dysfunction (EDF) is common in many clinical groups and childhood neurodevelopmental disorders (Goldstein & Reynolds, 2011) including Attention Deficit Hyperactivity Disorder (ADHD) (Skogan, Egeland, Zeiner, Øvergaard, Oerbeck, Reichborn-Kjennerud & Aase, 2016), Autism Spectrum Disorder (ASD) (Pellicano, 2010), Tourette Syndrome (Hughes & Brown, 2011), and Fetal Alcohol Spectrum Disorder)

(Green, Mihic, Nikkel, Stade, Rasmussen, Munoz, et al., 2009) and in conditions with cerebral damage (Monette et al., 2011). EF is, therefore, a highly salient construct for research investigating early childhood SR outcomes in 'at-risk' populations (Aarnoudes-Moens, Smidts, Oosterlaan, Duivenvoorden, & Weisglas-Kuperus, 2009; Mulder, Pritchfor, Hagger & Marlow, 2009).

Early signs of EDF may manifest as behavioural, adaptive, and/or cognitive difficulties during the preschool years. For some, EDF may not be identified until deficits in academic output, social skills, or productivity emerge in the middle or high school years when the mismatch between the child's abilities and environmental or inter-personal demands increases. Secondary problems with motivation, effort, persistence, academic self-concept, and self-efficacy often become significant by this time (Metzler, 2010), particularly if early difficulties were not identified or addressed. This emphasizes the importance of timely identification of and intervention for emergent EF difficulties.

The manner in which EDF is expressed varies considerably. Factors impacting this include: the neurological substrates impacted; the nature, timing, and extent of the insult or injury; the impact of such on maturation of residual EF and cognitive skills; and the presence or absence of protective familial, environmental, or socioeconomic factors (e.g., responsive early parent–child interactions and higher maternal socioeconomic status and/ or education). Given that dysfunction in one EF substrate may impact the integrity of others both within and between 'hot' and 'cool' systems, the importance of investigating these components concurrently has been identified as critical to understanding the nature of EDF (Willoughby et al., 2011). Despite this, few studies have explored 'hot' and 'cool' EF in tandem in clinical groups, excluding limited work with school-aged populations diagnosed with ADHD or ASD (Mosconi, Kay, D'Cruz, Seidenfeld, Guter, Stanford, et al., 2009; Pellicano, 2010).

Deficits in both 'hot' and 'cool' components have been implicated in early psychopathology (Bassett et al., 2012). More specifically, 'cool' EDF has been linked to the presence of academic and metacognitive difficulties. It is expressed by difficulties with learning, planning and organization, sequencing, and/or strategic problem solving, particularly in novel or complex situations, and evident also in altered adaptive outcomes. 'Hot' EDF, in contrast, is expressed by difficulties with self-esteem, self-control, theory of mind, behavioural flexibility, resiliency and/or coping, most evident when situational demands, stress, or personal frustration increase (Willoughby et al., 2011). 'Hot' EDF has been linked with externalizing psychopathology and problem behaviours in preschool populations (Espy et al., 2011) including the presence of disruptive, inattentive, overactive behaviours (Willoughby et al., 2011) and problems in motivation, effort, persistence, academic self-concept, and/or self-efficacy across clinical populations (Metzler, 2010). "Too little" inhibition is associated with ADHD and externalizing problem behaviours, "too much" inhibition with anxiety, behavioural rigidity, and increased internalizing problems. Interestingly, Schoemaker and colleagues (2012) found preschoolers with Disruptive Behaviour Disorder demonstrated poorer 'hot' inhibitory control when the motivational quality of the incentives increased (e.g, snack delay task), even after controlling for IQ. These findings suggest emotional valence may mitigate outcome, suggesting expression of EF may vary depending on the "temperature" of the task or setting at the time of the observation.

For other clinical populations, the psychosocial expression of EDF (evident in anxiety, behavioural rigidity/perseveration, and/or depression) impairs interpersonal relationships and alters engagement in day-to-day living. For example, in young children with ASD, parent reported deficits in inhibition, WM, shifting, and planning/organization correlated with deficits in adaptive outcome, as evident by lower ABAS-II test scores (Noggle, Thompson & Davis, 2014). In older

students, social perception impairments were linked to deficits on tasks associated with both executive and right hemisphere functioning (Schafer & Semrud-Clikeman, 2008).

In combination, these findings have relevance to the research proposed involving a clinical population of preschoolers born very or extremely prematurely. Insults to the developing brain, such as those often associated with prematurity, may impact EF expression and, in turn, development of broader SR capacities (Blair, 2016). Further, children born prematurely have demonstrated elevated rates of ADHD, Conduct Disorder (CD), anxiety, weak social and peer play skills, and ASD (D'Onofrio et al., 2013; Hofheimer, Skeinkopf, & Eyler, 2014; Treyvaud, Ure, Doyle, Lee, Rogers, Kidokoro, Anderson et al., 2013) (discussed in greater detail in Chapter 2) suggesting broad EDF concerns. Once concerns are identified, access to appropriate early intervention becomes paramount.

Early Intervention to Support Populations At Risk

Early identification of the child with SR difficulties enables more timely access to appropriate interventions. Evidence that SR problems frequently go unrecognized for several years after school entry (Avchen, Scott, & Mason, 2001) is concerning, particularly given observations that "public health outcomes may find roots in the self-regulatory capacities of individuals in the earliest years of life" (Maniar & Zaff, 2011, p. 78). Preschool assessment of SR is, therefore, important given emergent neuropsychological, socio-emotional and behavioural competencies unfold to influence the development of one another (Arpi & Ferrari, 2013). International research investigating the effects of intervention has demonstrated promising results in enhancing early SR outcomes across cultures, but particularly for those who are socioeconomically disadvantaged (Bierman et al., 2008; Dias & Seabra, 2015). Further, early intervention has been widely found to enhance early school adjustment and learning (Scott, et al., 2012) particularly for boys with greater difficulties at school entry (Matthews et al., 2009).

Early identification of SR strengths and difficulties widens the window for intervention and capitalizes on greater behavioural and neurodevelopmental plasticity evident in early childhood. As such, review of neonatal and perinatal medical history, early learning, and markers of preschool mental health may enhance prediction of those at greater SR risk. Those children may then benefit most from closer developmental surveillance, lower thresholds for referral, and/or quick access to specific interventions. Recognizing that 'hot' and 'cool' EF mediate SR to predict classroom success (Wyatt, 2013), assessment of preschool behaviour and cognition may further enhance early mental health by identifying children who require more support prior to school entry. Delaying identification of those who might benefit from and respond to interventions until after age five misses key preventative opportunities (Arpi & Ferrari, 2013), particularly given evidence-based interventions for the treatment of ADHD and anxiety disorders (Pelham & Fabiano, 2008; Silverman, Pina, & Viswesvaran, 2008) and EDF (Diamond, 2016) exist. Such interventions are likely to also be effective for other clinical populations, such as children born prematurely, given shared neurobiological commonalities (Treyvaud et al., 2013).

Access to appropriate and timely interventions reduces educational and social difficulties across the lifespan including 'at-risk' adolescents and young adults and those born extremely prematurely (Espy et al., 2009; Johnson, Hennessy, Smith, Trikic, Wolke, & Marlow, 2009). Adaptive behaviour, while under-studied in the early intervention literature, may also be enhanced given evidence of positive and significant associations between the total number of hours of early intervention and adaptive outcome in the first 3 years of life for premature populations (DeBattista et al., 2015). Of significance, these adaptive benefits persisted despite the presence of additional risks to early development (e.g., being male, of greater prematurity, or living in disadvantaged environments), suggesting the importance of early SR identification for children born too soon.

Impact of Sex, Ethnicity, and Caregiving on Early EF

Population based studies report mixed findings regarding the impact of sex and ethnicity on early EF development. EF differences between sexes appear to be discernable prior to school entry (Kochanska et al., 2000), though research findings vary due to differences in terminology, study populations, and assessment methods. Parents have reported significantly stronger inhibitory and effortful control in girls than in boys (Else-Quest, Hyde, Goldsmith, and Van Hulle, 2006; Kochanska, Murray & Harlan, 2000; Ponitz et al., 2008), including increased 'cool' executive control in preschool girls (Carlson & Moses, 2001). Moreover, Denham and colleagues (2015) proposed greater advantages for preschool girls than boys, specifically on 'hot' executive control tasks, relating this to enhanced social competency and behavioural regulation skills..

Ponitz and colleagues (2009) demonstrated sex differences in EF, but not academic achievement in kindergarten. They noted that boys in their study began kindergarten at a significant disadvantage and failed to catch-up with female peers until the end of the school year. A subgroup of boys ranking at the bottom 10% initially, made even fewer gains over this period. Matthews, Ponitz and Morrison (2009) posited that evidence of a sex gap in Kindergarten EF skills may be the beginning of a problem waiting to take root in later years, an assertion congruent with literature indicating differences between boys and girls in later school years. Caughy and colleagues (2013), however, cautioned that sex differences may reflect task-specific characteristics (i.e., which specific measurement task was used) rather than actual differences in the underlying SR skill and consequently recommend using multiple tasks or information sources to advance both theory and practice in order to better elucidate sex and outcome linkages.

In addition to considering differences that may be attributable to sex, both cultural and ethnic influence also merit consideration. Ethnic influences on socialization and behaviour (including parenting values, attitudes, goals and practices) in turn influence children's SR (LeCayer & Zhang,

2015). As such, it is important to consider the impact of culture and ethnicity on SR components and developmental trajectories. Caughy and colleagues (2013) for example, found that ethnicity impacted performance on measures of inhibition, WM, and shifting when comparing African American and Latino children. Statistics indicate that children from non-dominant backgrounds are often impacted by socioeconomic challenges (Raver et al., 2011) . Further, low family income has been associated with substantial EDF in preschoolers (Caughy et al., 2013). Likewise, Raver and colleagues (2013) identified poverty as a predictor of lower classroom EF and SR in 4-year-olds. While these findings suggest ethnicity and/or socio-economic considerations, a study by Owens and colleagues (2013) failed to find ethnicity, family income, father's employment, or levels of education to be significant factors for minority preschoolers, suggesting the need for further review, pointing to the need to understand that promoting childhood SR in our global and diverse society requires consideration of both contextual and developmental perspectives (LeCayer & Zhang, 2015). Further to this, intentionally supporting children from culturally diverse and low-income families is critical for improving school readiness and SR skills and to eliminate later school achievement disparities (Caughy et al., 2013)[1].

Finally, caregiver relationships also influence the development of executive and SR functions (Eisenberg et al., 2010). Longitudinal maternal-child studies suggest a genetic-environment interplay impacts development of EF, with moderate correlations between mother and child EF skills evident by 24 months of age and stable through 48 months, even after controlling for maternal education and verbal ability (Cueva, Deter-Deckard, Kim-Spoon, Wang, Morasch & Bell, 2014). In addition, the importance of synchrony in mother–child interactions to later child mental

[1] The results indicated that the experience of administering SR tasks to very young low-income ethnic minority children was very different from that reported in the literature with children this young, much of which is based on predominantly white middle-class samples. Particular difficulties in rates of completion were reported.

health is well established, with abundant evidence linking sensitive, affectionate, and responsive caregiving to enhanced EF and, therefore, SR (Bernier, Carlson & Whipple, 2010; Coll, 2008). Further, early relationship quality with mothers and childcare providers predicted children's attention and regulation in first grade (Coll, 2005), with maternal use of positive discipline acting as a buffer for children with biological vulnerability (Kok, Lucassen, Bakermans-Kranenburg, van Jzendoorn, Ghassabian, Roza, et al., 2014). In combination these findings suggest the significance of early familial and inter-personal influences, particularly on the young 'at-risk' child.

Summary and Gaps in the Literature

In summary, as SR capacity evolves, children master increasingly complex demands, expectations, and environments, attaining and maintaining levels of cognitive, emotional, behavioural, and motivational arousal conducive to responding appropriately to the immediate situation (Blair & Diamond, 2008). SR together with its substrate EF enables flexible and adaptive responding and predicts lifelong learning, achievement, adjustment, mental health, wealth, and quality of life (Denham et al., 2012; Diamond, 2013). As such, timely identification of children at early SR/EF risk, paired with rapid access to intervention services (as indicated), is a critical strategy for promoting childhood mental health.

Complex issues, however, have hampered research and service delivery for young at-risk populations (Cramm, Krupa, Missuna, Lysaghy, & Parker, 2013b). Research challenges include a history of different traditions resulting in different taxonomies for similar constructs, challenges measuring and differentiating typical and atypical SR and EF development across settings (e.g., home, school, and clinic), and difficulties identifying and assessing the impact of specific components of SR in preschool populations. Further, research is needed to clarify how deficits in

components of SR may impact preschool development and function and to explore the use of parent observations to measure SR outcomes in preschool populations (Poehlman et al., 2010).

SR knowledge translation has also been poor (Nigg, 2017), negatively impacting health service delivery. Validated interventions exist to address early SR concerns, proposed as central to improving child health initiatives (Diamond, 2011). However, early identification of SR concerns requires integration of sound theory and measurement practices for preschoolers, which in turn provide empirical evidence to guide caseload/waitlist prioritization, access to more effective and targeted early intervention services, and monitoring or response to interventions. By studying SR in a clinical 'at-risk' sample of preschoolers using a novel 'In Sync'/'On Track' framework, it may be possible to better define complex early brain–behaviour–environmental relationships which considers functional, adaptive, and neurobehavioural outcomes (Howard, Anderson & Taylor, 2008; Pritchard & Woodward, 2011). The addition of adaptive outcomes to SR research in particular provides concrete, observable, ecologically sound examples of SR function across settings and times, important to strengthening service delivery. Further, placing the proposed study within the larger framework of pediatric mental health addresses the call for future SR research to investigate the "neurobiological mechanisms underlying developmentally defined phenotypes that cut across diagnostic categories" (Dougherty et al., 2015, p. 17), while also offering information related to real life, observable behaviours, thus increasing opportunities to address the research to knowledge gap. As such the theoretical framework proposed for this study may be applicable for broad clinical populations while also providing a framework that may be particularly amenable to bringing practical information emerging from research directly to clinicians.

CHAPTER 2: PREMATURE BIRTH AND SELF-REGULATION

Children born preterm provide a particularly appropriate clinical population to investigate the impact of early medical and learning variables on expression of preschool SR, recognizing preterm birth is "a condition of multiple interacting atypical constraints" (Sansavini et al., 2011, p. 102). According to the World Health Organization (2012), more than 15 million babies are born prematurely every year around the world. Children born prematurely are commonly classified as very premature (VP) (≤ 32 weeks gestation), extremely premature (EP) (< 28 weeks gestation), and/or very low birth weight (VLBW) (≤ 1500 g.) or extremely low birth weight (ELBW) (≤ 1000 g.). Premature infants represent a growing population with increased morbidity, despite medical innovations beginning in the 1980s aimed at reducing mortality (Glass, Costarino, Stayer, Brett, Cladis, & Davis, 2015). The reason for persistence of high disability rates are complex, but include improved survival rates for the most immature (and therefore most vulnerable) infants (Doyle & Anderson, 2010). Prematurity is the leading cause of death in the first month of life, the second leading cause of death in children under the age of five years, and contributes to approximately one half of childhood disability (Glass et al., 2015). Both prematurity and its management in the NICU potentially contribute to perturbations to normal brain structure and organization that correlate with neuropsychological abnormalities impacting learning, behaviour, EF, and mental health. Consequently this particular 'at-risk' group warrants targeted research to understand and prepare to address early neurobiological risk and related SR outcomes.

Identifying and preventing morbidities associated with VP/EP birth is 'a moving target' due to ongoing advances in medical care. As such, research interests have recently shifted to the lower limits of viability. Increasing recognition of the importance of SR in preschoolers born too early is also noted, though with only a few inconclusive studies available (Arpi & Ferrari, 2013). VP/EP birth is associated with elevated rates of behaviour and/or learning difficulties, and mood disorders,

including clinical and subclinical endophenotypes of ADHD and ASD (see below). Research suggests that for this population, psychosocial issues emerging in the preschool years may persist with variable expression throughout adulthood, negatively impacting quality of life if untreated (Boyle, et al., 2011; Vederhus, Eide, Natvig, Markestad, Graue, & Halvorsen, 2015; Waxman, Van Lieshout, Saigal, Boyle, & Schmidt, 2013). Further, lifespan outcome studies concur that premature birth is a risk factor that extends through adulthood, where persistent personality and social difficulties may impact roles, peer and partner relationships, and career development (Eryigit-Madzwamuse, Strauss, Baumann, Bartmann, & Wolke, 2015). Given the acknowledged and documented risk associated with being born VP/EP, and high frequencies of comorbidities, timely assessment of SR capacity is important to advancing knowledge related to child health surveillance. This may guide selection of appropriate early intervention targets and inform preschool developmental, behavioural, and mental health practices for this population.

Premature Birth as a Significant Developmental Concern

Premature birth (before 37 weeks gestation) can be caused by multiple and complex biological factors including gene-environment interactions, which produce cascading pathophysiological pathways to result in atypical, not merely delayed, development (Behrman & Butler, 2007; Sansavini et al., 2011). Preterm birth represents a major public health problem, not just due to significant medical costs of care [estimated nearly a decade ago at $26.2 billion dollars per annum in the United States alone (Behrman et al., 2007)] but, more importantly, due to the steady increase in the number of fragile premature infants surviving across lower gestational ages (GA) and birth weights (BW), who often demonstrate long-term neurodevelopmental morbidity (Allen, 2008; Aylward, 2005). Increased survival rates are attributed to improvements in obstetric and neonatal care beginning in the late 1980s, including introduction of surfactant therapy, new ventilator strategies, and increasing use of pharmacological agents (Thompson, Warfield, Carlin, Pavlovic,

Wang, Bear et al., 2007). In addition, concomitant increases in Caesarean section, induction of labour, use of assistive reproductive technologies, multiple gestations, increased maternal age, and societal variables (e.g., poverty) contribute to the escalating rate of preterm birth (Leppert & Allen, 2009). The smallest and most premature infants are the most vulnerable to the complications initially contributing to the premature birth, those associated with the delivery, and those associated with subsequent efforts to sustain life in the Neonatal Intensive Care Unit (NICU) (Leppert & Allen, 2009).

Survival rates for EP infants have improved to over 50%, however, fewer than 40% of these survivors escape major neonatal morbidity given the biological vulnerability of the brains, lungs, and organs (Anderson & Doyle, 2003). These vulnerabilities contribute to high rates of long-term neurological, health, and behavioural problems, developmental delays, and impairments requiring a broad spectrum of specialty care and services (Allen, 2008; Aylward, 2005; Saigal & Doyle, 2008). In Manitoba, approximately 80–95 infants are registered each year with the High-Risk Newborn Follow-Up Program (HRNFP) at Children's Hospital with complications secondary to significant prematurity. Examining the developmental impact of VP/EP birth on the immature brain of these survivors may provide an informative working model for the study of other forms of neurodevelopmental disabilities, which share atypicalities in neurological maturation and organization. Typical early brain development is therefore reviewed to provide context for the subsequent discussion of neurocognitive and neurobehavioural atypicalities associated with being born premature. Unless otherwise specified, for the remainder of the document the terms "premature" or "preterm" will refer to populations born VP/EP or with VLBW/ELBW[2].

[2] Study results excluded GA but included BW as a significant predictor of participant outcomes. Recognizing this, the term "preterm" or "premature" is more appropriate moving forward in the document.

Typical Early Brain Development

The last half of gestation is a critical period in the growth and development of the human brain, characterized by discrete, time-sensitive neurological events that follow biologically or genetically prescribed sequences. These sequences are sensitive to epigenetic and environmental influences (Aylward, 1997; Dubois, Dehaene-Lambertz, Kulikova, Poupon, Huppi, & Hertz-Pannier, 2014). By six months gestation, the majority of the billions of neurons that will populate the mature brain have been created, generating at a rate of more than 250,000 per minute (Sun & Buys, 2012). Following organized proliferation and maturation, oligodendrocyte precursor cells migrate to different parts of the brain, axons and dendrites grow, synaptic formation begins, myelination follows, and antioxidant enzyme and neurotransmitter production occurs. This process of gyration, synaptogenesis, and axonal elongation continues for the first two years of life, with development in each region following its own distinct timing and tempo.

Developing neurons quickly assume specialized roles within the immature brain such that the majority are appropriately located by 40 weeks gestation (Sun & Buys, 2012). Advanced Magnetic Resonance Imaging (MRI) techniques have correlated GA with this network-specific development, which undergirds coherent inter-hemispheric activity and performance in specific neural systems (Tusor, Arichi, Counsell & Edwards, 2014). By 25 weeks gestation, half of the numbers of resting-state sub-networks found in healthy adult brains are evident (Fransson et al., 2007), followed by increasing frontal and occipital lobe connectivity (Brown et al., 2014). This enables the emergence of higher cortical brain function so that, at term, a full complement of neocortical brain cells and basic functional networks exist. The infant's brain continues to mature and organize in a regional, asynchronous, and protracted manner through to early adulthood, with a timetable that varies by region. For example, while sensory-motor areas develop quickly, associative regions and the prefrontal cortex develop slowly over decades (Dubois et al., 2014).

Sensitive periods for the development of specific systems in the brains, such as language or vision, have been identified, providing evidence that experience and environmental influences at crucial times alter early brain function (Cioni, D'Acunto, & Guzzetta, 2011).

Commencing around six months post-term, remarkable frontal lobe development is noted, contributing to significant changes in neural physiology and infant behaviour. At this point in time, maximum synaptic density (excess) occurs, after which selective elimination of pathways (pruning) begins. During months 6–12 post-term, secondary to frontal lobe growth, the infant begins to demonstrate the rudiments of EF, WM and focused attention, holding information in mind for increasingly longer periods of time, and directing his responses to people or items of interest. The infant becomes playful, can carry out brief sequences of novel behaviour, and begins to demonstrate inhibitory capacities to simple prepotent responses (e.g., finding hidden objects or following visual displacement of a toy) (Sun, Mohay & O'Callagham, 2009).

Over the next three to four years, ongoing myelination and organization of the prefrontal cortex (PFC) facilitates more definitive expression of core EF components, particularly inhibition, WM, and flexibility/shift, which are crucial to higher order cognitive performance (Diamond, 2006) and SR. The dopamine neurons projecting to the PFC, however, are unusual in that they have a paucity of transporter proteins, making the PFC particularly vulnerable to genetic and environmental variations that have more limited effect if occurring elsewhere (Diamond, 2012). The particular susceptibility of the PFC to disruptions secondary to stress, lack of sleep, social isolation, or lack of exercise (Diamond, 2012) is relevant to VP/EP populations given it suggests that even less noxious postnatal environmental influences impact the developing brain.

In the later years, almost one half of the mature brain's volume is white matter, a densely packed collection of myelinated neurons and glial cells that rapidly relay nerve impulses between different brain regions, enabling discrete mental operations (Sun & Buys, 2012). Just as wires

conduct electricity to where it is needed, white matter tracts enable rapid information flow between higher and lower brain centers (projection tracts), left and the right cerebral hemispheres (commissural tracts), and different regions on the same hemisphere (association tracts), enabling typical neurodevelopment. Disruptions to the developing PFC and/or cerebral white matter injury, not uncommon following premature birth, have been linked to poorer neurocognitive and neurobehavioural outcomes, though with marked heterogeneity, as described below.

Premature Birth and Early Brain Injury

Multiple environmental, intrinsic, and maternal factors combine to negatively impact early brain development and organization in the preterm infant. Preterm birth deprives the infant of his or her normal in-utero environment; this is significant as the preterm infant's unique cerebrovascular and brain anatomy and physiology are immature and particularly susceptible to the effects of ischemia, inflammation, and the extraordinary physiological stress associated with extra-uterine life (Back, Riddell, & McClure, 2007; Khwaja and Volpe, 2008). Atypical NICU environmental experiences (e.g., light, sound, handling, painful procedures) compound concerns relating to the biological vulnerability of the preterm infant, potentially interrupting normal neurological maturation at the molecular, neurochemical, and structural levels. Early brain development is further imperilled by the presence of medical complication and medical distress in the mother, both during and after birth (Sun & Buys, 2012).

Intrinsically, preterm brain development varies with the degree of fetal immaturity and stress inherent at the point of transitioning from intrauterine to extrauterine life. Significant fluctuations in blood pressure secondary to apnea and bradycardia damage immature blood vessels in the brain, with particular selective vulnerability noted in the germinal matrix. One hallmark feature of the resulting hypoxia-ischemia injury is a disturbance of the white matter, evident when immature neurons and pre-oligodendrocytes fail to fully differentiate during a critical window in neural

circuitry development (Back, 2014). In addition to hypoxia, chronic exposure to inflammation and infection contribute to a broad spectrum of brain injury that negatively impacts outcomes (Back, Riddle, & McClure, 2007; Dudink, Kerr, Paterson, & Counsell, 2008).

Brain injury rates also vary. For example, brain injury has been identified in at least 30% of infants born below 750 grams (Volpe, 2009), 49% of infants < 27 weeks gestation with 18% in the moderate to severe range (Anderson, Jacobs, & Spencer Smith, 2008). A clear gradient effect between poorer neurological outcome and increased prematurity has been reported, with diffuse WMI the characteristic pattern of brain injury in contemporary premature cohorts (Back & Miller, 2014). Preterm brain injury may preferentially impact males by young adulthood, suggesting regional vulnerabilities may persist (Ment & Constable, 2007). This in turn may impact expression of SR over time, recognizing the hierarchical cascade developmentally associated with both SR and EF. As such, chronological age may influence outcome findings.

Documentation as to the nature and severity of perinatal brain injury varies also with the sensitivity of the imaging technologies employed. While cerebral ultrasound is reliable for detection of large haemorrhages and cystic periventricular leukomalaica (PVL), MRI is more sensitive for detection of cerebellar haemorrhages, punctate and diffuse WMI (Benders, Kersbergen, & de Vries, 2014). As such, routine use of MRI technology has suggested a far greater prevalence and spectrum of WMI than previously documented, including a broad based brain injury even in the absence of gross neonatal brain insults in 50 % (Volpe, 2009) to 75% of infants born VLBW (Constable, Ment, Vohr, Kesler, Fulbright, Lacadie et al., 2008). Consequently, reliance on cerebral ultrasound to document preterm brain injury may be insufficient other than for more severe insults (Benders et al., 2014), despite its routine use in Manitoba NICUs.

The broad spectrum of brain injuries associated with preterm birth in includes diffuse WMI, interventricular haemorrhage (IVH), periventricular leukomalaica (PVL), and/or microstructural perturbations. IVH (occurring in the first few days after birth) is the most commonly noted brain injury in preterm babies, a significant problem given its association with neurologic sequale and longer-term problems with mental health and EF (Ballabh, 2014). IVH arises due to fragility of the germinal matrix, which may rupture resulting in blood filling the lateral cerebral ventricle(s) and damaging adjacent tissue and may be associated with concomitant PVL, a less frequent but significant complication of prematurity.

PVL is a distinctive form of cerebral WMI accompanied by neuronal abnormalities affecting the thalamus, basal ganglia, cerebral cortex, brain stem, and cerebellum (Volpe, 2009). It occurs in 5% to 15% of very low birth weight (VLBW) (< 1500 grams) infants. Cystic necrosis of fibres surrounding the lateral ventricles affects all cell types, resulting in subtle to profound neurological and neurocognitive impairments, depending on the extent and distribution of the early brain injury. These range from cerebral palsy (Martin Bax, Tydeman, & Flodmark, 2006) to deficits in visual perception, attention, learning, and social cognition (Atkinson & Braddick, 2007; Bottcher, 2010). Given PVL is often bilateral, it restricts the developing brain from reorganizing in order to preserve those functions at risk (Pavlova & Kraheloh-Mann, 2013), resulting in more significant neurological impairment. Spastic diplegia CP is common following PVL, however increasing evidence indicates that cognitive deficits can occur even in the absence of such frank motor impairments (Back & Miller, 2014). This may be attributed to small foci of necrosis that are not readily visualized by current MRI practices despite an overall pronounced reduction in the incidence of PVL in recent years (Back & Smith, 2014).

Neurologically “intact” survivors of VP/ EP birth who lack evidence of focal abnormality on conventional MRI at term may still demonstrate specific neurodevelopmental impairments

associated with microstructural perturbations in particular regions of cerebral white matter (Lubsen, Vohr, Myers, Hampson, Lacadie, Schneider, Katz, et al., 2011). Back (2014) examined a contemporary cohort of preterm infants, finding less severe frank brain injury (defined as not involving pronounced neuronal or glial loss), but instead noted reduced cerebral growth and widespread disturbances in neuronal maturation of dendritic arbours. Such perturbations may later be expressed as altered functional outcomes, neurocognitive and neurobehavioural morbidity, poorer processing efficiency, and/or network functional disorganization (Counsell, Edwards, Chew, Anjari, Dyet, Sirinivasan et al., 2008; Dubois et al., 2014), which would, in turn, negatively impact SR. As such, despite remarkable improvements in perinatal care, early brain injury continues to impact connectivity and future function in premature infants previously thought to be exempt from overt neurological problems. This early brain injury influences the development of SR subcomponents.

Premature brain injury occurs through several mechanisms. Functionally, injury to immature oligodendroglia compromises frontal-striatal and corticothalamic systems, impairs subsequent myelination, and slows transmission rates in surviving networks (Edgin et al., 2008), thereby contributing to executive dysfunction and slow processing efficiency (Anderson et al., 2008). Micro-structural perturbations to long association tracts impair cognitive control, problem solving, WM, manipulation of information, attention, and communication, particularly as task complexity increases (Skranes, Lohaugen, Martinussen, Indredavik, Dale, Haraldseth et al., 2009), all significant influences on SR expression. Further, damage to subplate neurons and the surrounding white matter, important to synaptic refinement and plasticity, contributes to long-term cognitive deficits (Kinney, 2006) and a complex interplay of sensory and attention problems (Edmond et al., 2006) which potentially impact both top-down and bottom-up SR processes. Particular vulnerability of the thalamocortical system following VP/EP birth influences emotional and motor

control, somatosensory and pain perception, auditory and visual processing, and the prefrontal association areas (Ball, Srinivasan, Aljabar, Counsell, Durighel, Hajnal et al., 2013). These examples of a diversity of structural brain changes associated with preterm birth coincide with the heterogeneity of cognitive, early learning, and SR outcomes reported in the literature. Observable manifestations of WMI however, may not emerge until later childhood (i.e., years 8 – 12), with clinical expression varying with factors such as genetic loading, the child's age, the demands being made on the child, and even setting (e.g., home vs. school, familiar vs. novel, simple vs. complex). This complicates earlier detection of WMI related outcomes (Kinney, 2009; Saigal & Doyle, 2008). Given white matter development peaks later in middle age, this also enables an extended period of neuroplasticity, introducing the possibility of significant recovery/compensation following neonatal brain injury.

In summary, brain injury in preterm infants is expressed along a broad neurological spectrum. This spectrum, ranging from signal abnormalities to reduction in brain volume, cystic abnormalities and PVL, ventricular dilation, corpus callosum thinning, maturational delay, diffuse myelination disturbances, and hypoxic-ischemic encephalopathies, contributes to generally poorer clinical outcomes (Back, 2006; Kinney, 2009; Volpe 2009). At the macro level, brain injury may be evident in changes in the cerebral cortex and/or in brain volume; at the micro level, brain injury may be expressed as altered neuronal connectivity and efficiency. Particular vulnerability of projection, commissural, and association fibres following preterm birth have been found to impact development and function of the corpus callosum and ascending and descending fibre pathways (Volpe, 2009), influencing neuropsychological and SR development including early EF, cognitive and adaptive attainment and behavioural adjustment. Given that white matter connectivity and myelination may be adversely impacted well beyond the initial site of injury, it strongly predicts

preterm neurodevelopmental outcome in general (Allen, 2002), and has been found to impact EF at four years of age (Woodward, Clark, Pritchard, Anderson, & Inder, 2011).

In light of this information, the diversity of brain injuries associated with VP/ EP birth suggests it is a good model for understanding the impact of early neurological insult on child development, SR, and common neurodevelopmental disorders of childhood. Further, examining clinical markers of early prefrontal development such as EF, cognitive processing, or psychosocial skills in relation to medical variables that influence white matter development may enhance understanding of factors associated with SR risk and resilience in this population. Thus, the diversity of brain lesions evident in children born prematurely represents an important model for studying limitations on childhood brain development (Pavlova et al., 2013), including EF and SR.

Premature Birth and Neurodevelopmental Morbidity

Despite improvements in the care and survival of children born very early, concomitant decreases in rates of neurodevelopmental impairments, cognitive and executive difficulties, and behavioural or emotional disturbances have not occurred (Anderson & Doyle, 2003; Bayless & Stevenson, 2007; Edgin et al., 2008), even in those who escaped major disabilities such as cerebral palsy, blindness, or deafness (Msall & Park, 2008). Heterogeneity in outcome findings relates in part to different methodologies, terminologies, populations, standards of medical care, and follow-up strategies evident across sites. Heterogeneity is also explained by the complex interactions between genetic (e.g., sex), perinatal (e.g., brain injury, bronchopulmonary dysplasia), and social environmental factors (e.g., social risk, parenting) (Anderson & Doyle, 2008), suggesting a broad spectrum of potential SR risk factors. Despite this heterogeneity, the timely detection of broader indicators of early risk is crucial to enhancing school success, in part by enabling access to interventions that improve cognitive and SR component abilities (Squarza, Picciolini, Gardon, Gianni, Murru, Gangi et al., 2016).

Behavioural difficulties and temperament concerns reported in older children born VP/EP (Arpi & Ferrari, 2013; Delobel-Ayoub et al., 2009) are under-studied in preschool preterm populations. Examining clinical markers of early prefrontal development such as EF, cognitive processing, or psychosocial skills in relation to medical variables known to influence white matter development and parental observations of early behaviour and function may enhance understanding of factors associated with SR risk in preschool premature populations. These early markers include regulation of action (adaptive attainment), cognition and attention (early learning and EF) and emotion (psychosocial adjustment) as presented in Figure 1.

Adaptive Attainment. Research pertaining to adaptive attainment (practical everyday living skills) in young children born VP/EP is extremely limited, but suggest gaps exist that are not commonly captured. More specifically, DeBattista (2015) found that 43% of her sample of 219 two or three year old children born prematurely (≤ 37 weeks GA) had scores below the normative range, predicted in part by younger GA, male sex, and lower family income. A cumulative effect of borderline to low cognitive potential, executive dysfunction, slower processing efficiency, increased likelihood of learning disability, and ADHD further contributed to significant negative academic consequences that increased over time. Moreover, DeBattista and colleagues (2015) found quantifiable and persistent impairments in adaptive scores further declined between 2 and 4 years of age, leading them to reject the widely held assumption that children born prematurely catch-up to same aged peers by age 2.

Loe, Feldman, and Huffman (2014) investigated adaptive outcomes in 70 preschoolers born ≤ 34 weeks gestation using parent reports of adaptive behaviour [i.e., Vineland Adaptive Behaviour System-II (VABS-II) and EF (i.e., Behavior Rating Inventory of Executive Function-preschool (BRIEF-p)] in addition to laboratory measures. The impact of GA on outcome was considered. Only 14% of participants demonstrated IQ scores < 85, suggesting a relatively cognitively intact

study population. Of these 'intact' children, 25% demonstrated clinically significant global executive dysfunction (Global Executive Composite scores > 64) and 16% demonstrated frank adaptive impairments, suggesting that even cognitively 'intact' preschoolers born prematurely exhibit significant functional and executive impairments. Moreover, the researchers found EF significantly mediated the effects of GA, suggesting an influence of cognitive control processes on adaptive attainment.

Similarly, research with very low birth weight (VLBW) children age 10 – 11 years (n = 28) without major disabilities demonstrated adaptive behaviour scores significantly lower than those of full-term peers when using the VABS-II (Fjortoft, Grunewaldt, Lohaugen, Morkved, Skranes, & Evensen, 2015) which persisted even after accounting for sex, SES, IQ (WISC-III) and motor skills. In older children, Leppert et al. (2009) found that, while teens born prematurely did not self-report significant differences from peers in daily living competency, parent-ratings indicated significant behavioural concerns, lower peer acceptance, and poorer athletic, social, and scholastic competency. In addition, challenges securing employment, living independently, and cohabitating with others were reported by parents over the long term. This again suggests that neurodevelopmental gaps exist that are not commonly captured and further, that adaptive delays do not spontaneously resolve in populations born prematurely.

Better surveillance of adaptive outcomes in preschool VP/EP populations is indicated given the rapid developmental trajectories of typical adaptive attainment evident between birth and age five. Further, this speaks to the importance of measuring regulation of action (as presented in Figure 1) by considering daily functional outcomes. Emergent evidence suggests significant adaptive deficits present in preterm children prior to school entry in turn impact not only learning and behaviour, but may lead to the development of secondary problems such as negative self-concept, poor peer relations, or problem behaviours in later years (Bauer & Msall, 2010; Fjørtoft et

al., 2015; Papazoglou et al., 2013). This dynamic, bidirectional influence of one component of SR (e.g. action) impacting the regulation of another (e.g., behaviour or cognition), attests to the importance of considering how adaptive attainment is impacted by premature birth. Overall, while research is limited, children who survive preterm birth appear to present with increased risk for a life-long spectrum of adaptive challenges and vulnerabilities. This necessitates ongoing surveillance of functional outcomes beginning in very early childhood, paired with timely guidance for families regarding management of feeding, sleep, play, communication, discipline, and early learning concerns (Msall & Park, 2008).

Early Learning. Deficits in early language and cognition arise in children born prematurely through a variety of mechanisms as discussed previously, which potentially influence EF and SR (Blair, 2016; Diamond, 2013). Decreased white matter volumes and frank changes at the microstructural level contribute to adverse neuropsychological outcomes in children born VP/EP (Counsell et al., 2008; Back, 2014), persisting through age 12 years and beyond, depending on the timing and nature of the insult (Allen, 2008; Constable et al., 2008; Inder, Wells, Mogridge, Spencer, & Volpe, 2003). Increased risk for minor neurobehavioural and cognitive long-term deficits has also been reported (Marlow, Wolke, Bracewell, & Samara, 2005), including poorer academic performance, higher rates of learning disabilities, and elevated rates of special education supports (Msall, 2010; Squarza et al., 2016).

During the first 2 years of life, cognitive impairment is the most common and severe disability following preterm birth, with neuropsychological impairments persisting through adolescence (Pugliese et al., 2013). High rates of developmental delay also occur, concomitant with decreasing GA or BW, even for those without significant neurosensory or motor impairments (Larroque et al., 2008; Woodward et al., 2009). Developmental quotients in the toddler years ≥ 3 standard deviations (SD) below the norm predict later disabilities in preterm populations (Marlow et al.,

2005), with weak 2-year language scores identified as another risk factor for later learning disabilities, despite intact broad intelligence (Squarza et al., 2016). Cognitive problems in VP/EP populations can be reliably diagnosed at 20 months of age, and remain relatively stable from early childhood through to adulthood (Breeman, Jaekel, Bartmann, & Wolke, 2015). This provides strong evidence for the importance of 2-year-old early learning assessments (Breeman et al., 2015) as one approach to enhance early identification of those with SR risk.

By the preschool years, gaps in cognitive development for preterm children relative to peers may increase (Allen, 2008). This relates to a combination of variables including an increasing complexity of cognitive demands being made on the child and the expression of more subtle underlying neurobiological deficits as higher order cognitive and cognitive control skills come online. Additional variables associated with poorer cognitive outcomes included neuroimaging evidence of brain injury, the presence of neuromotor abnormalities, male sex, and a history of chronic lung disease. A clear gradient effect with decreasing GA and BW linked to increasing intellectual disability has been reported, including a reduction of 1.7 IQ points per week for decreasing GA (Anderson et al., 2008). For children born EP, this presents as a mean IQ score of 0.8 to 1.5 SD lower than of those born VP (Anderson et al., 2008). Others report cognitive delays ($\geq$ 1 SD below the mean) in 33% of EP 4-year-olds and 36% of same aged VPs (Woodward et al., 2009).

Given widely acknowledged cognitive and developmental deficits, it is unsurprising that children born preterm present with a range of early learning challenges. They may appear clinically as disorganized, impulsive, inattentive, slower to acquire language and problem-solving skills, and/or clumsy or dyspraxic (Baron, Erickson, Ahronovich, Baker, & Litman, 2011). Sensory processing atypicalities, susceptibility to daily stress, and behavioural characteristics such as anxiety, withdrawal, and/or irritability in response to external stimuli are noted (Adams,

Feldman, Huffman, & Loe, 2015). Further, minor motor and attentional difficulties paired with a lack of personal independence and emotional immaturity introduce particular vulnerabilities for transitioning to school (Squarza et al., 2016), and thus suggest barriers to learning. Moreover, language delays are a commonly reported problem for preschool children born preterm, negatively impacting both early school and social success (Sansavini et al., 2010).

Outcome for preterm children at school age varies, though deficits in early academic achievement (reading, spelling, and mathematics) have been linked with decreasing GA, BW, and the presence of WMI (Aarnoudse-Moens et al., 2009; Anderson & Doyle, 2008; Taylor & Clark, 2011). Significantly higher rates of Learning Disability are noted, with the incidence varying by study cohort (e.g., inclusion of children with neurosensory or cognitive impairments) from 24% (Squarza et al., 2016) to 50% (Johnson et al., 2009). Overall, preterm children have a three-fold increase in Learning Disabilities and are up to 50% more likely to receive special education and classroom assistance than peers born on time (Behrman & Butler, 2007; Msall, 2012; Msall & Park 2008). Those born under 1000 grams are up to five times more likely than peers to fail a grade and up to six times more likely to have Learning Disabilities (Leppert & Allen, 2009), clearly indicating ongoing learning concerns.

By eight years of age, poorer learning efficiency, delayed recall of verbal and visual information, inattention to detail, impulsiveness, difficulties shifting attention, weak planning, mental flexibility, and WM have been reported (Leppert & Allen, 2009). Cognitive rigidity, paired with poor ability to manage practical situations, negatively affects academic attainment beginning in the elementary years (Squarza et al., 2016), with difficulties persisting through adolescence (Johnson, Wolke, Hennessy, & Marlow, 2011). These outcomes clearly implicate SR/EF concerns and highlight the ongoing impacts of early challenges.

Early cognitive performance is one marker for later psychosocial risk which has been linked to SR deficits, including poor frustration tolerance, inattention, and hyperactivity (Lowe, Woodward & Papile, 2005). Thus, the timely detection of broader indicators of early learning risk is crucial in assisting the successful transition to school for premature populations (Orton, Spittle, Doyle, Anderson, & Boyd, 2009). Interestingly, social variables such as higher maternal and paternal education and caregiver employment may offer only limited neuroprotective effects, evident by each of these improving a VP/EP child's IQ score by 3.6 points (Manley, Roberts, Doyle, Schmidt, Anderson, Barrington et al., 2015). These particular social variables are thought to continue to enhance cognitive performance throughout the preschool years, particularly for the youngest and smallest premature infants, demonstrating the influence of environmental variables on cognitive outcomes of children born prematurely (Manley et al., 2015). Conversely, disadvantaged socioeconomic environments predict mild cognitive and behavioural disorders at school age in preterm children (Fan, Wetters Portuguea, & Nunes, 2013), though difficulties in academic progress and behaviour problems may remain even after controlling for sociodemographic variables (Hutchinson, De Luca, Doyle, Roberts, & Anderson, 2013). Clearly, these findings suggest a confluence of factors is necessary to consider when understanding outcomes in preterm populations.

Given the broad spectrum of cognitive processing and early learning concerns associated with preterm birth, identifying patterns of early neurodevelopmental strength and weakness may enhance understanding of the impact of underlying structural pathology on early SR outcomes. In particular, examining cognitive processes in preschoolers born prematurely and with documented early brain injury may inform adaptive and early learning mechanisms, including the role of EF on early academic attainment. In addition, consideration of the role of attention and executive

function underpinning the learning problems preterm children face at school is of importance (Mulder et al., 2009), given elevated rates of educational challenges noted in this group.

Preterm Executive Function. While preschool research is limited, existing studies indicate that children and adolescents born VP/EP are at particular risk for executive dysfunction (EDF) (Beauchamp, Thompson, Howard, Doyle, Egan, Inder & Anderson, 2008; Edgin et al., 2008; Luu, Ment, & Allen, 2011; Skanes et al., 2009; Woodward et al., 2011), with the core EF components of inhibition, WM, and cognitive flexibility noted as particular concerns. For example, deficits in simple and complex working memory and inhibition have been documented in 3 year olds who were born ELBW (Baron, Kerns, Müller, Ahronovich, & Litman, 2012). At 4 years of age, children born VP/EP demonstrate moderate deficits on measures of selective attention, inhibitory control, cognitive flexibility, and planning ability (Woodward et al., 2011), with more noticeable effects, in general, for those born very small or very early (Anderson & Dewey, 2011). By school age, children born preterm demonstrate elevated rates of impairments in selective, sustained, shifting and divided attention (Anderson, DeLuca, Hutchinson, Spencer-Smith, Roberts, & Doyle, 2011). When paired with a slow and highly fluctuating response style, attention deficits negatively impact day-to-day function across test and class settings (Mulder et al., 2009). Further, impairments on measures of switching, verbal fluency, strategic planning during complex problem-solving tasks, and working memory identified in school aged preterm children contribute to additional learning and psychosocial challenges (Taylor & Clark, 2016).

The negative impact of preterm birth on WM, a core component of 'cool' EF, merits particular attention given that WM has ecological relevance across an individual's lifespan and is particularly important for adaptive outcomes. WM plays a key role in the development of reasoning and future-oriented problem solving (Baron, Kerns, Muller, Ahronovich, & Litman, 2012; Diamond, 2013). Moreover, WM supports early learning, academic, and interpersonal success (Jacobson &

Mahone, 2012; Mulder et al., 2010). WM also undergirds emotion regulation and social-information processing and predicts aspects of childhood psychosocial adjustment (Diamond, 2013; Sequin & Zelaso, 2005), demonstrating the foundational import for real life social emotional outcomes and clearly implicating SR. Parents of school aged children with complex neurological disorders (including brain tumour, leukemia, and epilepsy) identified metacognitive deficits including WM and planning/organization (Krivitzky, 2016). This suggests that a diversity of brain injury may impact 'cool' EF, with variable patterns and severities of brain injury common to VP/EP populations.

Identification of EDF in 'healthy' preterm populations suggests that early developmental outcomes may not be sensitive predictors of future EF risk. For example, Ni and colleagues (2001) identified deficits in planning, cognitive flexibility, and nonverbal working memory in six-year-old VLBW children previously presenting with normal early development. Taylor and Clark (2016) in their review of risk factors and outcomes observe that EDF frequently occurs in preterm children with broadly average global cognitive ability, but may be difficult to recognize due to heterotypic continuity in patterns of SR across childhood. Recognizing EDF and SR dysregulation manifest differently across the lifespan, chronological age is considered to be highly relevant in studying childhood EF skills and the neural networks that support them, developmentally (Wolfe, Vannatta, Nelin, & Yeates, 2015).

Other variables linked to variable expression of EDF in premature populations include sex, SES, and early environmental influences (Mulder et al., 2009; Vohr, 2014). For example, greater EDF and attention impairments have been associated with male disadvantage (Hack, 2009; Mulder et al., 2009). This may be related to more severe neonatal illness after preterm birth documented for males than for females (O'Shea, Downey, & Kuban, 2013) and/or later brain volume reduction within multiple cognitive systems impacted in males (Kesler, et al., 2008). Meta-analyses also

suggests that while decreasing GA in premature children has been linked with poorer executive outcomes for school aged children and young teens, chronological age at assessment may also confound interpretation of test results.

Gaps in 'cool' EF skills are noted to increase (e.g. attention, fluency), decrease (e.g. inhibition), or stay constant (e.g. WM) over time (Mulder et al., 2009) depending on the presence of previously noted factors. Moreover, some suggest that early deficits in inhibitory control demonstrated by children born preterm may diminish by the middle school years, representing a maturational lag rather than overt dysfunction for this EF component (Aarnoudes-Moens et al., 2012). Comparison of 'cool' and 'hot' EF components in preterm populations is therefore indicated to advance understanding of SR development and difficulties, which is particularly important to consider given the range of early EF concerns reported for children born prematurely. Further, this comparison is important given the impact of EDF on the subsequent regulation of action, cognition, and behaviour.

Psychosocial Adjustment. Intact SR and 'hot' EF skills are reflected by appropriate social, emotional, and psychological development. Wide spectrums of behavioural SR difficulties relating to 'hot' EF have been described in VP/EP individuals, beginning as early as infancy. Specifically, poorer emotional regulation, orientation, and engagement, paired with disturbances in sleep, eating, and sensory reactivity have been reported between birth to age 2 for preterm children (Montagna & Nosarti, 2016). Further, temperament and behavioural problems arising in preterm infants have been attributed to attention difficulties, perceptual sensitivities, atypical motor activation, and lower evidence of qualities such as 'cuddliness' and self-soothing (Klein, Rocha, Martinez, Putnam, & Linhares, 2013), singularly and in combination. This "preterm behavioural phenotype", characterized by inattention, emotional and social difficulties, has been associated

with elevated risk of internalizing problems that emerge later (Johnson & Marlow, 2011) that may persist through the adult years (Montagna & Nosarti, 2016).

During the toddler years, those born EP demonstrate lower social competence (Spittle et al., 2009), increased withdrawal (O'Shea et al., 2014), heightened emotional reactivity, and poorer emotional regulation (Maclean, Erickson, & Lowe, 2009) relative to full-term peers, suggesting broad behavioural SR deficits in particular. Social-emotional competency problems have been found for 50% of ELBW toddlers heightened with low socioeconomic status (SES), low Bayley Mental Index (MDI) or Physical Development Index (PDI) (composite score < 70), or being female (Peralta-Carcelen, Bailey, Rector, & Gantz, 2013). This suggests multiple interacting determinants of poorer social regulatory outcome. By three years of age, an additional 15% of the study cohort demonstrated frequent social and behavioural concerns, most notable in those who had been the smallest infants, with a positive relationship between age, degree of prematurity, and early childhood behavioural or social problems evident (Peralta-Carcelen et al., 2103), indicating the need for ongoing monitoring of psychosocial outcomes.

Further, the presence of subtle social difficulties impairs the premature preschooler's ability to establish and maintain positive interpersonal relationships. For these preterm children, increased psychological distress, social isolation, and reduced self-esteem is felt to significantly and negatively impact quality of life. Further, weakness in picking up social cues, reading the nuances of social encounters, and maintaining positive relationships reported for children born preterm, in turn contribute to later difficulties with self-concept, confidence in athletics, school achievement and relationships, and/or vocational competency (Alduncin et al., 2014; D'Onofrio et al., 2013), again, clearly indicating the need for carefully monitoring these outcomes.

Conversely, Wolfe et al. (2015) failed to demonstrate similar significant deficits in social adjustment in VLBW preschoolers, however, their study cohort was very small (n = 20) clearly

limiting the ability to detect differences. Despite limitations, the authors suggested that differences in social development may emerge more clearly once children enter school and demands on them increase. This suggests a rationale for delaying assessment of social components of SR or 'hot' EF until age 5 given social behavioural difficulties become more apparent or measureable with increasing age.

In addition to poor social outcomes, preterm birth represents an independent risk factor for later behavioural and psychiatric difficulties (Montagna & Nosarti, 2016), with a 3- to 4-fold risk of developing psychiatric disorders reported in preterm children compared to full-term controls (Johnson & Marlow, 2011). During the preschool years, signs of the preterm behavioural phenotype, paired with increased anxiety/depression and emotional difficulties, social withdrawal, and attention difficulties (Montagna & Nosarti, 2016) are indicative of SR and EF concerns. Again, the degree of prematurity influences outcome, with children born VP demonstrating significantly fewer externalizing, aggressive, and oppositional concerns at 3 years of age than those born later (Shah, Robbins, Coelho, & Poehlmann, 2013), reflecting the previously mentioned assertion that these issues may not emerge until later. At 4 years of age, Jones and colleagues (2013) found greater emotional and behavioural maladjustment, less effective emotional SR, lower levels of positive peer play, and weaker synchronicity in interactions with parents in those born prematurely.

By the kindergarten years (age 5-6), increased rates of attention disorders (i.e., double the incidence of peers) and teacher-identified behavioural and socialization deficits have been reported for EP children, and these have been associated with EDF rather than global cognitive delay (Scott et al., 2012). This suggests poorer outcome even in those with disorganized, but not overtly delayed cognitive development. During the early school years, children born preterm continue to demonstrate more behavioural (Delobel-Ayoub et al., 2009; Woodward et al., 2009) and emotional

problems (Delobel-Ayoub et al., 2009; Jones et al., 2013; Stahlmann, Rapp, Herting, & Thyen 2009; Westrupp et al., 2012; Woodward et al., 2009) than children born full-term. Despite advances in medical care, by age 7 approximately one quarter of children born VP/EP meet criteria for any psychiatric diagnosis (Treyvaud et al., 2013), consistent with reported rates of psychiatric diagnosis in similar populations born in the 1980s (Johnson & Marlow, 2011).

Common behavioural and psychiatric concerns associated with prematurity include attentional or hyperactivity problems (Anderson et al., 2011; Bora et al., 2014; Chu et al., 2012; Delobel-Ayoub et al., 2009; Hall et al., 2012; Jones et al., 2013; Stahlmann et al., 2009; Treyvaud et al., 2013; Woodward et al., 2009). This includes a 2- to 3-fold risk for ADHD (particularly inattentive subtype) in children born VP relative to peers, increasing to 4-fold risk in those born EP (Indredavik, Vik, Heyerdahl, Kulseng, Fayers, & Brubakk, 2004; Johnson et al., 2010). Increased externalizing behaviours (Fjørtoft et al., 2014) and internalizing behaviours (Fjørtoft et al., 2014; Spittle et al., 2009; Vinall et al., 2013) have also been reported at the clinical and subclinical levels, relative to full term peers, with peer relationship problems and deficits in social cognition also evident (Delobel-Ayoub et al., 2009; Stahlmann et al., 2009; Woodward et al., 2009).

By adolescence, both increased internalizing and externalizing problem behaviours paired with emotional co-morbidities (e.g., anxiety, depression) present in a dose-response relationship relative to the degree of prematurity (Msall & Park, 2008). While an eleven-fold increase in depressive disorders during adolescence has been reported (Delobel-Ayoub, et al., 2009), boys are more likely to demonstrate elevated aggressive behaviour while girls more often demonstrate vulnerability to anxiety, depression and internalizing concerns (Hack, Youngstrom, Cartar, Schuluchter, Taylor, Flannery, et al., 2005; Spittle et al., 2009). These elevated rates of ADHD, shyness, anxiety, depression, social maladaptation, and emotional distress persist into adulthood (Boyle et al. 2011;

Gardner et al., 2011; Saigal, Pinelli, Hoult, Kim, & Boyle 2003; Saigal & Doyle, 2008), even after adjusting for cognitive impairment (Delobel-Ayoub et al., 2009).

An increased frequency of autism spectrum disorders (ASDs) and "autistic-like" traits has also been reported in preterm school aged populations relative to term controls (Hofheimer et al., 2014; Kittler, Gardner, Lennon, Flory, Mayes, & Karmel, 2011; Kuzniewicz, Wi, Qian, Walsh, Armstrong, & Croen, 2014; Williamson & Jakobson, 2014). Social-communication difficulties may emerge in the toddler years, and although often subthreshold for diagnosis for ASD, are clinically significant (Wong, Huertas-Ceballos, Cowan, & Modi, 2014). By 8 to 11-years of age, 'healthy' children born VLBW (without major intellectual/ language problems) may demonstrate clear deficits in social perception that parallel those with autistic traits in general populations (Williamson & Jakobson, 2014). These social cognitive deficits limit affective/ behavioural SR. Further, the emergent preterm ASD clinical presentation in older preterm children is seen as qualitatively different from classical autistic presentations, due to increased distractibility and inattention (Johnson et al., 2009; Johnson et al., 2011; Treyvaud et al., 2013).

In summary, multidimensional behavioural and emotional problems co-occur with prematurity. On a positive note, good quality of life has been self-reported in young adults born prematurely, who demonstrate fewer risk-taking behaviours, and lower levels of alcohol or drugs use and delinquent behaviour (Allen, 2008). Despite these positive outcomes, even those with low apparent risk demonstrate lifelong social and behavioural challenges, which suggests broad emotional and adaptive SR concerns. The expression of emotional and adaptive SR concerns is influenced by the breadth and depth of cognitive, language, visual perception, memory, learning, and executive impairments that can follow preterm birth (Msall & Park, 2008). Likewise, decreasing GA and increasing prematurity has been linked to increasing psychosocial difficulties across development (Cassiano et al., 2016), including greater behavioural difficulties, emotional

problems, hyperactivity/attentional problems, and peer relationship concerns at 4 years of age for EP children compared to VP children (Woodward et al., 2009). Further, the presence of bronchopulmonary dysplasia in school aged children born preterm has been related to more autistic-like traits (Williamson et al., 2014). Moreover, the presence of EDF in particular, has been related to a two to six-fold increase in ADHD (Behrman et al., 2007), particularly if WMI occurred (Gardener et al., 2011; Johnson et al., 2011). This suggests a link between early brain injury, bronchopulmonary dysplasia, deficits in EF, and poorer psychological outcomes in those born preterm, which has relevance for both research and clinical considerations.

Clinical and Measurement Implications

Gaps exist between research and best practice guidelines when it comes to documenting VP/EP outcomes. Further, follow-up practices differ between sites (Synnes et al., 2017), impacting the outcomes reported. Recognizing that neurodevelopmental and neurobehavioural concerns tend to increase over time, in synchrony with increasing demands on the child, and that early difficulties compound to influence later mental health and emotional-behavioural SR (Diamond, 2012), it is important that early SR outcomes are well recognized and aided in a timely manner. Thus, the importance of both detailed and ongoing early SR surveillance in preterm populations is noted (Arpi & Ferrari, 2013).

Typically, when surveillance indicates the presence of a concern, additional clinical assessment incorporating standardized tests for key developmental milestones are completed. The level of the child's risk is identified and described, concerns are clarified, and recommendations for follow-up, intervention, or support are provided (Alkon, 2013; Drotar, Stancin, Dworkin, Sices, & Wood, 2008). Despite the important role of early developmental surveillance, EF and SR may not be reflected in preschool assessments, which tend to emphasize cognitive and physical skills.

This is concerning recognizing problems arising prior to school entry have been demonstrated to predict later behavioural concerns in those born prematurely (Arpi & Ferrari, 2013).

Broadening the scope of preterm surveillance practices to include parent reports as measures of action, cognition, behaviour, and 'hot' and 'cool' EF subcomponents is clearly important to understand long term health and wellness. Using parent questionnaires for behaviour (Aarnoudse-Moens et al., 2009), adaptive and executive function (Loe et al., 2014), and cognition and language (Perra et al., 2015) provides cost-effective outcome measures critical to developmental surveillance for "at risk" preschoolers. In addition to broadening the scope of early surveillance, the importance of broadening the range of preterm children prioritized for early follow-up is noted, recognizing that subtle neurological changes may contribute to deficits that magnify with age (Anderson & Doyle, 2008; Howard et al., 2008). As such, even those with mild neurodevelopmental delay (indicated by scores more than 1 SD below the population mean) should be prioritized for follow-up and early intervention recognizing the influence of even milder SR delays on later school performance, achievement, and family outcomes (Broitman, Ambalavanan, Higgins, Vohr, Das, Bhaskar et al., 2007; Edgin et al., 2008; Potharst, van Wassenaer, Houtzager, van Hus, Last, & Kok, 2011).

In addition, broadening the duration of follow-up is indicated. More specifically, follow-up of VP/EP children to school entry enables earlier detection of EDF and SR concerns, thereby enhancing timely and critical access to focused intervention (Aarnoudse-Moens et al., 2009; Kittle et al., 2011; Korkman et al., 2008). Extending preterm follow-up better clarifies the relationship between early indicators of neonatal risk and preschool neurodevelopmental and neurobehavioural outcomes (Johnson et al., 2011). It addresses concerns that expression of SR strengths and limitations as well as learning and behavioural challenges emerge over time and persist at least through to young adulthood (Nosarti, 2013). As such, the Canadian Paediatric Association

recommends ongoing surveillance of infants born VP/EP to at least until age nine in order to better capture complex childhood learning and behavioural concerns (Sauvé & Synnes, 2006). This practice is, however, not common across Canada due to limited fiscal and practical resources (Synnes, personal communication), and the common standard clinical practice of stopping age correction for the degree of prematurity at 2 years of age when monitoring developmental outcomes (Bayley, 2006).

Research involving preterm populations faces the same measurement confounds as those described previously for typically developing peers. For example differences in definitions of the construct of interest and the method and test(s) used for measurement contributes to considerable variability in preterm outcomes reported (van de Weijer-Bergsma, Wijnroks, & Jongmans, 2008). Compounding this, a lack of congruence between cognitive and behavioural measures of EF in VP/VLBW children has been noted (Ritter, Perrig, Steinlin, & Everts, 2014). Similar to their full-term peers, a lack of congruence between direct measures of preterm performance and parent reports is noted, confusing interpretation of individual findings. For example, in a study of three to five year old preterm children, lower EF task performance correlated weakly with higher parent ratings of EDF ($r = -0.176$, $p = 0.034$) (Alduncin, Huffman, Feldman, & Loe, 2014). In contrast, Ritter and colleagues (2014) found task performance deficits in shifting in eight- to twelve-year-olds born VP/EP, but maternal reports identified only WM deficits in the same population. As with full term peers, multimodal, multidisciplinary SR assessment including 'cool' EF (cognitive strategic) and 'hot' EF (social, affective, behavioural) is recommended in premature populations.

Summary

Given a wide range of poor clinical, educational, social emotional, and adaptive outcomes noted for children born prematurely, and in light of their relationship to poor SR/EF, investigating these areas may lead to improved understanding for research, practice, and policy. For example,

despite a wide range of information implicating early learning, psychological, and EF difficulties in children born preterm, little is known about the developmental trajectories of SR processes in children at risk for later psychopathology (Marsh, Gerber & Peterson, 2008). These processes and outcomes may be amenable to early detection may hold promise to improve skills and functions. Data-driven clinically derived research, which forms the basis of this study, has many merits for providing information about 'typical' clinical populations (see Chapter 3). Using this approach, the following research questions were posed:

Research Questions

Question 1 aimed to clarify differences between study participants and normative scores across standardized parent report measures and inform and facilitate subsequent analysis. Further, given SR in VP/EP preschoolers is understudied (Arpi & Ferrai, 2013; De Battista, 2015; Myers et al., 2010; Wolfe et al., 2013), the research question aligned with this aim was:

> **Question 1:** Do *preschoolers born VP/EP in sample A differ from typically developing individuals (based on test norms and standardization information) with respect to parent ratings on executive functioning (EF), behavioural, and or adaptive scales, or on individually administered standardized measures of cognitive processing?*

Given differences in the SR components captured by discrete parent-report measures, Question 2 aimed to clarify commonalities across measures. A novel manipulation was introduced, using factor analysis of three preschool parent-report measures to identify latent factors that relate to current conceptualizations of SR. The research question aligned with this aim was:

> **Question 2.** *Do strong latent factors emerge from factor analysis of three parent-rating measures that of preschool self-regulation, adaptive development, executive function, and/or behaviour in children born VP/EP?*

Given the importance of early identification of populations at particular risk, Question 3 explored neonatal medical variables and or chronological age (Arpi & Ferrari, 2013; Sansavini et al., 2011; Msall & Park, 2008) to understand how these variables predict SR in the preschool years. Latent factors identified in Question 2 were incorporated (i.e., Adaptive, Executive Function, Flexibility /Adaptability, Externalizing, Internalizing, Social Communication, and Developmental). The research question aligned with this aim was:

Question 3: *Do medical variables, singularly or in combination, predict VP/EP populations at greatest risk across identified latent factor clusters?*

Given the importance of cognitive and language development to SR, Question 4 examined the ability of early cognitive and language scores to predict SR in the preschool years. Standardized measures of cognition and language were correlated with preschool SR scores to determine if they contribute additional indicators of early risk.

Question 4: *Do cognitive measures taken during the toddler (18 – 24 month) and/or preschool years predict and/or correlate with parent-reported measures of executive function, behaviour, and adaptive skills prior to school entry?*

Given the importance of understanding differences that may affect research participation and generalizability of study findings, comparisons were made between the two study samples (those who did and did not complete all test measures). This comparison was selected to facilitate identification of differences between these groups, which may elucidate particular risk markers impeding optimal SR and EF development. Further, this particular question was designed to allow evaluations of generalizability of Question 2 and 3 finding and to clarifying how cognitive relate to identifying those with greater SR risk. The research question aligned with this aim was:

Question 5: *Are there significant differences between sample A (for whom all parent-report measures were completed) and sample B (for whom only some parent-report measures were*

completed) in terms of medical history, performance on standardized tests, and the proportions of scores on parent-report measures that were considered typical, at risk, or clinically significant?

CHAPTER 3: METHODS

The current work investigates self-regulation (SR) in preschoolers born prematurely by comparing parent-reported adaptive development, executive function, and behaviour and participant psychometric cognitive performances with published test standardization norms. This research is a clinically driven, retrospective review of a convenience sample of 104 children born VP/EP who participated in the High Risk Newborn Follow-Up Program's School Readiness Project. The author (K.P.) served as the Neurodevelopmental Consultant on the team and was, therefore, intimately involved in the collection of the neurodevelopmental data reported in this thesis.

Project Background

This retrospective study examined data collected for the High Risk Neonatal Follow-up Program (HRNFP) of Children's Hospital in Winnipeg, which implemented a two-year pilot study, *Enhancing School Readiness Project* (SRP). The HRNFP enrols approximately 200 children per annum following admission to the NICU, 40% of whom are VP/EP, with 80% of premature populations surviving to discharge. This amounts to 75–85 infants enrolled in the HRNFP per annum due to VP/EP birth.

The SRP provided comprehensive developmental behavioural review just prior to school entry for 4 and 5 year old graduates of the NICU enrolled in the HRNFP. As such, the project included children born VP/EP in addition to other NICU survivors with histories of complex medical, neurological, cardiac, and/or genetic conditions. Inclusion criteria for the present study included enrolment in the SRP with a history of premature birth, classified by GA (≤ 32 weeks gestation) and/or BW (< 1500 gm). Only the premature population was reflected in the data set incorporated for the current study. Data for this study included neonatal medical variables collected from medical records, and early developmental variables collected at 2 time points: the 21 ± 3 month routine follow-up visit (referred to as 2-year visit in the remainder of this

document) and the SRP 4-5 years of age visit (referred to as 4-year visit henceforth) (*See Appendix B: Independent Medical Variables of Interest).*

Ethics. The project protocol and subsequent amendments were approved by the Bannantye Campus Health Research Ethics Board (HREB) of the University of Manitoba. Study participation was voluntary with caregivers/legal guardians providing informed consent, and preschoolers and caregivers/guardians being able to terminate testing at will.

Participants

Recruitment. Participants were recruited by a letter mailed to the caregivers/legal guardians of preschool aged children enrolled in the follow-up program who had provided consent for future contact. Respondents were sent project information, written consent and release of information forms, and a general patient health questionnaire to complete. The follow-up was then tailored from 1 to 3 appointments in order to meet the child and family's needs based on factors such as the family's geographical proximity to Children's Hospital, appointment and travel preferences, and the nature of the child's current services and supports. Geographical proximity was a concern given the catchment area for Children's Hospital includes Manitoba, North-Western Ontario, and Northern Canada. Some families preferred a single appointment due to difficulties inherent in scheduling and/or travelling to Winnipeg. These families received multidisciplinary assessments (Occupational Therapy, Speech Therapy, and/or Neurodevelopmental Consultant) but with abbreviated sessions to minimize child fatigue and family disruption. If children were receiving Speech Therapy and/or Occupational Therapy services, a copy of recent evaluations was requested to minimize duplication of service. This did not affect the neurodevelopmental component of the project, from which the current study's data were generated, as few children had received psychological or neurodevelopmental work-ups previously.

A total of 131 infants (89 VP, 42 EP) born prematurely in the catchment area between January 1, 2003 and December 31, 2005 survived to hospital discharge. Of these, 93 (57 VP / 36 EP) were seen for follow-up between 18-24 months and subsequently invited to participate in the SRP. Also included were 11 children born between 2005-2007 who met inclusion criteria (described in Procedures, below) and who required a school readiness assessment to support transitioning into Kindergarten in 2009 to 2011. A total of 51 preschoolers born VP and 53 preschoolers born EP met inclusion criteria and participated with parental/guardian consent, resulting in a total *N* of 104. For analysis purposes, study participants were organized into 2 samples: Sample A included 60 preschoolers whose parents completed all three parent report measures ($M = 54.8$, $SD = 4.2$ months of age) while sample B included 44 preschoolers whose parents completed only one or two parent report measures ($M = 54.4$, $SD = 6.1$ months of age). See *Figure 2* below for an overview of study participants and the project's organization. Although enrolment criteria for the School Readiness Project (SRP) included a 2-year-old developmental quotient score ≥ 70, 17% of the current study sample A, which was drawn from the SRP, did not meet this criterion based upon 2-year-old GDS cognitive scores.

Measures

Test measures were selected for the SRP based on age appropriateness, sensitivity to detect subtle differences in neurodevelopment, documented ability to characterize outcomes in children across a spectrum, ability to review multiple domains concurrently, and high objectivity. Parent report measures are described first, followed by cognitive measures. In addition, measures were chosen based on the Standards for Educational and Psychological Testing including reliability validity, design, development, norms, and other considerations (American Educational Research Association (AERA), American Psychological Association (ARA), National Council on

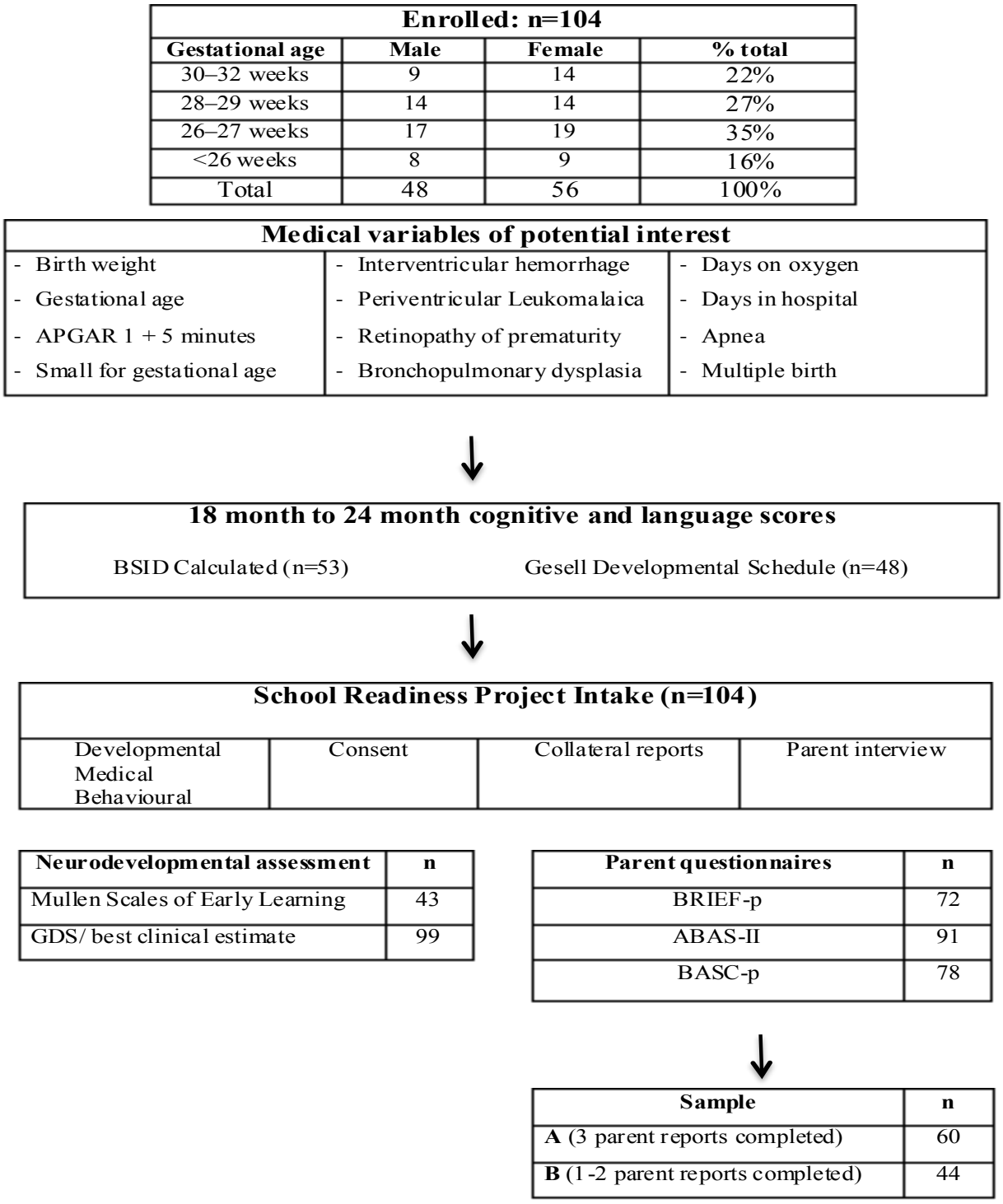

Figure 2: Schematic Drawing Of Project Organization.

Note: Some children were administered both neurodevelopmental assessment measures.

Measurement in Education (NCME), 2014). Properties of measures in this study are provided in *Appendix C: Psychometric Properties of Test Measures.*

Parent Report Measures. Measures completed by parents have been shown to be as accurate as those administered by professionals in identifying children with developmental problems (Bedford, Walton, & Ahn, 2013; Glascoe & Dworkin, 1995). A brief review of each measure and the rationale for its inclusion follows. See *Appendix D: Components and Cut-offs of Study Standardized Measures* for a comprehensive list of scales and subscales contained within individual measures.

Behavioural Rating Inventory of Executive Function- Preschool Version (BRIEF-p). The BRIEF-p (Gioia, Espy, & Isquith, 2003) for children aged 0–5 years, is comprised of 63 items that capture observable EF behaviours, including purposeful, goal-directed, problem-solving at home and daycare/school. Individual items are clustered into five separate scales: Inhibit, Working Memory, Shift, Emotional Control, and Planning/Organization, each scored on a three-point scale (never, sometimes, and often). Raw scores are converted into T scores and percentiles with the five clinical scales combined to form three broad indexes measuring Inhibitory Self-Control (Inhibit + Emotional Control), Flexibility (Shift + Emotional Control), and Emergent Metacognition (WM + Planning/ Organization), and one broad composite score -the Global Executive Composite (GEC). The BRIEF-p is widely used in clinical, research, and educational settings, being well validated also in samples of Canadian preschool children (Duku & Vaillancourt, 2014). The scales demonstrate good internal consistency, convergent validity, and reliability (Mahone & Hoffman, 2007; Papazouglou et al., 2013; Roth, Erdodi, McCullocha & Isquith, 2014; Skogan et al., 2015).

Adaptive Behavioural Assessment System –II (ABAS-II): Parent Report Form 0 – 5 years. The ABAS-II (Harrison & Oakland, 2003) is a comprehensive, well-normed standardized assessment tool based on sound measurement theory, with good reliability and construct validity (Burns, Meikamp & Suppa, 2005). It assesses everyday living skills and behaviours across home and community settings using 460 items scored on a 4-point Likert-type scale (0-3: *is not able; never or almost never when needed; sometimes when needed; always or almost always when needed*). Individual items are clustered into 10 discrete skill areas, which match American Association of Intellectual Disabilities and DSM-IV conceptualizations of adaptive function (Harrison, & Oakland, 2003). Scaled scores are provided for each skill area, which combine to generate three composite standard scores (Conceptual, Social, and Practical) and an overall Global Adaptive Composite (GAC).

The ABAS-II was standardized with a wide spectrum of children with special needs, including those with physical and motor impairments, ASD, ADHD, emotional and behavioural disturbances, visual impairment, hearing impairment, and Learning Disabilities, suggesting a broad clinical utility. As such, the ABAS-II is appropriate for clinical populations and has been used in studies of preschoolers with developmental delay or ASD, and those being followed after complex cardiac surgery, to demonstrate patterns of strength and deficit (Alton et al., 2015; Milne et al., 2012), though seldom with premature populations. The ABAS-II provides a scale specific to preschoolers (ages 0 – 5), and as such is appropriate for research with this age group. Scores are norm referenced with concurrent validity supported by moderate correlations with related measures (Oakland & Daley, 2013). Reliability and validity are reported to be strong (Papazouglou et al., 2013).

Behavioural Assessment System for Children- preschool version, Parent Report System (BASC-p PRS[3]). The BASC-p (Reynolds & Kamphaus, 2004) is a multidimensional assessment sampling parent observations of children ages 2–5, using a four-point scale (0-3: *never, sometimes, often, and almost always*). It includes 123 items organized into distinct behavioural and adaptive domains. T-scores and percentile ranks are produced for the 11 individual behavioural scales, which further combine as listed in parenthesis, to generate Internalizing (Anxiety, Depression, and Somatization), Externalizing (Hyperactivity, Aggression) and an overall Behaviour Symptom Index (BSI) scores. In addition Atypicality, Aggression, and Withdrawal behaviours are coded. Higher behavioural scores suggest increasing concern. The BASC-p yields a composite Adaptive Index score derived from the four individual adaptive scales including Adaptability, Functional Communication, Social Skills, and Activities of Daily Living. Lower adaptive scores indicate greater concern. Concurrent validity is supported by moderate correlations with other similar measures (Reynolds & Kamphaus, 2004) with the BASC-p demonstrating high reliability and validity scores (Papazouglou et al., 2013).

Individually Administered Cognitive Measures:

Bayley Scales of Infant Development – 2nd (BSID-II) and 3rd edition (BSID-III). The Bayley Scales of Infant Development II/III (Bayley, 1993; Bayley, 2006) are a comprehensive tool evaluating cognitive, language, and motor function in children up to 42 months of age. They are the most widely-used measures of neurodevelopment of premature infants, are strongly predictive of later cognitive and language functioning (dos Santos, de Kieviet, Königs, van Elburg, & Oosterlaan, 2013; Jarjour, 2015; Creighton, Robertson, Sauve, Moddemann, Alton, Nettel-Aguirre, et al., 2007), and are considered the 'gold standard' for infant developmental assessment,

[3] Henceforth referenced as the BASC-p for brevity within this document.

particularly for young children with biological risk (Schonhaut, Armijo, Schonstedt, Alvarez, & Cordero, 2013). The BSID-II, completed as part of the current study until 2006 when the BSID-III was published, provides a single Mental Developmental Index (MDI), which estimates cognitive, and language development jointly. It also provides a second Physical Developmental Index (PDI) estimating motor development. The Bayley-III, in contrast, generates scores for three composite indices (Cognitive, Language, and Motor) and five subtests (Cognitive, Expressive Communication, Receptive Communication, Fine Motor, and Gross Motor). It was standardized with a US population that included 10% with developmental problems, thought to better reflect the general population (Bayley, 2006). Reliability and validity are strong (Bayley, 2006).

Special Considerations: Despite its strong psychometric properties, controversy has arisen pertaining to interpreting scores derived from the BSID-III (Johnson et al., 2014; Moore, Johnson, Haider, Hennessy, & Marlow, 2012). Relative to its predecessor, BSID-III scores may over-estimate performance, thereby under-estimating developmental delay in preterm populations (Anderson et al., 2010; Vohr, Stephens, Higgins, Bann, Hintz, & Das, 2012), particularly in EP boys (Skiod et al., 2014). Broader studies comparing the BSID-II and BSID-III revealed an average difference in mean composite score for cognition of 10 points, and for language of 1.4 points, with the disparity linked to test construction differences and sample standardization (i.e., the BSID-III included clinical populations in the standardization), rather than a Flynn effect (Acton, Biggs, Creighton, Penner, Switzer, Thomas & Robertson, 2011).

In order to compute equivalent scores across the second and third editions of the Bayley Scales, a variety of approaches have been proposed. These have included using different cut-offs or local norms for scores derived from the third edition (e.g. BSID-III mild cognitive impairment = <95; moderate cognitive impairment = <90; mild language impairment = <91; moderate language impairment = <77) (Johnson et al., 2014)). While the use of local reference data at 24 months of

age to classify delay was found to increase BSID-III sensitivity, it reduced specificity (Spencer-Smith, Spittle, Lee, Doyle, & Anderson, 2015) and was not possible for this current study. Others recommend combining BSID-III cognitive and language scores to gain the advantage of producing a single continuous outcome measure similar to the MDI of the BSID-II. Proponents of this approach suggest it provides a relevant and practical composite outcome for research identifying delays, although this requires further validation (Johnson et al., 2014). Some recommend using conversion algorithms or tables (Lowe et al., 2012; Mansson & Stjernqvist, 2014; Moore et al., 2012), or published scores in related literature (Skiod, 2014), to enhance accuracy of comparisons across test editions. The present study adopted the conversion algorithm of Moore et al. (2012) to equalize comparison of BSID-II and BSID-III scores. Moore's algorithm converts Bayley-III scores into MDI scores to improve predictive value (sensitivity 95%; specificity 97%). The resulting BSID-calculated scores (BSID-C) were then used in the present analyses. Common administrative and technical errors reported for the Bayley Scales were addressed in this study by using a consistent, certified and experienced examiner, computerized scoring, and an external audit for common administrative, scoring, and reporting errors (Costantini, D'Illario, Moddemann, Penner, & Schmidt, 2015).

Geselle Developmental Schedule (GDS): The GDS (Ball, 1979) is a well-established intelligence measure for children aged 0 to 72 months. The GDS has been widely used in seminal research in autism and/or intellectual disabilities (Alwinesh, Thanka, Jansirani, Abel, Shankar, Satya et al., 2012), with hearing impaired populations, and in those with intellectual or neurodevelopmental delay (Wiley & Meinzen-Derr, 2013). The GDS generates a Developmental Quotient (the ratio between the developmental age and the chronological age) with a *M* of 100 and an *SD* of 15 points for Cognitive, Language, Adaptive, Motor, and Social domains. The GDS, which was administered by the medical director of the HRNFP for this study, was also recorded as

a “Best Clinical Estimate” score if augmented by collateral documentation from Occupational Therapy or Speech Therapy. Use of best clinical estimates enhances accuracy of diagnoses and reduces the rate of false positives (Kosten & Rounsaville, 1992). GDS test reliability and validity are acceptable with good predictive validity for typical and for lower functioning populations (Roe, McLure, & Roe, 1983) and in comparison with the Bayley Scales of Infant Development (Bayley, 1993).

Mullen Scales of Early Learning (MSEL). The Mullen Scales of Early Learning (MSEL) (Mullen, 1995) are a popular and well-validated test battery used to assess children, including those with neurodevelopmental concerns, from age 0–68 months (Akshoomoff, 2006; Ference & Curtin, 2015). The MSEL has been commonly used in research and clinical evaluation of children with autism spectrum disorders, cerebral palsy, epilepsy, hearing impairment, developmental delay or intellectual disabilities (Bishop, Guthrie, Coffing, & Lord, 2011; Burns, King & Spencer, 2013; Swineford, Guthrie, & Thurm, 2015). The 159 items of the MSEL are organized into five scales: Gross Motor, Visual Reception, Fine Motor, Receptive Language, and Expressive Language, which combine to provide a global Early Learning Composite score (M = 100, SD = 15). The test demonstrates strong construct, convergent, and divergent validity (Farmer, Golden, & Thrum, 2015; Swineford et al., 2015), including with the Bayley Scales of Infant Development-II language scales (0.72 - .085) (Halle, Zaslow, Wessel, Moodie, & Darling-Churchill, 2011) and the Vineland Adaptive Behaviour System-II (.57-.60) (Swineford et al., 2015). Further, construct and criterion validity is well established for clinical populations and general developmental delays (Burns, et al., 2013). Reliability and validity are acceptable in terms of test standards (Mullen, 1995).

Procedures

Children were screened at intake by the clinic research nurse who reviewed medical, developmental, and parental documentation, supplemented as needed by parent telephone

interview. Inclusion criteria included a toddler visit language or cognitive score ≥70, no uncorrected significant hearing or visual loss, and sufficient visual motor coordination to manipulate smaller items and hold a pencil. Sixteen participants who had been previously diagnosed with cerebral palsy (CP) were retained. These participants ranked at level 1 or 2 on the Gross Motor Functional Classification System (Russell, Rosenbaum, Avery, & Lane, 2002), suggesting only mild motor impairment; as such, their fine motor abilities were judged to be adequate for the present purposes. Children were required to be English-speaking or to have access to an interpreter at the time of their assessment. Initially, project participants were to reside within 1–1½ hours of the city of Winnipeg to facilitate more than one coordinated appointment. This criterion was later dropped to accommodate remote families who often had limited access to resources for their children and were eager to participate.

Based on prior year-end summaries provided by the HRNFP, it was anticipated that 25% of Manitoban children born VP/ EP would demonstrate cognitive disabilities (developmental quotient [DQ] <70), 10–17% CP, 2–9% sensory-neural hearing loss, and 1–2% significant visual impairment at their 6-month or 18 to 24-month medical follow-up visits. Children with a history of profound developmental delay and/or significant behavioural dysfunction (e.g., ASD), sufficient to preclude their ability to participate in standardized psychometric testing, as determined by review of intake information, received only the medical component and the Gesell Developmental Schedule (GDS) and were excluded from this study.

All SRP participants were reviewed by the Medical Director of the HRNFP, a senior developmental behavioural paediatrician, who completed the clinical health review and the GDS and/or best clinical estimate of 4-years-old language and cognitive skills. The study's research nurse completed a current health and social summary with the parents, and ensured consent and history forms were completed. Assessment of cognitive processing at the preschool visit was

completed by the author (K.P.) using the Mullen Scales of Early Learning (MSEL) and/or by Dr. Diane Moddeman using the Gesell Developmental Schedules (GDS) depending on examiner's availability and number of visits scheduled. Foster parents of children-in-care completed the parent questionnaires if the placement had been stable for a minimum of six months and consent had been attained from the legal guardian, Child and Family Services. Given very poor return rates for questionnaires mailed out in advance, parent scales were ultimately provided at the time of the child's appointment. Giving them in person potentially improved completion rates as translators or project staff were available for assistance. Despite a wide range of flexible accommodations, some parents were unwilling or unable to complete all measures. As such, the total number of each parent questionnaire completed varied, resulting in gaps in data reflective of missing test batteries, rather than random missing data points. These gaps were addressed through appropriate data analysis techniques, described later in the document.

Standardized testing procedures were followed across measures. Testing was completed in a low-distraction, quiet, out-patient clinic room with one parent in attendance and all others observing from behind a one-way mirror. Child-sized furniture was provided, as was ample time to settle in and warm up prior to testing. Short movement and water or snack breaks were provided as needed, and parents were positioned just out of the child's sightline with instructions to reassure their child when appropriate but to otherwise provide no cues or assistance. Testing adaptations were limited to scoring the final rather than initial response if the child spontaneously self-corrected, or if clarification of response was required due to the child's providing ambiguous, changing, or anticipatory responses, as per test guidelines.

Data Management

Key medical neonatal variables were identified from the literature and recorded in the project's neurodevelopmental database as independent variables. For a comprehensive list of specific medical variables collected please see *Appendix B*: *Independent Medical Variables of Interest.* Continuous independent variables were further grouped into categorical variables representing severity scores (e.g., none, mild, or significant IVH) or functional groupings (e.g., GA group 1 = 30 – 32 weeks; GA group 3 = 26 – 27 weeks) for later statistical analysis. GA and BW were treated as a continuous variables for analysis purposes with functional grouping incorporated during sample comparisons. Documentation of the nature (IVH or PVL)[4] and severity (none, mild, significant) of early brain injury was confirmed by a neonatal neurologist via MRI completed at term equivalent and/or via serial cranial ultrasound.

Data Checking

Accuracy of the data captured was reviewed at multiple points. Initially, individual parent questionnaires were reviewed for item omissions and parental response bias at the time of completion, with computer scoring enhancing consistency and accuracy of calculations. Then scores were checked by a trained research assistant and entered into the neurodevelopmental database using an Excel spreadsheet. The primary researcher rechecked entries. Finally, a summer research assistant added raw scores on all dependent variables to the database, double checked all scores entered, and corrected gaps or inaccuracies identified by external audit across variables.

Data Analysis

Overview. Analyses were completed using SPSS Statistics Version 24. Given that this study explored the relationships between a large range of early medical and cognitive variables and their

[4] IVH Graded using criteria from Papile, Burstein, Burstein, & Koffler, 1978; PVL diagnosed using criteria from Pinto-Martin, Riolo, Cnaan, Holzman, Susser, Paneth, 2002. Both read by radiologist.

ability to predict SR outcomes, factor analysis was employed to reduce the number of variables for subsequent multiple regression analysis and shared factors across measures (discussed below; see Question 2). A number of challenges arose pertaining to the analysis, given that much of the data was clinical and retrospective in origin, varied test metrics were produced from different measures, information on convergence between measures was limited, and collecting data from full-term controls was not feasible. These created various considerations across design, analysis, and interpretation in the current study (see *Limitations* for additional detail).

The performances of preschoolers born VP/EP were compared with normative test standardization groups across measures, using published test values as the control and one-sample *t*-test statistics to compare mean and standard deviations. Norms were based on US samples, as Canadian equivalents have not been published for most measures. Since previous research has not identified a clear justification for using Canadian norms for adaptive, behavioural, and/or EF preschool measures, in contrast to specific cognitive, language, and achievement testing, and has described benefits of using consistent norms across analyses (Sattler, 2008), incorporation of American test standardization norms was deemed acceptable.

Data were reviewed for potential sources of bias including the presence of outliers, non-normality of residuals or distribution sample, heteroscedasticity of variance, additivity and linearity, and independence of residuals (Field, 2013). The presence of outliers was determined using standardized scores provided from each measure. As recommended by Tabachnick and Fidell (2013), *z* scores with values greater than 3.29 or less than -3.29 were considered outliers and replaced with the next highest/lowest values in the data in order to minimize their impact on the results, and to avoid a reduction in sample size. A total of 13 outliers were replaced, representing <1% of the total data.

Given the number of different measures (53) derived from parent-report (39) and standardized performance assessments (14), and the different ways in which individual scores were reported (e.g., T scores vs. standard scores; scaled scores vs. composite scores), original test scores for all measures were converted to *z* scores prior to the factor analysis to ensure all measures were on a common scale. To further enhance interpretation, the directionality of individual variables was adjusted so that high scores indicated better performance and low scores poorer performance across all measures. This required reversing the sign of the *z* scores for any score in which high values indicated poorer performance (i.e., all BRIEF-p scores, BASC-p clinical scores). These standardized (*z*) values were then used in the factor analysis, and in the multiple regressions that followed.

The potential for Type I error (finding an effect that is not genuine) was addressed using Bonferroni corrections, recognizing caution in interpretation of results is needed given the small, exploratory sample size. Applying this correction may result in increased Type II errors (missing a genuine effect) (Rothman, 1990) and, as such, results following correction should be considered very conservative. Two-tailed significance testing was used, as recommended for research with few pre-existing studies (Tabichnek & Fidell, 2013). To understand the practical significance of findings, effect sizes were calculated, and correlations between medical variables were computed. Effect size was considered small (≥.2), medium (≥.5), or large (≥.8) when considering differences between groups using Cohen's *d* (Cohen, 1988), and weak (≥.1), moderate (≥.3), or strong (≥.5) when using the *r* family when considering associations (Morgan, Leech, Gloeckner, & Barrett, 2012).

The specific analyses carried out to address each of the five research questions are described below. Prior to answering Question 1, descriptive statistics were generated for continuous and categorical medical variables separately, given that different analyses are required for

measurement and nominal data. For continuous medical variables, central tendency (mean, median, and mode) and dispersion (variance, standard deviation, and range) were calculated. Distributions were examined for skewness and kurtosis and 13 outliers were identified and replaced with the next closest value. Quantitative variables were compared using one-sample *t*-tests, using test normative standards as the standard for comparison. For categorical variables, frequency counts were calculated. Pearson Chi-square testing assessed whether there was a statistically significant relationship between two categorical variables (Morgan et al., 2012).

Question 1: Do *preschoolers born VP/EP in sample A differ from typically developing individuals (based on test norms and standardization information) with respect to parent ratings on executive functioning (EF), behavioural, and or adaptive scales, or on individually administered standardized measures of cognitive processing?*

One sample *t*-tests were conducted on sample A to determine if preschoolers born VP/EP differed from normative scores for parent reported adaptive, executive, and behavioural ratings and/or for standardized measures of cognitive processing. Computer generated calculated test scores were used, which convert raw scores using chronological age.

Question 2. *Do strong latent factors emerge from factor analysis of three parent-rating measures that of preschool self-regulation, adaptive development, executive function, and/or behaviour in children born VP/EP?*

For all measures, calculated test scores (derived from norms adjusted for sex and chronological age in months) were converted to *z* scores to provide a common metric given the parent report measures provided standard, scale, and T scores. The sign for *z* scores was reversed

for test scales in which higher scores were of greater concern[5], providing a consistent direction of effect to aid interpretation. As such, negative scores on any variable represented a "poorer" outcome regardless of measure. These standardized (*z*) values were then used for the factor analysis conducted to address Question 2, and in the regression analyses performed to address Question 3 (see below).

Given that several test scores (dependent variables) may measure aspects of the same underlying construct (e.g., over 15 items measured components of adaptive development), and that these may be highly correlated with one another, factor analysis was used to identify the underlying relationships between manifest variables (Norris & Lecavalier, 2010). Factor analysis is an appropriate, clinically meaningful method used by others to combine related measures that can then be used in further analyses of domains of SR (Denham et al., 2011; Raver, Smith Carter, McCoy, Roy, Ursache, & Friedman, 2012; Wiebe et al., 2008). By doing such factor analysis increases confidence that the measures used yield valid, reliable data pertaining to childhood SR. Further, factor analysis provides a source of potential validation evidence for particular frameworks. Additionally, factor analysis results may point to clinical implications. In particular, findings showing some measures may contribute little new information for particular constructs and may lead to recommendations for assessment batteries incorporated into outcome studies.

Common latent factors and the pattern of variables loading onto each factor were identified to more accurately conceptualize SR constructs and organize variables into meaningful subgroups. Only participants with complete data sets (sample A) were included in the factor analysis, given missing values were random and participants with missing values for any variable are excluded from the subsequent regression (Field, 2013).

[5] All BRIEF-p measures, and all BASC-II clinical measures (excludes the Adaptive scales and the Adaptive composite score).

Principal Axis Factoring, a multivariate and preferred standard method for extracting linear combinations of variables (factors), was used to reduce the dataset to key components while preserving as much information as possible (Field, 2013). Using Kaiser's criterion (Kaiser, 1960) the eigenvalue was set to >1 to determine which factors were retained. Scree plot analysis was then used to confirm which factors would be retained, with those to the left of the point of inflection on the curve considered valid (Cattell, 1966). Both the eigenvalue and scree plot determined factors were compared for consistency.

An orthogonal rotation was added to the Principal Axis Factoring to impose restrictions so that the factors could not be correlated; this kept the factors independent to improve the interpretation of results and eliminated problems of multicollinearity (Field, 2013). Rotation does this by maximizing the load of each variable onto one of the extracted factors while minimizing its loading on all other factors (Field, 2013). The standard orthogonal rotation maximized the percent of variance accounted for by each of the latent factors identified, which was important given the relatively small sample size (n = 60) on which this analysis was based. A component matrix was produced, with test items with the highest loadings identified for each of the latent factors that emerged.

When interpreting factor analysis results, both the total variance explained by each latent factor identified, and the corresponding component matrix, were considered. The first variable explained the largest portion of variance, with all following factors explaining smaller and smaller portions of the variance. When interpreting the individual variables (test scores) loading onto each factor generated, those >.7 are considered excellent; .63 - .69 very good; .55 - .62 good, and .45-.54 fair. Only loadings >.4 were maintained in the model as those closer to zero indicated a weak effect (Stevens, 1992). Factor names were then derived from expert consultation and examination

of the strongest weighted test variables within each factor. These names reflected key themes related to self-regulation and served to organize later interpretation and discussion.

Question 3: *Do medical variables, singularly or in combination, predict VP/EP populations at greatest risk across identified latent factor clusters?*

Each of the factors identified in the factor analysis was entered as the outcome (dependent) variables in a standard multiple regression analysis to explore early medical variables that may predict preschool SR outcomes. Independent variables included chronological age, birth weight, presence of bronchopulmonary dysplasia (coded as 0 (none) or 1 (present). In addition the number of days of stay in the NICU were entered. Given 7 of the 8 children in the study sample diagnosed with PVL also presented with IVH, a new variable named Brain Injury was created. Brain injury was coded as 0 (none) or 1 (present) if IVH and/or PVL was evident in the perinatal history. In addition sex, and both chronological and corrected age (in months) at the time of the 4 year assessment, were entered into the initial analysis (although corrected age was subsequently removed due to problems with multicollinearity and that preschool calculated test scores were derived using chronological not corrected age. Models for each of the multiple regressions were generated, incorporating the final factors identified. Given the relatively small sample size, the standard method was employed in 'exploratory' multiple regressions, with model fit considered through review of *R* square, *F* ratio, and *b*-values.

Question 4: *Do cognitive measures taken during the toddler (18 – 24 month) and/or preschool years predict and/or correlate with parent-reported measures of executive function, behaviour, and adaptive skills prior to school entry*

Pearson correlational analysis examined the relationships between cognitive measures taken at the toddler (2 year) and preschool (4 year) assessment and parent-report measures of adaptive

skills, behaviour, and executive function. This informs as to if children's cognitive and SR competence are interrelated.

Question 5: *Are there significant differences between sample A (for whom all parent-report measures were completed) and sample B (for whom only some parent-report measures were completed) in terms of medical history, performance on standardized tests, and the proportions of scores on parent-report measures that were considered typical, at risk, or clinically significant?*

It was important to determine if sample A, which was used for the factor analysis and regression analyses, was comparable to sample B. To the extent that this was true, it would suggest that the results could be reasonably generalized to children who met the inclusion criteria (see Procedures section, above). Comparisons were also conducted to examine to differences that may have impacted research participation and completion, which also has important clinical applications.

Descriptive statistics were generated for sample B, replicating the process described in Question 1 above. One sample *t*-tests were then conducted on sample B to determine if parent report scores differed from normative test data across adaptive, executive, and behavioural domains, and if cognitive scores also differed. Independent samples T-test were employed to compare 6 medical outcomes including birth weight, gestational age, Apgar scores at 1 and at 5 minutes, days on oxygen, and days in the NICU. Chi-square tests of independence were then used to compare frequencies for categorical medical variables (e.g. sex, frequency of brain injury or bronchopulmonary) and also to compare the distribution of typical, at risk, and clinically significant scores on the parent-report and performance-based measures. For cut scores used to identify at risk and clinically significant problems, see *Appendix D: Components and Cut-offs of Study Measures.* Mann Whitney *U* tests were conducted to compare parent-report scores to performance-based measures.

Limitations

Use of a retrospective clinical data set introduces many challenges. For this study, information regarding those who declined to participate was unavailable. Similarly, no information was available regarding which of the participants had previously accessed early intervention services (and to what extent), or regarding the social histories of the families involved. Due to privacy regulations, information on culture, sex of parental respondent, socioeconomic status, maternal mental health, and parental education was not collected. Missing data resulted in only 60 of the total eligible SRP participants being included in the factor analysis and multiple regressions, though information from the other 44 participants was considered in ancillary analyses. As mentioned, Type 1 errors were controlled for using a Bonferroni correction; however, the possibility of increasing Type II errors (missing potentially significant results) suggests the need for caution in interpretation of findings given this more conservative approach may lead to under-reporting of significant findings.

Test scoring procedures introduced challenges given that this was a retrospective data set. In terms of the tests themselves, information pertaining to convergent validity was limited for some measures and individual measures produced a variety of types of test scores (e.g., standard, T, percentile). When calculating test scores, age correction for prematurity did not occur past 2 years of age and local norms were not available, both considerations introducing some debate given different clinical and research guidelines (see Discussion). Data were not collected from collateral sources, such as daycare, preschool, or nursery school teachers, limiting observations of child function within natural group settings. This may be important given that children's interpersonal characteristics and classroom behaviour may be important antecedents of kindergarten success (Denham et al., 2012). The possibility of parental response bias, both positive and negative, is

typically addressed by test validity scales, but could be addressed in future studies by including information from other sources (Cassidy, 2016).

In terms of the follow-up process itself, it is not possible to determine: the order, timing, or duration of the individual assessment components for each participant; if siblings or specialists attended; if parental sex, literacy, ethnicity, or child rearing practices impacted the report measures completed; if the child's behaviour and engagement on the day of testing was typical; or if positive or negative parental bias impacted the ratings. Parental response bias may be negative, for example, if parents attended only to secure future classroom support for their child, which requires demonstration of significantly poorer outcomes. However, standardized test scoring procedures provide validity scales to account for error due to reporting issues, such as bias. Finally, available data did not include information on parental mental health. This may be an important consideration, given that parental behaviour plays a crucial role in early stages of child development and may impact response patterns on parent-report measures (Montagna & Nosarti, 2016).

Summary

Statistical analysis involved an iterative, data-driven process emerging from preliminary analysis, but guided by the previously described decision-making process. By sequentially addressing the proposed research questions, this study sought to identify early medical and developmental variables that influence preschool SR outcomes, particularly with reference to identifying which VP/EP populations present with greater risk and may benefit from more intensive follow-up prior to school entry.

CHAPTER 4: RESULTS

Findings are presented first for general descriptive information, and then for each research question.[6] Data analysis was conducted using SPSS version 22 (SPSS, 2015) and version 24 (SPSS, 2017). Both descriptive and inferential information were generated in this exploratory analysis.

Preliminary data analysis identified 13 outliers in the total participant scores that were replaced with the next highest/lowest value, representing <1% of the total data. One child in sample A was born over 2000 g but was included given his GA of 32 weeks. Normality of distributions was confirmed through inspection of histograms, review of frequency tables, Shapiro-Wilks test, and measures of skewness and kurtosis. As such, parametric testing was used for further analysis for questions 1 through 4, given relatively normal data distributions. In contrast, nonparametric procedures were required for question 5 comparisons of sample A and B given unequal sample sizes, in order to understand whether the two samples reflect similar populations. Further, given the large number of comparisons, Bonferonni corrections were applied with specific calculations provided in each respective section.

Descriptive Statistics

Sample A. Table 1 presents descriptive statistics for continuous medical variables for sample A (whose parents completed all parent report measures) and sample B (whose parents completed only 1 or 2 measures). Both chronological age and corrected age (chronological age – weeks of prematurity) were recorded. Only data from sample A were used to address the primary research

[6] For brevity, scores attained at the toddler High Risk New-Born Follow-Up visit (21 ± 3 months) will be referred to as the '2-year-old scores' and scores attained at the School Readiness Visit will be referred to as '4-year-old scores'.

questions (Questions 1-4) given full data sets are required for factor analysis (Field, 2013). Group comparisons are discussed under Question 5.

Table 1
Descriptive Statistics for Continuous Medical Variables

Variable	Sample A (n = 60)		Sample B (n =44)	
	M (SD)	Range	*M (SD)*	Range
Age (months)	54.8 (4.2)	47-64	54.4 (6.1)	41-67
Corrected age (months)	51.9 (4.3)	45-61	51.4 (6.0)	38.5-64
Birth weight (g)	1186.6 (375.9)	515-2122	1091 (310.2)	575-1703
Gestational age (weeks)	28.3 (2.4)	24-33	27.9 (2.3)	25-33
Apgar 1	5.4 (2.4)	1-9	5.3 (2.3)	0-9
Apgar 5	7.4 (1.8)	2-9	7.5 (1.8)	2-10
Days on oxygen*	41.2 (43.4)	0-163	61.5(53.9)	0-221
Days in NICU	87.6 (52.5)	23-180	99.2 (47.1)	28-183

* Sample A and sample B distributions differ, t (8)= -2.11, p= 0.03.

While continuous variables for birth weight were used for multiple regression, review of corresponding categorical data is also informative. Table 2 displays detailed descriptive statistics for the categorical demographic and medical variables, including variable subgroups where appropriate. Sample A mean scores suggest that generally this particular group reflects overall an EP (< 28 weeks GA) and VLBW (<1500 g BW) population. Approximately half of sample A was VLBW (1000-1499 g), and another third fell in the ELBW category (< 1000 g). Both study samples A and B contained micropremi, however more met this classification due to their GA (birth at ≤ 26 weeks) than due to BW (≤ 800 g), suggesting good intrauterine growth for developmental age in the youngest and smallest study participants. Slightly more than half of sample A were female (57%). Roughly half had IVH, with equal frequency of mild (IVH grade I-II) and significant (IVH III-IV) cases. Almost all had experienced apnea, and 45% were diagnosed with bronchopulmonary dysplasia (BDP), a chronic lung disease that results from damage to the lungs caused by mechanical ventilation and long-term use of oxygen. Days on oxygen and days in

the NICU were broadly distributed.

Table 2
Descriptive Statistics for Categorical Medical Variables by Sample

Variable	Category	% of Sample A	% of Sample B
Sex	Male	43.3	50.0
	Female	56.7	50.0
Gestational age group	29 – 32 weeks	46.7	43.3
	27 - 28 weeks	26.7	23.3
	26 weeks or less	26.7	33.3
Birth weight group	≥ 1500 g	13.3	13.6
	1000 – 1499 g	53.3	43.2
	801 – 999 g	13.3	29.5
	≤ 800 g	20.0	13.6
Small for gestational age	No	86.7	86.4
	Yes	13.3	13.6
Multiple births	No	81.7	75.0
	Yes	18.3	25.0
IVH[a] grade	No IVH	46.7	48.8
	Mild	26.7	23.3
	Significant	26.7	27.9
PVL[b] grade	No PVL	88.3	79.5
	PVL	11.7	18.2
Brain Injury	No	47.0	45.5
	Yes	53.0	52.3
ROP[c] grade	No ROP	53.3	29.5
	Mild	30.0	40.9
	Significant	16.7	27.3
Bronchopulmonary dysplasia*	No	55.0	31.8
	Yes	45.0	65.9
Apnea	No	1.7	2.3
	Yes	98.3	97.8

Note. Not all percentages sum to 100.0% due to rounding and missing values.
[a] IVH = intraventricular haemorrhage: mild =grade I & II, significant=grade III & IV. [b]PVL = periventricular leukomalacia, [c]ROP = retinopathy of prematurity: mild=grade 1&2, significant =grade 3-5.
* Sample A and Sample B distributions differ, $\chi^2(1) = 5.09$, $p = .024$

Question 1: *Do preschoolers born VP/EP in sample A differ from typically developing individuals (based on test norms and standardization information) with respect to parent ratings on executive,*

behavioural, and or adaptive scales, or on individually administered standardized measures of cognitive processing?

Comparison to normative standardization data. One sample *t*-tests were conducted on sample A to determine if preschoolers born VP/EP differed from normative scores for parent reported adaptive, executive, and behavioural ratings and/or for standardized measures of cognitive processing. Table 3 displays tof the one sample *t*-tests and effect sizes for sample A ($n = 60$). Bonferroni corrections required for significance were set at $p = < .001$ ($p = .05/53$).

Table 3

One Sample t-Tests for Parent Report and Individual Standardized Measures

Instrument	Test value	Index/Composite/Scale	*M*	*n*	*p* (2-tailed)	Cohen's *d*
BRIEF-p (age 4)	50	Inhibitory Self Control Index	56.6	60	.001	0.45
		Flexibility Index	56.7	60	.002	0.43
		Emergent Metacognitive Index	60.4	60	< .001	0.67
		Global Executive Composite	59.7	60	< .001	0.60
		Inhibit	56.7	60	< .001	0.48
		Shift	56.6	60	.001	0.45
		Working Memory	61.3	60	< .001	0.71
		Plan / Organize	56.9	60	< .001	0.50
		Emotional Control	55.4	60	.005	0.37
BASC-p (age 4)	50	Externalizing	53.0	60	.061	0.25
		Internalizing	54.5	60	.010	0.35
		Behavior Symptoms Index	55.9	60	.001	0.47
		Hyperactivity	54.7	60	.006	0.36
		Attention	54.4	60	.003	0.40
		Aggression	51.0	60	.492	0.09
		Anxiety	53.7	60	.028	0.29
		Depression	53.2	60	.048	0.26
		Somatization	52.6	60	.072	0.24
		Atypicality	57.3	60	< .001	0.55
		Withdrawal	55.0	60	.003	0.40
		Adaptive Composite	45.2	60	< .001	-0.94
		Adaptability	47.3	60	.063	-0.49

Table 3 continued.

Instrument	Test value	Index/Composite/Scale	Sample A			
			M	*n*	*p* (2-tailed)	Cohen's *d*
		Social	49.3	60	.595	-0.14
		Functional Communication	44.9	60	< .001	-1.05
		Activities of Daily Living	42.9	60	< .001	-1.37
ABAS-II (age 4)	100	Conceptual Composite	93.8	60	.007	-0.36
		Social Composite	93.0	60	.003	-0.40
		Practical Composite	84.4	60	< .001	-0.97
		Global Adaptive Composite	88.3	60	< .001	-0.67
	10	Self Direction	9.7	60	.510	-0.09
		Social	9.4	60	.085	-0.23
		Preacademic	8.5	60	< .001	-0.48
		Communication	9.7	60	.465	-0.09
		Motor	8.1	60	< .001	-0.58
		Community Use	9.0	60	.011	-0.34
		Home	9.0	60	.014	-0.33
		Health	8.0	60	< .001	-0.63
		Leisure	8.8	60	.014	-0.33
		Self Care	5.2	60	< .001	-1.85
MSEL (age 4)	100	Early Learning Composite	72.3	28	< .001	-3.62
	50	Visual Processing	38.4	28	< .001	-1.23
		Fine Motor	28.8	28	< .001	-2.11
		Receptive Language	36.6	28	< .001	-1.10
		Expressive Language	35.5	28	< .001	-1.21
BSID (age 2)	100	BSID 3 Cognitive	94.1	19	.035	-0.52
		BSID 3 Language	84.1	19	.001	-0.90
		BSID 2 Mental Dev. Index	90.6	13	.154	-0.42
		BSID Calculated Mental Index	83.2	31	< .001	-0.89
GDS (age 2)	100	Cognitive	80.6	27	< .001	-1.25
		Language	75.4	28	< .001	-1.15
GDS (age 4)	100	Cognitive	86.1	56	< .001	-0.85
		Language	91.1	57	< .001	-0.50

Note. BRIEF-p = Behavioural Rating Inventory of Executive Function - Preschool Report; BASC-p = Behavioural Assessment System for Children - Preschool Report ABAS-II = Adaptive Behaviour Assessment System - II; MSEL = Mullen Scales of Early Learning (age 4); BSID = Bayley Scales of Infant Development; GDS = Gesell Developmental Schedules. Test values of 100, 50, and 10 were used for standard, T, and scaled scores, respectively.Outlined values are significantly different from the test value, after Bonferroni correction (one-sample *t*-tests, $p < .001$).

Executive function scores. In comparison to test normative data, sample A displayed significantly higher mean scores, suggesting greater dysfunction, for the BRIEF-p Global Executive Composite. Somewhat greater dysfunction was suggested in "cool" EF compared to "hot" EF, as evidenced by significant elevations of scores in the Emergent Metacognition Index and its component parts, Working Memory and Planning/Organization. Significant elevation in the Inhibit scale was also evident. Effect sizes ranged from small to medium for these scales and indices. Self-Direction scores, as measured by the ABAS-II, were not significantly different from published test norms.

Behaviour Scores. In comparison to BASC-p test normative data, sample A displayed few emotional or behavioural problems. Behaviours associated with Externalizing, Internalizing, or Attention problems ranked within normal limits for age. Moreover, mean ABAS-II and BASC-p test scores for Social skills suggested typical interpersonal development in sample A. Emotional Control (BRIEF-p) scores suggested typical emotional regulation as rated by parent observations. Elevated scores approaching statistical significance were noted however, for the BASC-p Behavior Symptoms Index and the Withdrawal scale, both ranking in the clinically "at risk" range, with small effect sizes were noted. Significantly higher mean score, suggesting greater dysfunction, was evident in the BASC-p Atypicality scale, with medium effect size. The Adaptability scale derived from the BASC-p and the Self-Direction scale of the ABAS-II were also non-significant, suggesting parents rated their child's ability to make flexible choices, take responsibility, and show self-control as average.

Adaptive Scores. Sample A displayed typical mean scores when compared to test normative data for the ABAS-II Self Direction, Social, Communication, Community Use, Home Living, and Leisure scales. In contrast, sample A displayed significantly lower mean scores compared to test normative data for the ABAS-II Global Adaptive and Practical Composites, suggesting greater

dysfunction. Further review suggested that the lower Practical composite score related to very low Self-Care abilities, with lower Health, Motor, and Preacademic scale scores, suggesting broader parental concerns. Small (Preacademic), moderate (Health, Motor), and large effect sizes (Self-Care) were noted. Similarly, significant concerns were evident by low test scores the BASC-p Activities of Daily Living scale.

Cognitive and Language Scores. Cognitive and language scores were derived from standardized performance-based measures completed at 2 and at 4 years of age. At 2 years of age, sample A's cognitive processing (as measured by the BSID-Calculated score)[7] presented as significantly delayed, with a large effect size noted. The BSID-Calculated scores approximated BSID-III Language scores, but were lower than BSID Cognitive scores alone. The GDS at 2 years yielded significantly lower Cognitive scores in addition to weak Language scores. These significantly lower GDS scores (relative to test normative data) persisted at 4 years of age despite developmental gains suggested by an increase in both cognitive and language mean scores over this period of time. Scales on the MSEL completed at age 4 were globally and significantly lower than test normative data; however, this measure was completed by less than half of sample A, thus limiting conclusions[8].

At 4 years of age, parent reports indicated moderate but significant Preacademic delays (ABAS-II). Communication scores derived from the ABAS-II were not statistically significant, contrasting with significant concerns identified for the BASC-p Functional Communication scale. Mean Language test scores derived from the GDS suggest a gain of approximately 15 points between 2 and 4-year-old GDS.

[7] BSID-Calculated cognitive scores were derived using Moore's (2012) conversion algorithm, combining BSID-III Cognitive and Language scores into a single metric equivalent to the BSID-II Mental Developmental Index (MDI).
[8] This contrasts with the GDS at 4 years, which was completed by approximately 94% of subjects.

In summary, in comparison to test normative data derived using age/sex-based norms, sample A presented with poorer outcomes relative to norms as evident in significantly elevated composite scores for EF (BRIEF-p GEC) and adaptive attainment (ABAS-II GAC, BASC-p Adaptive Composite). Further review of individual scales suggests these concerns were most evident for components measuring "cool" EF (Metacognitive, Working Memory, Planning and Organization scores), inhibitory control (Inhibit scores), and Practical and Self Care skills. Despite frank gains for mean Cognitive and Language scores (GDS) between 2 and 4 years of age, sample A participants continued to demonstrate significantly weaker test scores than the normative sample. In short, the present data suggested that parental concerns for this sample center encompass their children's adaptive, developmental, and/or 'cool' executive outcomes (i.e., being "on-track"), rather than on their behavioural, self-control, interpersonal, and engagement outcomes (i.e., being "in-sync").

Question 2. *Do strong latent factors emerge from factor analysis of three parent-rating measures that of preschool self-regulation, adaptive development, executive function, and/or behaviour in children born VP/EP?*

Factor Analysis. An exploratory factor analysis was conducted on data from sample A to determine if latent factors emerged for parent-rated abilities and behaviours. As noted earlier (see Chapter 3), data entered into this analysis were computer test scores derived from norms adjusted for sex and age in months, expressed as *z* scores with the sign adjusted as necessary so that a negative score on any variable would represent a "poorer" outcome.

Table 4 displays the results of the Principal Axis Factoring extraction using calculated test scores. Seven factors were extracted with eigenvalues[9] greater than 1, cumulatively accounting for 84% of the rotated factor variance, indicating strong support for this model. Factor 1 and Factor 2 accounted for 22.24% and 21.60% of this variance, respectively. Factor 3 accounted for 10.13% of the variance, and the remaining four factors combined accounted for 30.69% of the variance. Specific values associated with each factor before extraction, after extraction, and after rotation are detailed below (see Table 5). An examination of the scree plot supported the 7-factor solution.

Table 4
PCA, Factor Names, and Cumulative % of Variance Added to Model

Factor Number	Factor Name	Cumulative % of Variance Added to Model
1	Adaptive	22.24
2	Executive Function	43.84
3	Flexibility /Adaptability	53.97
4	Externalizing	63.38
5	Internalizing	71.59
6	Social Communication	79.56
7	Developmental	84.66

Table 5
Total Variance Explained for Individual Factors

	Initial Eigenvalues		Extraction Loadings		Rotated Loadings	
Factor	Total	% of Variance	Total	% of Variance	Total	% of Variance
1	19.38	49.69	19.38	49.69	8.67	22.24
2	5.42	13.88	5.42	13.88	8.42	21.6
3	2.84	7.28	2.84	7.28	3.95	10.13
4	1.7	4.35	1.7	4.35	3.67	9.41
5	1.47	3.77	1.47	3.77	3.2	8.21
6	1.18	3.03	1.18	3.03	3.11	7.97
7	1.04	2.67	1.04	2.67	1.99	5.1

[9]The eigenvalue associated with each factor represents the variance explained by that particular linear component, displayed also by SPSS as the percent of variance explained by the given factor (Field, 2013).

Table 6 displays the rotated factor loadings for each of the test items in the analysis. The items with the highest loadings (minimum factor loadings >.40) were identified for each factor (Field, 2012). A total of 15 items loaded onto Factor 1 (Adaptive); 13 related to the broad constructs of adaptive development and 2 related specifically to communication. Factor 1 included all scales and composites derived from the ABAS-II in addition to the BASC-p Functional Communication scale. Fifteen items loaded on Factor 2 (Executive Function) and related to executive function. Six items loaded strongly on Factor 3 (Flexibility /Adaptability) and were associated with flexibility/adaptability including Shift, Withdrawal, Flexibility Index, Adaptability, Emotional Control, and Depression. Factor 4 (Externalizing) was defined by seven variables related to externalizing problems (Aggression, Hyperactivity, Externalizing Problems) and general problem behaviours

Table 6

Rotated Component Matrix for Factor Analysis

	Factor						
Item[a]	1	2	3	4	5	6	7
A Practical Composite	0.92						
A Global Adaptive Composite	0.88						
A Home	0.85						
A Social Composite	0.77						
A Self-care	0.77						
A Health	0.76						
A Leisure	0.74						
A Social skills	0.74						
A Community Use	0.74						
A Conceptual Composite	0.67					0.40	
A Self-Direction	0.53			0.43			
B Emergent Metacognitive Index		0.86					
B Working Memory		0.85					
B Global Executive Composite		0.84					
B Planning / Organization		0.83					
B Inhibit		0.83					
B Inhibitory Self Control Index		0.79					
BC Attention		0.62		0.42		0.48	
B Emotional Control		0.61	0.53				

Table 6 continued.

Item[a]	Factor 1	2	3	4	5	6	7
BC Atypicality		0.58					
B Shift		0.48	0.77				
BC Withdrawal			0.71				
B Flexibility Index		0.57	0.70				
BC Adaptability			0.62				
BC Externalizing		0.51		0.80			
BC Aggression				0.84			
BC Hyperactivity		0.60		0.68			
BC Behaviour SI		0.52		0.54			
BC Internalizing Problems					0.88		
BC Somatization					0.83		
BC Anxiety					0.81		
BC Depression			0.45	0.42	0.52		
BC Socialization						0.72	
BC Adaptive Composite						0.62	
A Communication	0.49					0.61	
BC Functional Communication	0.47	0.50				0.50	
BC Activities of Daily Living							0.72
A Preacademics	0.48						0.66
A Motor	0.61						0.63

Note: Extraction method: principal axis factoring. Rotation method: varimax with kaiser normalization.

[a]A: ABAS-II item; B: BRIEF-P item; BC: BASC-P test scale

(Behavioural Symptoms, Attention, Self-Direction, Depression). The component matrix for Factor 5 (Internalizing) yielded four variables related to internalizing problems (Internalizing Problem Behaviours, Somatization, Anxiety, and Depression). Items loading most strongly onto Factor 6 (Social Communication) were related to social success and communication, (Socialization, Adaptive, Composite, Communication/ Functional Communication, Attention, and Conceptual Composite). Finally, items that loaded most strongly on Factor 7 (Developmental) included general developmental markers including Activities of Daily Living, Motor skills, and Functional Preacademics. In combination, the results suggest that the factor analysis model was useful for conceptualizing the concepts investigated and was able to identify seven underlying key constructs. Factors were named following advisory committee consultations based on the predominant item(s)

identified for the rotated component matrix for each of the 7 factors, mapping nicely with the proposed framework (see Figure 3)[10].

Question 3: *Do medical variables, singularly or in combination, predict VP/EP populations at greatest risk across latent factor clusters?*

Composite scores were generated reflecting each factor using the regression method within the SPSS FACTOR command (DiStefano, Zhu, & Mindrila, 2009). Composite scores then served as dependent variables for the seven multiple linear regression analyses that followed. Assumptions for parametric testing were met. A standardized composite score was computed from the items loading on each factor, resulting in composite scores that were each equally weighted. The standard variable entry method was used for multiple regression procedures, as appropriate in exploratory designs.[11] For each multiple linear regression, the dependent variable was the composite score for a discrete numbered factor emerging in the previous step. Independent variables included chronological age, birth weight (continuous variable), brain injury (presence of IVH grade I – IV and/or PVL), bronchopulmonary dysplasia (chronic lung disease), and days in the NICU. PVL and IVH were combined for these analyses as IVH was present in seven of the eight children presenting with PVL, making separation of these variables problematic.

Reliable outcome information commonly incorporates both GA and BW as means of stratification (Vohr, 2014), however this introduces collinearity. A decision was made to retain BW and not GA in the final analyses for several reasons. First, BW is an important composite indicator of neonatal health (Kuo & Duchon, 2015) that has been utilized in VP/EP studies

[10] For clarity, factor names are provided in parentheses after first mention and also listed in figure 3.

[11] Unless theory and/or research suggest the use of an alternative method, the standard method of variable entry is appropriate for exploratory research, particularly when both theory and research are limited (Tabachnick &Fidell, 2013).

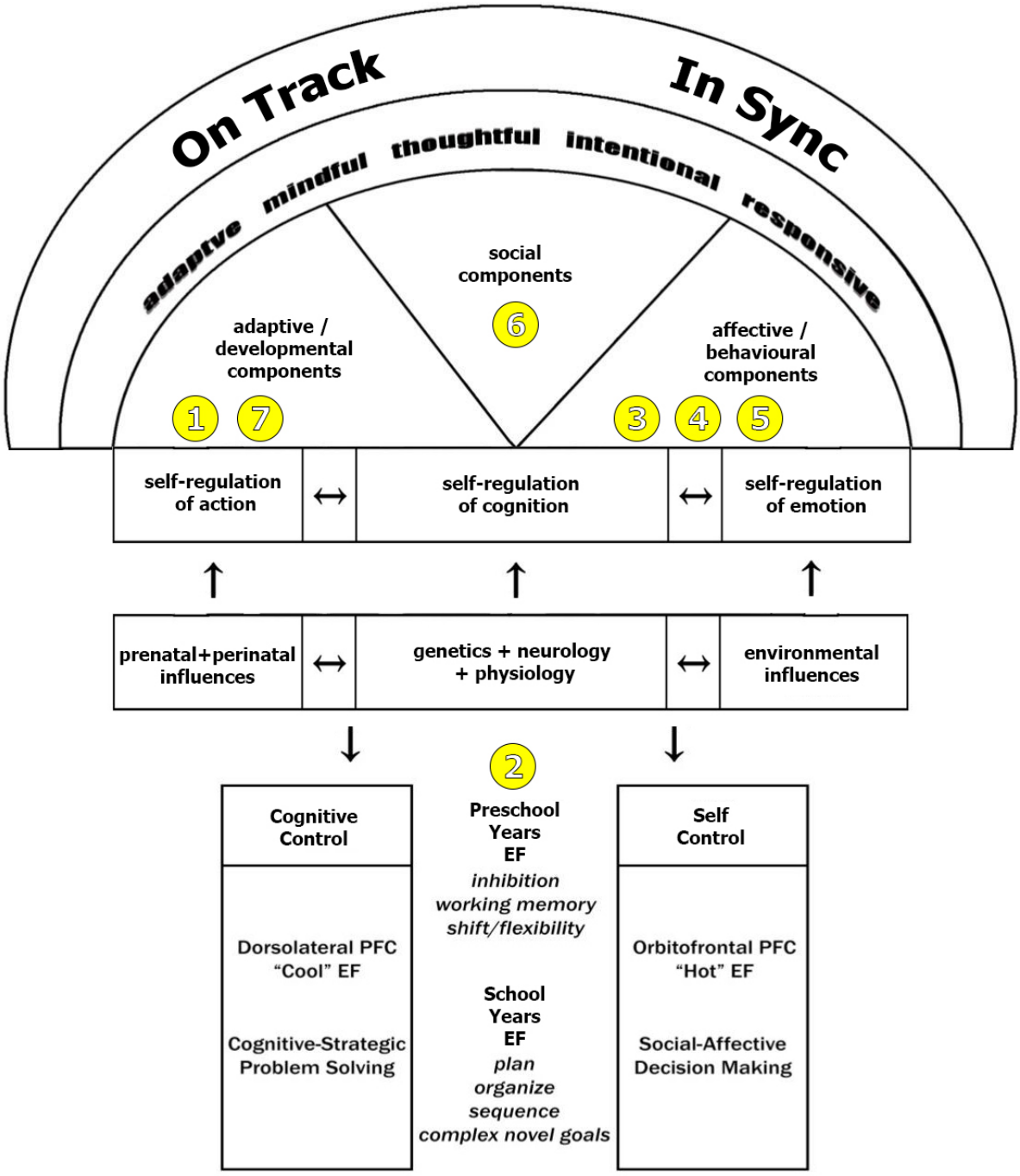

Figure 3. Latent factors identified mapped onto study theoretical framework including 1 (Adaptive), 2 (Executive Function), 3(Flexibility/Adaptability), 4 (Externalizing), 5(Internalizing), 6 (Social Communication), and 7 (Developmental).

of neuropsychological (Taylor et al, 29004), EF (Anderson & Doyle, 2004; Baron et al., 2012), and cognitive (Orchinik et al., 2011) outcomes. Second, the use of BW is pragmatic when collecting, reporting and monitoring health and developmental outcomes (Mercier, Dunn, Ferrelli, Howard & Soll, 2010) and helpful to this study given the need to be judicious and keep comparisons manageable. Finally, preliminary analysis for this study identified BW as more frequently correlated significantly to SR outcomes than GA.

Preliminary analysis confirmed that sex was not a significant predictor of any of the outcome variables and, as such, it was not considered in the final analyses to minimize the number of predictors. Preliminary analysis also included comparison of chronological age with corrected age at the time of the preschool testing. However, given multicollinearity problems when using both, only chronological age at the time of testing was retained given that preschool outcome scores were derived using chronological, not corrected age test norms.

Prior to conducting the regressions, the assumptions of multiple linear regression were assessed for each of the seven models independently. The assumption of normality was assessed by examination of a normal P-P plot. For all cases, the data did not deviate strongly from the normal line, indicating that the regression residuals were normally distributed (Tabachnick, & Fidell, 2013). The assumption of homoscedasticity was assessed by examination of a scatter plot of residuals versus predicted values. The data were approximately equally distributed around zero, so this assumption was met (Tabachnick, & Fidell, 2013) across the multiple linear regressions completed. Finally, the presence of multicollinearity was assessed using Variance Inflation Factors (VIF)[12] and VIF values were found to be acceptable.

[12]Stevens (2009) suggests that VIF values greater than 10 indicate the presence of multicollinearity, which may impact findings if two or more variables are very closely linearly related, and may bias the regression model.

Multiple regression procedures resulted in significant models for: Factor 1 (Adaptive), Factor 5 (Social Communication), Factor 6 (Internalizing), and Factor 7 (Developmental) (see below for details on significant models). The models for the remaining three factors were not significant; these included Factor 2 (Executive Function/Communication), $F(5,54) = .732$, $p = .603$, $R^2 = .02$, Factor 3 (Flexibility/Adaptability), $F(5,54) = .907$, $p = .488$, $R^2 = .01$, and Factor 4 (Externalizing), $F(5,54) = .821$, $p = .540$, $R^2 = .02$.

Factor 1: Adaptive. Using the standard method, the model for Factor 1 (Adaptive) was significant, $F(5,54) = 4.38$, $p = .002$, $R^2 = .22$. Employing the more conservative R^2 value, the model explained 22% of the variability in Factor 1 scores. Table 7 provides information for the predictor variables entered into the model. Both brain injury ($p = .005$) and birth weight ($p = .010$) were significant predictors for this model, indicating that for this sample and analysis the presence of brain injury was more predictive of later adaptive outcome than birth weight. A negative relationship was noted. Counter-intuitively, heavier birth weights were also associated with poorer Factor 1 outcomes.

Table 7
Multiple Linear Regression Predicting Latent Factor 1: Adaptive

Variable	*B*	Std. Error	Beta	*t*	Sig.	VIF
Age	-0.04	0.03	-0.15	-1.27	0.210	1.07
Birth weight	0.00	0.00	-0.40	-2.67	0.010	1.72
BPD[13]	0.23	0.27	0.11	0.84	0.403	1.38
Days in NICU	0.00	0.00	-0.06	-0.39	0.696	1.91
Brain Injury	-0.77	0.27	-0.39	-2.91	0.005	1.35

Factor 5: Internalizing. Again using the standard method, the model for Factor 5 (Internalizing) was significant, $F(5,54) = 3.08$, $p = .016$, $R^2 = .15$. Employing the more conservative R^2 value, the model explained 15 % of the variability in Factor 5 scores. Table 8

[13] BPD: Bronchopulmonary Dysplasia: Chronic Lung Disease.

provides information for the predictor variables entered into the model. Chronological age (p = .008) was a significant predictor for this model. The model indicates that, for this sample and analysis, parents of older children were more likely to express concern regarding their child's somatic complaints (e.g. pain), anxiety, and depression (e.g., cries frequently) than were parents of younger children.

Table 8
Multiple Linear Regression Predicting Latent Factor 5: Internalizing

Variable	*B*	Std. Error	Beta	*T*	Sig.	VIF
Age	-0.08	0.03	-0.34	-2.75	0.008	1.07
Birth weight	0.00	0.00	0.25	1.57	0.122	1.72
BPD	-0.38	0.28	-0.19	-1.36	0.179	1.38
Days in NICU	0.00	0.00	0.19	1.12	0.268	1.91
Brain Injury	-0.18	0.28	-0.09	-0.65	0.518	1.35

Factor 6: Social Communication. Again using the standard method, the model for Factor 6 (Social Communication) was significant, $F(5,54) = 3.55$, $p = .008$, $R^2 = .178$. Employing the more conservative R^2 value, the model explained 18 % of the variability for Factor 6 scores. Table 9 provides information for the predictor variables entered into the model. The number of days in the NICU (p = .008) was a significant predictor for this model. The model indicates that, for this sample and analysis, more medically fragile children with longer stays in intensive care were at greater risk for poor social, adaptive, and communication outcomes than peers who were discharged more quickly (see Table 9).

Table 9
Multiple Linear Regression Predicting Latent Factor 6: Social Communication

Variable	*B*	Std. Error	Beta	*T*	Sig.	VIF
Age	-0.01	0.03	-0.03	-0.27	0.786	1.07
Birth weight	0.00	0.00	-0.05	-0.34	0.738	1.72
BPD	0.35	0.28	0.18	1.28	0.206	1.38
Days in NICU	-0.01	0.00	-0.59	-3.62	0.001	1.91
Brain Injury	0.10	0.27	0.05	0.38	0.704	1.35

Factor 7: Developmental. Again, using the standard method, the model for Factor 7 (Developmental) was significant, $F(5,54) = 5.49$, $p < .001$, $R^2 = .28$. Employing the more conservative R^2 value, the model explained 28 % of the variability in Factor 7 scores. Table 10 provides information for the predictor variables entered into the model. Chronological age (p = .002), Bronchopulmonary Dysplasia (BPD) (p = .008), and Birth Weight (p = .025) were significant predictors for this model. The model for Factor 7 indicates that, for this sample and analysis, better developmental scores were predicted in older than in younger children and in those escaping BPD. Counter-intuitively, heavier birth weight was associated with poorer preschool developmental outcome.

Table 10
Multiple Linear Regression Predicting Latent Factor 7

Variable	*B*	Std. Error	Beta	*T*	Sig.	VIF
Age	0.09	0.03	0.37	3.20	0.002	1.07
Birth weight	0.00	0.00	-0.34	-2.31	0.025	1.72
BPD	-0.71	0.26	-0.36	-2.75	0.008	1.38
Days in NICU	0.00	0.00	0.12	0.80	0.428	1.91
Brain Injury	-0.49	0.26	-0.25	-1.91	0.062	1.35

Regression Summary. Factor analysis reduced 39 independent parent reported variables into 7 factors, which were then used for multiple regression analysis to determine if medical variables and/or chronological age predicted 4-year-old adaptive, executive, and behavioural outcomes. Multiple regression analyses suggested that 4 of these seven factors [Factor 1 (Adaptive), 5 (Internalizing), 6 (Social Communication), and 7 (Developmental)] were predicted by combinations of medical variables, with both positive and negative relationships noted and summarized in Table 11 below. This combination of four factors accounted for 43.68% of the total variance that could be explained by the retained factors, with Factor 1 (Adaptive) accounting for considerably more variance than the others. Executive Function (Factor 2),

Flexibility/Adaptability (Factor 3), and Externalizing Behaviours (Factor 4) could not be adequately predicted by the model variables. The variables that were significant predictors of outcome across these four analyses included the presence of brain injury (with Adaptive and Developmental outcomes being worse for those with greater involvement), and chronological age (with Internalizing concerns and Developmental outcomes being somewhat greater for older than younger children). The presence of BPD and longer NICU stays were significantly associated with poorer Developmental and Social Communication outcomes, respectively. Counter-intuitively, birth weight was negatively associated with both Adaptive and Developmental outcome.

Table 11
Summary of Variables Predicting Individual Factors

	Predicted by				
Factor	Age	Birth Weight	BPD	Days NICU	Brain Injury
1: Adaptive		-			-
5: Internalizing:	-				
6: Social Communication				-	
7: Developmental	+	-	-		

Note. - Negative relationship, + positive relationship.

Question 4: *Do cognitive measures taken during the toddler (18 – 24 month) and/or preschool years predict and/or correlate with parent-reported measures of executive function, behaviour, and adaptive skills prior to school entry*

A Pearson correlation was conducted to determine if the standardized Cognitive and Language scores taken at two and four years predicted results generated by the parent report measures taken at four years.[14] Calculated test scores, generated using raw scores, sex, and age, were used for the

[14] The relationship between Mullen Scales of Early Learning (MSEL) scores and parent report scores were not explored given the small sample size that had completed the MSEL and observations that the mean MSEL Early Learning Composite score was well below comparable GDS cognitive and language mean scores derived from a larger number of sample participants.

analysis with Bonferroni corrections applied (p =.05 /60, p = <.001) to address multiple comparisons.

Correlations of parent reports with 2-year cognitive and language scores. Table 12 displays the Pearson correlation coefficients between the performance-based cognitive and language measures completed at two and four years of age, respectively, with the three parent-report measures completed at 4 years of age. As evident in Table 12, the number of significant correlations varied with age at assessment and with the measure used. GDS two-year-old Cognitive scores did not correlate significantly with preschool measures of EF, behaviour, or adaptive attainment. GDS two-year-old Language score correlated significantly only with the preschool ABAS-II Communication scale. In contrast, significant and positive relationships were evident between 2-year-old BSID-Calculated MDI scores (which combine cognitive and language standardized scores into a common metric) and select components of the ABAS-II. These included the Social Composite, Communication, Community Use, Health, and Leisure scores (see Table 12).

Correlations for parent reports and 4-year cognitive and language scores. Table 12 displays the Pearson correlation coefficients for the GDS Cognitive and Language scores and parent-report measures collected at the four year assessment. Preschool Cognitive and Language scores significantly and positively correlated with adaptive attainment (ranging from r =.48 -.72 and from r = .46 - .75 respectively). More specifically, both Cognitive and Language preschool GDS scores independently correlated with all ABAS-II composite and scaled scores, and with the BASC-p Adaptive Composite and three of its four adaptive subscales (Social Skills, Functional Communication, and Activities of Daily Living). Further, preschool GDS Cognitive and Language

Table 12
Pearson Correlations Between Cognitive Measures at Two and Four Years of Age and Parent Report Measures

Parent Report Measure	BSID-II Calculated (*n* =31)	GDS @2 yr. Cognitive (*n*=27)	GDS @2 yr. Language (*n* =28)	GDS @4 yr. Cognitive (*n* =56)	GDS @4 yr. Language (*n* =57)
ABAS II					
Conceptual Composite	.49	.44	.39	**.72**	**.75**
Social Composite	**.61**	.37	.32	**.70**	**.73**
Practical Composite	.47	.34	.26	**.63**	**.63**
Global Adaptive Composite	.48	.38	.30	**.66**	**.67**
Self-Direction	.45	.32	.22	**.56**	**.59**
Social	.49	.28	.24	**.49**	**.51**
Preacademics	.28	.33	.30	**.62**	**.61**
Communication	**.61**	.18	**.49**	**.51**	**.53**
Motor	.33	.21	.09	**.52**	**.46**
Community Use	**.46**	.41	.36	**.67**	**.68**
Home living	.34	.23	.20	**.50**	**.49**
Health	**.53**	.25	.19	**.64**	**.66**
Leisure	**.63**	.29	.27	**.71**	**.74**
Self-care	.36	.40	.22	**.48**	**.46**
BASC-p					
Externalizing problems	-.34	-.02	-.03	-.24	-.26
Internalizing problems	-.11	-.09	-.10	-.05	-.02
Behavior Symptom Index	-.42	-.15	-.12	**-.39**	**-.39**
Hyperactivity	-.40	-.15	-.13	-.27	-.30
Attention	-.44	-.19	-.18	**-.49**	**-.53**
Aggression	-.21	.13	.08	-.18	-.19
Anxiety	.16	.05	.08	.11	.19
Depression	-.19	-.20	-.23	-.19	-.19
Somatization	-.12	-.04	-.04	-.04	-.04
Atypicality	-.42	-.26	-.19	**-.44**	**-.42**
Withdrawal	-.24	-.04	.06	-.28	-.22
Adaptive Skills Composite	.37	.27	.21	**.62**	**.58**

Table 12 continued:

Parent Report Measure	BSID-II Calculated	GDS @2 yr. Cognitive	GDS @2 yr. Language	GDS @4 yr. Cognitive	GDS @4 yr. Language
Adaptability	0.28	0.08	0.06	**.31**	**0.25**
Social skills	.28	.39	.31	**.55**	**.57**
Functional Communication	.19	.34	.35	**.62**	**.63**
Activities of Daily Living	.36	.34	.13	**.53**	**.45**
BRIEF-p					
Inhibitory Self-Control Index	-.22	-.08	-.13	-.33	-.34
Flexibility Index	-.12	-.10	-.13	-.36	-.29
Emergent Metacognition Index	-.35	-.16	-0.2	**-.45**	**-.48**
Global Executive Composite	-.29	-.12	-.17	**-.42**	**-.43**
Inhibit	-.31	-.04	-.14	-.27	-.35
Shift	-.09	-.08	-.08	-.34	-.22
Working Memory	-.37	-.18	-.19	**-.44**	**-.46**
Planning/ Organization	-.32	-.13	-.19	**-.41**	**-.45**
Emotional Control	-.12	-.09	-.15	-.34	-.34

Note. BSID-II Calculated: Common metric derived using Moore's algorithm (2012) converting BSID-III individual Cognitive and Language scores into a BSID-II Mental Developmental Index equivalent in order to combine results from test editions 2 and 3. GDS=Gesell Developmental Schedules. Outlined values represent significant correlations after Bonferroni correction (p =<.001).

scores correlated significantly and negatively with measures of Attention and Atypicality (BASC-p) and with similarly negatively with components of EF including Emergent Metacognition, Working Memory, Planning and Organization, and the Global Executive Composite (BRIEF-p). Cognitive or language scores at any age did not correlate significantly with components of 'hot' EF (e.g., BRIEF-p Emotional Control, Flexibility Index, Inhibitory Self-Control Index).

Summary. Recognizing that sample size limitations and the high number of comparisons limited analysis of correlations between cognitive, language, and SR outcome scores, the results suggest that higher BSID scores at age 2 correlated with more positive parent-reported adaptive outcomes (5 /14 ABAS-II scales) at 4 years of age. GDS 2-year scores, in contrast, failed to correlate with 4-year SR scores, excluding 2-year Language (GDS) and 4-year Communication (ABAS-II) scales. By 4-years-of-age, however, GDS scores correlated positively across broad aspects of adaptive attainment (ABAS-II), negatively with Withdrawal and Attention concerns were linked to lower 4-year-old cognitive and language scores, as were problems relating to poorer metacognitive development, particularly impacting Working Memory (BRIEF-p). Finally, GDS Language at 4 years predicted Planning and Organization skills (BRIEF-p).

Question 5: *Are there significant differences between sample A (for whom all parent-report measures were completed) and sample B (for whom only some parent-report measures were completed) in terms of medical history, performance on standardized tests, and the proportions of scores on parent-report measures that were considered typical, at risk, or clinically significant?*

Sample A was compared to other participants from the School Readiness Project who met inclusion criteria but whose parents failed to compete all parent-report measures (sample B) to understand the generalizability of study findings. There were a total of 44 cases in sample B. In addition, a large number of incomplete behaviour (27/44 BASC-p) and EF (33/44 BRIEF-p) measures for sample B restricted meaningful analysis, and thus only ABAS-II (n=31), GDS at 4 years (n=42), and BSID-II Calculated MDI (n = 21) results are reported.

Comparison of Medical Variables by Sample.[15] Independent samples *t*-tests were conducted to determine how similar Samples A and B were for medical variables. The mean days

[15] Descriptive statistics for continuous medical variables were presented previously in Table 1.

on oxygen of sample B (M = 58.8, SD = 54.2) differed from that of sample A (M = 41.2, SD = 43.4), t (8) =-2.11, p = .03) and included a broad distribution for sample B. However, none of the remaining comparisons were significant, suggesting that the two samples were of similar composition with respect to other medical variables of interest.

Chi-square tests of independence were run to compare the groups on categorical variables[16]. The only significant difference observed was that sample B had a higher proportion of children who had a positive history of BPD compared to sample A, $\chi^2(1) = 5.08$, p = .024. Despite the increased incidence of BPD evident in sample B, the sample did not display significant differences from sample A in the length of stay in the NICU.

Comparison of Sample A and Sample B on Parent Ratings and Test Scores. Comparisons between sample A and sample B were completed in three stages. Bonferroni corrections for this particular analysis resulted in a p value of < .0025 (reflecting .05/ 20). Sample B displayed significantly poorer adaptive outcomes on the ABAS-II across all composite and scale scores excluding Social Skills, relative to test normative data, with medium to large effect size (see Table 13). Despite very small numbers, cognitive and language scores at 2 and 4 years of age were significantly lower for sample B relative to normative standards, with large effect size.

Sample A was compared to sample B on mean test scores with a series of nonparametric Mann-Whitney U tests, recognizing the uneven sample sizes (see Table 13). Bonferroni corrections were computed given the large number of comparisons, resulting in a p value of < .003 (as calculated by p =.05/20). Significant differences were not noted between samples A and B when comparing cognitive performances at 2 years of age and the MSEL at age 4 years. However, significantly poorer cognitive and language scores were evident for sample B at 4 years of age. In

[16] Descriptive statistics for categorical variables were presented previously in Table 2.

Table 13
One Sample t-Tests and Sample Comparisons for Parent Report and Individual Standardized Measures

Test	Test value	Index/Composite/Scale	Sample B (n=44)				A vs. B compared on test scores[b]	A vs. B compared on clinical classification
			M[a]	*n*	*p* (2-tailed)	Cohen's *d*	*U*	χ^2
ABAS-II age 4	100	Conceptual Composite	**74.6**	31	< .001	1.30	**471.0**	**17.85**
		Social Composite	**76.3**	31	0.001	1.19	**520.5**	**17.07**
		Practical Composite	**70.9**	31	0.002	1.48	**559.5**	**14.30**
		Global Adaptive Composite	**71.0**	29	< .001	1.44	**452.0**	**11.92**
	10	Self Direction	**6.2**	30	< .001	1.17	**513.0**	**22.58**
		Social	7.1	31	0.002	0.79	**530.5**	**20.86**
		Preacademic	**6.4**	30	< .001	1.18	599.5	7.43
		Communication	**6.0**	31	< .001	1.17	**537.5**	9.00
		Motor	**6.4**	29	< .001	1.11	582.5	13.22
		Community Use	**6.2**	30	< .001	1.14	595.5	**16.87**
		Home	**6.9**	30	< .001	0.96	631.5	7.96
		Health	**5.8**	30	< .001	1.23	652.0	7.89
		Leisure	**5.9**	30	< .001	1.21	**631.5**	8.67
		Self Care	**3.8**	31	< .001	2.49	673.5	0.72
BSID (age 2)	100	BSID Calculated Mental Developmental Index	**70.3**	21	< .001	1.68	204.0	6.04
MSEL (age 4)	100	Early Learning Composite	**60.5**	15	< .001	2.59	140.5	0.69
GDS (age 2)	100	Cognitive	**71.0**	19	< .001	1.62	188.5	0.79
		Language	**65.7**	19	< .001	1.97	189.5	1.95
GDS (age 4)	100	Cognitive	**70.3**	41	< .001	1.88	**657.0**	**6.95**
		Language	**69.4**	42	< .001	1.48	**604.0**	**19.14**

Note. ABAS-II = Adaptive Behaviour Assessment System - II; MSEL = Mullen Scales of Early Learning (age 4); BSID = Bayley Scales of Infant Development; GDS = Gesell Developmental Schedules. Test values of 100, 50, and 10 were used for standard, T, and scaled scores, respectively.
[a] Outlined values are significantly different from the test value, after Bonferroni correction (one-sample t-tests, $p < .0025$). [b] Outlined values indicate that means for Samples A and B differ, after Bonferroni correction (Mann-Whitney U test, $p < 003$). [c] Outlined values indicate that distribution of typical, at risk, and clinically significant scores differ across samples,) after Bonferroni correction (chi-square test, $p<.003$).

addition global adaptive outcome (ABAS-II) were significantly poorer for sample B, particularly for Conceptual, Social, Practical and Global Adaptive Composite scores. Further, sample B displayed significantly weaker Self-direction, Social, and Communication skills than sample A at 4 years of age.

Chi-square tests of independence with Bonferroni correction were conducted to determine if there were significant differences between sample A and sample B in the proportions of scores which by clinical definition were considered "typical", "at risk" or "clinically significant" on the study variables (See Appendix D for the "at-risk" and "clinically significant" cut-off values for individual test scores). Comparisons based on clinical classifications typically replicated the comparisons reflecting mean test scores (see Table 12). In addition, 3 ABAS-II individual scales were markedly poorer for Sample B when compared on clinical classification. Specifically, Self Direction (with 46.4% more "clinically significant scores" than sample A), Social Skills (with 48.1% more "clinically significant" scores than sample A), and Community Use (with 36.8% more "clinically significant" scores than sample A) were significant concerns identified for sample B. As such, significant differences emerged between sample A and B preschool in both Cognitive scores and Adaptive Functioning, with more frequent "at risk" and/or "clinically significant" scores reflected for sample B. On a positive note, many of the sample B adaptive composite scores fell into the "typical" category. Specifically, "typical" scores were evident for the ABAS-II Conceptual (32.3% of scores), Social (38.7% of scores), Practical (22.6% of scores), and Global Adaptive (27.6% of scores) Composites for sample B.

Summary

Results presented in this chapter suggest that, in general, scores of preschoolers born VP/EP (sample A) differed significantly from normative test scores, with poorer parent-rated outcomes

demonstrated for adaptive attainment, 'cool' EF, and discrete components of behaviour (BASC-p Atypicality), with medium to large effect sizes noted. Further, significantly poorer cognitive and language outcomes were evident on standardized performance measures, varying with the test used and chronological age. Further, improvements were noted for Sample A's GDS Language scores between 2 and 4 years of age for sample A not replicated in corresponding Cognitive scores.

While sample A and sample B were quite comparable in terms of the medical variables studied here, excluding the presence of bronchopulmonary dysplasia and days on oxygen, the two samples differed in several important ways. Generally speaking, the children comprising sample B at 4 years of age demonstrated significantly poorer Cognitive and Language scores (GDS) and parent reported adaptive attainment, the latter including Self-Direction, Social, Communication, Community Use, and Leisure scales.

CHAPTER 5: DISCUSSION

To be successful in daily life, one must meet changing social, emotional, cognitive and functional demands. This requires self-regulation (SR) and executive function (EF), which include the ability to mentally manipulate ideas and see new connections amongst elements, appreciate different perspectives and situations, creatively problem-solve to meet novel or unanticipated challenges, exercise self-control and discipline, resist temptations, and stay focused (Diamond & Lee, 2011). Such capacities play a critical role in on-task engagement and learning (Wyatt, 2012) and contribute to competent functioning over the life span (Bronson, 2000; Posner et al., 2008). Recognizing the life long significance of these capacities, the current study further recognizes that "one of the greatest challenges for contemporary investigations of SR involves the definition and measurement of these skills in young populations" (Denham et al., 2012, p. 667).

The research framework in this study spoke to this challenge and addressed several gaps in the literature. By examining the influence of perinatal biological risk on preschool SR expression in those born EP/VP, the current study enhances understanding of complex early neurodevelopmental relationships within a clinical context (Marsh, 2008). Few studies have directly investigated SR, EF, social and adaptive function, and early learning (cognition and language) concurrently in young children (Perlman & Pelphrey, 2011), particularly those born prematurely (Poehlmann et al., 2010; Wolfe et al., 2013) despite knowledge that SR influences school readiness and undergirds academic and social emotional competency across the lifespan. Further, while accurate identification of the needs of young children is essential to the success of early intervention or prevention services, identification of emerging behavioural and/or social-emotional problems in preschoolers is not widely established or systematized (DiStefano, Greer, & Dowdy, 2017). By proposing a novel 'In-Sync' and 'On-Track' framework incorporating parental reports to document

preschool VP/EP outcomes, this study contributes to this discussion pertaining to assessing early SR.

The selection of preschool aged participants in the current study recognizes that the preschool years are a critical period in the development of early SR and EF skills, which in turn influence lifetime outcomes. Further, SR is particularly challenged during transitions from home into school or daycare (Wyatt, 2013). As such, school-readiness review for high-risk preschoolers is important, given SR difficulties at this age are widely associated with later childhood and adolescent clinical impairments (Sonuga-Barke, 2005; Shanmugan, Wolf, Calkins, Moore, Ruparel, Hopson, Vandekar, et al., 2016; White, McDermott, Degnan, Henderson & Fox, 2011; Willoughby et al., 2011).

The following discussion pertains to the primary analysis completed for participants who had full data sets (sample A), unless otherwise indicated. A comparison of sample A with those who had incomplete data sets (sample B) follows, speaking as to how representative the sample included in the primary analysis was. Recognizing this was clinically derived, exploratory research, design constraints are acknowledged (see Limitations) which impact generalizability of findings.

It is important to note that apriori study definitions of prematurity emphasized GA over BW, evident in describing participants to this point in this document as VP/EP. However given GA was not retained in the final analysis due to issues pertaining to multicollinearity with BW and its demonstration of fewer correlations with outcome scores than BW, it is judicious to refer to study participants as "preterm" from this point forward in the discussion. The term preterm includes those born at VLBW, ELBW, and $\leq$ 32 weeks GA.

Heterogeneity of Outcomes

Findings of heterogeneous SR outcomes in the current study samples were anticipated given previous research identifying a spectrum of neurodevelopmental strengths and concerns in preterm preschoolers (Aarnoudse-Moens et al., 2009; Iono et al., 2016; Sansavini et al., 2011). Variables associated with early medical risk (e.g., BW, IVH, PVL, BPD, days in the NICU) and chronological age interplay with genetic, social (e.g., home life, maternal education or attachment), parental (e.g., socioeconomic status, mental health) and/or environmental (e.g., early intervention, daycare) influences, resulting in outcome diversity similar to our findings (Anderson, 2014; Baron & Rey-Casserly, 2010; Manley et al., 2015; Msall et el., 2014; Vohr, 2016). In addition, referral biases, differences in cohort and outcome definitions, evaluation methods and sample sizes, and significant site variations in neurodevelopmental impairment rates within Canadian follow-up sites (Synnes et al., 2017) impede evaluation of longer-term preterm outcomes across centers (Vohr, 2014),). Despite such influences, current study findings contribute to the understanding the context of preterm birth via the theoretical SR framework for this study.

Key study findings include:

1. Despite significantly poorer global outcome scores (BRIEF-p Global Executive Composite, ABAS-II Global Adaptive Composite, BASC-p Adaptive Composite) compared to test standardization norms, analysis of individual subscales suggest specific rather than global SR concerns in preschoolers born preterm.
2. Perinatal risk factors predict select latent SR factors.
3. Early Cognitive and Language scores predict parent-reported preschool SR outcomes.
4. Children who completed the assessment demonstrated both strengths and limitations in their SR skills prior to school entry. Children who did not complete the assessment process however, may be at particular risk.

1. Specific Rather Than Global Self-Regulatory Concerns.

In the current exploratory study, parents of preschoolers born preterm identified many age appropriate behavioural, social, and 'hot' EF scores ("In-Sync" components), even when using very conservative significance levels. They also identified specific areas of concern relating to preschool adaptive, 'cool' EF, and early learning outcomes ("On-Track" components) (ranging from small to large effect size) and indicated significant concerns for one measure reflecting behavioural regulation (BASC-p Atypicality (medium effect size). Such divergent outcomes are consistent with research identifying variable and specific, rather than global concerns following preterm birth (Arpi & Ferrari, 2013; Baron & Erickson, 2011; Baron & Rey-Casserley, 2010), as discussed under the headings of Adaptive Behaviour, Executive Function, Behavioural Attainment, and Early Learning outcomes below. Toddler and preschool outcome scores were derived using norm-referenced measures with strong psychometrics (see Appendix C), with calculated scores taking participant age and sex into account. As such, the reliability of individual scales and composite scores across measures was acceptable to good and individual test construction accommodated for normal developmental variability and the hierarchical nature of skill expression. Consequently a large range of skills was documented as appropriately developed.

Adaptive Behaviour. There is remarkably little information relating to preterm adaptive outcomes across life stages (De Battista, 2014; Taylor et al., 2006), despite the relation to both child and family quality of life (Janvier, Farlow, Baardsnes, Pearce, & Barrington, 2016), family function (Treyvaud et al., 2014), and longer-term burden of care (Sullivan & Msall, 2007). Parents in the current study reported several areas of typical preschool adaptive attainment [Self-Direction (ABAS-II), Communication (ABAS-II), Social Skills (ABAS-II, BASC-p), Community Use, Home skills, and Leisure Skills (ABAS-II)], suggesting preterm children fulfill many appropriate

social participation roles within groups, with peers, and with family, including community contexts, despite difficulties across other adaptive domains.

In contrast, significant deficits were reported for preterm preschoolers which ranged from large effect size [Practical Composite and Self-Care scores (ABAS-II); Adaptive Composite, Functional Communication, and Activities of Daily Living scales (BASC-p)] to medium effect size [(Global Adaptive Composite, Motor, Preacademic, Health scales (ABAS-II)]. These findings suggest broader functional difficulties than previously reported (Anderson et al., 2015; Msall et al., 1993), evident in both a screening tool (BASC-p) and a more in-depth review of function (ABAS-II) prior to age 5. Adaptive impairments evident across multiple scales (ABAS-II, BASC-p) in the current study align with prior research indicating significant adaptive deficits in preterm children at 2-3 years of age (Baron et al., 2011; DeBattista, 2013; Killeen, Shiel, Law, Segurado, & O'Donovan, 2015), which persist (Fjortoft et al., 2015; Loe et al., 2014), and may increase over time (DeBattista, 2014). This study extends these arguments by identifying deficits not just in the Global Adaptive Composite scores, but further across multiple specific domains (e.g., Self-Care, Health, Motor, Preacademic) at 4 years-of-age. This richer detail highlights more specific areas of weakness, which may point to important information to considering for monitoring and intervention planning.

The combination of poorer Health, Motor, and Preacademic status in the context of pronounced deficits in Self-Care, introduces barriers to early independence and learning, which are foundational to home and school success. This is consistent with research linking poorer health in children born preterm with restricted participation in age-appropriate activities (Sullivan & Msall, 2007). When paired with delays in achievement of milestones associated with independence (e.g., dressing, toileting, grooming, or eating skills), this further increases the burden of care on the families (Sullivan & Msall, 2007) and family stress.

The current findings suggest that preterm preschoolers demonstrated difficulty fulfilling functional, but not social roles- with the additive effect of both health and motor limitations likely compromising practical self-sufficiency (Sullivan & Msall, 2007). Given that adaptive deficits have been linked with greater risk for secondary mental health concerns, including increased disruptive, internalizing, and affective behavioural dysregulation (Papazoglou et al., 2013), and with challenges securing employment, living independently, and cohabitating with others as an adult (Leppert et al., 2009), current study findings highlight the importance of incorporating adaptive outcomes in early follow-up to optimize long term outcomes.

While moderate deficits in Functional Communication on the BASC-p seem to conflict with average Communication scores reported on the ABAS-II, this likely reflects differences in test construction, conceptualizations, and scale content. For instance, the BASC-2 uses almost half as many items as the ABAS II with BASC-p items oriented to assist with interpretation of problem behaviours (Reynolds & Kamphouse, 2004). The BASC-p Functional Communication scale is more explicitly communication focused and measures the child's ability to express ideas and communicate in a way others can understand. Further, since the ABAS-II adaptive scales were initially developed for intellectual diagnostic purposes, they provide a greater range (10 scales) and depth (e.g. 21- 25 items per skills area) of adaptive behaviours and skills and scores (standardized scores & scaled scores) (Harrison & Oakland, 2008). Convergent validity evidence is limited between measures, however individual item review suggests the ABAS-II items sample a large range of verbal and nonverbal developmental milestones and include very specific examples, which may reflect the lower communication scores. While cross-comparison of the BASC-2 and the ABAS-II in an older clinical population have yielded comparable scores between scales and

composite scores (Lopata, et al., 2013)[17], future research could investigate individual item responses across similar scales and measures, with a focus on age related differences and construct representation differences.

Current study findings of average Social Skills scores (ABAS-II, BASC-p) contrasts with reports identifying significant social difficulties in younger (Peralta-Carcelen et al., 2013), similar aged (Arpi & Ferrari, 2013; Delobel-Ayoub et al., 2006), and older premature populations (Dahl, Kaaresen, Tunby, Handegard, Kvernmo, & Ronning, 2006). However, these studies incorporated different measures than those in the current study and thus again, difference may reflect differences in construct elements. In contrast, current study findings do align with prior BASC-p findings in which preterm and ELBW 3-year-olds did not demonstrate significant social differences relative to term controls (Baron et al., 2011). In the context of the current study, this suggests that preterm birth does not impact very early social outcomes, but may also reflect the low level of social demands at this age, as well as differing contributions and representations of constructs across individual assessments. Future research may consider evaluating convergent validity of preschool social measures to clarify this finding.

Significant Practical, Self-Care, and Activities of Daily Living deficits found in the current study support the recommendation that the measureable effects of preterm birth on 'childhood occupations' merit further investigation (Killeen et al., 2014). Clearly, to be meaningful, outcomes collected among survivors of the NICU should have a relationship to quality of life and the function of children and their families (Janvier et al., 2016), including interactions with others within a community context (Alton et al., 2015). Given the multiple areas of moderately to significantly delayed adaptive attainment evident, current study findings demonstrate the

[17] Individual ABAS-II scales (and corresponding BASC-2 equivalent) included Communication (Functional Communication), Social (Social), Self Direction (Adaptability), Practical skills (Activities of Daily Living).

importance of considering not only disability severity but also functional ability as important preterm outcome indicators (Rogers & Hintz, 2016; Rosenbaum, Eliasson, Hidecker, & Palisano, 2014). Further, assessment of function clearly captures the overall burden of preterm morbidity (Vohr & Msall, 1997) in the context of the child's ability to meet expected social roles both physically and emotionally (Sullivan & Msall, 2007).

Current study findings further align with prior research indicating adaptive impairments may exist within the context of broadly normal intelligence (cognition) in preterm populations (Papazoglou et al., 2013), complicating early identification of difficulties. Moreover, these findings support earlier observations that measuring functional and adaptive skills and health-related quality of life is important for devising intervention strategies that optimize developmental independence, family supports, and community participation among at-risk children (Msall, 2005). While this may in turn facilitate smoother transitions across early life stages, future research would benefit from quantifying opportunities for and participation in daily activities to clarify potential practice and exposure effects, for example through incorporation of childhood participation scales. Further, future research would benefit from clarifying parental expectations pertaining to their child's readiness to participate. For example, including rankings of 'how important' a skills is perceived to be in addition as to 'how well' a child performs this skill may elucidate responder bias impact on scores. This would also enable more precise understanding of real life outcomes for this population.

Participation may further be negatively impacted by socio-demographic variables such as poverty, access to transportation and childcare, geographic isolation, parental literacy, culture, or the presence of complex family or work related demands, which were not examined in the current study. Future research incorporating such broader variables would be informative. Despite the absence of these variables, the profile of multiple low composite and scale scores evident in this

sample of preterm preschoolers remains concerning, given adaptive skills should be well established by Kindergarten entry and play a foundational role for later personal and social sufficiency and life participation (Sparrow et al., 2005).

Executive Function: Current study findings of significant impairments in Global Executive Composite (BRIEF-p) scores are consistent with previous work involving older preterm children (Bayless & Stevenson, 2007; Luu et al., 2011; Roze et al., 2009). Further analysis of individual BRIEF-p test scales, however, suggests a range of specific rather than global lower level executive difficulties in 4-year-olds born preterm. Specific EDF was suggested by elevated Emergent Metacognition Index scores, attributed to clear deficits in its component scales of WM and Planning/Organization. WM deficits limit the child's capacity to retain information required to complete a multiple-step task, an activity involving sequential actions, or follow increasingly complex instructions (Duku & Vaillancourt, 2014). Further, the poorer Planning scores evident suggest that our group showed difficulties in the ability to anticipate future events, execute instructions or steps towards a goal and/or plan, and process/identify needs to complete tasks or activities. Relatively low Organization scores reflect difficulties in organizing information, actions, and/or materials to reach a goal (Duku et al., 2014).

In addition to WM and Planning/Organization difficulties, parents recognized signs of EDF as expressed by difficulties in Inhibit scale. Inhibition results are more difficult to interpret when using the BRIEF-p (Inhibit, Inhibitory Flexibility Control Index) as impulse control items appear to tap both 'hot' and 'cool' EF (Sherman & Brooks, 2010) and both attentional and social/behavioural subcomponents (Skogan et al., 2015). This suggests a need for better construct validation of this scale and index, use of factor analysis to understand individual scale items more robustly, and inclusion of broader measures to sample these constructs in future work. Broader

measures could include performance tasks with increased emotional valiancy such as delay of gratification and/or frustration paradigms.

Despite these limitations, behavioural markers of 'hot' EDF (including Inhibitory Self Control and Flexibility Indices, and Emotional Control and Shift scales) examined in the current study demonstrated only small to moderate effect size deficits, and only approached significance in the direction anticipated given the existing literature (Aarnoudse-Moens et al., 2012; Alducin et al., 2014). This suggests that parents viewed preterm preschoolers' ability to adjust behavior according to the situation at hand - or switch from one situation, activity, set of rules, or aspect of a problem to another as only mildly problematic. Given these difficulties were less pronounced than anticipated, results may again reflect lack of age-related measurement sensitivity or conversely typical age related diversity, as these EF skills emerge more clearly following school entry at 5 years of age (McCann, Rider, Weiss, Litman, & Baron, 2014). Study findings are consistent with observations that the behaviours associated with 'hot' EF follow distinct developmental trajectories that come online more clearly in the later years (Willoughby et al., 2011), with emergent skills felt to be unstable and therefore subject to considerable extraneous variation during the preschool period of development (Skogan et al., 2015). Lack of significant parental concern pertaining to 'hot' EF at 4 years of age however, merits further review as these executive processes are closely linked to later externalizing child psychopathology (Espy, Sheffield, Wiebe, Clark, & Moehr, 2011).

In summary, the current study investigated 'hot' and 'cool' EF concurrently in preterm preschoolers, to elucidate more precise thinking about the diversity of functions subsumed under the construct of SR (Willoughby et al., 2011; Espy et al., 2011). Greater difficulties with 'cool' than 'hot' EF at 4-5 years of age were found. Current findings highlight the importance of close EF surveillance in children born preterm given EF facilitates more effortful and deliberate aspects

of SR through its critical top-down role in behavioural regulation and learning (Blair, 2016), plays a key role in kindergarten readiness (Bauer & Msall, 2010; Monette et al., 2015), early academic outcome (Gerst, Cirino, Fletcher & Yoshida, 2017; Monette et al., 2011), and classroom adjustment (Denham, et al., 2015), and demonstrates inter-individual stability over time (Vandenbourke et al., 2017). As such early EDF is anticipated to persist. Further, increased risk of early learning difficulties in current study participants may be anticipated by impairments in Inhibition, Planning/Organization, and WM skills, which mediate individual differences in cognitive reasoning, IQ, and academic attainment (Blair, 2016; Wass, 2015). Likewise, findings of EDF in the current study may also contribute to low adaptive scores in our population, given the role of cognitive control and behavioural regulation in undergirding early adaptive function (Papazoglou et al., 2013). The small sample size and multiple comparisons in the current study necessitated use of conservative analysis techniques. Thus, findings approaching significance observed in 'hot' EDF (e.g., Emotional Control, Shift) merit further review with the addition of performance based measures, collateral reports, a larger sample size, and a broader range of participant ages.

Behavioural Adjustment: Current study findings suggest that the behaviour of our sample A cohort of nondisabled VLBW children at 4 to 5 years of age was, on the whole, within the "normal" range, aligning with reports identifying similarities between 3-year-old ELBW children and their typically developing peers when using the BASC-p (Baron et al., 2011). Further, findings are congruent with those of Brown and colleagues (2017) who, though using a different

assessment[18], found preschoolers born ELBW failed to demonstrate behavioural problems both at 4 and at 5 years of age.

Despite largely preserved behavioural functioning when viewed globally, some specific behavioural concerns were suggested related to significant Atypicality (of medium effect size). Behaviours described in the preschool Atypicality scale involve 'acting strangely', 'seeming disconnected from his/her surroundings', 'babbling to self', or 'demonstrating behaviour inappropriate to the situation', suggesting overlaps with attentional, EF, and social-communication constructs. While the Atypicality scale was initially designed to be a psychoticism scale, at this age it is also seen as another indicator of hyperactive-impulsive disorders in young children (Reynolds & Kamphaus, 2004). This latter interpretation would be consistent with current study findings given that while Atypicality scores were significant, the BASC-p Internalizing Problems, Anxiety, Depression, and Social scores were not. This suggests some participants demonstrate more frequent ADHD-like behaviour, rather than frank disturbances of mood, affect, and/or interpersonal skills as would be anticipated with the presence of psychoticism. Further, supporting this interpretation linking increased Atypicality scores with hyperactive-impulsive difficulties in preschoolers are findings approaching significance for the Hyperactivity (p =.006) and Attention (p =.003) (BASC-p), with elevated rates of ADHD evident in children born preterm (Johnson et al., 2010).

Elevated scores approaching significance for the Withdrawal scale (of small effect size) are clinically relevant given previous research has documented similar BASC-2 profiles of elevated Atypicality and Withdrawal behaviours in children with ASD (Goldin, Matson, Konst, & Adams,

[18] Child Behavior Checklist (CBCL)/ 1.5-5 years for preschool children was used to determine the frequency of behavioural
and emotional problems (Achenbach & Resorla, 2000).

2014). For example, the Atypicality scale includes items that pertain to the presence of unusual, repetitive, and restrictive behaviours and a disconnect from reality while the Withdrawal scale includes items relating to a preference for being alone and difficulty forming friendships. Elevated rates of ASD characteristics, subclinical ASD endophenotypes (Johnson & Marlow, 2011; Treyvaud et al., 2013), and 'high functioning' Autism Spectrum Disorder in older preterm children (Volker et al., 2010) have been reported. Given the mean age of diagnosis for children with 'high functioning' Autism Spectrum Disorder is 8 years of age (U.S. Department of Health and Human Services, 2012), current behavioural findings which approach significance may represent early markers of risk and merit further review with larger sample sizes. While current study results support findings that children born prematurely have a greater risk of ASD relative to peers, it has conversely been suggested that emotional regulation differences relative to full term controls may reflect greater parental attention to their premature child's difficulties, beginning at birth and persisting as heightened awareness of their child's feelings or odd behaviours (McCann et al., 2015). If present, this parental sensitivity introduces the potential for a negative bias that merits particular consideration during diagnostic assessments of preschoolers born preterm.

Measurement issues relating to interpretation of test scores may also further complicate clinical diagnosis in preschoolers born preterm. In the current study BASC-p Adaptability scores (which measure emotional and behavioural regulation) ranked within normal limits. Further, BRIEF-p Shift and Flexibility Index scores (which emphasize the cognitive components of switching) (Sherman & Brooks, 2010) only approach significance. Interpretation of these test scores suggests parents identified generally appropriate behavioural and cognitive flexibility in their preterm preschoolers, evident in their child's ability to shift or transition easily between environments, tasks, and expectations. Such scores however, do not negate the presence of related ASD characteristics (e.g., the presence of repetitive and restricted interests and rigidity of set)

given Adaptability scores within normal limits have been reported for older children diagnosed with ASD (Goldin et al., 2014). This suggests researchers and clinicians evaluating SR for clinical diagnostic purposes should consider how measures reflect various SR components singularly or in combination in order to facilitate more strategic assessment. Further, construct validation research may be an important step to clarify overlap and distinctions between different scales and measures incorporated into clinical diagnostic assessment.

As previously mentioned, while many researchers indicate appropriate behavioural outcomes in preschool and school aged preterm populations, some researchers present contrasting work suggesting children born preterm demonstrate more behavioral and/or emotional problems than full-term counterparts (Cassiano et al., 2016; Hutchinson et al., 2013), including Aggression, Somatization, and Externalizing problems (Davis, Ford, Anderson, & Doyle, 2002), Inattention, Anxiety, and Depression (Poole, Schmidt, Missiuna, Saigal, Boyle, Van Lieshout, 2015). However, given only 20% of Cassiano and colleagues' (2016) meta-analysis pertained to preschool populations and different measures were used [19] across studies, applications to this age group are limited and clearer differences would be anticipated in the middle school years. Further, current study results support the idea that chronological age and the assessment used may impact behavioural profiles of preterm preschoolers (Meyers, Bour, Sidebottom, Murphy, & Hakman 2010) and are also consistent with research suggesting that parent reports of behavioural issues may become clearer after school entry (age 5+) when demands on the child increase (Wolfe et al., 2013), clearly pointing to the need for consideration of age related measurement issues for future research. Finally, findings of emergent focal behavioural concerns align with previous literature (Aarnoudse-Moens, et al., 2009; Farooqi et al., 2007; Gardner et al., 2004; Vieira & Linhares,

[19] Typically the Strengths and Difficulties Questionairre (Goodman, 2001) or the Child Behaviour Checklist (Achenbach & Rescorla, 2000).

2011) and likewise suggest the importance of school readiness behavioural review for premature populations.

2. Perinatal Factors Predict Select Latent Factors

Principal Axis Factoring successfully reduced 39 parent-reported preschool outcome scores to seven clinically relevant latent Factors, four of which (Adaptive, Social Communication, Internalizing, and Developmental) were predicted by discrete perinatal variables and/or chronological age. Of significance, the latent factors were congruent with SR theory (Nigg, 2017) and the specific 'In-Sync" and 'On-Track' framework proposed, differentiating parent report scores into regulation of emotion (Factors 3, 4, 5, and 6), cognition (Factor 2 and 6), and action/goal attainment (Factor 1 and 7). Review of the component matrix (Table 6) suggested each of the three parent report assessments measured different components of early SR with limited overlap, particularly for the ABAS-II and BRIEF-p scales. Further review of the specific components grouped within each of the 7 identified latent factors further suggest that the statistical grouping yielded theoretically meaningful factors for regression analysis.

Perinatal variables determined by a review of the literature and preliminary analysis included neonatal brain injury (IVH and/or PVL), chronic lung disease (BPD), birth weight, and a marker of complexity of medical care (days in the NICU). However, problems associated with multicollinearity resulted in chronological age (vs. corrected chronological age) and BW (vs. GA) being selected for in the final analyses. Likewise, sex did not demonstrate sufficient correlations and was also removed. All children with PVL in this study were also diagnosed with IVH, with four children identified as having mild IVH (grades 1-2) while three others were identified with significant IVF (Grade 3+). As such, brain injury was designated as a combined neonatal medical variable. Each remaining variable predicted differing SR Factors, most often reflecting a negative relationship.

More specifically, early brain injury predicted poorer Adaptive (cognitive, social, and practical) and scores approaching significance related to poorer Developmental outcomes ("On-Track"). This aligns with previous research indicating that IVH/PVL conditions are linked with poorer developmental, learning, social, and language outcomes in older preterm children (Anderson, 2014; Downie, Frisk, & Jacobson, 2005; Feldman, Lee, Loe, Yeom, Grill-Specroe, & Luna, 2012; Limperopoulos et al., 2008), with current study findings extending this to a younger population and predicting significant adaptive concerns. Additionally, longer stays in the NICU were associated with poor interpersonal skills (Social Communication Factor) ("In-Sync") and this is consistent with literature indicating the presence of increased social-emotional concerns in those born ELBW (Peralta-Carcelen, 2013) and increased rates of clinical and subclinical Autism Spectrum Disorder in preterm populations (Dudova et al., 2014). While children previously diagnosed with an ASD were excluded from the School Readiness Project, these findings suggest those with milder phenotypes may have participated. This further highlights the importance of longitudinal follow-up for children presenting with early risk given that diagnosis of milder ASD phenotypes peaks, as noted previously, at 8 years of age.

The presence of BPD predicted poorer preacademic, motor skills, and activities of daily living outcomes (Factor 7). This is consistent with research identifying chronic lung disease as a risk factor affecting school readiness in premature infants (Wong et al., 2014), in part, through its association with increased risk of brain injury (Back & Miller, 2011; Hack & Fanaroff, 2000; Patrianakos-Hoobler, Msall, Marks, Huo, & Schreiber, 2009). BPD as a negative predictor of motor outcome is also congruent with the literature (Aylward, 2005), recognizing however, that those with significant CP were excluded from the current study. While a positive relationship between BPD and EDF was anticipated (Sun & Buys, 2012), EF impairment was not predicted by medical variables or chronological age in the current study.

With regard to chronological age, results suggest a predictive role for increasing chronological age and greater Internalizing concerns, including Somatization, Anxiety, and Depression. This may reflect increasing parental awareness of their child's mood as children approach school entry, recognizing mean scores in the current study were below clinical thresholds. Internalizing problems increasing with age may also relate to the child developing either greater insight into their deficits as more complex competencies are demanded, or more advanced vocabulary to process pain, worries, or sadness (Sansavini et al., 2011). Increasing chronological age further predicted poorer Activities of Daily Living, Preacademics, and Motor outcomes (Factor 7), suggesting a widening of the attainment gap over time in this already vulnerable population. This is congruent with previous work documenting a widening of gaps in adaptive development over time (DeBapttista, 2014). As such, even smaller early developmental delays in preterm populations may suggest greater later SR risk.

With reference to BW, findings from this study indicate BW predicts Adaptive and Developmental attainment, however these relationships were in the opposite direction of expected results; higher BW was associated with poorer outcome. Counterintuitive findings suggest that despite a range of BWs and GAs evident across participants in this study, enrolment criteria and sample size were restricted such that study BW scores represented a small range relative to the premature population as a whole. Further, sampling distributions were uneven with a greater proportion of study participants in the larger than smaller birth weight group. Findings suggest issues related to sampling or the presence of a confound or influencing variable (see Basso, Wilcox, & Weinberg, 2006). For example, in the current study, 4 infants in the sample A who weighed > 1250 g. presented with more significant brain injury (including PVL and grade 3-4 IVH), which may be a potential confound. In addition, diffuse WMI in heavier infants could be under-reported due to use of less sensitive cranial ultrasound to diagnose early brain injury.

Despite potential confounds, findings are consistent with earlier suggestions that the use of BW alone to estimate preschool functional performance may be insufficient given other predictors can add significant variance for the effects (Sullivan & Msall, 2007). While collinearity tests for this analysis were satisfactory, future research with a larger sample and more sensitive imaging (e.g. MRI) may clarify this apparent low birth weight paradox.

Overall, study findings and the theoretical SR framework proposed appear potentially useful for research and clinical work. Findings support monitoring a broad range of biological risk factors, including variables beyond intelligence, to better conceptualize and address complex early SR developmental interrelationships, important to advancing theory, evaluation practices, and intervention planning (Papazoglou et al., 2013). In the current study for example, neonatal brain injury and BPD predicted later "On-Track" concerns, while the presence of increased days of stay in the NICU predicted increased "In Sync" concerns. Study findings support observations that greater deficits in learning and psychosocial functioning are evident in preterm children with more neonatal complications and related brain abnormalities (Taylor & Clark, 2016). Further, findings that increasing chronological age predicted poorer academic, self-care, motor, and internalizing outcomes highlight the importance of extending developmental follow-up at least until school entry, and preferably beyond, for these at risk infants. Results extend current discussions by proposing discrete perinatal variables other than GA or IQ scores (Richards et al., 2016) or sex (DeBattista et al., 2015) may identify those at greater early SR risk.

Finally, these findings support the merit of distilling multiple parent report measures for preschool preterm populations into theoretically meaningful factors for subsequent analysis. Of importance to future clinical and research work, the factors derived were consistent with components proposed in the original study framework, mapping nicely onto the three framework

components of SR: Emotional /Behavioural, Social, and Adaptive/Developmental, suggesting some evidence of validity for the framework presented.

3. Early Cognitive And Language Performance Correlate With Preschool SR

In contrast to prior research suggesting cognitive impairments follow preterm birth, irrespective of testing age, birth year, or measurement instrument used (Baron et al., 2011), participants in the current study demonstrated cognitive and language delays of medium to large effect size, that varied with the test used (BSID vs. GDS) and child's chronological age at testing. In terms of differences between tests used, at 2-years-of-age, participants demonstrated heterogeneity in cognitive and language outcomes. Findings included at-risk scores (of large effect size) for BSID-III Language scale and Calculated MDI[20] scores. While GDS scores similarly identified a particular weakness in language skills, GDS Cognitive and Language mean scores were even lower than the BSID counterparts. This is difficult to resolve given the lack of evidence for concurrent validity available between these specific measures, however this may reflect the GDS being considered a measure of children's development rather than a specific 'intelligence' test (Konvold & Shukla, 2014). In contrast, the BSID-III is a more comprehensive evaluation and is considered the cognitive "instrument of choice" for this age group (Venn, 2007). Higher BSID scores may also suggest the algorithm used to derive the BSID-Calculated MDI masks the severity of language impairment evident in the current study population, or that results reflect the very small sample size. Given the newer BSID-III provides distinct cognitive and language scores and is currently routinely used for outcome research, direct comparison between GDS and BSID-III scales will be important and possible for future research. Factor analytic work may also provide additional support for construct validity across measures.

[20] BSID-Calculated Mental Developmental Index, a composite of BSID-III Language and Cognitive scores; refer to page 78.

Despite these test considerations, current findings suggest age may further contribute to differences in cognitive and language scores. For example, by 4 years of age, developmental catch-up in language skills to low average limits was evident in the GDS scores (Language scale +15.6 points; medium effect size deficit persisting). This is particularly important given that using age correction would likely show increased gains between the two assessment periods. Further, gains in Cognitive scores over this period were smaller (+5.5 points; large effect size deficit persisting), suggesting relative stability in cognitive processing scores, consistent with research suggesting a moderate relationship (.40 - .61) between early GDS and preschool intelligence test scores (Meinzen-Derr, Wiley, Phillips, Altaye & Choo, 2017; Werner, 1965) over this short time period. Further, gains in GDS scores were congruent with parent report scores indicating only mild delays in Preacademic (ABAS-II) and Functional Communication (BASC-p) skills prior to school entry in sample A, demonstrating clinical utility for these measures.

Two-year-old GDS Language and Cognitive scores typically did not correlate with preschool SR outcomes other than Language scores, which correlated moderately with comparable Communication scales from both the ABAS-II and BASC-p. In contrast, the BSID-II Calculated MDI, correlated with five preschool adaptive scales (in descending order: Leisure, Social Composite, Health, Conceptual Composite, Social Skills), but no other measure of behaviour or EF. This BSID-II Calculated MDI correlation suggests a link between early cognitive and language proficiency, and subsequent play, social, group, and recreational abilities.

Cognitive function is a common primary outcome in clinical research involving preterm populations, however the stability of this variable over time has been questioned given cognitive scores derived at very young ages provide limited information at older ages (Hack, Taylor, Drotar et al., 2010; Potharst, Houtzager, van Sonderen, et al., 2012; dos Santos et al., 2013). Study findings align with the assertion that GDS Cognitive scores may not be sensitive enough for future

prediction, (Werner, 1965; Konvold & Shukla,2014) and may relate to individual test items or be impacted by the rapid trajectory of language and cognitive development emerging at 2 years of age, resulting in a large range for 'typical' development.

Despite the general lack of significant correlations for GDS scores at age 2, by 4-years-of-age GDS scores (Cognitive and Language) were highly correlated with preschool outcomes in the direction expected, suggesting utility of the GDS for this age group prior to school entry. Further, strong and positive correlations between GDS scores and all Adaptive Composite scores and scales (ABAS-II and BASC-p) in this study are congruent with previous research showing correlations between developmental ability and adaptive function in preschoolers with special needs (Milne et al., 2012) and further suggest those presenting with preschool developmental concerns (for either cognitive or language development) should be flagged for early in-depth adaptive assessment. However, in the current study, adaptive attainment for preterm preschoolers was lower than anticipated by cognitive status, suggesting the influence of other predictors and variables on daily life participation and functional outcomes.

Despite strong correlations with Adaptive scores, the 4-year-old GDS scores were not significantly correlated with measures of 'hot' EF, which may reflect the very limited number of items measuring this component in the BRIEF-p, as well as and the later development of clear behaviours associated with 'hot' EF. Conversely, 4-year-old GDS scores in this study were significantly yet negatively correlated with measures of 'cool' EF (i.e., lower GDS scores are associated with greater EDF), consistent with prior work correlating cognition with metacognitive outcomes (Ardila, 2013). Low 4-year-old GDS cognitive and language scores further correlated with increased Attention and Atypicality concerns, suggesting broad early school interpersonal and learning risk. Likewise, findings that preschool language scores correlate with emergent

metacognitive skills (including Planning and Organization) are congruent with contemporary theory linking the development of private speech, inner language, and verbal mediation skills (e.g., mnemonic strategies or verbal self-guidance) to better cognitive control capacities (Alarcón-Rubio et al., 2014; Wass, 2015), suggesting language assessment may identify those at greater risk of early metacognitive difficulties.

Moreover, while cognitive or language delays at 2 years of age predicted adaptive difficulties, neither predicted anticipated school readiness problems, despite research indicating a relation (Patrianakos-Hoobler et al., 2010). Given those with frank neurological impairments (motor or sensorineural) or diagnosis of Autism Spectrum Disorder were excluded from the study, low cognitive and language scores evident at 2 and 4 years of age in the current study are especially concerning given this was a healthy sample of 'intact' survivors of preterm birth. Such low scores however, suggest the final study sample includes a broader preterm population than originally proposed by the study's exclusion criteria, specifically those with a DQ $\leq$ 70, given the large range of cognitive and language scores demonstrated at 2 years of age.

4. Participants Who Failed To Complete Are At Particular Risk For Poorer Outcomes.

Current study findings revealed generally poorer outcomes in those who failed to complete follow-up assessment (sample B) compared to those who did (sample A). Although the samples were of similar composition relating to common medical variables of interest, sample B demonstrated a greater number of days on oxygen in the NICU, likely related to more frequent neonatal BPD. Findings further suggest significant differences in preschool outcomes between samples, evident in higher preschool cognitive, language, and adaptive scores (GDS and ABAS-II) for those who completed testing than those who did not. This limits generalization of findings for

research questions 2 and 3, recognizing sample A demonstrated globally significantly better 'On-Track' scores.

Overall, as anticipated global developmental concerns were suggested for sample B by preschool parent report (ABAS-II) and by standardized cognitive testing completed at the toddler and preschool periods (BSID- Calculated MDI, GDS Cognitive and Language scores at 4 years of age). Lower scores in sample B were anticipated given both the antecedents and the early correlates of BPD are known to place the child at increased risk of brain dysfunction related to inflammatory processes and disrupted perfusion impacting the developing brain (Logan et al., 2017; Rose et al., 2014). Further, BPD has been associated with poorer behavioural, emotional and executive function outcomes (Anderson & Doyle, 2008; Cassiano et al., 2016; Potharts et al., 2013), and did indeed confer later risk for developmental delay (as measured by Factor 7) in the regression analyses involving sample A.

Significantly poorer scores across all four Adaptive Composite, Self-Direction, and Social scales (ABAS-II) were noted for sample B when compared to sample A. In contrast, participants in both groups were significantly and similarly impaired in PreAcademic, Motor, Health, and Self-Care domains relative to test normative scores. Sample B was additionally compromised in their Communication, Community Use, Home, and Leisure skills, suggesting a broad range of impairments (across multiple scales). Sample B participants were, however, rated as 'typical' in Social skills by parent report, suggesting a lack of overall negative parental ratings, and more importantly, a area of underlying strength which may be useful to incorporate in early intervention efforts.

In summary, sample B presented as a more developmentally delayed group of children born preterm with histories of increased BPD, days on oxygen, and greater apparent difficulty completing routine developmental follow-up. Pervasive adaptive difficulties suggested by this

study cohort are concerning given a downward trend in adaptive behaviour over time has been reported for young preterm children (DeBattista et al., 2015), with the widening of the attainment gap interfering with the child's availability for learning, social engagement, and developing self-concept. As such, strengthening opportunities to develop early adaptive skills across home, school and community settings to foster personal and social sufficiency may be one pathway to enhancing early SR and longer-term mental health in this particularly vulnerable population (Sparrow et al., 2005).

Clinical Implications

Both practical and clinical suggestions pertaining to the management of young children born preterm and their families emerge from findings in this exploratory study. This study is positioned within a crucial developmental window (Arpi & Ferrari, 2013), as the preschool years are critical for identification of SR concerns, given SR skills support later school readiness and social and academic learning success (Baron et. al., 2011; Johnson et al., 2011; Neuenschwander, et al., 2012). Further, the presence of even subtle preschool behavioural concerns and atypicalities may contribute to later psychiatric symptomatology (Burnett, Anderson, Cheong, Doyle, Davey, & Wood, 2011), increasingly evident in school age and adolescent periods (Pugliese et al., 2013). Findings of significant 'On-Track" deficits spotlight the importance of preventative interventions, extended assessment and follow-up services, and timely access to supports for vulnerable preterm children and families. Child and family-centered care is needed to support broad determinants of health in this increasing population, with current study findings demonstrating the negative impact of prematurity on cognition and language at 2 and 4 years of age, and on SR and EF prior to school entry.

Prevention. Premature birth is associated with multiple complex and poorly understood, but interrelated, biological, psychological, and social factors that appear to be expressed in the

common pathway of preterm birth (Behrman et al., 2007). Prevention of preterm birth remains the principal means of reducing mortality and morbidity, requiring improvements in preterm risk assessment, foetal health promotion, and neonatal medical intervention planning (Baron et al., 2010). Once preterm birth occurs however, new considerations emerge.

Both pre- and peri-natal medical problems disrupt early cortical development and brain connectivity (Baron et al., 2010; Back, 2017), resulting in white matter abnormalities that constrain subsequent development (Clarke et al., 2008). Current study findings identified BPD, the presence of brain injury (IVH/PVL), and longer stays in the NICU as contributing to future adaptive, developmental, and social communicative risk. The findings of diverse but significant neonatal issues predicting important outcomes is consistent with observations from the Canadian Neonatal Follow-Up Network suggesting biomedical approaches that support premature lung and brain development not only to enhance survival rates, but potentially reduce later neurodevelopmental impairments (Synnes et al., 2017). In particular, early identification and management of cerebral circulation and auto-regulation problems in the NICU reduces neural damage, enhances plasticity, and enables the immature brain to better reorganize (Back et al., 2007).

Extended Follow-up Services. Enhanced neuro-protection for children following preterm birth may be facilitated by thorough, timely, and responsive monitoring, assessment, and provision of services within everyday home and community contexts (Msall, 2009). A critical component of this is mapping broader neurodevelopmental trajectories through comprehensive assessment and surveillance in children born preterm, hugely beneficial for not only identification of strengths and concerns, but also central to developing strategies for future remedial, therapeutic, and educational service delivery.

Assessment. Study findings support recommendations that broad neuropsychological domains (e.g. adaptive skills, attention, memory, language, EF) be assessed longitudinally as part of routine

preterm follow-up (Pugliese et al., 2013). This is clinically important given the diverse, though at times subtle, impairments identified predict important outcomes. Further, findings suggest extending surveillance to include adaptive components beginning in the toddler years and behavioural domains in the later preschool years may facilitate identification of specific, but critical intervention targets to optimize SR. Early functional limitations may not self-correct (DeBattista, 2013) and are associated with poorer long-term educational, social, and vocational outcomes (Hille, Weisglas-Kuperus, Van Goudoever, Jacobusse, Ens-Dokkum, De Groot et al., 2007; Taylor, Klein, Drotar, Schluchter, & Hack, 2006), suggesting adding broad indicators of adaptive risk to routine developmental surveillance, as done in the current study, is important to elucidate future real life outcomes.

Developmental surveillance, which produced the data for this study, included ongoing clinical monitoring of development, identification of risk factors, and elicitation of parental concerns. Reliance on standardized tools to screen for developmental concerns is deemed a cost-effective and acceptable standard of clinical care (Canadian Task Force on Preventative Health Care, 2016). However, the diagnostic accuracy of such is limited as screening tools are designed to catch even subtle impairments, which may lead to a high proportion of false positives. Those with concerning screening scores are typically referred for more detailed diagnostic assessment recognizing the goals of developmental surveillance.

Research suggests that the use of parent questionnaires alone may be sufficient for behavioural screening purposes prior to school entry (Aarnoudse-Moens et al., 2009), which is critical given evidence that early behavioural problems predict later problem behaviours (Arpi & Ferrari, 2013). Despite this, current study findings support the use of parent screening questionnaires to assess the 'On Track' (adaptive, developmental, 'cool' EF) component of SR, but less so for 'In Sync' (behavioural and 'hot' EF) concerns. This is consistent with research indicating that 'cool' EF

matures ahead of 'hot' EF (Zelaso & Cunningham, 2007), with potential parent report measurement difficulties for the latter noted in this age range (McCann et al., 2014). Consequently, measurement for 'In Sync' components may be more informative if delayed until after Kindergarten entry when using parent reports, repeated after that time, or with additional age appropriate performance measurement strategies added.

Given findings of select 'cool' but not 'hot' EDF when using the BRIEF-p, in contrast to the wider range of previously documented EF impairments in premature populations, incorporation of a standardized preschool assessment EF battery that includes collateral (screening) reports and discrete standardized 'hot' and 'cool' EF performance testing would provide corroboratory information helpful to interpreting parent scores and predicting outcome. Further, given the range of functional impairments demonstrated, study findings support inclusion of toddler and preschool adaptive reviews, which are typically neglected in follow-up but useful for intervention planning (Oakland & Daley, 2013). Incorporating adaptive reviews as part of routine developmental surveillance may elucidate the impact of prematurity on foundation skills for day-to-day function and clarify how particular difficulties may exacerbate familial burden of care, which is important information for family intervention planning.

Current study findings indicating impairments in areas not previously documented support the use of individual scale scores, not just composite scores, to more clearly document specific patterns of strength and concern in preterm populations prior to school placement (Garon, Piccinin, & Smith, 2015). Use of scale scores also facilitates more precise intervention planning, recognizing composite or index scores may hide the variance for specific impairments. For example, consideration of BRIEF-p subscale scores in the current study suggests that EDF (using a composite score) is not a pervasive concern, but subscale findings reflect clinical impairments in specific EF components (e.g. metacognition and inhibition) for current study participants. It is

then imperative that scaled scores be highly reliable and valid, with their relationship to future functioning examined in future research. Further the use of more than one scale to measure a construct of interest may increase reliability and confidence in findings.

Follow-up. Systematic, vigilant, multidimensional and sequential developmental surveillance combined with ready access to programs emphasizing everyday routines and activities is recommended for children born preterm (Bauer & Msall, 2010). Current findings suggest more complex medical concerns and significantly poorer 2-year-old outcomes for participants whose parents did not engage in completing the follow-up review (sample B) than for those who did. This suggests barriers to participating that require further evaluation. While it is not possible to evaluate the reasons that sample B did not complete, common barriers to participation include a more remote geographic location, lower socio-economic status, or poorer parental coping (discussed below). Study findings also suggest that families with more medically vulnerable children, for example those living with the sequale of more significant neonatal BPD, may be more difficult to engage in follow-up and research. If this is the case, access to ongoing monitoring, intervention, and parental support may be in turn be restricted, highlighting the importance of targeting specific families at birth for early ongoing monitoring.

Targeting two-year-olds born preterm has been proposed as a viable benchmark for more optimally supporting these children prior to kindergarten entry (Class et al., 2011) and may hold potential to address risk in families with children who had more severe and complex medical histories. At this age, measures such as the BSID-III, which include the option of caregiver assessment of adaptive and social-emotional status, may be useful, with repeated monitoring recommended to clarify potentially atypical (vs. delayed) preterm developmental trajectories. In addition to identifying early markers of adaptive and social emotional risk, continued monitoring

may capture families commonly lost to attrition and identify those requiring more intensive or focal supports through earlier and more frequent points of contact.

Given the heterogeneity of preschool SR outcomes evident in the current study, results point to the importance of extending preterm follow-up past 2 years of age. Further, the potential for 'In Sync' difficulties to escalate and 'On-Track' gaps to widen over time suggests that current provincial health surveillance practices (which typically stop at age 2) could be improved if extended to older and more difficult to reach populations. Within Manitoba, specific economic, geographic, and cultural barriers may limit access to the recommended 6 month and 2 year developmental follow-ups for NICU survivors. Since children identified with significant delays at these visits are referred to provincial outreach early intervention services and community therapy supports (Physical, Occupational, and Speech Language Therapy, Child Development), those who may be more difficult to engage are clearly at risk of being missed, regardless of the specific reasons. Further, lengthy wait lists of up to 2 years in Manitoba may be particularly problematic for northern, remote, and difficult to engage families, limiting opportunities to support key developmental pathways early in life. Moreover, children born preterm who live on a reserve have been typically and particularly restricted in access to early assessment and intervention supports (Blackstock, 2011). Consequently, clinicians, policy makers, and researchers should consider these challenges as they develop approaches to reduce the impact of such barriers on both surveillance and intervention practices.

Study findings suggest preterm infants who demonstrate only mild-to-moderate delays at 2-year visits, but who also have histories of significant medical concerns (e.g. born EP, demonstrate significant brain injury, BPD, or long NICU stays), and/or adverse social and economic risk (Baron et al., 2010; DeBattista et al., 2015) should be prioritized for ongoing assessment and early supports. Extending preterm developmental surveillance until at least school entry and ideally up

to 9 years of age is indicated given more subtle behavioural and learning issues emerge over time. Such regular re-assessment through the school age years can verify progress and early intervention targets and benefits (Sansavini et al., 2011).

Supporting Vulnerable Families. Although the current study highlighted the outcome of NICU survivors born prematurely, children develop within a family context, and thus consideration of this environment is essential for improved outcomes. Supporting families of preterm children begins within the NICU, as the NICU experience itself impacts not only the infant, but also family members as they attempt to cope with the stress of having their newborn require intensive care. High levels of parental anxiety, depression, anger, guilt and stress (including post-traumatic stress disorder) emerging within the NICU (Treyvaud et al., 2014) may persist to influence parental interactions with their child and others, and potentially impede later engagement in follow-up and therapy (Iono et al., 2016) even through the school years (Drotar et al., 2006). This may also impact childhood SR, which is facilitated by sensitive, responsive parenting (Clark et al., 2008; Poehlman et al., 2011).

Given parents of preterm infants may go through repetitive grieving when their child does not meet hopes and expectations common to their peers and siblings (Barnett, Clements, Kaplan-Estrin, & Fialka, 2003) and since the presence of parental mental health symptoms confers particular familial risk beyond the severity of the child's neurodevelopmental deficits, with maternal well-being in particular linked to later behavioural problems in preterm children (Delobel-Ayoub et al., 2009), monitoring parental mental health until the child is at least school age is recommended (Drotar et al., 2016). Parental emotional recovery in general relies in part upon updating, rebuilding, and modifying the hopes and expectations held prior to their child's traumatic birth with the realities of their child's actual prognosis (Barnet et al., 2003). One mechanism for this is provision of family-centered care addressing both parental (e.g. grieving,

coping, and resiliency) and child (e.g. sensitive responding to the infant's cues) mental health, which augments traditional approaches that tend to emphasize the child's achievement of developmental milestones.

Encouraging sensitive, responsive parenting improves cognitive, motor, and behavioural outcomes[21] in preterm infants over the longer term (Flierman, et al., 2015; Spittle, et al., 2012; Van Wassenaer-Leemhuis et al., 2016), including benefits to reciprocal social interactions, sustained attention, language, and the later emergence of strategic and executive behaviours (Ford et al., 2011). By promoting the parent's cognitive, emotional, and behavioural adaptation to their child's condition, parental-child attachment and family well-being is enhanced, also supporting later SR capacities (Clark et al., 2008; Hughes, 2011). Given that current study findings suggest many SR skills are non-optimal in preschoolers born preterm, family-centered care which emphasizes responsive caregiving may provide important opportunities that support access to both future clinical intervention and outcomes research with this population.

A continuum of care: Despite initial parental stress, time in NICU offers important early opportunities to compensate for the "extremely atypical constraints" (e.g. neonatal immaturity, medical complications, neurological damages/alterations, environmental and social factors) that characterize preterm birth (Sansavini et al., 2011. p 110) by providing early opportunities to empower parents in their engagement and support of their infant. Evidence-based research demonstrates individualized family-focused developmental care as described facilitates both patient- and family outcomes. It enhances the premature infant's neurological, physiological, and regulatory capacities, promoting more optimal growth and development even through simple

[21] Effect sizes (after correction for baseline variables) were small for internalizing and competence behaviour, receptive language, and problem solving; medium for cognitive development and parent-child interaction; and large for externalizing and dysregulation behaviour and motor development.

practices such as *Kangaroo Care* (Als et al., 2004). Family-centered care that includes daily educational sessions, structured and supportive opportunities for parents to care for their infants directly for at least 8 hours per day within the NICU, and enables parents to participate in medical rounds, has been demonstrated to increase parental problem solving strategies, better emotionally prepare caregivers for the transition from the NICU to home, and enable parents to better recognize their own personal strengths (Bracht, O'Leary, Lee, & O'Brien, 2013). Promoting sensitive responsiveness of the preterm parent beginning within the NICU enhances infant resiliency (Spittle et al., 2012), which is particularly important given the behavioural cues of preterm infants are more difficult to read and often related to and confounded by medical risk factors. As such, specifically providing this practice may potentially support longer-term emotional and behavioural regulation.

Family-centered care must not stop at discharge from the NICU, but rather continue to build on early learning once the infant is home (Van Wassenaer-Leemhuis et al., 2016). Preventive early intervention programmes focusing on sensitive and responsive parenting while supporting infant development must be initiated within the first 12 months of life, given that this provides opportunities to have the greatest impact on developmental outcomes in preterm infants (Guralnick, 2012). Further, extending individualized family-focused care following hospital discharge has been demonstrated to accelerate brain development in the first year of life (Als et al., 2004), attentional regulation during toddlerhood, and broader SR capacity in the preschool years (Arpi & Ferrari, 2013; Hughes & Ensor, 2008; Samerhoff, 2009).

As the premature infant grows, provision of frequent home visits, multidisciplinary professional support, and ongoing parent training (Ford et al., 2011), including interpreting behaviours and concerns, supports SR development through the preschool years (Hummer, Lehner, & Pruckner, 2014). Further, intervention models that consider parental motivation and provide longer-term maternal scaffolding techniques (Guare, 2014) better support early child mental health

(Hughes & Ensor, 2009) and EF capacities (Moriguchi, 2014). Providing parents with ongoing emotional support, particularly for those who are ambivalent about intervention, follow-up, or medical services, or who live with more challenging children, may in turn enhance participation in therapy and reduce attrition.

Supporting parents beyond the NICU is particularly important when living in chaotic, traumatic, or stressful environments (Daelmans et al., 2015; Sheridan & McLaughlin, 2016). To provide an appropriately stimulating and responsive early home environment requires not only educational, practical, and emotional supports for parents of NICU graduates, but also fiscal support, which needs to be prioritized for premature children living in social disadvantage (Bauer & Msall, 2010). To provide a continuum of care however, requires policy development that addresses barriers related to access and continuity of care. It requires identification of families at particular SES risk, given research supporting the benefits of addressing the effect of impoverished social environments in children born preterm (Patrianakos-Hoobler et al., 2009).

In addition to ongoing support programs, clinicians and policy makers need to develop strategies to engage 'reluctant' families rather than broadly adopt current 'readiness to change' paradigms. Such paradigms equate attendance at medical appointments with readiness to benefit from the assistance provided, which may doubly handicap more severely involved or challenged families who have difficulty attending appointments, are deemed 'not interested' in engaging, and are then discharged and lost to attrition despite clear need for supports. Compounding this concern are observations that premature populations by history, tend not to access early intervention and resources as consistently as those in families with more severely and physically impaired children (Roberts et al., 2008). This suggests multiple barriers to premature child and family participation in clinical treatment and in outcome studies that merit future research for clinical and policy applications.

Supporting vulnerable children. Many studies verify the merits of early intervention in improving preterm children's developmental, cognitive, behaviour and social skills (Nordhov et al., 2012; Spillet et al., 2009), particularly when customized to the child's family, social, and learning needs (Baron et al., 2010). Further, randomized controlled trials demonstrate behavioural and social skills of children born prematurely can be improved through specific interventions directed towards families (Arpi & Ferrari, 2013). Significant developmental and adaptive delays evident in sample B introduced clinical practice concerns, given the increased likelihood of their being eligible for and potentially receiving early intervention services than sample A. Sample B's greater early chronic lung disease (BPD) may compound individual and family challenges, in turn compromising access to and ability to benefit from early traditional therapies and the social, practical, and learning opportunities provided at home and/or school (e.g. participating in recess, small group play). This contributes to poorer preschool adaptive outcomes. However the proportion of sample B that actually accessed early intervention prior to their school readiness review in this study, or the frequency, nature, or duration of therapies actually completed, is not known and this raises important questions for future research.

Given the findings of diverse and significant impairments in previously undocumented areas, lowering therapy and early intervention referral thresholds [presently set at demonstrating a cognitive or language score ≤ - 2 SD. (e.g., ≤ 70), to ≤ -1 or ≤ -1.5 SD (e.g., <85)] when early indicators of risk are present may facilitate greater access to care and enhance longer-term outcomes for preterm children (Battista et al., 2015). Early referral enabled by lower thresholds would facilitate delivery of broader preventative (vs. later remedial) interventions for premature populations in this province, which may be particularly important for children with a history of BPD, brain injury, and longer NICU stays.

In addition to family focused programs, childhood EF, social, and behavioural curricula are numerous (Baron & Rey-Casserly, 2010; Blair, 2016; Diamond, 2012; Ford et al., 2011) and share some commonalities (Otero, Barker, & Naglieri, 2014). For example, interventions including follow-along programs and provision of language rich, active, structured play (Blair, 2016; Shaheen, 2014), computer-based training, (Schwartz, 2014) and guided educational opportunities involving children and their caregivers (Ford et al., 2011) support SR and EF development and should be considered in efforts to facilitate optimal outcomes for children born too early. However, even informal interventions such as increasing the amount of time spent in a daycare or classroom settings, music instruction, aerobic or physical exercise, and engagement in mindfulness or yoga practices can enhance EF and SR in preschoolers (Diamond, 2013; Diamond, 2016; Otero et al., 2014) and hold promise for improved outcomes. Further, computerized cognitive training programs support development of attention and WM, provided longer training periods and rotating tasks are presented for young participants (Wass, 2015) may be helpful for clinicians addressing the metacognitive needs of EP/VP children. Future evaluations of these multimodal interventions with young children born preterm are needed to determine if potential benefits extend to this particular population, despite early life disadvantages.

Limitations

Study conclusions are constrained by the restricted time- and age-span, the small sample size, the use of a retrospective, convenience clinical sample, the lack of a term-born control group, and developmental heterogeneity. While the dates of data collection ranged from 2003-2007, the study cohort remains representative of today's premature populations, recognizing only modest reductions in several morbidities were observed between 1993-2012 while the incidence of BPD concomitantly increased marginally (Stoll, Hansen, Bell, et al., 2015). The use of postnatal steroids decreased over this period, but did not impact study cohorts as those with more significant

Cerebral Palsy (who are most likely to be prescribed steroids) were excluded in the current research.

The small number of participants and the high number of comparisons in the current study introduced statistical limitations, which warrant caution for interpretation. Sample size limitations are of importance recognizing that Type I error is inversely proportional to sample size. To detect a smaller difference and clarify scores approaching significance, a sample of larger size is recommended, recognizing this was an exploratory study. Further, when conducting factor analysis, the minimum number of participants necessary to obtain reliable factor solutions under various conditions has been debated resulting in many 'rules of thumb'. Zapnas and Zeller (2012) noted that a sample size of at least 50 and not more than 100 subjects is adequate in research to evaluate the psychometric properties of measures of social constructs when using factor analysis, cautioning that the common '10 respondents per item' advice builds a sample size disincentive into clinical research design. A sample size of 50, though not large for psychometric samples, is considered appropriate for factor analysis, providing participants are carefully screened (Lobata et al., 2012). Consequently, the current study's sample A of 60 screened participants is acceptable for factor analysis, particularly given the exploratory and clinical nature of the design.

Given the data were retrospective, the researcher had little control over sampling procedures, how constructs were measured, and the use of age correction past 24 months. Further, gaps in the data limited analysis and interpretation. More specifically, it is known that school readiness outcomes in children born preterm may be affected by additional variables not captured in this study including nutritional, developmental, and cultural life experiences (Msall, 2014; Patrianakos-Hobbler et al., 2016). For example, social advantages strongly predict gains in cognitive scores across the preschool years (Manley et al., 2015), with general intelligence in turn influencing expression of 'cool' (metacognitive) EF functions (Ardila, 2013). As such, lower socioeconomic

status adds a double jeopardy relating to kindergarten readiness in premature populations (Bauer & Msall, 2010). Likewise, data pertaining to maternal mental health, parental level of education, ethnicity, early intervention services accessed, and reasons for declining follow-up or failing to complete assessments was unavailable, though these may have influenced outcome and should be considered in future research. For example, differences in item performance may, in part, be due to differences between cultural (race/ethnicity) norms at home (DiStefano et al., 2017). More specifically, parents of Caucasian children may be less likely to report problematic behavior than parents of Hispanic or Afro-American children, suggesting the merits of developing culturally appropriate norms for scoring and/or interpretations in future research (DiStefano et al., 2017).

In terms of measurement concerns, SR outcomes in this study were heavily derived from parent report as opposed to performance-based measures, introducing both strengths and limitations. For example, using only parent reports to determine 4-year SR outcomes may introduce common method error (Podsakoff, MacKenzie, Lee & Podsakoff, 2003), thereby introducing a possible confound to the type of information provided. Further, parental completion rates and interpretation of individual test items may be influenced by differences in literacy levels between respondents, individual responder bias, or higher rates of parental stress or mental health problems following preterm birth (Spittle & Treyvaud, 2016), arising from observations that parents share the NICU experience with their child (McCann et al., 2014). However, psychometrically sound, parent report measures provide validity measures that have been standardized to include this. This data was not available in the current study but would have provided more evidence of findings (Hintz, 2016). and is recommended in in future work

Further, using additional measures to explore different aspects of EF and behaviour may have been helpful to provide sources of evidence to validate findings and add more depth to this study. For example, use of collateral reports (e.g., teacher or daycare provider reports), including

naturalistic observations of behaviour and function, and preschool performance measures of 'hot' and 'cool' EF could address concerns related to parent ratings and may provide a more comprehensive picture of early SR for future research. Moreover, performance-based measures could be included to provide a more realistic assessment of 'hot' EF in this population, particularly given some problem behaviours are setting-specific and a child may behave differently at home, school, or during a follow-up visit.

The question of when to stop age correction in outcome studies of premature infants is noted. This has been recommended for outcome studies of young children born prematurely (AAP, 2002) and is common in language, cognition, and academic attainment research, but is less common for neuropsychological or adaptive function assessments (Aylward, 2009; Iono et al., 2016; Wilson-Ching et al., 2014). Despite common use of age correction for some areas, a high level of variability is evident in contemporary research, particularly with regards to cessation of age corrections, which range widely between 18 months to 8 years (Cassiano, et al., 2016). While age correction may result in higher developmental test scores and lower prevalence of developmental delay, this practice may underestimate risk and produce missed opportunities for early intervention. For example, if preterm children present with 'at-risk' instead of 'clinically significant' scores they may become ineligible for services (Parkeh et al., 2016). Consequently, clinicians and researchers would benefit from careful consideration of the implications of using age-corrected scores

Current study findings that preschoolers born preterm do not "catch-up" to same aged peers by age 4, particularly across adaptive domains, endorses use of age correction practices at least to school entry. However, age correction for preschool outcomes was not possible in the current study given inaccessibility of original test records required for recalculation of scores. As such, it is recognized that the current study's exploratory approach and used of 4-year scores derived using

chronological age calculations may overestimate risk across early learning, cognitive and language scores (Iono et al., 2016), though not in other domains (Cattani et al., 2010; Devescovi & Capobianco, 2013). Future longitudinal research directly comparing age corrected to chronological age scores would contribute to ongoing discussion of when to stop age adjustment and may rule out the potential for a small but potentially important bias against those born preterm (Wilson-Ching et al., 2014). This may enhance interpretation of potential patterns of change and better distinguish developmental impairments from delays in this population.

In addition to these considerations, analysis methods in the current study also introduced potential limitations. Given the number of variables included in this exploratory study, Bonferonni corrections were applied to decrease Type I errors (false positives), which conversely increases the chance for Type-II errors (false negatives). As such, results may significantly underestimate the degree of impairment. Despite this risk for underestimation of impairments, moderate to large effect sizes were found across multiple outcomes. The high number of comparisons made was not ideal, however given gaps in data and lack of similar research, findings were considered exploratory. As such, results should be viewed with caution, understanding the goal of the large number of comparisons was to distil global composite scores into a more fine tuned analysis of which specific areas of performance components that may be a strength or a concern for participants. This not only informs future research, but also more clearly spotlights potential areas of early intervention that may benefit children born preterm. Finally, generalizing findings to the larger population is limited by the small sample size, with early predictors of SR outcome identified for the developmentally stronger of the two study samples. Despite missing data in Sample B, this suggests subgroups may be important to consider in terms of impairments.

In spite of these limitations, potentially important information about preterms born in Manitoba emerged from analysis of the available exploratory data that informs future research,

clinical practice, and policy. A particular strength of the current study was the concurrent use of three well-validated preschool measures, which then combined to produce theoretically and clinically relevant factors used for further analysis. As such, this study may provide a valuable starting point for further study given its key findings pertaining to the presence of specific SR deficits in preterm preschoolers, the use of perinatal variables, chronological age, and early developmental scores to predict select preschool outcomes, and evidence of the clinical utility of factor analysis.

Future Research: In addition to the previously mentioned suggestions to address limitations, future research should explore sampling issues (e.g., larger sample size, narrower age range) and broader predictor variables (e.g., medical, parental, environmental). In addition, incorporation of prospective data, local term-born controls, and preschool performance and teacher based SR measures is needed to validate findings and better interpret the lack of early predictors found for Factors 2 (EF), 3 (Flexibility/ Adaptability) and 4 (Externalizing). Recognizing site variations have been linked to differing developmental outcomes in very preterm Canadian cohorts, with Manitoba at particular risk, (Synnes, Luu, Moddemann, Church, Lee, Vincer et al., 2017), future research could aim to clarify varying individual NICU protocols and hospital-specific medical complication rates (Baron & Rey-Casserly, 2010).

Given that parent and performance measures suggest possible brain based impairments, future studies could strengthen this with the inclusion of more detailed brain imaging studies, such as MRI. Inclusion of more advanced imaging techniques would better map the spectrum of brain injury common to this population. For example, Diffusion Tensor Imaging and cortical surface area and cerebral volumetric measures provide better surrogate biomarkers of neuromotor and cognitive impairment (Limperopoulos et al., 2007), are more sensitive to white matter microstructural perturbations, and therefore may be better predictors of SR related outcomes than

global brain injury (Adams et al., 2015), especially if captured by cranial ultrasound, as in the current study. This preferred technology however, may not be widely available or interpretable in follow-up or clinical settings.

In addition, future studies should explore reasons for the divergent trajectories evident between those who complete and those who fail to complete assessments. Comparisons as to the nature, duration, and frequency of early intervention services actually utilized by each group prior to the school readiness review would be informative. In addition following the study cohort through the early school years would clarify if elevated rates of academic difficulties, reported in more than 50% of children born EP (Johnson et al., 2009) occur in this study's participants and are linked to 2-year-old cognitive or language difficulties.

Equivocal results pertaining to EF are not unusual in existing literature (Diamond, 2013; Sansavini et al., 2011; van de Weijer-Bergsma et al., 2008), yet also point to the need for further investigation. Incorporating multi-method assessment is essential to better conceptualization of a child's EF. For example, examining the associations between parent reports (BRIEF-p), direct EF laboratory measures, and objective observational measures of EF in ecologically valid contexts has been demonstrated to clarify patterns of early EDF (Garon et al., 2015) and is recommended for future research. This is particularly needed for preterm populations to better capture emergent 'hot' EF behaviours and concerns, given that tests more precisely assess cognitive control, whereas behaviour ratings assess these skills under less structured conditions to better evaluate the child's ability to meet everyday demands for self-regulation of behaviour and emotions (Taylor & Clark, 2016). Finally, the association between preschool adaptive function and parent reported EF should be further explored, given associations between EDF and poorer adaptive and behavioural outcomes reported in older preterm children (Loe, Chatva, & Alducin, 2015). Iincluding

assessment of every day behaviours, such as during mealtime (Anderson, McNamara, Andridge, & Kleim, 2015) may be particularly informative.

In contrast to previous work identifying poorer executive control in school aged boys when compared to girls (Else-Quest et al., 2006; Urben, Van Hanswijck De Jonge, Barisnikov, Pizzo, Monnier, Lazeyras, Borradori Tolsa, et al., 2015; Woodward et al., 2011) and poorer neurodevelopmental outcomes generally in preterm boys than girls (Johnson et al., 2009; Synnes et al., 2017), current results did not identify sex differences. Sex-based norms were used to calculate preschool SR scores, and the proportions of male: female were not significantly different, suggesting issues related to sampling. Given the potential of sex-based norms to reduce the ability to detect differences common to one sex, future research would benefit from comparing both general and sex-based norms using a larger sample and local controls.

Despite broad indicators of the benefits of early intervention approaches and generally supportive and positive findings, considerably more research is needed before it is possible to identify specific evidence-based practices for promoting discrete components of SR or EF with confidence in this population (Ricco & Gomes, 2013). Further, the need to identify what compromises and supports successful transition to school across family, community and school settings for preterm children at risk requires further elucidation (Bauer & Msall, 2010), given the large range of under-reported, potentially impairing SR difficulties exhibited in this study.

Summary

Regulation of emotion, cognition, and action is a major achievement of early childhood and an important marker of academic, adaptive, and psychosocial risk and resilience. SR plays a critical role across development given it supports autonomous and purposeful action in the world (Blair, 2016), with early assessment predicting a broad range of important long-term outcomes (Eisenberg et al., 2004). The current study implemented a novel SR framework identifying neonatal and early

developmental variables that may predict developmental, adaptive, and behavioural outcomes in preschoolers born preterm. Contrary to widely held beliefs, these results suggest that children born preterm do not catch up developmentally by 2 or by 4 years of age. Further, perinatal variables (brain injury, BPD, days on oxygen, days in the NICU, BW) and chronological age predicted adaptive, developmental, and/or select behavioural (internalizing, social communication) outcomes, though not EF or externalizing problems at age 4. Identifying early predictors of strengths and weaknesses in preterm preschoolers may enhance access to interventions and support broad determinants of health. This is critical to promoting quality of life and more positive long-term outcomes for both the child at risk and his/her family.

Despite methodological limitations, this exploratory work suggests the potential of retrospective clinically based research to capture real life outcomes and to guide future research. Study conclusions echo those of Sansavini et al., (2011, p. 110) which "call attention to the wide heterogeneity and the different individual profiles within the preterm population depending on the interaction among the degree of neonatal immaturity, medical complications and neurological damages, proximal and distal environmental and social factors, and the impact of the time of their occurrence". These factors, in combination, support or hinder the development of children born preterm, in turn influencing their and their family's future quality of life. Adopting a broader 'In Sync' (behavioural adjustment) and 'On-Track' (adaptive/developmental attainment) viewing lens during follow-up visits and early intervention programming may reframe challenging or puzzling behaviours, shift caregivers interpretations of a child's strengths and difficulties, and enhance more positive life outcome.

REFERENCES

Aarnoudse-Moens, C. S., Smidts, D. P., Oosterlaan, J., Duivenvoorden, H. J., & Weisglas-Kuperus, N. (2009) . Executive function in very preterm children at early school age. *Journal of Abnormal Child Psychology*, *37*(7), 981-993.

Acton, B. V., Biggs, W. S., Creighton, D. E., Penner, K. A., Switzer, H. N., Thomas, J. H. P., . . . Robertson, C. M. (2011) . Overestimating neurodevelopment using the Bayley-III after early complex cardiac surgery. *Pediatrics*, *128*(4), e794-e800.

Adams, J. N., Feldman, H. M., Huffman, L. C., & Loe, I. M. (2015). Sensory processing in preterm preschoolers and its association with executive function. *Early human development*, *91*(3), 227-233.

Akshoomoff, N. (2006) . Use of the Mullen Scales of Early Learning for the assessment of young children with autism spectrum disorders. *Child Neuropsychology*, *12*(4-5), 269-277.

Alarcón-Rubio, D., Sánchez-Medina, J. A., & Prieto-García, J. R. (2014) . Executive function and verbal self-regulation in childhood: Developmental linkages between partially internalized private speech and cognitive flexibility. *Early Childhood Research Quarterly*, *29*(2), 95-105.

Alduncin, N., Huffman, L. C., Feldman, H. M., & Loe, I. M. (2014) . Executive function is associated with social competence in preschool-aged children born preterm or full term. *Early Human Development, 90*(6), 299-306.

Alkon, A. (2013). Developmental Surveillance and Screening. *Pediatric Physical Examination: An Illustrated Handbook*, 24 -35.

Allen, M. C. (2008) . Neurodevelopmental outcomes of preterm infants. *Current Opinion In Neurology, 21*(2), 123-128.

Als, H., Duffy, F.H., McAnulty, G.B., Rivkin, M.J., Vajapeyam, S., Mulkern, R.V., . . . Eichenwald, E.C. (2004). Early experience alters brain function and structure. *Pediatric*s, *113*, 846–857.

Alton, G. Y., Taghados, S., Joffe, A. R., Robertson, C. M., & Dinu, I. (2015) . Prediction of preschool functional abilities after early complex cardiac surgery. *Cardiology in the Young*, *25*(4), 655-662.

Alwinesh, M. T. J., Joseph, R. B. J., Daniel, A., Abel, J. S., Shankar, S. R., Mammen, P., . . . Russell, P. S. S. (2012). Psychometrics and utility of Psycho-Educational Profile–Revised as a developmental quotient measure among children with the dual disability of intellectual disability and autism. *Journal of Intellectual Disabilities 16*(3), 193-203.

Anderson, P. (2002) . Assessment and development of executive function (EF) during childhood. *Child Neuropsychology*, *8*(2), 71-82.

Anderson, P. J. (2014, April). Neuropsychological outcomes of children born very preterm. In *Seminars in Fetal and Neonatal Medicine* (Vol. 19, No. 2, pp. 90-96). WB Saunders.

Anderson, V., Anderson, P. J., Jacobs, R., & Smith, M. S. (2008). Development and assessment of executive function: From preschool to adolescence. *Executive functions and the frontal lobes: A lifespan perspective*, 123-154.

Anderson, P. J., De Luca, C. R., Hutchinson, E., Spencer-Smith, M. M., Roberts, G., Doyle, L. W., & Victorian Infant Collaborative Study Group*. (2011). Attention problems in a representative sample of extremely preterm/extremely low birth weight children. *Developmental neuropsychology*, *36*(1), 57-73.

Anderson, P. J., & Dewey, D. (2011) . Introduction: the consequences of being born very early or very small. *Developmental Neuropsychology*, *36*(1), 1-4.

Anderson, P., Doyle, L. W., & Victorian Infant Collaborative Study Group. (2003). Neurobehavioral outcomes of school-age children born extremely low birth weight or very preterm in the 1990s. *JAMA*, *289*(24), 3264-3272.

Anderson, S.E., McNamara, K., Andridge, R., & Kleim, S.A. (2015). Executive function and mealtime behaviour among preschool-aged children born very preterm. *Eating Behaviors*, 19: 110-114.

Anderson, V., Jacobs, R., & Anderson, P. (Eds.) (2008) . *Executive functions and the frontal lobes- a lifespan perspective*. New York, NY: Taylor & Francis Group.

Ardila, A. (2013) . Development of metacognitive and emotional executive functions in children. *Applied Neuropsychology: Child*, *2*(2), 82-87.

Arpi, E., & Ferrari, F. (2013) . Preterm birth and behaviour problems in infants and preschool-age children: a review of the recent literature. *Developmental Medicine & Child Neurology*, *55*(9), 788-796.

Atkinson, J., & Braddick, O. (2007) . Visual and visuocognitive development in children born very prematurely. *Progress In Brain Research*, *164*, 123-149.

Avchen, R. N., Scott, K. G., & Mason, C. A. (2001) . Birth weight and school-age disabilities: a population-based study. *American Journal of Epidemiology*, *154*(10), 895-901.

Aylward, G. P. (2005) . Neurodevelopmental outcomes of infants born prematurely. *Journal of Developmental & Behavioral Pediatrics*, *26*(6), 427-440.

Back, S. A. (2006) . Perinatal white matter injury: the changing spectrum of pathology and emerging insights into pathogenetic mechanisms. *Mental Retardation And Developmental Disabilities Research Reviews*, *12*(2), 129-140.

Back, S. A. (2014) . Cerebral white and gray matter injury in newborns: new insights into pathophysiology and management. *Clinics in Perinatology, 41*(1), 1-24.

Back, S. A. (2017). White matter injury in the preterm infant: pathology and mechanisms. *Acta Neuropathologica*, 1-19.

Back, S. A. & Miller, S. P. (2014). Brain injury in premature neonates: A primary cerebral dysmaturation disorder? *Annals of Neurology*, 75, 469-486.

Back, S. A., Riddle, A., & McClure, M. M. (2007) . Maturation-dependent vulnerability of perinatal white matter in premature birth. *Stroke, 38*(2), 724-730.

Baddeley, A. (1998) . The central executive: A concept and sme misconceptions. *Journal of the International Neuropsychological Society*, *4*(5), 523-526.

Baddeley, A. D., & Hitch, G. J. (1994). Developments in the concept of working memory. *Neuropsychology*, *8*(4), 485.

Ball, G., Srinivasan, L., Aljabar, P., Counsell, S. J., Durighel, G., Hajnal, J. V., . . . Edwards, A. D. (2013) . Development of cortical microstructure in the preterm human brain. *Proceedings of the National Academy of Sciences, 110*(23), 9541-9546.

Ballabh, P. (2014). Pathogenesis and prevention of intraventricular hemorrhage. *Clinics in perinatology*, *41*(1), 47.

Barnett, D., Clements, M., Kaplan-Estrin, M., & Fialka, J. (2003). Building new dreams: Supporting parents' adaptation to their child with special needs. *Infants & Young Children*, *16*(3), 184-200.

Baron, I.S. (2017). Preschoolers: Not just young children. *Clinical Neuropsychologist, 31*(2): 301-306.

Baron, I. S., Erickson, K., Ahronovich, M., Baker, R., & Litman, F. (2011) . Neuropsychological and behavioral outcomes of extremely low birth weight at age three. *Developmental Neuropsychology, 36*(1), 5-21.

Baron, I.S., Kerns, K.A., Müller, U., Ahronovich, M.D., & Litman, F.R. (2012). Executive functions in extremely low birth weight and late-preterm preschoolers: Effects on working memory and response inhibition. Child Neuropsychology, 18(6). 586-599.

Baron, I. S., & Rey-Casserly, C. (2010) . Extremely preterm birth outcome: a review of four decades of cognitive research. *Neuropsychology Review*, *20*(4), 430-452.

Bassett, H. H., Denham, S., Wyatt, T. M., & Warren-Khot, H. K. (2012) . Refining the preschool self-regulation assessment for use in preschool classrooms. *Infant and Child Development*, *21*(6), 596-616.

Basso, O., Wilcox, A. J., & Weinberg, C. R. (2006) . Birth weight and mortality: causality or confounding? *American Journal of Epidemiology, 164*(4), 303-311.

Bauer, S. C., & Msall, M. E. (2010). Kindergarten readiness after prematurity: Integrating health, development, and behavioral functioning to optimize educational outcomes of vulnerable children. *Developmental disabilities research reviews*, *16*(4), 313-322.

Bayless, S., & Stevenson, J. (2007) . Executive functions in school-age children born very prematurely. *Early Human Development, 83*(4), 247-254.

Bayley, N. (1993) . *Bayley scales of infant development: Manual*. San Antonio, TX: The Psychological Corporation.

Bayley, N. (2006) . *Bayley scales of infant and toddler development* (3rd ed.): *Manual*. San Antonio, TX: The Psychological Corporation.

Beauchamp, M. H., & Anderson, V. (2010) . SOCIAL: an integrative framework for the development of social skills. *Psychological Bulletin*, *136*(1), 39.

Beauchamp, M. H., Thompson, D. K., Howard, K., Doyle, L. W., Egan, G. F., Inder, T. E., & Anderson, P. J. (2008) . Preterm infant hippocampal volumes correlate with later working memory deficits. *Brain*, *131*(11), 2986-2994.

Beck, D. M., Schaefer, C., Pang, K., & Carlson, S. M. (2011) . Executive function in preschool children: Test–retest reliability. *Journal of Cognition and Development*, *12*(2), 169-193.

Behrman, R. E., & Butler, A. S. (Eds.). (2007) . *Preterm birth: causes, consequences, and prevention*. Washington, DC: National Academies Press.

Benders, M. J., Kersbergen, K. J., & de Vries, L. S. (2014). Neuroimaging of white matter injury, intraventricular and cerebellar hemorrhage. *Clinics in perinatology*, *41*(1), 69-82.

Bernier, A., Carlson, S. M., & Whipple, N. (2010) . From external regulation to self-regulation: Early parenting precursors of young children's executive functioning. *Child Development*, *81*(1), 326-339.

Bernstein, J. H., & Weber, D. P. (2007) . Executive capacities from a developmental perspective. In L. Meltzer (Ed.), *Executive function in education: From theory to practice* (pp. 39-54) . New York, NY: The Guilford Press.

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child development*, *81*(6), 1641-1660.

Bhutta, A. T., Cleves, M. A., Casey, P. H., Cradock, M. M., & Anand, K. J. S. (2002) . Cognitive and behavioral outcomes of school-aged children who were born preterm: a meta-analysis. *JAMA, 288*(6), 728-737.

Bialystok, E. (2015). Bilingualism and the development of executive function: The role of attention. *Child Development Perspectives*, *9*(2), 117-121.

Bierman, K. L., Domitrovich, C. E., Nix, R. L., Gest, S. D., Welsh, J. A., Greenberg, M. T., . . . Gill, S. (2008) . Promoting academic and social-emotional school readiness: The head start REDI program. *Child Development*, *79*(6), 1802-1817.

Bishop, S. L., Guthrie, W., Coffing, M., & Lord, C. (2011) . Convergent validity of the Mullen Scales of Early Learning and the differential ability scales in children with autism spectrum disorders. *American Journal on Intellectual and Developmental Disabilities*, *116*(5), 331-343.

Blair, C. (2016). Developmental science and executive function. *Current directions in psychological science*, *25*(1), 3-7.

Blair, C., & Diamond, A. (2008) . Biological processes in prevention and intervention: The promotion of self-regulation as a means of preventing school failure. *Development and Psychopathology*, *20*(3), 899-911.

Blair, C., & Raver, C. C. (2015) . School readiness and self-regulation: A developmental psychobiological approach. *Annual Review of Psychology*, *66*, 711.

Blair, C., & Razza, R. P. (2007) . Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*(2), 647-663.

Bodrova, E., & Leong, D. J. (2007) . *Tools of the mind: The vygotskian approach to early childhood education* (2nd ed.) . Upper Saddle River, NJ: Pearson Education, Inc.

Böhm, B., Smedler, A. C., & Forssberg, H. (2004) . Impulse control, working memory and other executive functions in preterm children when starting school. *Acta Paediatrica*, *93*(10), 1363-1371.

Boyle, M. H., Miskovic, V., Van Lieshout, R., Duncan, L., Schmidt, L. A., Hoult, L., . . . Saigal, S. (2011) . Psychopathology in young adults born at extremely low birth weight. *Psychological Medicine, 41*(8), 1763-1774.

Bracht, M., O'Leary, L., Shoo, K., & O'Brien, K. (2013). Implementing family integrated care in the NICU: A parent education and support program. *Advances in Neonatal Care, 13*(2), 115-126.

Breeman, L. D., Jaekel, J., Baumann, N., Bartmann, P., & Wolke, D. (2016). Attention problems in very preterm children from childhood to adulthood: the Bavarian Longitudinal Study. *Journal of child psychology and psychiatry*, *57*(2), 132-140.

Broitman, E., Ambalavanan, N., Higgins, R. D., Vohr, B. R., Das, A., Bhaskar, B., . . . National Institute of Child Health and Human Development Neonatal Research Network. (2007) . Clinical data predict neurodevelopmental outcome better than head ultrasound in extremely low birth weight infants. *The Journal of Pediatrics*, *151*(5), 500-505.

Bronson, M. (2000) . *Self-regulation in early childhood: Nature and nurture*. New York, NY: Guilford Press.

Brown, C. J., Miller, S. P., Booth, B. G., Andrews, S., Chau, V., Poskitt, K. J., & Hamarneh, G. (2014) . Structural network analysis of brain development in young preterm neonates. *Neuroimage, 101,* 667-680.

Burman, J. T., Green, C. D., & Shanker, S. (2015) . On the meanings of self-regulation: Digital humanities in service of conceptual clarity. *Child Development*, *86*(5), 1507-1521.

Burnett, C., Anderson, P., Cheong, J., Doyle, L., Davey, C., & Wood, S. (2011) . Prevalence of psychiatric diagnoses in preterm and full-term children, adolescents and young adults: A meta-analysis. *Psychological Medicine*, *41*(12), 2463-2474.

Burns, M. K., Meikamp, J., & Suppa, C. H. (2005). Review of the adaptive behavior assessment system. In Robert A. Spies and Barbara S. Plake, (Eds). *The Sixteenth Mental Measurements Yearbook*. Buros Institute of Mental Measurement. USA.

Burns, T. G., King, T. Z., & Spencer, K. S. (2013) . Mullen scales of early learning: The utility in assessing children diagnosed with autism spectrum disorders, cerebral palsy, and epilepsy. *Applied Neuropsychology: Child*, *2*(1), 33-42.

Cacioppo, J. T. (2002) . Social neuroscience: Understanding the pieces fosters understanding the whole and vice versa. *American Psychologist*, *57*(11), 819.

Calkins, S. D., & Bell, M. A. E. (2010) . *Child development at the intersection of emotion and cognition*. Washington, DC: American Psychological Association.

Carlson, S. M. (2005) . Developmentally sensitive measures of executive function in preschool children. *Developmental Neuropsychology*, *28*(2), 595-616.

Carlson, S. M. (2009) . Social origins of executive function development. *New Directions For Child And Adolescent Development*, *2009*(123), 87-98.

Carlson, S. M., & Moses, L. J. (2001) . Individual differences in inhibitory control and children's theory of mind. *Child Development*, *72*(4), 1032-1053.

Cassiano, R., Gaspardo, C., & Linhares, M. (2016) . Prematurity, neonatal health status, and later child behavioral/emotional problems: A systematic review. *Infant Mental Health Journal*, *37*(3), 274-288.

Cassidy, A. R. (2016) . Executive function and psychosocial adjustment in healthy children and adolescents: A latent variable modelling investigation.*Child Neuropsychology*, *22*(3), 292-317.

Cattell, R. B. (1966) . The scree test for the number of factors. *Multivariate Behavioral Research*, *1*(2), 245-276.

Caughy, M. O. B., Mills, B., Owen, M. T., & Hurst, J. R. (2013) . Emergent self-regulation skills among very young ethnic minority children: A confirmatory factor model. *Journal of Experimental Child Psychology*, *116*(4), 839-855.

Cioni G, D'Acunto G, & Guzzetta A. (2011). Perinatal brain damage in children: neuroplasticity, early intervention, and molecular mechanisms of recovery. Prog Brain Res.; 189: 139–54.

Clark, C. A., Woodward, L. J., Horwood, L. J., & Moor, S. (2008) . Development of emotional and behavioral regulation in children born extremely preterm and very preterm: Biological and social influences. *Child Development*, *79*(5), 1444-1462.

Cohen, J. (1988) . Statistical power analysis. *Current Directions in Psychological Science, 1*(3), 98-101.

Cole, P.M., Martin, S.E., & Dennis, T.A. (2004). Emotion regulation as a scientific construct: Methodological challenges and directions for child development research. *Child Development*, *75*(2): 317-333.

Coll, C. G. (2005) . Predicting individual differences in attention, memory, and planning in first graders from experiences at home, child care, and school. *Developmental Psychology*, *41*(1), 99-114.

Coll, C. G. (2008) . Mothers' and fathers' support for child autonomy and early school achievement. *Developmental Psychology*, *44*, 895-907.

Constable, R. T., Ment, L. R., Vohr, B. R., Kesler, S. R., Fulbright, R. K., Lacadie, C., . . . Makuch, R. W. (2008) . Prematurely born children demonstrate white matter microstructural differences at 12 years of age, relative to term control subjects: an investigation of group and gender effects. *Pediatrics, 121*(2), 306-316.

Costantini, L., D'Ilario, J., Moddemann, D., Penner, K., & Schmidt, B. (2015) . Accuracy of Bayley scores as outcome measures in trials of neonatal therapies. *JAMA*, *169*(2), 188-189.

Counsell, S. J., Edwards, A. D., Chew, A. T., Anjari, M., Dyet, L. E., Srinivasan, L., . . . Cowan, F. M. (2008) . Specific relations between neurodevelopmental abilities and white matter microstructure in children born preterm. *Brain*, *131*(12), 3201-3208

Cramm, H.A., Krupa, T.M., Missiuna, C.A., Lysaght, R. M., & Parker, K. C. (2013a). Broadening the occupational therapy toolkit: An executive functioning lens for occupational therapy with children and youth. *American Journal of Occupational Therapy*, *67*(6), e139-e147.

Cramm, H. A., Krupa, T. M., Missiuna, C. A., Lysaght, R. M., & Parker, K. H. (2013b) . Executive functioning: A scoping review of the occupational therapy literature/Les fonctions exécutives: Une analyse de la portée de la littérature en ergothérapie. *Canadian Journal of Occupational Therapy*, *80*(3), 131-140.

Creighton, D. E., Robertson, C. M., Sauve, R. S., Moddemann, D. M., Alton, G. Y., Nettel-Aguirre, A., . . . Rebeyka, I. M. (2007) . Neurocognitive, functional, and health outcomes at 5 years of age for children after complex cardiac surgery at 6 weeks of age or younger. *Pediatrics*, *120*(3), e478-e486.

Cuevas, K., Deater-Deckard, K., Kim-Spoon, J., Wang, Z., Morasch, K. C., & Bell, M. A. (2014) . A longitudinal intergenerational analysis of executive functions during early childhood. *British Journal of Developmental Psychology*, *32*(1), 50-64.

D'Onofrio, B. M., Class, Q. A., Rickert, M. E., Larsson, H., Långström, N., & Lichtenstein, P. (2013) . Preterm birth and mortality and morbidity: a population-based quasi-experimental study. *JAMA Psychiatry*, *70*(11), 1231-1240.

Dahl, L. B., Kaaresen, P. I., Tunby, J., Handegård, B. H., Kvernmo, S., & Rønning, J. A. (2006). Emotional, behavioral, social, and academic outcomes in adolescents born with very low birth weight. *Pediatrics*, *118*(2), e449-e459.

Daelmans, B., Black, M. M., Lombardi, J., Lucas, J., Richter, L., Silver, K., . . . Dua, T. (2015) . Effective interventions and strategies for improving early child development. *BMJ, 351*. http://www.bmj.com/content/351/bmj.h4029.short

Dahan-Oliel, N., Mazer, B., Riley, P., Maltais, D., Naduea, L., & Majnemer, A., (2014) . Participation and enjoyment of leisure activities in adolescents born ≤ 29 week gestation. *Early Human Development, 90*, 307-314.

Davis, N. M., Ford, G. W., Anderson, P. J., & Doyle, L. W. (2007) . Developmental coordination disorder at 8 years of age in a regional cohort of extremely-low-birthweight or very preterm infants. *Developmental Medicine & Child Neurology, 49*(5), 325-330.

DeBattista, A. (2014) . *Factors influencing early trajectories of adaptive behavior in children born prematurely* (Doctoral dissertation) . Available from ProQuest Dissertations & Theses A&I. (1562957381) . http://uml.idm.oclc.org/login?url=http://search.proquest.com.uml.idm.oclc.org/docview/1562957381?accountid=14569. (Order No. 3630100)

DeBattista, A., Huffman, L., Alkon, A., Cooper, B., & Weiss, S. (2015) . Factors influencing trajectories of early adaptive behavior among children born prematurely. *Developmental Medicine & Child Neurology,* 57(S5), 24.

De Luca, C. R., & Leventer, R. J. (2008). Developmental trajectories of executive functions across the lifespan. (pp. 23-56) . In Anderson, V., Jacobs, R., & Anderson, P. (Eds.). *Executive functions and the frontal lobes- a lifespan perspective*.. New York, NY: Taylor & Francis Group.

Delobel-Ayoub, M., Arnaud, C., White-Koning, M., Casper, C., Pierrat, V., Garel, M., . . . Kaminski, M. (2009) . Behavioral problems and cognitive performance at 5 years of age after very preterm birth: the EPIPAGE Study. *Pediatrics*, *123*(6), 1485-1492.

Delobel-Ayoub, M., Kaminski, M., Marret, S., Burguet, A., Marchand, L., Sylvie, N., . . . Poher, M. (2006) . Behavioral outcome at 3 years of age in very preterm infants: the EPIPAGE study. *Pediatrics*, *117*(6), 1996-2005.

Denham, S. A., Bassett, H. H., Sirotkin, Y. S., Brown, C., & Morris, C. S. (2015) . "No-ooo peeking": Preschoolers' executive control, social competence, and classroom adjustment. *Journal of Research in Childhood Education*, *29*(2), 212-225.

Denham, S. A., Warren-Khot, H. K., Bassett, H. H., Wyatt, T., & Perna, A. (2012) . Factor structure of self-regulation in preschoolers: Testing models of a field-based assessment for predicting early school readiness. *Journal of Experimental Child Psychology*, *111*(3), 386-404.

Dewey, D., Creighton, D. E., Heath, J. A., Wilson, B. N., Anseeuw-Deeks, D., Crawford, S. G., . . . Sauve, R. (2011) . Assessment of developmental coordination disorder in children born with extremely low birth weights. *Developmental Neuropsychology*, *36*(1), 42-56.

Diamond, A. (2006) . The early development of executive functions. In E. Bialystok & F. I. M. Craik, *Lifespan Cognition: Mechanisms of Change* (pp. 70-95) . New York, NY: Oxford University Press.

Diamond, A. (2011) . Biological and social influences on cognitive control processes dependent on prefrontal cortex. *Progress in Brain Research*, *189*, 319.

Diamond A. (2013) . Executive functions. *Annual Review of Psychology, 64,* 135-68. http://www.annualreviews.org/doi/abs/10.1146/annurev-psych-113011-143750

Diamond, A. (2016) . Why improving and assessing executive functions early in life is critical. In J. A. Griffin, P. McCardle, & L. Freund (Eds.), *Executive function in preschool age children: Integrating measurement, neurodevelopment and translational research* (pp. 11-43) . Washington, DC: American Psychological Association.

Diamond, A., & Lee, K. (2011) . Interventions shown to aid executive function development in children 4 to 12 years old. *Science*, *333*(6045), 959-964.

Diamond, J. (2012) . *The world until yesterday: What can we learn from traditional societies?*. Toronto, ON: Penguin Group.

Dias, N. M., & Seabra, A. G. (2015) . The promotion of executive functioning in a Brazilian public school: A pilot study. *The Spanish Journal of Psychology*, *18*, E8.

DiStefano, C., Zhu, M., & Mindrila, D. (2009) . Understanding and using factor scores: Considerations for the applied researcher. *Practical Assessment, Research & Evaluation*, *14*(20), 1-11.

Ditterline, J., & Oakland, T. (2009) . Relationships between adaptive behavior and impairment. In S. Goldstein & J. A. Naglieri (Eds.), *Assessing impairment: From theory to practice* (pp. 31-48) . Salt Lake City, UT: Springer US.

D'Onofrio, B. M., Class, Q. A., Rickert, M. E., Larsson, H., Långström, N., & Lichtenstein, P. (2013) . Preterm birth and mortality and morbidity: a population-based quasi-experimental study. *JAMA Psychiatry*, *70*(11), 1231-1240.

dos Santos, E. S. L., de Kieviet, J. F., Königs, M., van Elburg, R. M., & Oosterlaan, J. (2013) . Predictive value of the Bayley scales of infant development on development of very preterm/very low birth weight children: A meta-analysis. *Early Human Development*, *89*(7), 487-496.

Dougherty, L. R., Leppert, K. A., Merwin, S. M., Smith, V. C., Bufferd, S. J., & Kushner, M. R. (2015) . Advances and directions in preschool mental health research. *Child Development Perspectives*, *9*(1), 14-19.

Downie, A. L., Frisk, V., & Jakobson, L. S. (2005). The impact of periventricular brain injury on reading and spelling abilities in the late elementary and adolescent years. *Child Neuropsychology*, *11*(6), 479-495.

Doyle, L. W., & Anderson, P. J. (2010) . Adult outcome of extremely preterm infants. *Pediatrics*, *126*(2), 342-351.

Drotar, D., Hack, M., Taylor, G., Schluchter, M., Andreias, L., Klein, N., (2006) . The impact of extremely low birth weight on the families of school-aged children. *Pediatrics, 117*(6), 2006–2013.

Drotar, D., Stancin, T., Dworkin, P., Sices, L., & Wood, S. (2008). Selecting Developmental Surveillance and Screening Tools. *Pediatrics in Review*, *29* (10) e52-e58

Dubois, J., Dehaene-Lambertz, G., Kulikova, S., Poupon, C., Hüppi, P. S., & Hertz-Pannier, L. (2014) . The early development of brain white matter: A review of imaging studies in fetuses, newborns and infants. *Neuroscience, 276*, 48-71.

Dudink, J., Kerr, J. L., Paterson, K., & Counsell, S. J. (2008) . Connecting the developing preterm brain. *Early Human Development, 84*(12), 777-782.

Dudova, I., Kasparova, M., Markova, D., Zemankova, J., Beranova, S., Urbanek, T., & Hrdlicka, M. (2014) . Screening for autism in preterm children with extremely low and very low birth weight. *Neuropsychiatric Disease and Treatment*, *10*, 277-282.

Duku, E., & Vaillancourt, T. (2014) . Validation of the BRIEF-P in a sample of Canadian preschool children. *Child Neuropsychology*, *20*(3), 358-371.

Edgin, J. O., Inder, T. E., Anderson, P. J., Hood, K. M., Clark, C. A., & Woodward, L. J. (2008) . Executive functioning in preschool children born very preterm: Relationship with early white matter pathology. *Journal of the International Neuropsychological Society, 14*(1), 90-101.

Egger, H. L., & Angold, A. (2006) . Common emotional and behavioral disorders in preschool children: Presentation, nosology, and epidemiology. *Journal of Child Psychology and Psychiatry*, *47*(3-4), 313-337.

Eisenberg, N., Spinrad, T.L., & Smith, C.L. (2004). Emotion-related regulation: Its conceptualization, relations to social functioning, and socialization. *The Regulation of Emotion,* 31: 281-311.

Eisenberg, N., Spinrad, T. L., & Eggum, N. D. (2010) . Emotion-related self-regulation and its relation to children's maladjustment. *Annual Review of Clinical Psychology*, *6*, 495.

Eisenberg, N., Valiente, C., & Eggum, N. D. (2010) . Self-regulation and school readiness. *Early Education and Development*, *21*(5), 681-698.

Else-Quest, N. M., Hyde, J. S., Goldsmith, H. H., & Van Hulle, C. A. (2006) . Gender differences in temperament: A meta-analysis. *Psychological Bulletin*, *132*(1), 33.

Epstein, I. (2011) . Reconciling evidence-based practice, evidence-informed practice, and practice-based research: The role of clinical data-mining. *Social Work, 56*, 284–287.

Epstein, I. (2015) . Building a bridge or digging a pipeline? Clinical data mining in evidence-informed knowledge building. *Research on Social Work Practice*, *25*(4), 499-506.

Eryigit-Madzwamuse, S., Strauss, V., Baumann, N., Bartmann, P., & Wolke, D. (2015) . Personality of adults who were born very preterm. *Archives of Disease in Childhood-Fetal and Neonatal Edition, 100*(6), F524-F529.

Eslinger, P. J., Flaherty-Craig, C. V., & Benton, A. L. (2004) . Developmental outcomes after early prefrontal cortex damage. *Brain and Cognition*, *55*(1), 84-103.

Espy, K. A., Fang, H., Charak, D., Minich, N., & Taylor, H. G. (2009) . Growth mixture modeling of academic achievement in children of varying birth weight risk. *Neuropsychology*, *23*(4), 460.

Espy, K. A., Kaufmann, P. M., Glisky, M. L., & McDiarmid, M. D. (2001) . New procedures to assess executive functions in preschool children*. *The Clinical Neuropsychologist 15*(1), 46-58.

Espy, K. A., Sheffield, T. D., Wiebe, S. A., Clark, C. A., & Moehr, M. J. (2011) . Executive control and dimensions of problem behaviors in preschool children. *Journal of Child Psychology and Psychiatry*, *52*(1), 33-46.

Fan, R. G., Portuguez, M. W., & Nunes, M. L. (2013). Cognition, behavior and social competence of preterm low birth weight children at school age. *Clinics*, *68*(7), 915-921.

Farmer, C., Golden, C., & Thurm, A. (2016) . Concurrent validity of the differential ability scales, with the Mullen Scales of Early Learning in young children with and without neurodevelopmental disorders. *Child Neuropsychology*, *22*(5), 556-569.

Farooqi, A., Hägglöf, B., Sedin, G., Gothefors, L., & Serenius, F. (2007). Mental health and social competencies of 10-to 12-year-old children born at 23 to 25 weeks of gestation in the 1990s: a Swedish national prospective follow-up study. *Pediatrics*, *120*(1), 118-133.

Feeney-Kettler, K. A., Kratochwill, T. R., & Kettler, R. J. (2011) . Identification of preschool children at risk for emotional and behavioral disorders: Development and validation of a universal screening system. *Journal of School Psychology*, *49*(2), 197-216.

Field, A. (2013) . *Discovering statistics using IBM SPSS statistics*. Washington, DC: Sage Publishing.

Feldman, H., Lee, E., Loe, I., Yeom, K., Grill-Spector, K., Luna, B. (2012) . White matter microstructure on diffusion tensor imaging is associated with conventional magnetic resonance imaging findings and cognitive function in adoloescents born preterm. *Developmental Medicine and Child Neurology*, *54*(9), 809-814.

Ference, J., & Curtin, S. (2015) . The ability to map differentially stressed labels to objects predicts language development at 24 months in 12‐month‐olds at high risk for autism. *Infancy*, *20*(3), 242-262.

Ferrier, D., Bassett, H., Denham, S. (2014) . Relations between executive function and emotionality in preschoolers: Exploring a transitive cognitive-emotion linkage. *Frontiers in Psychology*, *5*, 487.

Fjørtoft, T., Grunewaldt, K. H., Løhaugen, G. C. C., Mørkved, S., Skranes, J., & Evensen, K. A. I. (2015) . Adaptive behavior in 10–11 year old children born preterm with a very low birth weight (VLBW) . *European Journal of Paediatric Neurology*, *19*(2), 162-169.

Flierman, M., Koldewijn, K., Meijssen, D., van Wassenaer-Leemhuis, A., Aarnoudse-Moens, C., van Schie, P., & Jeukens-Visser, M. (2016) . Feasibility of a preventive parenting intervention for very preterm children at 18 months corrected age: A randomized pilot trial. *Journal of Pediatrics, 176*, 79-85. 10.1016/j.jpeds.2016.05.071.

Floyd, R. G., Shands, E. I., Alfonso, V. C., Phillips, J. F., Autry, B. K., Mosteller, J. A., & Irby, S. (2015) . A systematic review and psychometric evaluation of adaptive behavior scales and recommendations for practice. *Journal of Applied School Psychology*, *31*(1), 83-113.

Follmer, A., Dowsett, C. (2012) . Secondary data analysis: An important tool for addressing developmental questions. *Journal of Cognition and Development, 13*(1), 2-18.

Fransson, P., Skiöld, B., Horsch, S., Nordell, A., Blennow, M., Lagercrantz, H., & Åden, U. (2007) . Resting-state networks in the infant brain. *Proceedings of the National Academy of Sciences, 104*(39), 15531-15536.

Frisk, V., Montgomery, L., Boychyn, E., Young, R., McLachlan, D., & Neufeld, J. (2009) . Why screening Canadian preschoolers for language delays is more difficult than it should be. *Infants & Young Children*, *22*(4), 290-308.

Fuhs, M. W., Nesbitt, K. T., Farran, D. C., & Dong, N. (2014) . Longitudinal associations between executive functioning and academic skills across content areas. *Developmental Psychology*, *50*(6), 1698-1709.

Fujita, K. (2011). On conceptualizing self-control as more than the effortful inhibition of impulses. *Personality and Social Psychology Review,* 15, 352-366.

Gardener, H., Spiegelman, D., & Buka, S. L. (2011) . Perinatal and neonatal risk factors for autism: A comprehensive meta-analysis. *Pediatrics*, *128*(2), 344–355. http://doi.org/10.1542/peds.2010-1036

Garon, N., Bryson, S. E., & Smith, I. M. (2008) . Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin*, *134*(1), 31.

Garon, N., Piccinin, C., & Smith, I. (2015) . Does the BRIEF- P predict specific executive function components in preschoolers? *Applied Neuropsychology: Child, 5*(2), 110-118. 10.1080/21622965.2014.1002923.

Gerst, E., Cirino, P., İletcher, J., & Yoshida, H. (2017) . Cognitive and behavioural rating measures of executive function as predictors of academic outcomes in children. *Child Neuropsychology*, *23*, 381-407.

Giles, R., Epstein, I., & Vertigan, A. (Eds.) . (2011) . *Clinical data mining in an allied health organisation: A real world experience*. Sydney, AU: Sydney University Press.

Gioia, G., Espy, K., & Isquith, P. (2003) . *Behavioral Rating Inventory of Executive Function-Preschool Version.* Odessa, FL: Psychological Assessment Resources.

Gioia, G. A., Isquith, P. K., & Kenealy, L. E. (2008) . Assessment of behavioral aspects of executive function. In V. Anderson, R. Jacobs, & P. Anderson (Eds.), *Executive functions and the frontal lobes: A lifespan perspective* (pp. 179-202) . New York, NY: Taylor & Francis Group.

Glass, H. C., Costarino, A. T., Stayer, S. A., Brett, C. M., Cladis, F., & Davis, P. J. (2015) . Outcomes for extremely premature infants. *Anesthesia and Analgesia*, *120*(6), 1337-1351.

Goldin, R. L., Matson, J. L., Konst, M. J., & Adams, H. L. (2014). A comparison of children and adolescents with ASD, atypical development, and typical development on the Behavioral

Assessment System for Children, (BASC-2). *Research in Autism Spectrum Disorders*, *8*(8), 951-957.

Goldstein, S., & Reynolds, C. R. (Eds.) . (2010) . *Handbook of neurodevelopmental and genetic disorders in children* (2nd ed.) . New York, NY: Guilford Press.

Gooch, D., Hulme, C., Nash, H. M., & Snowling, M. J. (2014) . Comorbidities in preschool children at family risk of dyslexia. *Journal of Child Psychology and Psychiatry*, *55*(3), 237-246.

Government of Canada (2006) . The Human Face of Mental Illness. Cat.: HP5-19/2006E. ISBN: 0-662-43887-6. Ottawa, ON: Minister of Public Works and Government Services Canada.

Green, C., Mihic, A., Nikkel, S., Stade, B., Rasmussen, C., Munoz, D., et al. (2009). Executive function deficits in children with fetal alcohol spectrum disorders (FASD) measured using the Cambridge Neuropsychological Tests Automated Battery (CANTAB). Journal of Child Psychology and Psychiatry and Allied Disciplines, 50, 688–697.

Greenhoot, A. F., & Dowsett, C. J. (2012) . Secondary data analysis: An important tool for addressing developmental questions. *Journal of Cognition and Development*, *13*(1), 2-18.

Guralnick, M. J. (2012). Preventive interventions for preterm children: effectiveness and developmental mechanisms. *J Dev Behav Pediatr (33):* 352–64.

Hack, M. (2009) . Adult outcomes of preterm children. *Journal of Developmental and Behavioral Pediatrics, 30*(5), 460–470.

Hack, M., & Fanaroff, A. A. (2000, May). Outcomes of children of extremely low birthweight and gestational age in the 1990s. In *Seminars in neonatology*(Vol. 5, No. 2, pp. 89-106). WB Saunders.

Hack, M., Taylor, H. G., Drotar, D., Schluchter, M., Cartar, L., Wilson-Costello, D., . . . Morrow, M. (2005) . Poor predictive validity of the Bayley Scales of Infant Development for cognitive function of extremely low birth weight children at school age. *Pediatrics*, *116*(2), 333-341.

Hack, M., Youngstrom, E. A., Cartar, L., Schluchter, M., Taylor, G. H., Flannery, D. J., . . . Borawski, E. (2005) . Predictors of internalizing symptoms among very low birth weight young women. *Journal of Developmental & Behavioral Pediatrics*, *26*(2), 93-104.

Hackman, D. A., & Farah, M. J. (2009) . Socioeconomic status and the developing brain. *Trends in Cognitive Sciences*, *13*(2), 65-73.

Halle, T., Zaslow, M., Wessel, J., Moodie, S., and Darling-Churchill, K. (2011) . Understanding and choosing assessments and developmental screeners for young children: Profiles of selected measures. Washington, DC: Office of Planning, Research, and Evaluation, Administration for Children and Families, U.S. Department of Health and Human Services. https://www.acf.hhs.gov/sites/default/files/assets/screeners_final.pdf

Hansen, B. M., Dinesen, J., Hoff, B., & Greisen, G. (2002) . Intelligence in preterm children at four years of age as a predictor of school function: A longitudinal controlled study. *Developmental Medicine & Child Neurology*, *44*(8), 517-521.

Harrison, P., & Oakland, T. (2003) . *Adaptive Behavior Assessment System (ABAS-II)* . San Antonio, TX: The Psychological Corporation.

Hille, E. T. M.,Weisglas-Kuperus, N., Van Goudoever, J. B., Jacobusse, G. W., Ens-Dokkum, M. H., De Groot, L., . . . Verloove-Vanhorick, S. P. (2007) . Functional outcomes and participation in young adulthood for very preterm and very low birth weight infants: The Dutch project on preterm and small for gestational age infants at 19 years of age. *Pediatrics, 120*, e587–e595.

Hintz, S. R. (2016, December). Defining outomes for high-risk infants: Problems and possibilities. In *Seminars in perinatology* (Vol. 40, No. 8, pp. 495-496). Elsevier.

Hofheimer, J. A., Sheinkopf, S. J., & Eyler, L. T. (2014) . Autism risk in very preterm infants—new answers, more questions. *The Journal of Pediatrics*,*164*(1), 6-8.

Hongwanishkul, D., Happaney, K. R., Lee, W. S., & Zelazo, P. D. (2005) . Assessment of hot and cool executive function in young children: Age-related changes and individual differences. *Developmental Neuropsychology*, *28*(2), 617-644.

Howard, K., Anderson, P. J., & Taylor, H. G. (2008) . Executive functioning and attention in children born preterm. In V. Anderson, R. Jacobs, & P. J. Anderson (Eds.), *Executive functions and the frontal lobes: A lifespan perspective* (pp. 219-242) . New York, NY: Taylor & Francis Group.

Howell, D. C. (2010) . *Statistical methods for psychology (7th ed.)* . Belmont, CA: Wadsworth Cengage Learning.

Hughes, C. (2011) . Changes and challenges in 20 years of research into the development of executive functions. *Infant and Child Development*, *20*(3), 251-271.

Hughes, A., Daly, B., & Brown, R. (2011). Gilles de la Tourette Syndrome. In Goldstein, S., & Reynolds, C. Handbook of neurodevelopmental and genetic disorders in children- 2nd edition. (pp. 171-187), New York. USA: The Guildford Press.

Hughes, C., & Ensor, R. (2008) . Does executive function matter for preschoolers' problem behaviors?. *Journal of Abnormal Child Psychology*, *36*(1), 1-14.

Hughes, C. H., & Ensor, R. A. (2009) . How do families help or hinder the emergence of early executive function?. *New Directions for Child and Adolescent Development*, *2009*(123), 35-50.

Hughes, C., & Graham, A. (2008) . Executive functions and development. In J. Reed, & J. Warner-Rogers (Eds.), *Child neuropsychology: Concepts, theory and practice* (pp. 264-284) . Malden, MA: Blackwell Publishing Ltd.

Hughes, C., Ensor, R., Wilson, A., & Graham, A. (2009) . Tracking executive function across the transition to school: A latent variable approach. *Developmental Neuropsychology*, *35*(1), 20-36.

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

Hummer, M., Lehner, T., & Pruckner, G. (2014) . Low birth weight and health expenditures from birth to late adolescence. *The European Journal of Health Economics*, *15*(3), 229-242.

Hutchinson, E. A., De Luca, C. R., Doyle, L. W., Roberts, G., Anderson, P. J., & Victorian Infant Collaborative Study Group. (2013). School-age outcomes of extremely preterm or extremely low birth weight children. *Pediatrics*, peds-2012.

Inder, T. E., Wells, S. J., Mogridge, N. B., Spencer, C., & Volpe, J. J. (2003) . Defining the nature of the cerebral abnormalities in the premature infant: A qualitative magnetic resonance imaging study. *The Journal of Pediatrics*, *143*(2), 171-179.

Indredavik, M. S., Vik, T., Heyerdahl, S., Kulseng, S., Fayers, P., & Brubakk, A. M. (2004). Psychiatric symptoms and disorders in adolescents with low birth weight. *Archives of Disease in Childhood-Fetal and Neonatal Edition*, *89*(5), F445-F450.

International Committee for the Classification of Retinopathy of Prematurity (2005) . The international classification of retinopathy of prematurity revisited. *Archives of Ophthalmology, 123*(7), 991–999.

Ionio, C., Riboni, E., Confalonieri, E., Dallatomasina, C., Mascheroni, E., Bonanomi, A., . . . Comi, G. (2016) . Paths of cognitive and language development in healthy preterm infants. *Infant Behavior and Development*, *44*, 199-207.

Jacobson, L. A., & Mahone, E. M. (2012). Educational implications of executive dysfunction. *Executive function and dysfunction*, 232-246.

Janvier, A., Farlow, B., Baardsnes, J., Pearce, R., & Barrington, K. J. (2016). Measuring and communicating meaningful outcomes in neonatology: A family perspective. In *Seminars in perinatology* (Vol. 40, No. 8, pp. 571-577). WB Saunders.

Jarjour, I. T. (2015) . Neurodevelopmental outcome after extreme prematurity: a review of the literature. *Pediatric neurology*, *52*(2), 143-152.

Jakobson, L. S., Frisk, V., & Downie, A. L. S. (2006) . Motion-defined form processing in extremely premature children. *Neuropsychologia*, *44*(10), 1777-1786.

Jensen, P. B., Jensen, L. J., & Brunak, S. (2012). Mining electronic health records: towards better research applications and clinical care. *Nature reviews. Genetics*, *13*(6), 395-405.

Johnson, S., & Marlow, N. (2011) . Preterm birth and childhood psychiatric disorders. *Pediatric Research*, *69*, 11R-18R.

Johnson, S., Hennessy, E., Smith, R., Trikic, R., Wolke, D., & Marlow, N. (2009) . Academic attainment and special educational needs in extremely preterm children at 11 years of age: the EPICure study. *Archives of Disease in Childhood-Fetal and Neonatal Edition*, *94*(4), F283-F289.

Johnson, S., Moore, T., & Marlow, N. (2014) . Using the Bayley-III to assess neuro-developmental delay: which cut-off should be used?. *Pediatric Research, 75*(5), 670-674.

Johnson, S., Wolke, D., Hennessy, E., & Marlow, N. (2011) . Educational outcomes in extremely preterm children: neuropsychological correlates and predictors of attainment. *Developmental Neuropsychology*, *36*(1), 74-95.

Jones, K. M., Champion, P. R., & Woodward, L. J. (2013) . Social competence of preschool children born very preterm. *Early Human Development*, *89*(10), 795-802.

Kaiser, H. F. (1960). Varimax solution for primary mental abilities. *Psychometrika*, *25*(2), 153-158.

Kataoka, S. H., Zhang, L., & Wells, K. B. (2002) . Unmet need for mental health care among US children: Variation by ethnicity and insurance status. *American Journal of Psychiatry*, *159*(9), 1548-1555.

Kesler, S.R., Reiss, A.L., Vohr, B., Watson, C., Schneider, K.C., Katz, K.H. et al.. (2008). Brain volume reduction within multiple cognitive systems in male preterm children at age twelve. *J Pediatr 152*:513–520.

Khwaja, O., & Volpe, J. J. (2008) . Pathogenesis of cerebral white matter injury of prematurity. *Archives of Disease in Childhood-Fetal and Neonatal Edition, 93(2),* F153-F161.

Killeen, H., Shiel, A., Law, M., Segurado, R., & O'Donovan, D. (2015) . The impact of preterm birth on participation in childhood occupation. *European Journal of Pediatrics*, *174*(3), 299-306.

Kinney, H. C. (2009) . The encephalopathy of prematurity: One pediatric neuropathologist's perspective. *Seminars in Pediatric Neurology*, *16*(4), 179-190.

Kittler, P. M., Gardner, J. M., Lennon, E. M., Flory, M. J., Mayes, L. C., & Karmel, B. Z. (2011) . The development of selective attention and inhibition in NICU graduates during the preschool years. *Developmental Neuropsychology*, *36*(8), 1003-1017.

Klein, V. C., Rocha, L. C., Martinez, F. E., Putnam, S. P., & Linhares, M. B. M. (2013) . Temperament and behavior problems in toddlers born preterm and very low birth weight. *The Spanish Journal of Psychology*, *16*, E18.

Kochanska, G., Murray, K. T., & Harlan, E. T. (2000) . Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. *Developmental Psychology*, *36*(2), 220.

Kochanska, G., & Thompson, R. A. (1997). The emergence and development of conscience in toddlerhood and early childhood. *Parenting and children's internalization of values*, 53-77.

Kok, R., Lucassen, N., Bakermans-Kranenburg, M. J., van IJzendoorn, M. H., Ghassabian, A., Roza, S. J., . . . Tiemeier, H. (2014) . Parenting, corpus callosum, and executive function in preschool children. *Child Neuropsychology*, *20*(5), 583-606.

Konvold, T., & Shukla, K. (2014) . Review of the Gesell developmental observation – Revised. In Carlson, J., Geisinger K., & Johnson J. (Eds.), The *nineteenth mental measurements yearbook*. Lincoln, Nebraska, Buros Mental Measurement.

Korkman, M., Mikkola, K., Ritari, N., Tommiska, V., Salokorpi, T., Haataja, L., . . . Fellman, V. (2008) . Neurocognitive test profiles of extremely low birth weight five-year-old children differ according to neuromotor status. *Developmental Neuropsychology*, *33*(5), 637-655.

Kosten, T. A., & Rounsaville, B. J. (1992) . Sensitivity of psychiatric diagnosis based on the best estimate procedure. *The American Journal of Psychiatry*, *149*(9), 1225.

Krivitzky, L., Walsh, K., Fisher, E., & Berl, M. (2016) . Executive functioning profiles from the BRIEF across pediatric medical disorders: Age and diagnosis factors. *Child Neuorpsychology*, *22*(7), 870-888.

Kuo, K.A. & Duchon, A., (2015). Neonatal Birth Weight Trends: Are Newborns Getting Smaller? [136]. *Obstetrics & Gynecology,* 125 Suppl 1, p.48S-48S.

Kuzniewicz, M. W., Wi, S., Qian, Y., Walsh, E. M., Armstrong, M. A., & Croen, L. A. (2014) . Prevalence and neonatal factors associated with autism spectrum disorders in preterm infants. *Journal of Pediatrics*, *164*(1), 20-25.

Lackner, C. L., Bowman, L. C., & Sabbagh, M. A. (2010) . Dopaminergic functioning and preschoolers' theory of mind. *Neuropsychologia*, *48*(6), 1767-1774.

Lane, J. D., Wellman, H. M., Olson, S. L., LaBounty, J., & Kerr, D. C. (2010) . Theory of mind and emotion understanding predict moral development in early childhood. *British Journal of Developmental Psychology*, *28*(4), 871-889.

Larroque, B., Ancel, P. Y., Marret, S., Marchand, L., André, M., Arnaud, C., ... & Burguet, A. (2008). Neurodevelopmental disabilities and special care of 5-year-old children born before 33 weeks of gestation (the EPIPAGE study): a longitudinal cohort study. *The Lancet*, *371*(9615), 813-820.

LeCayer, E., & Zhang, Y. (2015) . An integrative review of ethnic and cultural variation in socialization and children's self-regulation. *Journal of Advanced Nursing*, 71(4), 735-750.

Leppert, M., & Allen, M. (2009) . Neurodevelopmental consequences of preterm birth: Causes, assessment, and management. In W. B. Carey, A. C. Crocker, W. L. Coleman, E. R. Elias, & H. M. Feldman (Eds.), *Developmental-Behavioural Pediatrics* (4th ed.) (pp. 259-268) . Philadelphia, PA: Elsevier Press.

Lerner, R. M., Lerner, J. V., Bowers, E. P., Lewin-Bizan, S., Gestsdottir, S., & Urban, J. B. (2011) . Self-regulation processes and thriving in childhood and adolescence: A view of the issues. *New Directions for Child and Adolescent Development*, *2011*(133), 1-9. http://onlinelibrary.wiley.com/doi/10.1002/cd.300/abstract.

Liew, J. (2012) . Effortful control, executive functions, and education: Bringing self-regulatory and social-emotional competencies to the table. *Child Development Perspectives*, *6*(2), 105-111.

Limperopoulos, C., Bassan, H., Sullivan, N. R., Soul, J. S., Robertson, R. L. Jr., Moore, M., . . . du Plessis, A. J. (2008) . Positive screening for autism in ex-premature infants: Prevalence and risk factors. *Pediatrics*, *121*(4), 758-765.

Loe, I. M., Chatav, M., & Alduncin, N. (2015) . Complementary assessments of executive function in preterm and full-term preschoolers. *Child Neuropsychology*, *21*(3), 331-353.

Loe, I. M., Feldman, H. M., & Huffman, L. C. (2014) . Executive function mediates effects of gestational age on functional outcomes and behavior in preschoolers. *Journal of Developmental and Behavioral Pediatrics*, *35*(5), 323.

Logan, J. W., Dammann, O., Allred, E. N., Dammann, C., Beam, K., Joseph, R. M., . . . Kuban, K. C. K. (2017) . Early postnatal illness severity scores predict neurodevelopmental impairment at 10 years of age in children born extremely preterm. *Journal of Perinatology, 37*(5), 606-614.

Lopata, C., Smith, R. A., Volker, M. A., Thomeer, M. L., Lee, G. K., & McDonald, C. A. (2013). Comparison of adaptive behavior measures for children with HFASDs. *Autism research and treatment*, *2013*.

Lowe, J., Woodward, B., & Papile, L. A. (2005) . Emotional regulation and its impact on development in extremely low birth weight infants. *Journal of Developmental & Behavioral Pediatrics*, *26*(3), 209-213.

Lubsen, J., Vohr, B., Myers, E., Hampson, M., Lacadie, C., Schneider, K. C., . . . Ment, L. R. (2011) . Microstructural and functional connectivity in the developing preterm brain. *Seminars in Perinatology*, *35*(1), 34-43.

Luu, T. M., Ment, L., Allan, W., Schneider, K., & Vohr, B. R. (2011). Executive and memory function in adolescents born very preterm. *Pediatrics*, *127*(3), e639-e646.

Maclean, P. C., Erickson, S. J., & Lowe, J. R. (2009) . Comparing emotional reactivity and regulation in infants born ELGA and VLGA. *Infant Behavior and Development*, *32*(3), 336-339.

Mahone, E. M., & Hoffman, J. (2007). Behavior ratings of executive function among preschoolers with ADHD. *The Clinical Neuropsychologist*, *21*(4), 569-586.

Maniar, S., & Zaff, J. F. (2011) . A life-span, relational, public health model of self-regulation: Impact on individual and community health. *New Directions for Child and Adolescent Development*, *2011*(133), 77-86.

Manley, B. J., Roberts, R. S., Doyle, L. W., Schmidt, B., Anderson, P. J., Barrington, K. J., . . . Caffeine for Apnea of Prematurity (CAP) Trial Investigators. (2015) . Social variables predict gains in cognitive scores across the preschool years in children with birth weights 500 to 1250 grams. *The Journal of Pediatrics*, *166*(4), 870-876.

Månsson, J., & Stjernqvist, K. (2014) . Children born extremely preterm show significant lower cognitive, language and motor function levels compared with children born at term, as measured by the Bayley‐III at 2.5 years. *Acta Paediatrica*, *103*(5), 504-511.

Marlow, N., Wolke, D., Bracewell, M. A., & Samara, M. (2005) . Neurologic and developmental disability at six years of age after extremely preterm birth. *New England Journal of Medicine*, *352*(1), 9-19.

Marsh, R., Gerber, A. J., & Peterson, B. S. (2008) . Neuroimaging studies of normal brain development and their relevance for understanding childhood neuropsychiatric disorders. *Journal of the American Academy of Child & Adolescent Psychiatry, 47*(11), 1233-1251.

Marsh, J. A., Pane, J. F., & Hamilton, L. S. (2006) . *Making sense of data-driven decision making in education: Evidence from recent RAND research*. Santa Monica, CA: RAND Corportation. http://www.rand.org/pubs/occasional_papers/OP170.html.

Martin Bax, D. M., Tydeman, C., & Flodmark, O. (2006). Clinical and MRI correlates of cerebral palsy. *JAMA*, *296*, 1602-1608.

Matthews, J. S., Ponitz, C. C., & Morrison, F. J. (2009) . Early gender differences in self-regulation and academic achievement. *Journal of Educational Psychology*, *101*(3), 689.

McCann, J. P., Rider, G. N., Weiss, B. A., Litman, F. R., & Baron, I. S. (2014) . Latent mean comparisons on the BRIEF in preterm children: Parent and teacher differences. *Child Neuropsychology*, *20*(6), 737-751.

McClelland, M. M., & Cameron, C. E. (2011) . Self-regulation and academic achievement in elementary school children. *New Directions for Child and Adolescent Development*, *2011*(133), 29-44.

Meinzen-Derr, J., Wiley, S., Phillips, J., Altaye, M., & Choo, D. I., (2017). The utility of early developmental assessments on understanding later nonverbal IQ in children who are deaf or hard of hearing. *International journal of pediatric otorhinolaryngology*, *92*, 136-142.

Meltzer, L. (2010) . *Promoting executive function in the classroom*. New York, NY: Guilford Press.

Ment, L. R., & Constable, R. T. (2007) . Injury and recovery in the developing brain: Evidence from functional MRI studies of prematurely born children. *Nature Clinical Practice Neurology*, *3*(10), 558-571.

Metcalfe, J., & Mischel, W. (1999) . A hot/cool-system analysis of delay of gratification: Dynamics of willpower. *Psychological Review*, *106*(1), 3.

Myers, C. L., Bour, J. L., Sidebottom, K. J., Murphy, S. B., & Hakman, M. (2010). Same constructs, different results: Examining the consistency of two behavior-rating scales with referred preschoolers. *Psychology in the Schools*, *47*(3), 205-216.

Milne, S., McDonald, J., & Comino, E. J. (2012) . The use of the Bayley scales of infant and toddler development III with clinical populations: A preliminary exploration. *Physical & Occupational Therapy in Pediatrics*, *32*(1), 24-33.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000) . The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49-100.

Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., . . . Sears, M. R. (2011) . A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences*, *108*(7), 2693-2698.

Monette, S., Bigras, M., & Guay, M. C. (2011) . The role of the executive functions in school achievement at the end of Grade 1. *Journal of Experimental Child Psychology*, *109*(2), 158-173.

Monette, S., Bigras, M., & Lafrenière, M. A. (2015). Structure of executive functions in typically developing kindergarteners. *Journal of experimental child psychology*, *140*, 120-139.

Montagna, A., & Nosarti, C. (2016). Socio-emotional development following very preterm birth: pathways to psychopathology. *Frontiers in psychology*, *7:80*.

Moore, T., Johnson, S., Haider, S., Hennessy, E., & Marlow, N. (2012) . Relationship between test scores using the second and third editions of the Bayley Scales in extremely preterm children. *The Journal of Pediatrics*, *160*(4), 553-558.

Morgan, G. A., Leech, N. L., Gloeckner, G. W., & Barrett, K. C. (2012) . *IBM SPSS for introductory statistics: Use and interpretation*. New York, NY: Routledge.

Moriguchi, Y. (2014) . The early development of executive function and its relation to social interaction: A brief review. *Frontiers in Psychology*, *5*, 388.

Mosconi, M. W., Kay, M., D'Cruz, A. M., Seidenfeld, A., Guter, S., Stanford, L. D., & Sweeney, J. A. (2009) . Impaired inhibitory control is associated with higher-order repetitive behaviors in autism spectrum disorders. *Psychological Medicine*, *39*(9), 1559-1566.

Msall, M. E. (2005) . Measuring functional skills in preschool children at risk for neurodevelopmental disabilities. *Mental Retardation and Developmental Disabilities Research Reviews, 11*(3), 263-273.

Msall, M. E. (2010). Measuring outcomes after extreme prematurity with the Bayley-III Scales of infant and toddler development: a cautionary tale from Australia. *Archives of pediatrics & adolescent medicine*, *164*(4), 391-393.

Msall, M. E. (2012). Academic achievement after extreme prematurity: optimizing outcomes for vulnerable children in times of uncertainty. *Acta Paediatrica*, *101*(12), 1196-1197.

Msall, M. E., & Park, J. J. (2008) . The spectrum of behavioral outcomes after extreme prematurity: Regulatory, attention, social, and adaptive dimensions. *Seminars in Perinatology, 32*(1), 42-50.

Mulder, H., Pitchford, N. J., Hagger, M. S., & Marlow, N. (2009) . Development of executive function and attention in preterm children: A systematic review. *Developmental Neuropsychology*, *34*(4), 393-421.

Neuenschwander, R., Röthlisberger, M., Cimeli, P., & Roebers, C. M. (2012) . How do different aspects of self-regulation predict successful adaptation to school?. *Journal of Experimental Child Psychology*, *113*(3), 353-371.

Ni, T., Huang, C., & Guo, N. (2011). Executive function deficit in preschool children born very low birth weight with normal early development. *Early Human Development, 87* (2), 137-141.

Nigg, J.T. (2017). Annual Research Review: On the relations among self-regulation, self-control, executive functioning, effortful control, cognitive control, impulsivity, risk-taking, and inhibition for developmental psychopathology. *Journal of Child Psychology and Psychiatry, 58*(4), 361-383.

Noggle, C., Thompson, J., & Davis, J. (2014) . Everyday executive functioning influences adaptive skills in autistic spectrum disorders. *Archives of Clinical Neuropsychology*, *29*(6), 543-544.

Norris, M., & Lecavalier, L. (2010). Evaluating the use of exploratory factor analysis in developmental disability psychological research. *Journal of Autism and Developmental Disorders*, *40*(1), 8-20.

Nosarti, C. (2013) . Structural and functional brain correlates of behavioral outcomes during adolescence. *Early Human Development*, *89*(4), 221-227.

Oakland, T., & Daley, M. (2013) . *Adaptive behavior: Its history, concepts, assessment, and applications*. Washington, DC: American Pyschological Association. http://psycnet.apa.org/books/14049/009.

Oakland, T., & Harrison, P. L. (Eds.) . (2011) . *Adaptive behavior assessment system-II: Clinical use and interpretation*. San Diego, CA: Academic Press.

Ohira, H., Nomura, M., Ichikawa, N., Isowa, T., Iidaka, T., Sato, A., . . . Yamada, J. (2006) . Association of neural and physiological responses during voluntary emotion suppression. *Neuroimage*, *29*(3), 721-733.

Orton, J., Spittle, A., Doyle, L., Anderson, P., & Boyd, R. (2009). Do early intervention programmes improve cognitive and motor outcomes for preterm infants after discharge? A systematic review. *Developmental Medicine & Child Neurology*, *51*(11), 851-859.

O'Shea, T., Downey, L., & Kuban, K. (2013). Extreme prematurity and attention deficit: epidemiology and prevention. *Frontiers in Human Ne.uroscience, 7*, 1-5.

Otero, T. M., Barker, L. A., & Naglieri, J. A. (2014). Executive function treatment and intervention in schools. *Applied Neuropsychology: Child*, *3*(3), 205-214.

Owen, M. T., Caughy, M. O. B., Hurst, J. R., Amos, M., Hasanizadeh, N., & Mata-Otero, A. M. (2013) . Unique contributions of fathering to emerging self-regulation in low-income ethnic minority preschoolers. *Early Child Development and Care*, *183*(3-4), 464-482.

Pagano, R. R. (2009) . *Understanding statistics in the behavioral sciences (9th ed.)* . Belmont, CA: Wadsworth Cengage Learning.

Papazoglou, A., Jacobson, L. A., & Zabel, T. A. (2013) . More than intelligence: Distinct cognitive/behavioral clusters linked to adaptive dysfunction in children. *Journal of the International Neuropsychological Society*, *19*(2), 189-197.

Papile, L. A., Burstein, J., Burstein, R., Koffler, H. (1978) . Incidence and evolution of subependymal and intraventricular hemorrhage: A study of infants with birth weights less than 1,500 gm. *The Journal of Pediatrics, 92*(4), 529-34.

Parekh, S. A., Boyle, E. M., Guy, A., Blaggan, S., Manktelow, B. N., Wolke, D., & Johnson, S. (2016) . Correcting for prematurity affects developmental test scores in infants born late and moderately preterm. *Early Human Development*, *94*, 1-6.

Patrianakos-Hoobler, A. I., Msall, M. E., Huo, D., Marks, J. D., Plesha-Troyke, S., & Schreiber, M. D. (2010) . Predicting school readiness from neurodevelopmental assessments at age 2 years after respiratory distress syndrome in infants born preterm. *Developmental Medicine & Child Neurology*, *52*(4), 379-385.

Patrianakos-Hoobler, A. I., Msall, M. E., Marks, J. D., Huo, D., & Schreiber, M. D. (2009) . Risk factors affecting school readiness in premature infants with respiratory distress syndrome. *Pediatrics*, *124*(1), 258-267.

Pavlova, M. A., & Krägeloh-Mann, I. (2013). Limitations on the developing preterm brain: impact of periventricular white matter lesions on brain connectivity and cognition. *Brain*, *136*(4), 998-1011.

Pelham Jr, W. E., & Fabiano, G. A. (2008) . Evidence-based psychosocial treatments for attention-deficit/hyperactivity disorder. *Journal of Clinical Child & Adolescent Psychology*, *37*(1), 184-214.

Pellicano, E. (2010) . Individual differences in executive function and central coherence predict developmental changes in theory of mind in autism. *Developmental Psychology*, *46*(2), 530.

Peralta-Carcelen, M., Bailey, K., Rector, R., & Gantz, M. (2013) . Behavioral and socioemotional competence problems of extremely low birth weight children. *Journal of Perinatology, 33*(11), 887-892.

Perlman, S. B., & Pelphrey, K. A. (2011) . Developing connections for affective regulation: age-related changes in emotional brain connectivity. *Journal of Experimental Child Psychology*, *108*(3), 607-620.

Perra, O., McGowan, J. E., Grunau, R. E., Doran, J. B., Craig, S., Johnston, L., ... & Alderdice, F. A. (2015). Parent ratings of child cognition and language compared with Bayley-III in preterm 3-year-olds. *Early human development*, *91*(3), 211-216.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003) . Common method biases in behavioral research: A critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879-903. 10.1037/0021-9010.88.5.879

Poehlmann, J., Schwichtenberg, A. M., Shah, P. E., Shlafer, R. J., Hahn, E., & Maleck, S. (2010) . The development of effortful control in children born preterm. *Journal of Clinical Child & Adolescent Psychology*, *39*(4), 522-536.

Ponitz, C. C., McClelland, M. M., Matthews, J. S., & Morrison, F. J. (2009) . A structured observation of behavioral self-regulation and its contribution to kindergarten outcomes. *Developmental Psychology*, *45*(3), 605.

Poole, K. L., Schmidt, L. A., Missiuna, C., Saigal, S., Boyle, M. H., & Van Lieshout, R. J. (2015). Motor coordination and mental health in extremely low birth weight survivors during the first four decades of life. *Research in developmental disabilities*, *43*, 87-96.

Posner, M. I., & Fan, J. (2005) . Attention as an organ system. In J. Pomerantz (Ed.), *Neurobiology of perception and communication: From synapse to society.* The IVth De Lange Conference. Cambridge, UK: Cambridge University Press.

Posner, M. I., Rothbart, M. K., & Rueda, M. R. (2008) . Brain mechanisms and learning of high level skills. In A. M. Battro, K. W. Fischer, & P. J. Léna (Eds.), *The Educated Brain: Essays in Neuroeducation* (pp.151-165) Cambridge, UK: Cambridge University Press.

Potharst, E. S., Houtzager, B. A., Van Sonderen, L., Tamminga, P., Kok, J. H., Last, B. F., & Van Wassenaer, A. G. (2012) . Prediction of cognitive abilities at the age of 5 years using developmental follow-up assessments at the age of 2 and 3 years in very preterm children. *Developmental Medicine & Child Neurology*, *54*(3), 240-246.

Potharst, E. S., van Wassenaer‐Leemhuis, A. G., Houtzager, B. A., Livesey, D., Kok, J. H., Last, B. F., & Oosterlaan, J. (2013) . Perinatal risk factors for neurocognitive impairments in preschool children born very preterm. *Developmental Medicine & Child Neurology*, *55*(2), 178-184.

Potharst, E. S., van Wassenaer, A. G., Houtzager, B. A., van Hus, J. W., Last, B. F., & Kok, J. H. (2011) . High incidence of multi-domain disabilities in very preterm children at five years of age. *The Journal of Pediatrics*, *159*(1), 79-85.

Potijk, M. R., de Winter, A. F., Bos, A. F., Kerstjens, J. M., & Reijneveld, S. A. (2012) . Higher rates of behavioural and emotional problems at preschool age in children born moderately preterm. *Archives of Disease in Childhood*, *97*(2), 112-117.

Premack, D., & Woodruff, G. (1978) . Chimpanzee problem-solving: A test for comprehension. *Science*, *202*(4367), 532-535.

Pritchard, V. E., & Woodward, L. J. (2011) . Preschool executive control on the Shape School task: Measurement considerations and utility. *Psychological Assessment*, *23*(1), 31.

Pugliese, M., Rossi, C., Guidotti, I., Gallo, C., Della Casa, E., Bertoncelli, N., ... & Ferrari, F. (2013). Preterm birth and developmental problems in infancy and preschool age Part II: cognitive, neuropsychological and behavioural outcomes. *The Journal of Maternal-Fetal & Neonatal Medicine*, *26*(16), 1653-1657.

Raver, C. (2012) . Low-income children's self-regulation in the classroom: Scientific inquiry for social change. *American Psychologist*, *67*(8), 681.

Raver, C., Jones, S., Li-Grining, C., Zhai, F., Bub, K., & Pressler, E. (2011) . CSRP's impact on low-income preschoolers' preacademic skills: Self-regulation as a mediating mechanism. *Child Development, 82*(1), 362-378.

Raver, C., Smith Carter, J., McCoy D.C., Roy, A., Ursache, A., & Friedman, A. (2012). Testing models of children's self-regulation within educational contexts: Implications for measurement. *Adv Child Dev Behav*., 42: 245-270.

Reynolds, C., & Kamphaus, R., (2004) . *Behaviour Assessment System for Children-II* (BASC-II). Bloomington, MN: Pearson Assessments.

Riccio, C., & Gomes, H. (2013) . Interventions for executive function deficits in children and adolescents. *Applied Neuropsychology: Child*, *2*, 133-40.

Rimm-Kaufman, S. E., Curby, T. W., Grimm, K. J., Nathanson, L., & Brock, L. L. (2009) . The contribution of children's self-regulation and classroom quality to children's adaptive behaviors in the kindergarten classroom. *Developmental Psychology*, *45*(4), 958.

Rimm-Kaufman, S. E., Pianta, R. C., & Cox, M. J. (2000) . Teachers' judgments of problems in the transition to kindergarten. *Early Childhood Research Quarterly*, *15*(2), 147-166.

Ritter, B. C., Perrig, W., Steinlin, M., & Everts, R. (2014) . Cognitive and behavioral aspects of executive functions in children born very preterm. *Child Neuropsychology*, *20*(2), 129-144.

Rizzolatti, G., Fabbri-Destro, M., & Cattaneo, L. (2009) . Mirror neurons and their clinical relevance. *Nature Clinical Practice Neurology*, *5*(1), 24-34.

Roe, K. V., McClure, A., & Roe, A. (1983) . Infant Gesell scores vs. cognitive skills at age 12 years. *The Journal of Genetic Psychology*, *142*(1), 143-147.

Roesch, M. R., Taylor, A. R., & Schoenbaum, G. (2006) . Encoding of time-discounted rewards in orbitofrontal cortex is independent of value representation. *Neuron*, *51*(4), 509-520.

Rosenbaum, P., Eliasson, A. C., Hidecker, M. J. C., & Palisano, R. J. (2014). Classification in childhood disability: focusing on function in the 21st century. *Journal of child neurology*, *29*(8), 1036-1045.

Roth, R. M., Erdodi, L. A., McCulloch, L. J., & Isquith, P. K. (2015). Much ado about norming: The behavior rating inventory of executive function. *Child Neuropsychology*, *21*(2), 225-233.

Rothbart, M. K. (2004) . Commentary: Differentiated measures of temperament and multiple pathways to childhood disorders. *Journal of Clinical Child and Adolescent Psychology*, *33*(1), 82-87.

Rothman, K. J. (1990) . No adjustments are needed for multiple comparisons. *Epidemiology*, *1*(1), 43-46.

Rueda, M., Rothbart, M., McAndliss, B., Saccomanno, L., & Posner, M. (2005). Training, maturation, and genetic influences on the development of executive attention. *Proceedings from the National Academy of Sciences, USA*, 102: 14931–14936.

Russell, D. J., Rosenbaum, P. L., Avery, L. M., & Lane, M. (2002) . *Gross motor function measure (GMFM-66 and GMFM-88) user's manual (No. 159)* . Cambridge, UK: Cambridge University Press.

Saigal, S., & Doyle, L. W. (2008) . An overview of mortality and sequelae of preterm birth from infancy to adulthood. *The Lancet*, *371*(9608), 261-269.

Saigal, S., Pinelli, J., Hoult, L., Kim, M. M., & Boyle, M. (2003) . Psychopathology and social competencies of adolescents who were extremely low birth weight. *Pediatrics*, *111*(5), 969-975.

Sameroff, A. J. (2009). Conceptual issues in studying the development of self-regulation. *Biopsychosocial regulatory processes in the development of childhood behavioral problems*, 1-18.

Sansavini, A., Guarini, A., & Caselli, M. C. (2011) . Preterm birth: Neuropsychological profiles and atypical developmental pathways. *Developmental Disabilities Research Reviews*, *17*(2), 102-113.

Sansavini, A., Pentimonti, J., Justice, L., Guarini, A., Savini, S., Alessandroni, R., & Faldella, G. (2014) . Language, motor and cognitive development of extremely preterm children: Modeling individual growth trajectories over the first three years of life. *Journal of Communication Disorders*, *49*, 55-68.

Sattler, J. M. (2008) . *Assessment of children: Cognitive foundations*. San Diego, CA: JM Sattler.

Schafer, V. & Semrud-Clikeman, M., (2008). Neuropsychological functioning in subgroups of children with and without social perception deficits and/or hyperactivity-impulsivity. *Journal of attention disorders, 12* (2), 177-90.

Schalock, R. L., Borthwick-Duffy, S. A., Bradley, V. J., Buntinx, W. H., Coulter, D. L., Craig, E. M., . . . Shogren, K. A. (2010) . *Intellectual disability: Definition, classification, and systems of supports*. Washington, DC: American Association on Intellectual and Developmental Disabilities.

Schiariti, V., Hoube, J. S., Lisonkova, S., Klassen, A. F., Lee, S. K. (2007) . Caregiver-reported health outcomes of preschool children born at 28 to 32 weeks' gestation. *Journal of Developmental and Behavioral Pediatrics, 28*(1), 9-15.

Schoemaker, K., Bunte, T., Wiebe, S. A., Espy, K. A., Deković, M., & Matthys, W. (2012) . Executive function deficits in preschool children with ADHD and DBD. *Journal of Child Psychology and Psychiatry*, *53*(2), 111-119.

Schonhaut, L., Armijo, I., Schönstedt, M., Alvarez, J., & Cordero, M. (2013) . Validity of the ages and stages questionnaires in term and preterm infants. *Pediatrics*, *131*(5), e1468-e1474.

Schreiber, J. E., Possin, K. L., Girard, J. M., & Rey-Casserly, C. (2014) . Executive function in children with attention deficit/hyperactivity disorder: The NIH examiner battery. *Journal of the International Neuropsychological Society*, *20*(1), 41-51.

Schwartz, D. M. (2014). Breaking Through Barriers: Using Technology to Address Executive Function Weaknesses and Improve Student Achievement. *Applied Neuropsychology: Child*, *3*(3), 173-181.

Scott, M. N., Taylor, H. G., Fristad, M. A., Klein, N., Espy, K. A., Minich, N., & Hack, M. (2012) . Behavior disorders in extremely preterm/extremely low birth weight children in kindergarten. *Journal of Developmental and Behavioral Pediatrics*, *33*(3), 202.

Séguin, J. R., & Zelazo, P. D. (2005) . Executive function in early physical aggression. In R. E. Tremblay, W. W. Hartup, & J. Archer (Eds.) . *Developmental origins of aggression* (pp. 307–329) . New York, NY: Guilford Press.

Shah, P. E., Robbins, N., Coelho, R. B., & Poehlmann, J. (2013). The paradox of prematurity: The behavioral vulnerability of late preterm infants and the cognitive susceptibility of very preterm infants at 36 months post-term. *Infant Behavior and Development*, *36*(1), 50-62.

Shaheen, S. (2014) . How child's play impacts executive function-related behaviors. *Applied Neuropsychology: Child*, *3*(3), 182-187.

Shanker, S. (2013) . *Calm, alert, and learning: Classroom strategies for self-regulation*. Toronto, Canada. Pearson.

Shanmugan, S., Wolf, D. H., Calkins, M. E., Moore, T. M., Ruparel, K., Hopson, R. D., . . . Satterthwaite, T. D. (2016) . Common and dissociable mechanisms of executive system dysfunction across psychiatric disorders in youth. *American Journal of Psychiatry*, *173*(5), 517-526.

Sheridan, M. A., & McLaughlin, K. A. (2016). Neurobiological models of the impact of adversity on education. *Current Opinion in Behavioral Sciences*, *10*, 108-113.

Sherman, E. M., & Brooks, B. L. (2010) . Behavior rating inventory of executive function–preschool version (BRIEF-P): Test review and clinical guidelines for use. *Child Neuropsychology*, *16*(5), 503-519.

Silverman, W. K., Pina, A. A., & Viswesvaran, C. (2008) . Evidence-based psychosocial treatments for phobic and anxiety disorders in children and adolescents. *Journal of Clinical Child & Adolescent Psychology*, *37*(1), 105-130.

Skiöld, B., Alexandrou, G., Padilla, N., Blennow, M., Vollmer, B., & Ådén, U. (2014) . Sex differences in outcome and associations with neonatal brain morphology in extremely preterm children. *The Journal of Pediatrics*, *164*(5), 1012-1018.

Skogan, A. H., Zeiner, P., Egeland, J., Urnes, A. G., Reichborn-Kjennerud, T., & Aase, H. (2015). Parent ratings of executive function in young preschool children with symptoms of attention-deficit/-hyperactivity disorder. *Behavioral and Brain Functions*, *11*(1), 16.

Skogan, A. H., Egeland, J., Zeiner, P., Øvergaard, K. R., Oerbeck, B., Reichborn-Kjennerud, T., & Aase, H. (2016) . Factor structure of the behavior rating inventory of executive functions (BRIEF-P) at age three years. *Child Neuropsychology*, *22*(4), 472-492.

Skranes, J., Lohaugen, G. C., Martinussen, M., Indredavik, M. S., Dale, A. M., Haraldseth, O., . . . Brubakk, A. M. (2009) . White matter abnormalities and executive function in children with very low birth weight. *Neuroreport, 20*(3), 263-266.

Sonuga-Barke, E. J. S. (2005) . Causal models of attention-deficit/hyperactivity disorder: From common simple deficits to multiple developmental pathways. *Biological Psychiatry, 57*(11), 1231–1238.

Sparrow, S. S., Cicchetti, D. V., & Balla, D. A. (2005) . *Vineland Adaptive Behavior Scales: (Vineland II), survey interview form/caregiver rating form*. Livonia, MN: Pearson Assessments.

Spencer-Smith, M. M., Spittle, A. J., Lee, K. J., Doyle, L. W., & Anderson, P. J. (2015) . Bayley-III cognitive and language scales in preterm children. *Pediatrics*, *135*(5), e1258-e1265.

Spittle, A. J., Brown, N. C., Doyle, L. W., Boyd, R. N., Hunt, R. W., Bear, M., & Inder, T. E. (2008) . Quality of general movements is related to white matter pathology in very preterm infants. *Pediatrics*, *121*(5), e1184-e1189.

Spittle, A., Orton, J., Anderson, P., Boyd, R., & Doyle, L. W. (2012) . Early developmental intervention programmes post‐hospital discharge to prevent motor and cognitive impairments in preterm infants. *Cochrane Database Syst Rev. 2012 Dec 12;12:CD005495*

Spittle, A., & Treyvaud, K. (2016, December). The role of early developmental intervention to influence neurobehavioral outcomes of children born preterm. In *Seminars in perinatology* (Vol. 40, No. 8, pp. 542-548). WB Saunders.

Spittle, A. J., Treyvaud, K., Doyle, L. W., Roberts, G., Lee, K. J., Inder, T. E., . . . Anderson, P. J. (2009) . Early emergence of behavior and social-emotional problems in very preterm infants. *Journal of the American Academy of Child & Adolescent Psychiatry*, *48*(9), 909-918.

Squarza, C., Picciolini, O., Gardon, L., Giannì, M. L., Murru, A., Gangi, S., ... & Mosca, F. (2016). Learning Disabilities in Extremely Low Birth Weight Children and Neurodevelopmental Profiles at Preschool Age. *Frontiers in psychology*, *7*.

Stahlmann, N., Rapp, M., Herting, E., & Thyen, U. (2009). Outcome of extremely premature infants at early school age: health-related quality of life and neurosensory, cognitive, and behavioral outcomes in a population-based sample in northern Germany. *Neuropediatrics, 40*(03), 112-119.

Stevens, J. P. (1992) . *Applied multivariate statistics for the social sciences (2nd ed.*) . Hillsdale, NJ: Erlbaum

Stoesz, B. M., Montgomery, J. M., Smart, S. L. and Hellsten, L. A. M. (2011) . Review of five instruments for the assessment of Asperger's Disorder in adults. *The Clinical Neuropsychologist, 25*(3), 376-401.

Stoll, B.J., Hansen, N. I., Bell, E.F., Walsh, M.C., Carlo, W.A., Shankaran, S., et al. (2015). Trends in Care Practices, Morbidity, and Mortality of Extremely Preterm Neonates 1993-2012. *JAMA. 8*;315(10: 1039-51.

Sullivan, M. C., & Msall, M. E. (2007). Functional performance of preterm children at age 4. *Journal of pediatric nursing*, *22*(4), 297-309.

Sun, J., & Buys, N. (2012) . Early executive function deficit in preterm children and its association with neurodevelopmental disorders in childhood: A literature review. *International Journal of Adolescent Medicine and Health*, *24*(4), 291-299.

Sun, J., Mohay, H., & O'Callaghan, M. (2009) . A comparison of executive function in very preterm and term infants at 8 months corrected age. *Early Human Development*, *85*(4), 225-230.

Swineford, L. B., Guthrie, W., & Thurm, A. (2015) . Convergent and divergent validity of the Mullen Scales of Early Learning in young children with and without autism spectrum disorder. *Psychological Assessment*, *27*(4), 1364-1378.

Synnes, A., Luu, T., Moddemann, D., Church, P., Lee, D., Vincer, M., . . . Lee, S. K., (2017) . Determinants of developmental outcomes in a very preterm Canadian cohort. *Archives of Disease in Childhood – Fetal and Neonatal Edition*, *102*, F235-F243.

Tabachnick, B. G., & Fidell, L. S. (2013) . *Using Multivariate Statistics- 6th edition*. Hokenboke, New Jersey USA. Pearson Education.

Tan, C. S. (2007) . Test Review: Reynolds, CR, & Kamphaus, RW (2004) . Behavior assessment system for children . Circle Pines, MN: American Guidance Service. *Assessment for Effective Intervention*, *32*(2), 121-124.

Taylor, H. G., & Clark, C. A. (2016, December). Executive function in children born preterm: Risk factors and implications for outcome. In *Seminars in perinatology* (Vol. 40, No. 8, pp. 520-529). WB Saunders.

Taylor, H. G., Filipek, P. A., Juranek, J., Bangert, B., Minich, N., & Hack, M. (2011). Brain volumes in adolescents with very low birth weight: effects on brain structure and associations with neuropsychological outcomes. *Developmental neuropsychology*, *36*(1), 96-117.

Taylor, H. G., Klein, N., Drotar, D., Schluchter, M., & Hack, M. (2006). Consequences and risks of< 1000-g birth weight for neuropsychological skills, achievement, and adaptive functioning. *Journal of Developmental & Behavioral Pediatrics*, *27*(6), 459-469.

Thompson, D. K., Warfield, S. K., Carlin, J. B., Pavlovic, M., Wang, H. X., Bear, M., . . . Inder, T. E. (2007) . Perinatal risk factors altering regional brain structure in the preterm infant. *Brain*, *130*(3), 667-677.

Todd, R. M., & Lewis, M. D. (2008) . Self-regulation in the developing brain. In J. Reed, & J. Warner-Rogers (Eds.), *Child neuropsychology: Concepts, theory and practice* (pp. 285-315) . Malden, MA: Blackwell Publishing Ltd.

Treyvaud, K., Doyle, L., Lee, K., Roberts, G., Cheong, J., Inder, T., & Anderson, P. (2011) . Family functioning, burden and parenting stress 2 years after very preterm birth. *Early Human Development*, *87*(6), 427-431.

Treyvaud, K., Ure, A., Doyle, L. W., Lee, K. J., Rogers, C. E., Kidokoro, H., . . . Anderson, P. J. (2013) . Psychiatric outcomes at age seven for very preterm children: Rates and predictors. *Journal of Child Psychology and Psychiatry*, *54*(7), 772-779.

Tusor, N., Arichi, T., Counsell, S. J., & Edwards, A. D. (2014) . Brain development in preterm infants assessed using advanced MRI techniques. *Clinics in Perinatology*, *41*(1), 25-45.

Urben, S., Van Hanswijck De Jonge, L., Barisnikov, K., Pizzo, R., Monnier, M., Lazeyras, F., . . . Hüppi, P. S. (2015) . Gestational age and gender influence on executive control and its related neural structures in preterm-born children at 6 years of age. *Child Neuropsychology*, *7049*, 1-20.

Valcamonico, A., Accorsi, P., Sanzeni, C., Martelli, P., La Boria, P., Cavazza, A., & Frusca, T. (2007) . Mid-and long-term outcome of extremely low birth weight (ELBW) infants: An analysis of prognostic factors. *The Journal of Maternal-Fetal & Neonatal Medicine*, *20*(6), 465-471.

Vallotton, C., & Ayoub, C. (2011) . Use your words: The role of language in the development of toddlers' self-regulation. *Early Childhood Research Quarterly*, *26*(2), 169-181.

Vandenbroucke, L., Spilt, J., Verschueren, K., Piccinin, C., & Baeyens, D. (2017). The classroom as a developmental context for cognitive development: a meta-analysis on the importance of teacher-student interactions for childrenâ s executive functions. *Review of Educational Research*.

van de Weijer-Bergsma, E., Wijnroks, L., & Jongmans, M. J. (2008) . Attention development in infants and preschool children born preterm: A review. *Infant Behavior and Development, 31*(3), 333-351.

Wassenaer-Leemhuis, A. G., Jeukens-Visser, M., Hus, J. W., Meijssen, D., Wolf, M. J., Kok, J. H., ... & Koldewijn, K. (2016). Rethinking preventive post-discharge intervention programmes for very preterm infants and their parents. *Developmental Medicine & Child Neurology*, *58*(S4), 67-73.

Vederhus, B. J., Eide, G. E., Natvig, G. K., Markestad, T., Graue, M., & Halvorsen, T. (2015) . Health-related quality of life and emotional and behavioral difficulties after extreme preterm birth: Developmental trajectories. *PeerJ*, *3*, e738.

Venn, J. (2007) . Review of the Bayley Scales of Infant and toddler Development –Third Edition. In R. Geisinger, J. Spies, J. Carlson, & B. Plake (Eds.), *The seventeenth mental measurements yearbook*. Lincoln, Nebraska. Buros Mental Measurement.

Verkerk G., Jeukens-Visser, M., van Wassenaer-Leemhuis, A., Koldewijn, K., Kok J., & Nollet, F. (2013) . Assessing independency in daily activities in very preterm children at preschool age. *Research in Developmental Disabilities, 34*(7), 2085-2091.

Vieira, M. & Linhares, M. (2011) . Developmental outcomes and quality of life in children born preterm at preschool- and school-age. *Jornal de Pediatria, 87*(4), 281-91.

Vinall, J., Miller, S. P., Synnes, A. R., & Grunau, R. E. (2013). Parent behaviors moderate the relationship between neonatal pain and internalizing behaviors at 18 months corrected age in children born very prematurely. *PAIN®*, *154*(9), 1831-1839.

Vohr, B. R. (2014). Neurodevelopmental outcomes of extremely preterm infants. *Clinics in Perinatology*, *41*(1), 241-255.

Vohr, B. R. (2016, December). Language and hearing outcomes of preterm infants. In *Seminars in perinatology* (Vol. 40, No. 8, pp. 510-519). WB Saunders.

Vohr, B. R., Stephens, B. E., Higgins, R. D., Bann, C. M., Hintz, S. R., Das, A., . . . Evans, P. W. (2012) . Are outcomes of extremely preterm infants improving? Impact of Bayley assessment on outcomes. *The Journal of Pediatrics*, *161*(2), 222-228.

Volpe, J. J. (2009) . Brain injury in premature infants: A complex amalgam of destructive and developmental disturbances. *The Lancet Neurology*, *8*(1), 110-124.

Vygotsky, L. (1978) . Interaction between learning and development. *Readings on the Development of Children*, *23*(3), 34-41.

Vygotsky, S. (1986) . *Thought and Language* (rev. ed.) . Cambridge, MA: MIT Press.

W

Wallis, J. D., Dias, R., Robbins, T. W., & Roberts, A. C. (2001) . Dissociable contributions of the orbitofrontal and lateral prefrontal cortex of the marmoset to performance on a detour reaching task. *European Journal of Neuroscience*, *13*(9), 1797-1808.

Wass, S. V. (2015). Applying cognitive training to target executive functions during early development. *Child Neuropsychology*, *21*(2), 150-166.

Waxman, J., Van Lieshout, R. J., & Schmidt, L. A. (2014) . Early adversity and mental health: Linking extremely low birth weight, emotion regulation, and internalizing disorders. *Current Pediatric Reviews*, *10*(3), 208-215.

Waxman, J., Van Lieshout, R. J., Saigal, S., Boyle, M. H., & Schmidt, L. A. (2013) . Still cautious: Personality characteristics of extremely low birth weight adults in their early 30s. *Personality and Individual Differences*, *55*(8), 967-971.

Wellman, H & Liu, D. (2004). Scaling theory of mind tasks. Child Development, 75(2): 523-541.

Werner, E. (1965) . Gesell Developmental Schedules. In Buros, O. (Ed.), *The Sixth Mental Measurements Yearbook.* Highland Park, NJ: Gryphon Press.

Westrupp, E. M., Northam, E., Doyle, L. W., Callanan, C., & Anderson, P. J. (2012). Longitudinal predictors of psychiatric disorders in very low birth weight adults. *Child Psychiatry & Human Development*, *43*(1), 113-123.

White, L. K., McDermott, J. M., Degnan, K. A., Henderson, H. A., & Fox, N. A. (2011) . Behavioral inhibition and anxiety: the moderating roles of inhibitory control and attention shifting. *Journal of Abnormal Child Psychology*, *39*(5), 735–47.

Wiebe, S. A., Espy, K. A., & Charak, D. (2008) . Using confirmatory factor analysis to understand executive control in preschool children: I. Latent structure. *Developmental Psychology*, *44*(2), 575.

Wiley, S., & Meinzen-Derr, J. (2013) . Use of the ages and stages questionnaire in young children who are deaf/hard of hearing as a screening for additional disabilities. *Early Human Development*, *89*(5), 295-300.

Williamson, K. E., & Jakobson, L. S. (2014) . Social perception in children born at very low birthweight and its relationship with social/behavioral outcomes. *Journal of Child Psychology and Psychiatry*, *55*(9), 990-998.

Willoughby, M. T., Blair, C. B., Wirth, R. J., & Greenberg, M. (2010) . The measurement of executive function at age 3 years: Psychometric properties and criterion validity of a new battery of tasks. *Psychological Assessment*, *22*(2), 306.

Willoughby, M., Kupersmidt, J., Voegler-Lee, M., & Bryant, D. (2011) . Contributions of hot and cool self-regulation to preschool disruptive behavior and academic achievement. *Developmental Neuropsychology*, *36*(2), 162-180.

Wilson‐Ching, M., Pascoe, L., Doyle, L. W., & Anderson, P. J. (2014) . Effects of correcting for prematurity on cognitive test scores in childhood. *Journal of Paediatrics and Child Health*, *50*(3), 182-188.

Winstanley, C. A., Theobald, D. E., Dalley, J. W., Cardinal, R. N., & Robbins, T. W. (2006) . Double dissociation between serotonergic and dopaminergic modulation of medial prefrontal and orbitofrontal cortex during a test of impulsive choice. *Cerebral Cortex*, *16*(1), 106-114.

Wolfe, K. R., Vannatta, K., Nelin, M. A., & Yeates, K. O. (2015) . Executive functions, social information processing, and social adjustment in young children born with very low birth weight. *Child Neuropsychology*, *21*(1), 41-54.

Wong, H., Huertas-Ceballos, A., Cowan, F., & Modi, N. (2014). Evaluation of early childhood social-communication difficulties in children born preterm using the quantitative checklist for autism in toddlers. *Journal of Pediatrics, 164* (1), 26-33.

Woodward, L. J., Clark, C. A., Pritchard, V. E., Anderson, P. J., & Inder, T. E. (2011) . Neonatal white matter abnormalities predict global executive function impairment in children born very preterm. *Developmental Neuropsychology*, *36*(1), 22-41.

Woodward, L. J., Lu, Z., Morris, A. R., & Healey, D. M. (2017). Preschool self regulation predicts later mental health and educational achievement in very preterm and typically developing children. *The Clinical Neuropsychologist*, *31*(2), 404-422.

Woodward, L. J., Moor, S., Hood, K. M., Champion, P. R., Foster-Cohen, S., Inder, T. E., & Austin, N. C. (2009). Very preterm children show impairments across multiple neurodevelopmental domains by age 4 years. *Archives of Disease in Childhood-Fetal and Neonatal Edition*, *94*(5), 339-344.

Woolf, S., Woolf, C. M., & Oakland, T. (2010) . Adaptive behavior among adults with intellectual disabilities and its relationship to community independence. *Intellectual and Developmental Disabilities*, *48*(3), 209-215.

World Health Organization. (2012) . Preventing early pregnancy and poor reproductive outcomes among adolescents in developing countries: What the evidence says. http://apps.who.int/iris/handle/10665/70813

Wyatt, T. M. (2013) . *Self-regulation in preschool children: Hot and cool executive control as predictors of later classroom learning behaviors* (Doctoral dissertation). Retreived from George Mason University, USA. http://hdl.handle.net/1920/8211.

Zapnas, K. G., & Zeller, R. A. (2002). Minimizing sample size when using exploratory factor analysis for measurement. *Journal of nursing measurement*, *10*(2), 135-154.

Zelazo, P. D., & Cunningham, W. A. (2007). Executive function: Mechanisms underlying emotion regulation.

Zelazo, P. D., & Frye, D. (1998) . Cognitive complexity and control: II. The development of executive function in childhood. *Current Directions in Psychological Science*, *7*(4), 121-126.

Zelazo, P. D., & Müller, U. (2002) . Executive function in typical and atypical development. In U. Goswami (Ed.) *Handbook of Childhood Cognitive Development* (pp. 445-469) . Oxford, UK: Blackwell.

Zelazo, P. D., Qu, L., & Kesek, A. C. (2010) . Hot executive function: Emotion and the development of cognitive control. In S. D. Calkins & M. A. Bell (Eds.), *Child development at the intersection of emotion and cognition* (pp. 97-111). Washington, D.C. American Pyschological Association.

Appendix A: Preschool Social Cognitive Milestones.

In typical development, the first year of life is characterized by development of face recognition and emotion perception, with social judgment, perspective taking (also referred to as theory of mind), and moral reasoning emerging in the preschool years. At this time, children's understanding of the mental states or "minds" of others changes rapidly as they begin to comprehend that their knowledge and beliefs about the world and others is person-specific. Three-year-olds can identify basic emotional expressions (e.g., mad, sad, happy, scared) and certain situations that generally elicit these emotions in themselves and others (Denham et al., 2003 in Lane et al., 2010). They begin to understand that others may not feel the same way as they do in similar situations and may hold different desires and beliefs (Wellman & Liu 2004). By four years of age, an understanding that others can hold beliefs that are contrary to reality (false beliefs), that others can lie or deceive, and that information can misrepresent the state of affairs emerges. By five years of age, preschoolers can differentiate between superficially apparent and underlying real emotions, understanding that the emotions a person intentionally displays may not be the same as internally experienced (Harris et al., 1986). Role playing and perspective taking emerge along with prosocial decision making as inhibitory control develops, enabling the young child to control initial or automatic reactions or to forgo a personally-advantageous decision in favour of a more socially acceptable decision (Kochanska, Murray, & Coy, 1997).

Appendix B: Independent Medical Variables Of Interest

Variable of Interest:	Coded:
Sex*	1 = male, 2 = female
Gestational Age (weeks)	By weeks. Further by group: 1= 30–32 weeks; 2= 28–29 weeks; 3= < 28 weeks
Chronological age at testing	By weeks
Corrected age at testing	By weeks
Birth Weight (g.)	By grams. Further by group: 1= 1250–1500 gm.; 2= 1000–1249 gm.; 3= < 1000 gm.
APGAR score	Range/10 at 1 minute and 5 minutes
Small for Gestational Age	Absent (0) or present (1)
Multiple Births	Absent (0) or present (1)
Brain Injury: Interventricular Hemorrhage (IVH)	By side &severity: 0 (none)– 4 (severe)/ left or right Further by group: 0 (none), 1 (mild - scores of 1 or 2), or 2 (significant - scores of 3 or 4)
Brain Injury: Periventricular Leukomalaica (PVL)	By side & severity: 0 (none)– 4 (severe); left or right. Further by group: No PVL (0) or PVL present (1)
Retinopathy of Prematurity (ROP)	By side & severity: Absent (0) or present (1)/ left or right Further by group: 0 (none), 1 (mild-scores of 1 or 2), or 2 (significant- scores of 3 to 5)
Apnea and Bradycardia	Absent (0) or present (1)
Bronchopulmonary Dysplasia	Absent (0) or present (1)
Supplemental oxygen	Total days administered during admission
Length of hospitalization	Total days prior to NICU discharge
* Information not available regarding gender identity.	

Appendix C: Psychometric Properties of Test Measures

Psychometric Properties of Test Measures.

Evidenceas:	BRIEF-p	BASC-p	ABAS-II 0-5 yrs.	Mullen Scales	BSID- III	GDS
a) Reliability						
Normative population $n \geq 200$.	✓	✓	✓	✓	✓	✓
Internal Consistency ≥.80	✓	✓	✓	.75-.83	✓	.61-.98
Test-Retest reliability ≥.70	✓	✓	✓	✓	.67-.94	✓
Inter-rater reliability ≥.75	n/a	.66-.69	✓	✓	✓	✓
b) Validity						
Content-related evidence	✓	✓	✓	✓	✓	✓
Criterion Referenced	✓	✓	✓	✓	✓	✓
Diagnostic validity	✓	✓	✓	✓	✓	✓

(For more information, see Ditterline & Oakland, 2009; Feeney-Kettler et al., 2011; Kaplan & Saccuzzo, 2009; McCann, Rider, Weiss, Litman, & Baron, 2014; Oakland & Daley, 2013; Sherman & Brooks, 2010; Mullen, 1995; Stoesz, Montgomery, Smart &Hellsten, 2011; Tan, 2007).

Appendix D: Components and Cut-offs of Study Measures

Test and Individual Scores	Score Type	At-Risk Cut-off	Clinically Significant Cut-off
Behavior Rating Inventory of Executive Function			
Inhibitory Self-Control Index	T score	>60	>65
Flexibility Index	T score	>60	>65
Emergent Metacognitive Index	T score	>60	>65
Global Executive Composite	T score	>60	>65
Inhibition scale	T score	>60	>65
Shift scale	T score	>60	>65
Working Memory scale	T score	>60	>65
Planning / Organization scale	T score	>60	>65
Emotional Control scale	T score	>60	>65
Behavior Assessment System for Children			
Externalizing Index	T score	>60	>70
Internalizing Index	T score	>60	>70
Behavior Symptom Index	T score	>60	>70
Hyperactivity scale	T score	>60	>70
Aggression scale	T score	>60	>70
Attention scale	T score	>60	>70
Anxiety scale	T score	>60	>70
Depression scale	T score	>60	>70
Somatization scale	T score	>60	>70
Atypicality scale	T score	>60	>70
Withdrawal scale	T score	>60	>70
Adaptive Composite Index	T score	< 40	<30
Adaptability scale	T score	< 40	<30
Social scale	T score	< 40	<30
Functional Communication scale	T score	< 40	<30
Activities of Daily Living scale	T score	< 40	<30
Adaptive Behavior Assessment System			
Conceptual Composite	Standard	< 85	<70
Social composite	Standard	< 85	<70
Practical Composite	Standard	< 85	<70
Global Aaptive Composite	Standard	< 85	<70
Self Direction scale	Scaled	< 8	<6
Social scale	Scaled	< 8	<6
Preacademic Scale	Scaled	< 8	<6
Communication scale	Scaled	< 8	<6

Motor scale	Scaled	< 8	<6
Community Use scale	Scaled	< 8	<6
Home living scale	Scaled	< 8	<6
Health scale	Scaled	< 8	<6
Leisure scale	Scaled	< 8	<6
Self-Care scale	Scaled	< 8	<6
Bayley Scales of Infant Development: 2nd edition			
Physical Developmental Index	Standard	< 85	<70
Mental Developmental Index	Standard	< 85	<70
Bayley Scales of Infant Development: 3rd edition			
Cognitive	Standard	< 85	<70
Langauge composite	Standard	< 85	<70
Receptive Langauge scale	Scaled	< 8	<6
Expressive langauge scale	Scaled	< 8	<6
Fine motor scale	Scaled	< 8	<6
Gesell Developmental Schedule			
Cognitive Scale	Standard	< 85	<70
Langauge Scale	Standard	< 85	<70
Mullen Scales of Early Learning			
Early Learning Composite	Standard	< 85	<70
Visual Perceptual scale	T score	< 40	<30
Fine Motor scale	T score	< 40	<30
Receptive Language scale	T score	< 40	<30
Expressive Langauge scale	T score	< 40	<30