A LATENT GROWTH MODELLING APPROACH TO INVESTIGATING GENDER DIFFERENCES IN THE DEVELOPMENT OF BEHAVIOURAL SELF-REGULATION AND ACADEMIC OUTCOMES FROM KINDERGARTEN TO GRADE 2

by

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A growing body of literature indicates the behavioural aspect of self-regulation, including paying attention, remembering instructions, controlling impulses and directing one’s action, amidst environmental distractions, is a critical component of successful school functioning. Some studies have identified differences between male and female students’ behavioural self-regulation abilities; however, it is unclear whether improvements in this ability are influenced by gender and whether they parallel growth in the development of reading and math abilities. The present study explored gender differences in the development of children’s behavioural self-regulation from kindergarten to Grade 2, using a direct assessment. Longitudinal associations between behavioural self-regulation and early reading and math skills were also examined. A latent growth modelling approach was utilized for the analyses across three waves of data collection. The study participants included 197 children (106 males and 91 females). On average, children were approximately five years old at the start of the study ($M=5.39$, $SD=0.593$). The study results revealed gender similarities in behavioural self-regulation growth, positive correlated initial skill levels and rates of growth.
between behavioural self-regulation and reading, and positive correlated initial skill levels between behavioural self-regulation and math. Implications for future research, as well as educational policies and instructional practices, are discussed.
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CHAPTER 1
INTRODUCTION

The ability to control one’s thoughts, emotions and behaviour in accordance with circumstantial demands and societal expectations is considered a strong determinant of one’s successes and failures throughout life (Berger, 2011; Duncan et al., 2007; Mischel et al., 2011). The broad and multidimensional construct of self-regulation emerges in a rudimentary format within the first few months of life and continues developing into young adulthood (Baumeister & Vohs, 2016; Bronson, 2000). Difficulties with self-regulation have been linked to a wide array of individual dysfunctioning, including social and behavioural problems (Montroy, Bowles, Skibbe, & Foster, 2014; Tarullo, Obradovic, & Gunnar, 2009; White et al., 1994), unfavourable academic outcomes (Blair & Raver, 2015), unsuccessful careers, poor relationships and physical health issues (Moffitt et al., 2011). Conversely, optimal levels of self-regulation have been associated with the capacity to avoid such self-defeating behaviour and underperformance (Bauer & Baumeister, 2011; Tangney, Baumeister, & Boone, 2004).

Children enter kindergarten with varying levels of self-regulation abilities. Although some children may outgrow behavioural difficulties associated with poor self-regulation, for others problem behaviour may persist and interfere with adaptive school functioning in subsequent years (Finn & Pannozzo, 2004; Graziano, Reavis, Keane, & Calkins, 2007; Sutherland, Lewis-Palmer, Stichter, & Morgan, 2008). Previous research suggests the ability to self-regulate is a foundational skill that facilitates positive classroom learning-related behaviour and academic achievement (McClelland et al., 2014). However, approximately one-third of kindergarten students display developmental vulnerabilities associated with poor self-regulation.
and are more likely to experience poor school outcomes and diminished school readiness
resulting from poor self-regulation can have long-term consequences that extend beyond
elementary school and into high school and later adulthood (McClelland, Acock, & Morrison,
2006; Moffitt et al., 2011).

1.1 Background

Compelling neuroscientific evidence suggests that the domains of self-regulation—
including cognition, emotion and behaviour—develop in parallel with dynamic changes that take
place in specific brain regions, most notably the prefrontal cortex during the early childhood
years (Calkins & Bell, 2010; Diamond, 2002; Posner & Rothbart, 2000; Posner, Rothbart, &
Voelker, 2016). As such, early self-regulation developmental trajectories are of particular
interest, since during this time, growth in brain development is accelerated and shows heightened
receptivity to environmental influences such as the quality of early caregiving and other social
experiences (Bronson, 2000; Kopp, 1982; Tarullo et al., 2009), both within the home (Bernier,
Carlson, & Whipple, 2010; Evans & Rosenbaum, 2008; Gunzenhauser & von Suchodoletz,
2015) and within the school environment (Hur, Buettner, & Jeon, 2015; Mashburn et al., 2008;
Peeters et al., 2014; Rimm-Kaufman, Curby, Grimm, Nathanson, & Brock, et al., 2009). That
said, the current study is guided by the theoretical perspective that the development of self-
regulation is influenced by the “transactional process” that occurs between biological maturation
and environmental factors (Duncan, McClelland & Acock, 2017). As children mature they
develop self-regulatory skills but the timing and rate of development can vary depending on
contextual influences. For example, poor-quality early life experiences can have adverse effects
on brain development, whereas high-quality early experiences that include nurturing and supportive relationships can foster healthy brain development and a strong foundation for future learning, behaviour, and health (National Scientific Council on the Developing Child, 2007). In addition to these contextual influences, child level factors (e.g., language skills) can affect the rate at which children develop self-regulatory skills and contribute to individual level differences in this important skill (Montroy, Bowles, Skibbe, McClelland, & Morrison, 2016). Thus, given our greater understanding of self-regulation processes and their emergence in early brain development, it is not surprising that many research studies in the area of developmental psychology and education have been conducted with young children upon entry into the formal school system. The preschool years are a pivotal point in the development of self-regulation (Diamond, 2002; Garon et al., Bryson, & Smith, 2008; Zelazo et al., 2003); however, children continue developing self-regulation skills throughout elementary school and later into adolescence, which further underscores the importance of investigating developmental trajectories beyond the preschool years (Best, Miller, & Jones, 2009; Diamond & Lee, 2011). The current study focuses on children from kindergarten to Grade 2.

Studies show that children’s self-regulation skills are predictive of their academic performance both concurrently (Schmitt, Pratt, & McClelland, 2014) and in the longer term (Lonigan, Allan, & Phillips, 2017; Montroy et al., 2016). For example, studies show kindergarten children with strong behavioural self-regulation skills are better equipped to navigate the school environment and do better academically compared to their peers who struggle to regulate their behaviour (Blair, 2002; McClelland et al., 2007; McClelland et al., 2014; Ponitz, McClelland, Matthews, & Morrison, 2009). In a classroom setting, individual behavioural self-regulation skills are seen as healthy when children can simultaneously integrate multiple cognitive abilities.
such as paying attention to the teacher’s directions, remembering those directions to complete a
given task and flexibly moving on to the next task despite irrelevant distractions (Diamond et al.,
2002; McClelland & Cameron, 2012). In contrast, children with difficulties regulating their
behaviours may be easily distracted and demonstrate inattentiveness and poor control over
impulsive behaviours, making it difficult for them to take advantage of learning opportunities in
the classroom. The skills underlying behavioural self-regulation are considered to be executive
functions and are typically assessed through the administration of objective measures of
individual behavioural self-regulation (e.g., holding multiple pieces of related information in
mind and simultaneously switching tasks, or if not switching tasks, being able to perform actions
while holding multiple sources of information in mind) as well as parent ratings of behaviour in
the home environment and teacher ratings of behaviour in the classroom. The current study
focuses on the behavioural aspect of self-regulation based on direct assessments.

To obtain a better understanding about the potential influences on academic achievement,
some studies have explored the development of behavioural self-regulation in different genders
to help explain gaps in achievement (Gestsdottir et al., 2014; Gunzenhauser & von Suchodoletz,
2015; Son, Lee, & Sung, 2013; Størksen, Ellingsen, Wanless, & McClelland, 2015; Wanless et
al., 2013). The current study specifically focuses on the role of gender in the development of
self-regulation skills to explore whether patterns of growth differ for girls and boys, as so few
studies have addressed this question. The role of gender is viewed from a sociocognitive
perspective, which sees gender identity or labelling as socially constructed and the development
of gender conceptions and behaviour as shaped by a wide range of social influences at the
familial and societal levels; however, this approach acknowledges that some gender differences
can be ascribed to biological factors (Bussey & Bandura, 1999). It is worth noting that
biologically-oriented theories about gender development focus primarily on the influence of sex differences (e.g., hormones, chromosomes and reproductive organs) on gender-related behaviour and typically downplay the influence of socialization and cognitive factors (Hines, 2010; Hines, 2011).

Girls typically score higher on standardized achievement tests and have fewer incidents of problem behaviours than boys. For example, elementary school girls outperform boys on standardized assessments of reading and writing and perform similarly to boys in math (Education Quality and Accountability Office, 2016). Within the province of Ontario and indeed internationally, education statistics indicate suspension and expulsion rates are higher for boys compared to girls (Matthews, Ponitz, & Morrison, 2009; Ontario Ministry of Education, 2016).

Previous research shows that self-regulation and externalizing behaviour problems such as conduct disorder, hyperactivity and peer problems in young children are linked both concurrently (Willoughby, Kupersmidt, Voegler-Lee, & Bryant, 2011) and longitudinally (Hughes & Ensor, 2011; Lonigan et al., 2017; Riggs, Blair, & Greenberg, 2004; Sulik et al., 2015). It is therefore important to further explore the influence of gender on the development of behavioural self-regulation as a potential explanation for achievement differences, given the link established between behavioural self-regulation and school functioning (Matthews et al., 2009; McClelland et al., 2007; Wanless et al., 2013). In addition, it is also important to investigate whether gender contributes to a more nuanced understanding of early developmental trajectories in behavioural self-regulation since research evidence can serve as a rationale for supporting changes to education policies regarding instructional practices aimed at reducing gaps in student achievement. If kindergarten boys lag behind girls in their behavioural self-regulation skills then perhaps education policies could focus on providing boys with tailored supports and structures to
help them successfully learn and develop self-regulation skills earlier in the formal school system and require school boards to act on early screening and identification of challenges in this area (Center on the Developing Child at Harvard University, 2011). The presence of gender similarities also has implications for education policies and practice as it may suggest the need for tailoring supports in an individualized manner for all students rather than on the basis of gender alone. Mounting evidence suggesting linkages between self-regulation and academic performance further underscores the importance of investigating potential influences on behavioural self-regulation development. This is because early academic performance sets the stage for later academic success and greater benefits can be derived both on a societal and individual level when proactive supports are in place early to help students successfully meet school demands, rather than relying on remedial programs and services in later school years (Heckman, 2013).

Results from previous studies using cross-sectional data or two-time point comparisons to study the influence of gender on behavioural self-regulation have varied in part due to the type of measurement used for assessment purposes and the context in which the assessment was conducted. For example, a proportionally large number of studies in the area of early behavioural self-regulation development have been conducted in the U.S. and overall the results show that girls between the age of three and six years outperform boys on direct assessments of behavioural self-regulation and teacher ratings of classroom-related behaviour (Matthews et al., 2009; McClelland et al., 2007; Montroy et al., 2016; Wanless et al., 2013). In contrast, results from the relatively smaller number of studies on children from other settings have been less consistent in terms of gender differences based on similar measures of behavioural self-regulation (Gestsdottir et al., 2014; Letourneau, Duffett-Leger, Levac, Watson, & Young-Morris,
2013; von Suchodoletz et al., 2013; Wanless et al., 2016). While a number of studies have explored the development of behavioural self-regulation and gender associations over the transition period from preschool to kindergarten, only a few have investigated the influence of gender on children’s developmental growth trajectories of behavioural self-regulation from kindergarten to early elementary school. Even fewer studies have examined the linkages between growth in behavioural self-regulation and simultaneous growth in early reading and math development. It is important to investigate these areas further given the growing empirical evidence showing the connections between these critical skills. Furthermore, these connections could have implications for instructional practices. In sum, it remains to be seen if gender influences growth in behavioural self-regulation in kindergarten children and whether this growth is paralleled with growth in early literacy and math skills.

1.2 Objectives of the study

Given the important role that self-regulation plays in academic performance, increasing attention continues to be placed on these skills in young children; however, it is unclear how the developmental process unfolds over time in relation to gender and other factors. In addition, little is known about the association between trajectories of growth in self-regulation and academic performance and how improvement in these skills relates over time. As previously mentioned, the majority of studies have investigated the influence of gender on the development of behavioural self-regulation and associations with academic performance using a cross-sectional research design to examine concurrent relations or predictive associations using two waves of data, controlling for initial scores on the outcome and assuming all children start at the same level (e.g., autoregressive models). Neither approach provides an accurate representation of the
developmental growth trajectories in terms of continuous change over time (Curran, Obeidat, & Losardo, 2010; Rogosa, Brandt, & Zimowski, 1982). Therefore, to better understand and support early development of self-regulation, there is a need to examine not only potential influences on the development of this ability but also how this development unfolds over time in relation to the development of emerging academic competencies (Curran, McGinley, Serrano, & Burfeind, 2012; Settersten & McClelland, 2015). Only one known study has examined the relationship between executive functions associated with behavioural self-regulation and academic competencies from preschool to kindergarten (Schmitt, Geldhof, Purpura, Duncan, & McClelland, 2017). No other studies have examined to what extent these trajectories develop in tandem across the kindergarten and early elementary school years.

The current study builds on and extends previous research by contributing to the understanding of the development of behavioural self-regulation as it unfolds over time in kindergarten children and exploring its potential influence on academic performance (Curran et al., 2012; Li-Grining, Votruba-Drzal, Maldonado-Carreño, & Haas, 2010). As such, the first goal of the current study is to explore the role of gender in the growth process of behavioural self-regulation from the spring of kindergarten to the spring of Grade 2 over three waves of data collection, through a latent growth modelling approach. As only a few studies have examined the co-development of behavioural self-regulation and academic achievement through latent growth modelling, the second goal of the current study is to explore whether growth in behavioural self-regulation parallels growth in reading ability. Similarly, the third goal is to examine the growth trends in behavioural self-regulation and math ability, from kindergarten to Grade 2.
CHAPTER 2
LITERATURE REVIEW

This chapter explores the current body of research concerning children’s development of self-regulation and its associations with academic performance. It includes a review of the literature on how self-regulation is defined, how it is measured and develops in children, how it relates to gender, and the role it plays in reading and math skills during kindergarten and early elementary school.

2.1 Diverse theoretical perspectives of self-regulation

There are multiple theoretical perspectives from diverse disciplines about the conceptualization of self-regulation. So it is not surprising that there is little consensus on a standard definition and common terminology. For instance, from a temperament perspective, emphasis is placed on effortful control (e.g., inhibitory control) and its connection to emotional and behavioural regulation (Blair & Razza, 2007; Raver, 2004; Rothbart & Ahadi, 1994). From a neuroscience-based approach, the neural connections among brain structures and other neurological systems are of interest, particularly as they relate to cognitive abilities (Hongwanishkul, Happaney, Lee, & Zelazo, 2005; Zelazo & Mueller, 2002). In the field of developmental psychology, cognitive and emotional control processes are studied under the broad construct of self-regulation (Blair & Raver, 2012; Calkins & Bell, 2010; Zelazo & Cunningham, 2007). Notwithstanding these divergent conceptualizations, there is consensus that self-regulation is highly complex and multidimensional (Bauer & Baumeister, 2011) with components that function independently yet are interrelated (Miyake et al., 2000) and observable across physiological, attentional, emotional, behavioural, cognitive and social domains (Calkins & Bell, 2010; Calkins & Fox, 2002; Shanker, 2013). Furthermore, it is generally agreed that self-
regulation is the ability to consciously control one’s thoughts, emotions and behaviour for purposes of adaptive functioning (Bauer & Baumeister, 2011; Calkins & Bell, 2010; McClelland, Cameron Ponitz, Messersmith, & Tominey, 2010; Schunk & Zimmerman, 1997).

2.2 Definition of behavioural self-regulation

The current study focuses on the behavioural aspects of self-regulation and children’s ability to integrate the core components of executive functions based on a behavioural self-regulation task (McClelland et al., 2007; Ponitz et al., 2009; Wanless, McClelland, Acock, Chen, & Chen, 2011). In accordance with this conceptualization, the definition of behavioural self-regulation for this study is adapted from McClelland et al. (2014) and is defined as adaptive behavioural responses observed in the form of gross motor movements that stem from the integration of underlying executive functions typically observed in a classroom setting (e.g., paying attention, taking turns, staying on task, switching tasks). Executive functions are cognitive skills or mental processes that facilitate controlled goal-directed behaviour for learning, academic achievement and adaptive behaviour, which in turn support self-regulation (Best & Miller, 2010; Carlson, 2005; Jacobson & Mahone, 2012; Lyons & Zelazo, 2011).

2.2.1 Components of behavioural self-regulation

The basic facets of executive functions are comprised of three separate but interrelated components: attentional flexibility, working memory and inhibitory control (Diamond, 2013). These components operate in an integrated and deliberate manner and provide children with the skills to regulate their behaviour, pay attention to the teacher’s instructions and recall those instructions in order to stay on-task (McClelland et al., 2010). Specifically, working memory includes the ability to store and manipulate information in a short period of time. For example, it
allows children to remember a set of instructions, carry out mental math, connect paragraphs while reading, think about options and understand events in temporal sequence (Blair & Ursache, 2011; Diamond, 2013; Shonkoff & Phillips, 2000). Inhibitory control includes the ability to stop an automatic or prepotent response (e.g., habitual, dominant or inappropriate response), ignore irrelevant stimuli (e.g., focusing on relevant information and ignoring distractions or extraneous information) and assess a potential response (e.g., error detection) to allow for a more favourable context-specific behaviour or response (Day, Connor, & McClelland, 2015; Dowsett & Livesey, 2000). Working memory and inhibitory control are both predictive of math ability in early elementary school children. For example, Bull and Scerif (2001) found that children with weak math skills can remember previously learned math strategies but cannot inhibit the learned strategy from coming into conscious awareness and switching to a new strategy to solve a math related task (e.g., perseveration or answering incorrectly based on the previously learned strategy), after accounting for reading ability and general intelligence. In addition, children with weak math skills also showed difficulties with inhibiting irrelevant information from entering working memory. These findings suggest that children who lack inhibitory control and have poor working memory also have difficulties switching and evaluating new strategies which can negatively affect their performance on math related tasks. The third component, attentional flexibility, refers to the ability to control one’s attention despite distractions in order to concentrate and sustain attention on a given task and flexibly shift to a new task (Barkley, 1997; Blair & Diamond, 2008; McClelland & Cameron, 2012; Rothbart & Rueda, 2005). Attentional flexibility builds on working memory and inhibitory control; improvements in the ability to hold abstract goal representations in mind such as task planning and inhibition of “old habits” facilitates greater flexibility in problem-solving skills (Munakata, Snyder, & Chatham, 2012).
Deficits in working memory and attentional flexibility have been linked to increased risks of reading and math difficulties in early elementary school children, after controlling for children’s reading and math ability in kindergarten and other background characteristics (Morgan et al., 2017).

2.3 Top-down and bottom-up processes

Although the current study focuses specifically on the behavioural aspect of self-regulation, it is important to acknowledge the interplay between the cognitive components of executive functions and emotion control processes, given both are central features of self-regulation (Blair & Dennis, 2010; Blair & Razza, 2007; Lyons & Zelazo, 2011; Zelazo & Cunningham, 2007). As discussed, the cognitive aspects of executive functions involve working memory, inhibitory control and attentional flexibility, whereas emotional regulation is generally described as the modulation of one’s emotional responses (Calkins & Bell, 2010; Eisenberg & Spinrad, 2004; Graziano et al., 2007; Shanker, 2013). Cognition and emotion control processes are interconnected on a biological and behavioural level through the processing of incoming stimuli and deployment of necessary responses (Calkins & Bell, 2010; Cole, Martin, & Dennis, 2004). One way to view this association or bidirectional relationship is in terms of top-down and bottom-up control processes (Blair & Ursache, 2011; Hongwanishkul et al., 2005). From the top-down, higher-order cognitive processes (i.e., executive functions) consciously direct and organize emotional processes. Higher-order executive functions enable goal-directed behaviour by controlling attention, thinking and actions in a top-down and deliberate manner (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Masten et al., 2012; Willoughby et al., 2011; Zelazo & Müller, 2002). Top-down processes are influenced by bottom-up processes that are
associated with more non-conscious and automatic emotional processes such as physiological arousal, stress, anxiety and motivation (Blair & Ursache, 2011; Blair & Dennis, 2010; Blair & Razza, 2007; Lyons & Zelazo, 2011; Zelazo & Cunningham, 2007). Simple tasks that have been overlearned invoke more automatized and less top-down control, while novel and unfamiliar tasks activate more top-down cognitive control processes. Automaticity occurs when tasks are simple, overlearned or routine such that less top-down executive function control processing is required (Anderson, Jacobs, & Anderson, 2008; De Luca & Leventer, 2008; Jacobson & Mahone, 2012).

2.4 Development of self-regulation

In general, theories concerning the development of self-regulation suggest that growth is gradual and parallels brain maturation of the prefrontal cortical region (Berger, 2011; Best & Miller, 2010; Diamond, 2006; Munakata et al., 2012; Zelazo & Müller, 2002; Zelazo et al., 2003). The prefrontal cortex requires at least two decades of development to reach full maturity, although this gradual change is characterized by periods of heightened growth, particularly at the end of the first 12 months of life, during the preschool and early elementary school years (Diamond, 2002; Diamond, 2013). The protracted development of the prefrontal cortex makes it susceptible to the influence of environmental input, particularly during these sensitive periods when the brain is highly receptive to such influences (Hertzman & Boyce, 2010). Environmental input shapes the development of brain circuitry that underlies executive functions associated with self-regulatory capacities (Center on the Developing Child at Harvard University, 2011). On a molecular level, both the environment and experiences can profoundly impact developmental outcomes such as behaviour, learning, and physical and mental health through chemical
modification of gene expression (National Scientific Council on the Developing Child, 2010; Tierney & Nelson, 2009). In the home environment, infants are almost completely dependent on the primary caregiver to support regulation of their emotions and behaviour (Tarullo et al., 2009); however, through increasing social engagement and development of language skills, gradual progression towards more self-directed and internally driven regulation of thoughts and actions is achieved by early elementary school (Berk & Winsler, 1995).

It is important to note that upon entry into kindergarten, children are still developing executive functions associated with self-regulatory skills and on an individual level differences in these skills may vary widely. The rate at which children develop and master self-regulatory skills may differ based on individual child characteristics and environmental factors (Montroy et al., 2016). For example, language skills may contribute to individual differences in self-regulation. On a theoretical basis, language provides children with the “mental tools” (e.g., the use of words in self-talk or private speech, at first externally and then internally) to organize and regulate their thoughts and behaviours in a manner that is conducive to the social expectations of a given situation (Vygotsky, 1934/1986). In line with this theory, previous research indicates that children who begin kindergarten with strong expressive (Montroy et al., 2016) or receptive (Wanless et al., 2016) language skills are more likely to develop self-regulation skills at an earlier age over the developmental trajectory through early elementary school, compared to children with weaker language skills. Other important sources that may contribute to individual differences in self-regulation include, but are not limited to, family processes such as early parent-child attachment and the degree of caregiver sensitivity and responsiveness for supporting the development of self-regulatory skills (Bernier, Carlson, Deschênes, & Matte-Gagné, 2012; Glaser, 2000), and child temperament in terms of the effects of high and low levels of emotion.
reactivity and regulation of emotion reactivity on behaviour (Rothbart, Posner, & Kieras, 2006). Hence, there are many reasons why children may show individual differences in self-regulation starting at school entry. The current study explores the influence of child gender and mother’s education on the development of behavioural self-regulation.

In the following section, the components of executive functions will be discussed in relation to the development of self-regulation.

2.41 Executive attention

Underlying the development of all facets of self-regulation is attention (Berger, 2011; Posner & Rothbart, 1998). Greater attentional flexibility supports effective self-regulation (Vohs & Baumeister, 2011). Attentional networks appear to play a foundational role in the development of executive functions (Garon et al., 2008). The attentional system is comprised of three interrelated neural networks: alerting, orienting and executive. The alerting or sustained attentional network maintains active awareness of or sensitivity to relevant external stimuli in order to facilitate readiness for a “vigilant” or “defensive” behavioural response (Derryberry & Rothbart, 1997). The orienting attentional network is responsible for positioning or placing attention in terms of movement from engagement to disengagement of attention (Rothbart, Sheese, Rueda, & Posner, 2011). The third network, the central executive attentional network (also referred to as the anterior attention system), is primarily involved with conflict resolution of thoughts, feelings and responses in relation to controlling goal-directed behaviour (Rueda, Posner, & Rothbart, 2011). Alertness emerges in the first three months of life and continues developing into middle childhood (Rueda et al., 2004). From around three to six months, the orienting network develops and becomes fully functional, allowing for selective and focused
attention. At 12 months, as executive attention matures, it exerts greater control over the orienting network and attention becomes more independently controlled and voluntary. Significant development in attention control occurs during the preschool years and continues into middle childhood with greater adeptness at shifting attention, sustaining attention for longer durations, engagement in structured activities, and conflict resolution (Garon et al., 2008; Ruff & Rothbart, 1996; Ruff & Capozzoli, 2003). Executive functions build on these attentional networks and facilitate information processing (Garon et al., 2008). The development of executive functions is discussed in the following section on the extant literature in terms of age-related changes as demonstrated on various performance tasks.

2.42 Inhibitory control

Inhibitory control enables one to resist the urge to be reactive and unthinking, to act on impulse without consideration of rules or socially acceptable norms, and to focus on distractions or irrelevant information that could interfere with staying on task (Diamond, 2013). Inhibitory control emerges in infancy at around eight to nine months of age and age-related improvements continue into later childhood. Barkley (2011) argues inhibitory control is central to the development and efficient functioning of other executive processes. Assessments of inhibition show that older infants and toddlers can successfully tackle simple inhibitory tasks such as withholding the impulse to touch a desirable toy when the caregiver or experimenter tells the child to suppress the impulse (Garon et al., 2008; Kochanska & Aksan, 1995). Whereas toddlers may be capable of inhibitory control occasionally, preschool children can exercise this skill more often. For example, delay of gratification tasks that have been used to examine age-related differences in inhibitory control show that older preschool children demonstrate stronger
inhibitory control compared to younger children, as they are able to suppress their desire for a reward for a longer duration of time (Carlson, 2005) or choose a larger but delayed reward in place of a smaller but more immediate reward (Lemmon & Moore, 2007). Difficulties emerge, however, with increasingly complex inhibitory control tasks that require the addition of working memory to hold several task rules in mind and inhibit a prepotent response in order to deliver the correct response (Best & Miller, 2010). For example, on conflict tasks such as the A-not-B task, younger infants have difficulty inhibiting a prepotent response and demonstrate difficulties with changing their search behaviour after a hidden object has shifted location (perseverative A-not-B error). Older infants aged eight to 12 months can successfully utilize working memory to remember where an object is hidden and to inhibit the inclination to repeat a previous response. When the task is further complicated, however, and the object is placed in an invisible container and subsequently hidden in a similar manner, task performance is unsuccessful up until around the age of two years (Diamond, 2006; Diamond, 1990; Diamond & Taylor, 1996). Rapid improvement in the development of inhibitory control is evident in the preschool years. By age four, children can successfully withhold a dominant response and provide a different response to more complex inhibition tasks. Improvement in inhibitory control as children mature is demonstrated through increased accuracy of responses on inhibition tasks and fewer errors. At 4.5 years of age, children can successfully complete complex inhibition tasks (Best et al., 2009; Best & Miller, 2010). Marked improvement in inhibitory control is also evident in early elementary school children. In a meta-analysis of studies about frontal lobe functioning and inhibitory control from age five to adulthood, Romine and Reynolds (2005) found the largest effect size for age-related increases in inhibition of perseveration (response accuracy) occurred
amongst children aged five to eight years. As children become more adept at inhibitory control, less effort is required on performance tasks to respond correctly.

2.43 Working memory

Working memory is the ability to store information in mind over a short time span; however, unlike short-term memory, it involves the ability to also recall information for purposes of manipulating it to meet a specific current goal (Baddeley, 1986; Best et al., 2010; Pelphrey & Reznick, 2003). For instance, the temporal aspect of working memory facilitates the ability to draw connections and make inferences based on past and current information items, and to manipulate the information in order to derive solutions or alternatives (Diamond, 2014). Children aged eight to 12 months are capable of holding information in mind (mental representation) over a period of delay as demonstrated by performance on the A-not-B task (Diamond, 1991); however, the ability to update and manipulate the information develops later (Garon et al., 2008). On the A-not-B task, a brief delay is administered between the time the object is hidden and when the infant is permitted to find the object. Infants are capable of waiting several seconds and holding information in mind before finding and reaching for the object. As infants mature, they are able to hold information in mind for increasingly longer durations (Gerstadt, Hong, & Diamond, 1994). This ability is the prerequisite for the capacity to retain many pieces of information in mind for purposes of processing (Garon et al., 2008; Pelphrey et al., 2004). Improvement in working memory, as demonstrated by better performance on increasingly complex working memory tasks, continues into the preschool years and early adolescence (Best, 2010). For example, Carlson (2005) showed that children performed with increasing success on the backward digit span task from age three to five years. The task involves the child recalling
and verbally repeating a list of digits backwards from two digits to five digits. In another study with participants aged five to 20 years, Cragg and Nation (2007) showed age-related improvements on the self-ordering pointing task from age five to 11 years, although the younger adults demonstrated better performance. The self-ordering pointing task involved pointing only once to each picture in a given set of four to 10 pictures per game trial until all pictures had been touched.

2.4.4 Attentional flexibility

Building on inhibitory control and working memory, the third core executive function is the ability to adeptly shift between two or more different mental sets or tasks in order to successfully adapt to a change in circumstance, demands, priorities or perspectives (Diamond, 2013). Attentional flexibility requires the inhibition of one or more mental sets, depending on the task at hand, as well as working memory to hold rules in mind, and update and manipulate rules in order to shift between mental sets (Best, 2010). For example, thinking “outside the box”, through the inhibition of previous ways of thinking and manipulation of information, might allow one to be better positioned to view an idea or perspective from a different angle (Diamond, 2014). On simple attentional flexibility tasks, three and four year olds can perform successfully when mental sets or inhibitory control demands are minimized (Hughes, 1998; Rennie, Bull, & Diamond, 2004). For example, on reverse sorting tasks, three-year-old children are capable of remembering sorting rules if only one dimension (e.g., shape or colour) is involved across a series of trials. This ability has been demonstrated in the shape game where two sets of rules are played: a “sensible” shape game that involves sorting trucks with trucks and stars with stars, and a “silly” shape game where trucks are sorted with stars and stars with trucks, which results in less
emphasis on inhibitory control since the stimuli in both games differs along only one dimension (Diamond, 2013; Rennie, Bull, & Diamond, 2004). Attentional flexibility improves with age as demonstrated by performance on more complex tasks. For example, on the Dimensional Card Change Sorting (DCCS) task children are asked to sort a set of cards that involve both shape and colour (e.g., yellow and red cars and trucks). In the pre-shift phase, children are cued to sort the cards according to the colour dimension (e.g., “put all the yellow cards here and all the red cards there”) and in the post-shift phase they must switch to a new pair of rules and are cued to sort the cards according to the shape dimension (e.g., “put all the cars here and all the trucks there”). Thus, they are asked to change their sorting system based on either the dimension of colour or shape. Despite knowing the rules, younger children have difficulty disengaging and pulling attention away from the initial rule and redirecting attention to the new relevant rule when the stimulus includes both the pre-shift and post-shift dimensions (e.g., colour and shape on the target card; Diamond, Carlson, & Beck, 2005; Zelazo, Frye, & Rapus, 1996). From age four to five, children are able to reduce perseveration on the previous dimension and to sort according to the relevant dimension (Diamond, 2006; Diamond et al., 2002; Zelazo, Frye, & Rapus, 1996; Zelazo et al., 2003). As is the case with inhibitory control and working memory, age-related improvements in attentional flexibility continue into adolescence (Best & Miller, 2010; Davidson, Amso, Anderson, & Diamond, 2006).

Although development of self-regulation from a neuroscientific perspective is beyond the scope of this study, it is worth noting how neuroimaging supports our understanding of the anatomical and functional nature of executive functions that underlie self-regulation. Neuroimaging and other techniques allow scientists to examine changes in brain structures associated with behaviour through mapping brain activity during specific performance tasks.
This allows us to understand how executive functions mature over time (Best et al., 2009; Konishi et al., 1998; Posner & Rothbart, 2000; Posner, 2001; Wood & Smith, 2008). For example, results from a neuroscientific study that examined the brain’s electrical activity using electroencephalogram during performance on simple and complex inhibitory control tasks that involved working memory, found increased global cortical activity in younger children (around 8 months of age) and more localized cortical activity (medial-frontal to right-frontal scalp regions) in older children, suggesting age-related changes or growth in brain efficiency and prefrontal cortex functioning (Best & Miller, 2010).

The field of neuroscience provides evidence that the prefrontal cortex plays an important role in executive functioning, specifically with executive processes associated with the regulation of emotion, cognition and behaviour (Posner & Rothbart, 2000). The prefrontal cortex functions in conjunction with other areas of the brain through a complex network of neural connections within itself and between other cortical, subcortical and limbic brain regions (Zelazo & Müller, 2002). For example, the anterior cingulate cortex appears to regulate cognitive and emotional processes through subdivided but reciprocal connections between the prefrontal cortex and other systems such as the limbic system and peripheral autonomic, visceromotor and endocrine systems (Bush, Luu, & Posner, 2000). These cortical processes are conceptualized in a hierarchical but integrated manner, whereby higher-order brain structures (anterior cingulate cortex and prefrontal cortex) facilitate more cool volitional executive processes and lower-order brain structures (amygdala and hypothalamus) are implicated in more hot executive processes involving automatized emotional responses (Bush et al., 2000).
2.3 Measurement of self-regulation in children

Interest in the assessment of self-regulation has grown dramatically over the past few decades, given increasing empirical evidence showing it to be a strong predictor of academic achievement and other important life outcomes, concurrently and longitudinally. However, self-regulation is construed as a broad construct and, as such, the study of its underlying mechanisms has generated numerous conceptualizations, definitions and terminology. These, in turn, have led to a wide array of measurement tools and the accompanying difficulties with synthesizing results from the large body of existing literature (Blair, Zelazo, & Greenberg, 2005; Raver et al., 2012). Despite the diverse conceptualizations, there is consensus that the key underlying mechanisms of executive functions include inhibitory control, working memory and attentional flexibility. Besides definitional issues, other concerns relate to the type of assessment tool used to measure children’s self-regulation. These measurement issues concern performance-based tasks and observer ratings (McClelland & Cameron, 2012; Toplak, West, & Stanovich, 2013).

2.3.1 Performance-based measures

Performance-based tasks typically assess executive functions associated with self-regulation within a controlled test environment that is generally distraction free and structured by way of instructions and guidance provided by the examiner. There are several measurement issues with performance-based assessments. First, this type of assessment is not practical for research within a school context as substantial time and specific materials are required (McClelland & Cameron, 2012). Second, some performance-based measures are administered in an attempt to assess individual components of executive functions; however, a lack of consensus exists with regards to the specific components that are actually being assessed (Martin &
Fallows, 2010). For example, the Wisconsin Card Sorting Task and Dimensional Change Card Sort task have been defined as performance-based inhibition tasks by some researchers; while others researchers have defined them as tasks that involve attentional flexibility (Best & Miller, 2010; Garon et al., 2008). Similar issues have surfaced with the Tower of London and Tower of Hanoi; they have both been defined as performance-based tasks that assess inhibition, working memory or planning skills (Best & Miller, 2010). Psychological assessments of executive functions that underlie self-regulation generally tap into more than one subcomponent, especially on more complex tasks that are novel and unfamiliar (Diamond, 2013). Executive function subcomponents are dissociable yet interrelated under the “unity and diversity” framework (Miyake et al., 2000), so although a given task may place more demands on one specific subcomponent, other underlying executive function processes may be activated since common regions in the prefrontal cortex are also activated (Blair & Razza, 2007; Bull & Lee, 2014). For example, complex set-shifting tasks rely on other executive processes such as working memory to hold and manipulate mental sets as well as inhibitory control of a prepotent response (Lan, Legare, Ponitz, Li, & Morrison, 2011). A third major issue with performance-based assessments involves the complexity of the setting; measures of behavioural self-regulation for purposes of early identification must be context-relevant or ecologically valid by matching tasks to the regulatory demands of the classroom environment, which is typically not free of distraction and also places demands on multiple executive functions (McClelland & Cameron, 2012).

2.32 Observer ratings

Teacher and parent ratings provide additional information about children’s self-regulation within the classroom and home environments, based on day-to-day interactions over a period of
time and variety of contexts. Parent ratings often assess children’s temperament (Rothbart, Ahadi, Hershey, & Fisher, 2001), while teacher ratings typically assess goal-oriented behaviour within the classroom in relation to academic and social circumstances (Bronson, 2000; Matthews et al., 2009; Schmitt et al., 2014; Schunk & Zimmerman, 1997). An advantage of observer reports is that they reflect behaviour across a range of observations and over a longer period of time compared to single observations on other measures. Observer reports are, however, prone to observational bias (Mashburn, Hamre, Downer, & Pianta, 2006; Rothbart, Ahadi, Hershey, & Fisher, 2001). The teacher’s cultural beliefs and values can influence their perceptions and expectations of what is considered developmentally appropriate behaviour in children and lead to biased ratings. For example, research findings show that a student’s ethnicity can influence teacher ratings such that they are higher when the cultural background of the student and teacher are the same (Beaman, Wheldall, & Kemp, 2006; Mashburn et al., 2006; Rothbart et al., 2001; Saft & Pianta, 2001). The teacher’s cultural beliefs and values can influence their perceptions and expectations of what is considered developmentally appropriate behaviour in children, leading to biased ratings (Beaman et al., 2006; Mashburn et al., 2006; Rothbart et al., 2001; Saft & Pianta, 2001). Modest correlations between teacher-ratings and performance-based measures of self-regulation have been documented in several studies (McClelland et al., 2007; Rimm-Kaufman et al., 2009). However, although both types of measures are associated with academic outcomes, each captures information about different aspects of children’s self-regulation (Lonigan et al., 2017; Toplak et al., 2013). The measurement challenges associated with performance-based measures and observer ratings have led to the use of integrative measures.
2.33 Integrative assessments

Integrative measures are now more commonly used in developmental research given the surge of interest in children’s self-regulation as it relates to school functioning (McClelland et al., 2010; McClelland et al., 2007). These measures provide a proximal assessment of children’s self-regulation and tap executive functions associated with learning-related behaviour through fun but challenging tasks (Matthews et al., 2009). The current study utilizes the Head-Toes-Knees-Shoulders (HTKS) task, which is a direct and ecologically relevant observational assessment of behavioural self-regulation that is both a valid and reliable measure of learning-related behaviour required for optimal school functioning (McClelland et al., 2014). The measure is administered in a naturalistic setting such as a designated area located in the child’s school and within a brief amount of time (McClelland et al., 2010).

2.5 Self-regulation and gender

Aside from the biological mechanisms and maturation processes involved with the development of self-regulation, gender has been investigated in the extant literature as a factor that could influence growth (McClelland et al., 2006; Raffaelli, Crockett, & Shen, 2005). Gender differences in behavioural self-regulation have also been explored in the literature as a potential explanation for academic achievement disparities between boys and girls. A number of studies have reported higher levels of behavioural self-regulation in kindergarten and early elementary school girls compared to boys (DiPrete & Jennings, 2012; Matthews et al., 2009; Wanless et al., 2013); however, the results vary across studies. For example, in a U.S. sample of five year olds, Matthews et al. (2009) compared the mean scores of behavioural self-regulation for boys and girls in the fall and spring of kindergarten and found all children improved but girls
outperformed boys at each time point. Teacher ratings of classroom behaviour corroborated these findings. Using a similar U.S. sample of children, a cross-sectional study showed results that were consistent with Matthews’ study (Wanless et al., 2013); however, other studies have reported nonsignificant associations between gender and behavioural self-regulation in children aged four to seven years (Connor et al., 2010) and preschool children (Becker, McClelland, Loprinzi, & Trost, 2014; Schmitt et al., 2014).

Varied results have also been reported in other samples of children across different settings. For example, in a cross-sectional study, six-year-old Icelandic girls outperformed boys in behavioural self-regulation skills, but there were no gender differences in the younger Icelandic and German preschool children aged four to five years (von Suchodoletz et al., 2013). Girls received higher teacher ratings on behavioural regulation in all three samples, controlling for age. Another study using two waves of data collection showed only the Icelandic girls aged six to eight scored higher than boys on the behavioural self-regulation assessment and teacher ratings, after controlling for age and mother’s education. However, for five- to seven-year-olds in the sample of children from France and Germany, there were no gender differences on either assessment as both groups demonstrated similar performance (Gestsdottir et al., 2014). Wanless et al. (2013) conducted a cross-sectional study on individual and teacher ratings of behavioural regulation using four diverse samples of children from the U.S., China, Taiwan and South Korea with children ranging in age from three to six years old. In the U.S. sample of children, girls had stronger behavioural regulation compared to boys but there were no apparent gender differences in the other three samples of children on the direct assessment of behavioural regulation. Teachers rated girls higher on classroom behavioural self-regulation in Taiwan, South Korea and the U.S. In these types of research studies (e.g., cross-section and autoregressive) that have used
multiple measures of behavioural self-regulation, the results appear to vary across contexts on direct assessments but teacher ratings are generally more consistent and show higher ratings for girls compared to boys.

The small number of longitudinal studies that have explored growth in behavioural self-regulation trajectories also show varied findings using direct assessments across samples of children within different settings. For example, having estimated a linear growth trajectory for behavioural self-regulation across three time points in a sample of German children aged three to six years, Gunzenhauser et al. (2015) reported initial levels were similar for boys and girls; however, over time boys showed greater improvement. Another study took a slightly different approach by investigating heterogeneity in developmental growth trajectories in relation to gender using a person-centered approach (Wanless et al., 2016). A person-centred approach groups children with similar growth trajectories to assess patterns of development for each trajectory classification and how the growth trajectories relate to covariates that may explain group membership. The study showed gender was not a significant predictor of patterns of development in a Taiwanese sample of children age four to six years based on three waves of data collection (six month and 12-month intervals), after controlling for age. One group of children demonstrated slow progress in behavioural self-regulation development relative to the other larger group who progressed at a faster rate; however, gender did not predict group membership and girls and boys were equally likely to be members of either group. One other study also explored the different types of trajectories children were most likely to follow and the influence of child and family background factors on trajectory membership, controlling for age at the first time point, ethnicity and primary language (Montroy et al., 2016). In this study, three different samples of children aged three to seven years were grouped based on the type of
behavioural self-regulation developmental trajectory they were likely to follow: early developers who demonstrated high initial levels and rates of growth, intermediate developers who performed at low levels initially but had high rates of growth, and late developers who demonstrated low initials levels and low rates of growth. The results from two of the three samples showed girls were more likely to be classified as early and intermediate developers of behavioural self-regulation compared to boys. The current study is therefore exploratory in nature given these inconsistent results across a relatively small number of studies and utilizes growth modelling to investigate how behavioural self-regulation develops over time in relation to gender.

In addition to child-level characteristics, previous research consistently shows how childrens’ environments influence their development of self-regulation (Blair, 2010; Grolnick & Farkas, 2002). Of particular importance is the level of maternal education and the role it plays in the developmental process (Miech, Essex, & Goldsmith, 2001; Montroy et al., 2016). Maternal education is often used as a proxy for family socioeconomic status and the availability of resources (Bradley & Corwyn, 2002; Hoff, Laursen, & Tardif, 2002). Lower levels of maternal education have been linked to reduced access to educational resources and elevated levels of family stress, which can impede children’s optimal development of self-regulatory skills within a poverty context over a prolonged period of time (Blair & Raver, 2015). Maternal education is also strongly linked to parenting behaviour. For example, higher levels of maternal education have been shown to reflect a warm, responsive, engaging and language-rich parenting profile (Guttentag, Pedrosa-Josic, Landry, Smith, & Swank, 2006) which promotes the development of children’s self-regulation (Berthelsen, Hayes, White, & Williams, 2017; Grolnick & Farkas, 2002; Hoff et al., 2002). This parenting style supports children’s development of more
autonomous self-regulatory skills by providing them with opportunities to develop these skills using set boundaries, instructions or direction and motivation so that they rely increasingly less on external supports as they mature (Davidov & Grusec, 2006; Grolnick & Ryan, 1989; Karreman, van Tuijl, van Aken, & Dekovic, 2006). Conversely, lower levels of maternal education have been shown to correlate with a harsher, intrusive and controlling parenting style that can impede the development of self-regulation (Davidov & Grusec, 2006; Fay-Stammbach, Hawes, & Meredith, 2014; Graziano, Keane, & Calkins, 2010; Grolnick & Ryan, 1989; Kopp, 1982). The current study incorporates mother’s education into the analysis of growth in behavioural self-regulation.

2.6 Relations between early reading, math and behavioural self-regulation skills

Accumulating evidence points to self-regulation as a consistent and important predictor of successful school functioning starting as early as preschool (Lonigan et al., 2017; McClelland et al., 2007; Ponitz et al., 2009; Schmitt et al., 2014; von Suchodoletz, Uka, & Larsen, 2015) through to subsequent schooling (McClelland, Acock, Piccinin, Rhea, & Stallings, 2013; Mischel et al., 1972). Research studies involving analyses of predictive (i.e., gains in scores across two time points controlling for initial achievement referred to as autoregressive models) and concurrent linkages between behavioural self-regulation and early reading and math skills have shown significant and positive associations. For example, in a study of preschool children aged four to six years, direct assessments of fall behavioural self-regulation predicted higher scores on letter-word identification and vocabulary scores in the spring of preschool, controlling for age, gender, the language utilized for the behavioural self-regulation assessment (Spanish or English), and fall achievement and behavioural self-regulation scores (McClelland et al., 2007). In a
similar study with a sample of kindergarten children aged five to six years, direct assessments of children’s behavioural self-regulation at the start of the kindergarten school year predicted their math performance at the end of kindergarten, controlling for age, parent education, language of behavioural self-regulation assessment and initial behavioural self-regulation and achievement scores (Ponitz et al., 2009). The math assessment measured competencies in applied math problems, including questions about quantities using pictures of items, time and money and word problems. Children with stronger initial behavioural self-regulation performed better in math later in the school year compared to those who started kindergarten with weaker skills. In another study, also based on two measurement time points and similar assessments of behavioural self-regulation and achievement, kindergarten children with stronger behavioural self-regulation in the fall demonstrated stronger applied math and sound awareness (e.g., phonological awareness) skills in the spring compared to their peers who started with weaker behavioural self-regulation skills, controlling for age, mother’s education and fall achievement (Matthews et al., 2009).

Cross-sectional studies demonstrate similar findings that further reinforce associations between early self-regulation and academic abilities (Becker, Miao, Duncan, & McClelland, 2014; Schmitt et al., 2014; Wanless et al., 2013) across different settings (Lan et al., 2011; von Suchodoletz et al., 2013).

Other studies that have utilized longitudinal analyses report that self-regulation measured in kindergarten is predictive of growth in early reading and math skills from kindergarten to elementary school (Li-Grining et al., 2010; McClelland et al., 2013). Of particular interest are the few studies that have taken a more nuanced approach to examining growth trajectories of behavioural self-regulation in relation to achievement over multiple time points. For example, Lonigan and colleagues (2017) utilized a growth modelling approach to examine the
development of early emergent reading skills in a sample of children aged four to five years over three waves of data collection (fall, spring and winter of the preschool year) in relation to behavioural self-regulation measured at the first time point. Behavioural self-regulation was a significant predictor of initial status and growth in alphabet knowledge, sound-letter correspondence and rudimentary word-decoding skills, controlling for age and general cognitive ability. Two other studies examined trajectory membership through growth modelling to examine heterogeneity in developmental trajectories of early behavioural self-regulation. Wanless et al. (2016) constructed a growth model of behavioural self-regulation trajectories with a sample of Taiwanese children aged four to six years and investigated trajectory membership in relation to math skills such as counting items, determining magnitude and simple calculations as well as receptive vocabulary skills based on identifying objects from pictures. The results showed that the majority of children were classified as increasing behavioural self-regulators (scores increased steadily over the duration of the study compared to the second group of steady-then-increasing regulators) and these children demonstrated greater growth in receptive vocabulary skills but not math skills compared to the group of steady-then-increasing behavioural self-regulators. The second study focused on investigating differences in the developmental trajectories of behavioural self-regulation in a sample of children between the ages of three and seven years and the associations with early language skills (Montroy et al., 2016). Results showed that heterogeneity in the development of children’s behavioural self-regulation and language skills was predictive of what trajectory children were most likely to follow, controlling for children’s age at the first time point, ethnicity, and whether English was a child’s primary language. Children with higher levels of expressive language skills were more
likely to be early developers of behavioural self-regulation compared to intermediate and late developers.

The current study builds on previous studies using a more nuanced approach to explore the development of behavioural self-regulation in relation to academic skills via latent growth modelling over multiple time points, from kindergarten to Grade 2. Only one other known study has explored parallel growth trajectories in behavioural self-regulation and achievement. Schmitt et al. (2017) constructed a three-trajectory growth model to examine growth simultaneously in a single construct of executive functions (which included a direct assessment of behavioural self-regulation), reading and math. Results from the study showed, in a sample of children between four to 6.5 years of age, initial skills levels of executive functioning, counting, simple calculations and letter-word identification were all correlated at the beginning of the study but only the growth trajectories for executive functions and applied math skills were correlated, not early reading skills, controlling for age, language status, program type and initial status on each of the three outcomes. Therefore, in light of the existing research studies, this study set out to explore the influence of gender on children’s improvement in behavioural self-regulation skills and whether these improvements paralleled improvements in reading and math abilities from kindergarten to Grade 2.
CHAPTER 3
METHODS

This chapter provides details about the research design and procedures, including information about the study participants, measures, procedures and treatment of missing data. It concludes with the analytical plan, which summarizes the research goals and specifies the statistical models used in the analyses.

3.1 Participants

The current study utilizes data from a longitudinal multi-site study on the implementation and impact of full-day kindergarten in Ontario, Canada (see Pelletier, 2012; Pelletier & Corter, in press). Data from four cohorts of kindergarten students have been collected under the larger study; however, the current study includes only the fourth cohort (2012–2013) since direct assessments of behavioural self-regulation were administered to all children in this group when they were in kindergarten. The cohort includes students from 16 publicly-funded elementary schools located within two large urban coterminous school boards in southern Ontario. The school communities represent a diverse sample of children from low- to middle-income families. The sample includes both junior kindergarten and senior kindergarten students from the 2012–2013 cohort who were followed over a three-year period. At the time of first measurement, children ranged in age from 4.42 to 6.42 years ($M = 5.39$ years, $SD = 0.593$). There was a comparable number of boys ($n = 106$) and girls ($n = 91$). Maternal education was used to capture information about socioeconomic status. Around 4% had some high school level education, 10% had a high school diploma, 13% had some college or university level education, 54% were university graduates and 19% had a graduate degree. Half the children in the sample were
identified as English First Language (EFL) and the other half as English Language Learners (ELL). All children were assessed in English. Almost half of the students spoke English at home. A relatively large percentage also spoke Punjabi, Urdu or Tamil (12%, 5% and 4%, respectively). Other demographic data included the students’ country of birth which was collected for 96% of the sample. Children born in Canada represented 40% of the sample and 20% were born in India. Each of the other national origins individually represented not more than five percent of the total sample. The larger study from which these data were drawn received ethics approval from the University of Toronto. In addition, each school board’s research ethics committee reviewed and approved the proposed study. Schools were initially selected for participation by the school boards because they were offering full-day kindergarten. Control schools were selected by the school boards as demographic matches. As some of the control group schools implemented full-day kindergarten, those schools were included as full-day kindergarten schools in subsequent years. Other control schools were selected by the school boards as demographic matches. Parents of all participating children provided informed consent. Teachers provided consent if they were asked to provide data for the study (e.g., interviews, ratings). Children provided verbal consent to participate at each time point.

3.2 Procedure

This study includes three years of data. Data collection took place between April and June each year (three time points) and the interval between time points was approximately 11 months, with a range between nine to 12 months. The junior kindergarten students were followed to Grade 1 and the senior kindergarten students were followed to Grade 2. Assessments were not administered in any particular order. At each wave of data collection, direct assessments of
behavioural self-regulation and academic achievement for early reading ability and number knowledge skills were administered to the children. A research team consisting of trained and supervised graduate students in psychology and education performed the student assessments. The research assistants were either Masters or PhD students, or were in a Masters-level teacher training program that included specific training in kindergarten. They were not students with an early childhood education certification although some had previous experience during their undergraduate studies.

Parents also provided responses to background questions. Children were assessed in a quiet area or hallway within close proximity to their classroom. Students were encouraged to participate in the assessments but any student who appeared reluctant was not made to participate. Assessments generally occurred in one session. The assessments for behavioural self-regulation and academic achievement took approximately 45 to 60 minutes to complete individually with each student. For all tasks, instructions were explained to the participants and brief practice trials and corrective feedback were provided. At the end of the assessments, each student was thanked and offered a sticker or a pencil (after kindergarten age) for his/her participation.

3.3 Measures

3.3.1 Behavioural self-regulation

The Head-Toes-Knees-Shoulders (HTKS) task was directly administered to the study participants to measure behavioural self-regulation. The task integrates components of executive functions into a game where children are required to listen to verbal commands from the assessor
and respond with overt gross motor actions that are the opposite of what is being requested. Specifically, the task measures attentional flexibility (paying attention to verbal directions), working memory (remembering multiple rules) and inhibitory control (inhibiting the impulse to touch the named body part and presenting the correct response) in an integrative manner (Cameron Ponitz et al., 2008; McClelland et al., 2007; McClelland & Cameron, 2012; McClelland et al., 2014; Ponitz et al., 2009). The task is an ecologically valid measure as it reflects skills that are most important for success within a classroom context, such as following the teacher’s instructions, completing tasks and taking turns (Matthews et al., 2009). Studies show that children who perform well on this task tend to be more successful in school (McClelland et al., 2007; Ponitz et al., 2009; von Suchodoletz et al., 2013; Wanless, McClelland, Tomainey, & Acock, 2011).

In the current study, the researchers introduced the task to the children as a short game and then proceeded to explain the rules and allow children to practice before the task was administered. The HTKS task included 20 behavioural commands sectioned into two parts (10 paired commands in each). The first part requires the participant to touch his/her body part (head or toes) opposite to the verbal command. The second part of the task increases in complexity with the addition of 10 new, paired commands. Therefore, in the second part, the participant must touch his/her body part (head, toes, knees or shoulders) opposite to the verbal command. For example, if the assessor says “touch your head,” the participant must touch his/her toes. The scores range from zero to 40 and higher scores indicate stronger behavioural self-regulation skills. For each correct response to a command, two points are assigned; for self-correction (the first movement begins as incorrect but the participant immediately corrects his/her response), the score is reduced to one; an incorrect response is scored as zero. Inter-rater reliability and internal
consistency are typically above .90 (McClelland et al., 2014; Ponitz et al., 2009; Wanless et al.,
2011).

3.32 Early reading

The Test of Early Reading Ability, Third Edition (TERA) is a norm-referenced and direct
assessment of emergent literacy skills in children aged three to eight years (Reid, Hresko, &
Hammill, 2001). It includes three subtests that measure children’s knowledge and use of
alphabets (Alphabet subtest), knowledge of print conventions used in reading and writing
(Conventions subtest), and the construction of meaning from print (Meaning subtest). The
Alphabet subtest specifically measures children’s knowledge of the names of letters, the sounds
of letters and basic word-decoding skills (i.e., reading the word “cat”). The Conventions subtest
measures children’s knowledge of print conventions, including identifying parts of a book and
the way it is organized, punctuation, capitalization and spelling within various texts. The
Meaning subtest measures children’s understanding of environmental print (e.g., signage, logos
and words), reading comprehension, sentence construction and paraphrasing.

As part of the assessment, raw scores, age and grade equivalents, percentile scores and
standard scores for each of the three subtests are recorded. A composite score called a Reading
Quotient is derived from the standard scores for each subtest, which are based on the raw scores.
The current study uses the raw scores for analysis and statistically controls for age. The subtests
are administered individually to each child and typically require 15 minutes in total to complete.
The starting point for the test is based on the child’s chronological age; however, a basal is
established when three items are correct in a row, and a ceiling is established when three items
are failed in a row. In other words, children start the first subtest at the age-appropriate item and
continue until all items in each subtest have been completed or until they answer three consecutive items incorrectly within a subtest. Some examples of questions on the upper end of the subtests include reading comprehension, sentence construction, and paraphrasing. Children provide verbal responses to each question without the aid of a pencil and paper. An incorrect response or no response is assigned zero and a correct response is assigned one. The TERA is a reliable and valid measure of early reading ability. The measure demonstrates sufficient content, construct, and criterion-predictive validity, and strong reliability around .90 (Lonigan et al., 2017; Reid et al., 2001).

3.33 Number knowledge

The Number Knowledge Test (NKT) is a non-standardized measure that assesses children’s early numeracy skills in terms of understanding whole numbers (Case et al., 1996). It is comprised of several increasingly challenging levels of assessment based on specific developmental stages. In the current study, the assessments included the predimensional, unidimensional and bidimensional levels. Kindergarten children start at the predimensional level where they are asked to count objects (e.g., “Can you count these chips and tell me how many there are?” and “Which pile has more?”). Children in Grades 2 and 3 start at the unidimensional level and at this level they are expected to count along a mental number line and understand the connection between numbers and quantities (e.g., “Which is bigger: 8 or 6?” and “What number comes three numbers before 5?”). Children in Grades 4 and 5 start at the bidimensional level where they are expected to understand two-digit numbers, compute the difference between two numbers and perform addition and subtraction (e.g., “Which is bigger: 32 or 28?” and “How much is 47 take away 21?”). Children start at the age appropriate level but can proceed to the
next level if they successfully complete items with fewer than five consecutive errors. The test is administered verbally and individually to each child. The test does not involve the use of paper or pencil as the child’s responses are verbal and the purpose of the assessment is to measure intuitive knowledge. The test typically takes 15 minutes to complete. The basal requirement is five consecutive correct answers and administration continues until the child gets five consecutive errors (ceiling). An incorrect response or no response receives a zero and a correct response receives a one. If testing commences at the unidimensional level, points are automatically assigned for predimensional level items. Test items on the upper end focus on calculation (e.g., “How much is 12 plus 54?”). A total raw score for each child on this test can be computed by summing the number of points the child received across all levels of the test.

3.34 Child and family characteristics

Parents completed a questionnaire at the first time point that included questions about children’s home language, country of birth and both parents’ education level. Participating schools provided information about age, gender, grade level (junior or senior kindergarten) and language status (English Language Learner or English First Language) at the first time point.

3.4 Missing data

There were partially missing scores on the HTKS, TERA and NKT outcome measures with two percent at the first time point, 20% at the second time point and 40% at the third time point. Cases were included where there was at least one score on the outcome variable on either the first, second, or third occasion. There were no missing data for any of the background variables, including child age, gender, language status and maternal education, used in the current study. Table 1 shows the number of children tested at each time point for the measures.
used in the current study. Participant attrition was due to naturally occurring movement of young children across schools over time and children being absent on assessment days. The data were assumed to be missing-at-random on the outcome variables (Hox, 2010). This assumption requires that variables associated with missingness be included in the models and other patterns of missingness are assumed to be random rather than systematic (Schafer & Graham, 2002). There is no definitive test to assess the missing-at-random assumption; however, in the current study logistic regressions were utilized to determine if any auxiliary variables that were not part of the initial models were associated with missingness. Theoretically relevant variables that were part of the initial models were included as predictors in the logistic regressions. For the bivariate logistic regressions, dummy variables were created for the outcome variables of interest (0 = present, 1 = not present) and results showed the auxiliary variables did not predict missingness.

Thus, missing data in the current study was addressed in two ways: first, individuals with partial data were retained in the analysis which greatly enhances the assumption of missing-at-random (Hox, 2010); second, preliminary analyses indicated that missing data at later time points were generally unrelated to patterns of individual data at earlier time points and the auxiliary variables were not associated with missingness. The missing-at-random assumption is reasonable when the missing outcome data are relatively similar across other variables in the model. In the current study, the missing data were noted to be relatively similar for categories of gender, language status and mother’s education (i.e., theoretically relevant variables included in the initial models). Full information maximum likelihood (FIML) estimation was used in the current study to provide unbiased estimates of the model parameters, under the missing-at-random assumption. The FIML estimation enhances the power to detect effects by including those
individuals who would be otherwise dropped from many studies due to having any missing values.

Table 1

*Counts for repeated measures of behavioural self-regulation, reading and math skills*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Time of Assessment</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTKS T1</td>
<td>Spring 2013</td>
<td>192</td>
</tr>
<tr>
<td>HTKS T2</td>
<td>Spring 2014</td>
<td>158</td>
</tr>
<tr>
<td>HTKS T3</td>
<td>Spring 2015</td>
<td>118</td>
</tr>
<tr>
<td>TERA T1</td>
<td>Spring 2013</td>
<td>194</td>
</tr>
<tr>
<td>TERA T2</td>
<td>Spring 2014</td>
<td>157</td>
</tr>
<tr>
<td>TERA T3</td>
<td>Spring 2015</td>
<td>119</td>
</tr>
<tr>
<td>NKT T1</td>
<td>Spring 2013</td>
<td>193</td>
</tr>
<tr>
<td>NKT T2</td>
<td>Spring 2014</td>
<td>158</td>
</tr>
<tr>
<td>NKT T3</td>
<td>Spring 2015</td>
<td>118</td>
</tr>
</tbody>
</table>

3.5 Analytical plan

The current study has three goals: (1) to test the role of gender on children’s development of behavioural self-regulation; (2) to test the relationship between trajectories of development in behavioural self-regulation and early reading ability; and, (3) test the relationship between trajectories of development in behavioural self-regulation and math skills. The initial analysis utilizes a univariate latent growth model with latent growth factors (i.e., intercept and slope) that represent repeated measures of behavioural self-regulation across three waves of data collection.
The remaining analyses involve testing two independent latent growth models each with dual trajectory outcomes on separate academic domains across the three waves of data collection. The first dual trajectory model represents longitudinal outcomes for repeated measures of behavioural self-regulation and early reading ability. The second dual trajectory model represents longitudinal outcomes for repeated measures of behavioural self-regulation and number knowledge skills.

There are a number of different approaches to analyze longitudinal data such as examining the change in mean scores between two time points, conducting repeated measures analysis of variance (ANOVA) and multilevel modelling over multiple time points; however, the latent growth modelling approach offers a more powerful and flexible statistical method to assess developmental change over time. For instance, multiple dependent variables (i.e., growth outcome processes) can be simultaneously modelled within a structural equation modelling framework to explore change over time which is not possible with ordinary least square regression since it is limited to a single dependent variable (Duncan & Duncan, 2009). A multilevel growth model approach yields results similar to the structural equation model latent approach (Curran et al., 2010) and both are suitable for developmental research; however, the latter approach allows testing of more complex processes and is therefore a better fit for the current study given one of the primary goals is to examine the association between joint trajectories of behavioural self-regulation and academic achievement (Heck & Thomas, 2015; UCLA Statistical Consulting Group, 2016).
3.6 Specifying the latent growth models

3.6.1 Latent growth model formulation

The latent growth model is based on the assumption that the pattern of change over time is inferred by the observed repeated measures but manifested in the underlying unobserved latent variables (Curran & Howard, 2014). The latent growth model estimates the overall mean structure (initial status and rate of change) of the outcome variable of interest for the sample and describes individual differences in trajectories based on covariates that might influence growth. In the current study, the latent growth model for behavioural self-regulation is represented by two interrelated sub-models specified under the structural equation framework: the measurement model and the structural model. The measurement model links the observed repeated measures of behavioural self-regulation to the underlying unobserved or latent variables (i.e., intercept and slope) in order to define the general shape of the growth trajectory (Heck & Thomas, 2015; Muthén & Muthén, 1998–2012). The general equation used for the measurement model, in matrix notation, is as follows:

\[ y_{it} = v_t + A_t \eta_t + \epsilon_{it} \]  \hspace{1cm} 3.1

where \( y_{it} \) is a vector of the observed dependent variable for behavioural self-regulation for individual \( i \) at time \( t \), \( v_t \) is a vector of measurement intercepts (the observed variable intercepts are typically fixed to 0 for model estimation), \( A_t \) is a matrix that specifies the factor loadings of the repeated measures of \( y \) in defining the latent growth factors (the factor loadings link the observed variables to their latent factors and represent the shape of the growth trajectory), \( \eta_t \) is a vector of latent variables (intercept and slope), and \( \epsilon_{it} \) is a vector of measurement errors (residuals) that are contained within the variance-covariance matrix \( \Theta \). The latent growth model
estimation includes estimates of the mean factor structure and covariance structures. The following equation shows the covariance structure in matrix notation:

\[ \Sigma = \Lambda \Psi \Lambda' + \Theta \]  

3.2

where \( \Sigma \) represents the variances and covariances of the observed variable for behavioural self-regulation based on the factor loadings denoted by \( \Lambda \), mean factor variances and covariances denoted by \( \psi \) and residual variances and covariances denoted by \( \Theta \) (Bollen, 1989; Preacher, 2009).

The second component of the structural equation model is the structural model, which links the latent variables together and can be extended to link covariates of interest to the latent variables. Time-invariant covariates are characteristics of individuals that do not vary over time (e.g., gender). The current study includes time-invariant covariates for gender, mother’s education, and statistically controls for age at the first time point and language status. The general equation for the structural model is as follows (Heck & Thomas, 2015; Muthén & Muthén, 1998–2012; Preacher, 2009):

\[ \eta_i = \alpha + \beta \eta_i + \Gamma x_i + \zeta_i \]  

3.3

where \( \alpha \) is a vector of latent variable intercepts, \( \eta_i \) is defined as a \( q \times 1 \) vector of latent factors, \( \beta \) is a matrix of regression coefficients relating the latent variables to each other, \( \Gamma \) is a matrix of regression coefficients relating covariates \( x_i \) to the latent variables and \( \zeta \) is a vector of residual variances in the equations that are contained in the covariance matrix \( \Psi \). The error term captures the assumption that the latent variables do not perfectly predict the population means of the observed variables.
3.62 Latent growth model identification

To estimate the intercept growth factor for behavioural self-regulation, the factor loadings in the first column (defining initial status) were set to 1 to constrain the loadings to be equal to the first time point since the intercept factor is constant for any individual over time. The slope growth factor represents the developmental trajectory of behavioural self-regulation over time. The slope factor loadings were fixed in alignment with the values corresponding to the linear time scale 0, 1 and 2 in the current study (McArdle & Kadlec, 2013):

\[
\Lambda_{e} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \\ 1 & 2 \end{bmatrix}
\]

Alternative factor loadings were also tested to assess possible non-linear growth patterns against the actual observed data for behavioural self-regulation by allowing the last time score to be freely estimated. A comparison of model fit indices indicated negligible differences. For example, the difference between -2 log likelihood (-2LL) values for the linear and non-linear model estimations was close to zero (i.e., -2LL difference was not statistically significant). The -2LL statistic is typically used to compare competing models and the model with the smaller value suggests a better fitting model (Kelloway, 2015). As such, factor loadings for a linear slope growth factor were defined as successive time points equal to 0, 1, and 2 (Heck & Thomas, 2015). A similar process was undertaken to identify the linear growth models for early reading and math ability.

3.63 Latent growth model estimation

To assess how well the latent growth model fits with the observed data, a number of indices are available. The overall model fit indices compare the covariance matrices from the
hypothesized model to the population covariance matrix based on the observed sample data to assess how well patterns in the data are represented by the model (Bollen, 1989). The chi-square statistic ($\chi^2$) is a widely used measure and a nonsignificant value indicates the model implied and population covariance matrices are consistent. Other indices that supplement the chi-square ($\chi^2$) index include the comparative fit index (CFI) and root mean square error of approximation (RMSEA). The CFI values range between 0 and 1 with values close to 0.95 or above indicating good model fit (Hu & Bentler, 1999). RMSEA provides a “close” statistical test of model fit, contrasting with the exact fit of the chi-square test. The RMSEA values are based on the analysis of residuals and smaller values suggest a better fitting model where values less than 0.10 indicate a “good” fit to the data and values below 0.05 indicate a “very good” fit (Kelloway, 2015).

Evaluation of the latent growth models in the current study are based on these fit indices along with the cut-off criteria to assess overall model fit.

Raw scores for the outcome measures in the latent growth models are utilized since they are better suited for analysis within a structural equation framework and can provide more accurate parameter estimates (Kline, 2005). The latent growth models for behavioural self-regulation included covariates for gender and mother’s education, controlling for age in months at the first time point and language status. Language status was included as a control variable to account for the potential limitations with English proficiency in the ELL compared to EFL students because those whose native language was not English were given English assessments for behavioural self-regulation, early reading and math. Child’s age was centered on junior kindergarten children at the grand mean (59 months) since executive functions underlying behavioural self-regulation undergo significant development during this time period (Bronson, 2000; Diamond, 2002; Shonkoff & Phillips, 2000). This variable was specified in months rather
than years to increase precision of the model estimates (age range is 53 to 77 months). Utilizing age as a statistical control is recommended in longitudinal analyses where there is considerable variation in the ages of the cohort at the beginning of the study (Singer & Willett, 2003).

All models were estimated using the Mplus software version 6.62 (Muthén & Muthén, 1998-2012) with FIML (Little & Rubin, 1987) to account for missing data through the use of all available data (Duncan et al., 2006; McArdle & Anderson, 1990; Mehta & Neale, 2005; Heck, 2004). FIML does not actually impute the missing values but instead it uses all the available data to produce estimates for the model parameters and standard errors (Abraham & Russell, 2004).
CHAPTER 4
RESULTS

The results are presented in four sections. The first section provides descriptive statistics for assessments of behavioural self-regulation, reading and math ability over the three waves of data collected. The second section provides the latent growth model results for behavioural self-regulation and gender. The third section provides results for the bivariate latent growth model for early reading skills and behavioural self-regulation. The fourth section provides the bivariate latent growth model results for early math skills and behavioural self-regulation.

4.1 Descriptive statistics

Univariate analyses for normality and outliers of the raw scores on the HTKS task for behavioural self-regulation, TERA for early reading ability, and NKT for early math ability show the distributions were not severely skewed or kurtotic (Kline, 2005). The overall mean scores on the behavioural self-regulation task increased over time and variability was highest at the first time point, reflecting a wider distribution around the mean. The mean scores on the early reading and math tasks also improved over time; however, in comparison to the behavioural self-regulation task less variability is apparent. A small proportion (10%) of children scored at floor on the HTKS task at the first time point. At subsequent time points, less than four percent of children scored at floor. No children scored at floor on the reading and math measures. Less than 10% of children scored at ceiling levels on each assessment. Descriptive statistics for all variables included in the current analysis are presented in Table 2.

The individually observed trajectories for a random subset of 100 children’s scores on the HTKS across time points are presented in Figure 1. There appears to be considerable variation in
children’s individual performance on the HTKS task as well as between children’s trajectory patterns. Bivariate correlations between the background variables and outcome variables are presented in Table 3.
Table 2

Descriptive statistics for background and outcome variables

<table>
<thead>
<tr>
<th>Background Variables</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Gender (male)</td>
<td>54%</td>
</tr>
<tr>
<td>Education level (junior kindergarten)</td>
<td>52%</td>
</tr>
<tr>
<td>Language status (English first language)</td>
<td>54%</td>
</tr>
<tr>
<td>Maternal education</td>
<td></td>
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<tr>
<td>Elementary school</td>
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</tr>
<tr>
<td>Some high school</td>
<td>4%</td>
</tr>
<tr>
<td>High school graduate</td>
<td>10%</td>
</tr>
<tr>
<td>Some college or university</td>
<td>13%</td>
</tr>
<tr>
<td>University graduate</td>
<td>54%</td>
</tr>
<tr>
<td>Graduate degree</td>
<td>19%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcome Variables</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
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<td>Age in months at time 1</td>
<td>195</td>
<td>64.73</td>
<td>7.12</td>
</tr>
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<td>Behavioural self-regulation (HTKS) at time 1</td>
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<td>21.76</td>
<td>12.36</td>
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<tr>
<td>Behavioural self-regulation (HTKS) at time 2</td>
<td>158</td>
<td>27.44</td>
<td>10.24</td>
</tr>
<tr>
<td>Behavioural self-regulation (HTKS) at time 3</td>
<td>118</td>
<td>31.94</td>
<td>6.60</td>
</tr>
<tr>
<td>Early Reading (TERA) at time 1</td>
<td>194</td>
<td>33.01</td>
<td>12.39</td>
</tr>
<tr>
<td>Early Reading (TERA) at time 2</td>
<td>157</td>
<td>45.36</td>
<td>12.11</td>
</tr>
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<td>Early Reading (TERA) at time 3</td>
<td>119</td>
<td>55.87</td>
<td>10.12</td>
</tr>
<tr>
<td>Number Knowledge (NKT) at time 1</td>
<td>193</td>
<td>13.24</td>
<td>4.91</td>
</tr>
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<td>Number Knowledge (NKT) at time 2</td>
<td>158</td>
<td>18.03</td>
<td>4.79</td>
</tr>
<tr>
<td>Number Knowledge (NKT) at time 3</td>
<td>118</td>
<td>22.12</td>
<td>4.56</td>
</tr>
</tbody>
</table>

Note. HTKS = Head-Toes-Knees-Shoulders, TERA = Test of Early Reading Ability, NKT = Number Knowledge Test.
Table 3

Correlations between background and outcome variables

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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<tbody>
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<td>HTKS at T1</td>
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</tr>
<tr>
<td>HTKS at T3</td>
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<td>.768*</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TERA at T1</td>
<td>.607*</td>
<td>.555*</td>
<td>.449*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>TERA at T2</td>
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<td>.456*</td>
<td>.776*</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TERA at T3</td>
<td>.523*</td>
<td>.550*</td>
<td>.560*</td>
<td>.723*</td>
<td>.716*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NKT at T1</td>
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<td>.568*</td>
<td>.531*</td>
<td>.734*</td>
<td>.687*</td>
<td>.621*</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NKT at T2</td>
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<td>.641*</td>
<td>.604*</td>
<td>.642*</td>
<td>.723*</td>
<td>.666*</td>
<td>.747*</td>
<td>1</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>NKT at T3</td>
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<td>.537*</td>
<td>.598*</td>
<td>.559*</td>
<td>.584*</td>
<td>.690*</td>
<td>.618*</td>
<td>.646*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
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<td>-0.089</td>
<td>-0.154</td>
<td>0.006</td>
<td>0.039</td>
<td>0.054</td>
<td>0.010</td>
<td>0.032</td>
<td>.190*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at T1</td>
<td>.496*</td>
<td>.471*</td>
<td>.361*</td>
<td>.518*</td>
<td>.529*</td>
<td>.551*</td>
<td>.477*</td>
<td>.503*</td>
<td>.468*</td>
<td>.108*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEd</td>
<td>0.032</td>
<td>0.112</td>
<td>.226*</td>
<td>.208*</td>
<td>.117*</td>
<td>.223*</td>
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<td>.171*</td>
<td>.260**</td>
<td>-0.023</td>
<td>0.010</td>
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<tr>
<td>Language</td>
<td>-.197*</td>
<td>-.169*</td>
<td>-.191*</td>
<td>-.177*</td>
<td>-.045</td>
<td>-.074</td>
<td>-.119</td>
<td>-.079</td>
<td>-.186*</td>
<td>-.020</td>
<td>-.081</td>
<td>-.103</td>
<td>1</td>
</tr>
</tbody>
</table>

Note. Gender (girls = 0, boys = 1); MEd = mother’s education (0 = not a university graduate, 1 = university graduate); Language (0 = English First Language, 1 = English Language Learner). *p < .05. **p < .01.
4.2 Latent growth model for behavioural self-regulation and gender

To explore the latent growth factors of behavioural self-regulation, the unconditional linear growth model was examined. This was followed by an analysis of the conditional latent growth model with child gender as a predictor and other background variables including mother’s education, language status and age at the first time point.

A visual representation of the unconditional latent growth model for behavioural self-regulation is presented in Figure 2. The circles represent the latent growth factors for the intercept (initial status) and linear slope (rate of change). The mean of the intercept factor ($\beta_{\text{INTERCEPT}}$) represents the average group score at the start of the study. The variance of the intercept factor ($\psi_{\text{INTERCEPT}}$) reflects individual differences at the start of the study. The mean of the slope factor ($\beta_{\text{SLOPE}}$) represents the average rate of change, and the variance...
around the slope factor ($\psi_{\text{SLOPE}}$) reflects the variation in individual rates of change. The residual variances represent measurement error or possibly other sources of variation unaccounted for by the model ($\epsilon$). The intercept and slope factors were allowed to covary. The curved line with double-headed arrows indicates the correlation between the latent growth factors ($r_{\text{INTERCEPT-SLOPE}}$). The factor loadings were fixed at 1 to account for the intercept factor being constant over time for each individual. The factor loadings for the slope were fixed to a linear time scale (i.e., 0, 1 and 2) and represent the constant rate of change over time.

Figure 2. A visual representation of the unconditional latent growth model for behavioural self-regulation

Results from the unconditional univariate growth model for behavioural self-regulation showed that the model fit the data well. For example, the chi-square coefficient
(with 2 degrees of freedom) was 3.16 ($p = .207$), which implies that the model is consistent with the data and, therefore, should not be rejected on statistical grounds alone. Similarly, the CFI (0.99) and RMSEA (0.06, $p = .353$) indicated a strong fit of the model to the data. The intercept factor had a significant mean ($\beta_{\text{INTERCEPT}} = 21.87$, $p < .001$) and variance ($\psi_{\text{INTERCEPT}} = 132.86$, $p < .001$). The slope factor was significant and positive ($\beta_{\text{SLOPE}} = 5.11$, $p < .001$) with a significant variance ($\psi_{\text{SLOPE}} = 20.60$, $p < .001$). The significant intercept and slope factors indicated that the rate of improvement in behavioural self-regulation increased over time. The significant variance around the mean intercept and slope factors indicated children demonstrated varying levels at the start of the study and increasing and decreasing rates of improvement or change over time in behavioural self-regulation. In other words, these results imply, on average, children improved their behavioural self-regulation skills over time and on an individual level there was substantial variation between their growth trajectories. The latent growth factors were negatively correlated ($r_{\text{INTERCEPT-SLOPE}} = -.82$, $p < .001$), suggesting that children with lower levels of behavioural self-regulation at the start of the study showed greater improvement over time in behavioural self-regulation compared to children with higher levels, and vice versa. Given the significant slope variance, the model was appropriate for further analysis using a latent growth analysis.

Table 4 provides the parameter estimates for the unconditional latent growth model and Figure 3 provides an illustration of the sample means and model-implied means for behavioural self-regulation, suggesting that the estimated model fits the observed sample means well.
Table 4

*Unstandardized parameter estimates and fit indices for the unconditional latent growth model for behavioural self-regulation*

<table>
<thead>
<tr>
<th>Parameters and fit indices</th>
<th>B</th>
<th>SE</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept mean</td>
<td>21.87**</td>
<td>0.92</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>Intercept variance</td>
<td>132.86**</td>
<td>18.54</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>Slope mean</td>
<td>5.11**</td>
<td>0.41</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>Slope variance</td>
<td>20.60**</td>
<td>3.97</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>Intercept-slope covariance</td>
<td>-43.01**</td>
<td>8.02</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>Intercept-slope correlation</td>
<td>-0.82**</td>
<td>0.04</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td><strong>Fit indices</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\chi^2$</td>
<td>3.16</td>
<td></td>
<td>0.207</td>
</tr>
<tr>
<td>CFI</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMSEA</td>
<td>0.06</td>
<td>(90% CI)</td>
<td>(0.00-0.17)</td>
</tr>
</tbody>
</table>

*Note.* The nonsignificant residual variance for the linear slope was fixed for model identification purposes. *p < .05, **p < .001. Parameter estimate is significantly different from zero.
Next, Table 5 provides the results for the conditional latent growth model. The results from the conditional model show no statistically significant association between gender and the latent growth factors for behavioural self-regulation, after controlling for background variables. This implies, on average, that girls and boys demonstrated similar levels at the start of the study and improvement in behavioural self-regulation skills over time. The statistically nonsignificant results from the independent samples $t$-test comparing behavioural self-regulation skills in boys and girls at each time point support these findings. The association between mother’s education and the slope factor of behavioural self-regulation was statistically significant ($1.62, p = .049$). This suggests that children with more educated mothers demonstrated a greater rate of growth in behavioural self-regulation compared to children with less educated mothers, and vice versa. Table 5 provides the parameter estimates for the conditional latent growth model.
Table 5

*Unstandardized parameter estimates for the conditional latent growth model for behavioural self-regulation*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>B</th>
<th>SE</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effect on Intercept</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at time 1</td>
<td>0.92**</td>
<td>0.11</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>Gender</td>
<td>-1.38</td>
<td>1.54</td>
<td>.370</td>
</tr>
<tr>
<td>Mother’s education</td>
<td>-1.80</td>
<td>1.72</td>
<td>.298</td>
</tr>
<tr>
<td>Language status</td>
<td>-3.48*</td>
<td>1.56</td>
<td>.026</td>
</tr>
<tr>
<td><strong>Effect on Slope</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age at time 1</td>
<td>-0.29**</td>
<td>0.05</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>Gender</td>
<td>-0.47</td>
<td>0.75</td>
<td>.529</td>
</tr>
<tr>
<td>Mother’s education</td>
<td>1.62*</td>
<td>0.83</td>
<td>.049</td>
</tr>
<tr>
<td>Language status</td>
<td>0.40</td>
<td>0.77</td>
<td>.603</td>
</tr>
</tbody>
</table>

*Note.* Gender (girls = 0, boys = 1); MEd = mother’s education (0 = not a university graduate, 1 = university graduate); Language = (0 = English First Language, 1 = English Language Learner). *p < .05, **p < .001. Parameter estimate is significantly different from zero.

### 4.3 Bivariate latent growth model for reading and behavioural self-regulation skills

A bivariate latent growth model was used to examine whether behavioural self-regulation and early reading ability would demonstrate correlated growth. This model extends the conditional univariate model for behavioural self-regulation with an additional outcome for reading ability (Bollen & Curran, 2006; Curran & Willoughby, 2003). Each
outcome has its own latent growth factors that are tied to the multiple repeated measures. The following section describes the results from the bivariate latent growth model analysis.

A preliminary analysis of the early reading growth trajectory was conducted prior to conducting the bivariate analysis. The results of the unconditional growth model analysis for early reading ability show that the linear model fit the data well. For example, the chi-square coefficient (with 1 degree of freedom) was 2.10 ($p = .147$), which implies that the null model is consistent with the data and, therefore, should not be rejected on statistical grounds alone. Similarly, the CFI (0.99) and RMSEA (0.08, $p = .242$) indices indicate a strong fit of the model to the data. The intercept factor had a significant mean ($\beta_{INTERCEPT} = 33.04, p < .001$) and variance ($\psi_{INTERCEPT} = 147.01, p < .001$). The slope factor was significant and positive ($\beta_{SLOPE} = 11.39, p < .001$) with a significant variance ($\psi_{SLOPE} = 11.69, p = .040$). The significant latent growth factors indicate that the rate of improvement in reading ability increased over time. The significant variance around the latent growth factors indicates children demonstrated varying levels at the start of the study and increasing and decreasing rates of improvement or change over time in reading ability. In other words, these results imply, on average, children improved their reading skills over time and on an individual level there was substantial variation between their growth trajectories.

Next, as part of the preliminary analysis, a conditional latent growth model for early reading ability was included with gender as a predictor, controlling for age, mother’s education and language status. The influence of gender on the development of reading skills was not the focus of the current study; however, this aspect of the reading latent growth model was noted in the preliminary analysis. The results from the conditional model show no
A statistically significant association between gender and the latent growth factors for reading ability, after controlling for background variables. This suggests that girls and boys demonstrated similar levels at the start of the study and improvement over time in their reading ability.

For the last analysis, the bivariate latent growth model for behavioural self-regulation and reading ability was examined to determine whether children’s growth in behavioural self-regulation paralleled growth in early reading ability. Figure 4 provides a visual representation of the bivariate latent growth model. Of interest in the current study are the correlations between the linear latent growth factors for behavioural self-regulation and early reading ability which are depicted by the double-headed arrows.

Figure 4. A visual representation of the bivariate latent growth model for behavioural self-regulation and early reading ability.
The conditional bivariate latent growth model accounted for the background variables, including age, gender, mother’s education, and language status. Preliminary analysis suggested that the presence of the background variables did not influence the strength of the correlations in any substantial manner\(^1\). The results presented in Table 6 show that the two slope factors for the trajectories of theoretical interest were positively and moderately correlated \((r_{\text{slopes}} = .44, p = .018)\). This statistically significant finding indicates the trajectories of reading ability and behavioural self-regulation were parallel and travelled in tandem. The results also show a moderate and positive correlation between the intercept factors \((r_{\text{intercepts}} = .64, p < .001)\).

Table 6

*Correlations between growth parameters for behavioural self-regulation and reading skills*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. HTKS – Intercept</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. HTKS – Slope</td>
<td>-.79*</td>
<td>-.79**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. TERA – Intercept</td>
<td>.64**</td>
<td>-.47**</td>
<td>-.47**</td>
<td></td>
</tr>
<tr>
<td>4. TERA – Slope</td>
<td>-.31*</td>
<td>.44*</td>
<td>-.68**</td>
<td></td>
</tr>
</tbody>
</table>

*Note. HTKS = Head-Toes-Knees-Shoulders; TERA = Test of Early Reading Ability.*

\(^*\)\(p < .05\), \(^**\)\(p < .001\) Parameter estimate is significantly different from zero

\(^1\) The correlations between the latent growth factors for behaviour regulation and early reading ability in the unconditional model were moderate \((r_{\text{intercepts}} = .75, p < .001); r_{\text{slopes}} = .46, p = .005\).
4.4 Bivariate latent growth model for math and behavioural self-regulation skills

A bivariate latent growth model was used to examine whether behavioural self-regulation and early math skills would demonstrate correlated growth. The bivariate model extends the conditional univariate model for behavioural self-regulation with an additional outcome for math ability (Bollen & Curran, 2006; Curran & Willoughby, 2003). The following section describes the results from the bivariate latent growth model analysis. Each outcome has its own latent growth factors that are tied to the multiple repeated measures.

A preliminary analysis of the math growth trajectory was conducted prior to the bivariate analysis. The results of the univariate linear growth model analysis for math ability show that the null model fit the data well. For example, the chi-square coefficient (with 1 degree of freedom) was 0.85 ($p = .357$), which implies that the model is consistent with the data and, therefore, should not be rejected on statistical grounds alone. Similarly, the CFI (1.00) and RMSEA (0.00, $p = .465$) indices indicate a strong fit of the model to the data. The intercept factor had a significant mean ($\hat{\beta}_{INTERCEPT} = 13.27$, $p < .001$) and variance ($\hat{\psi}_{INTERCEPT} = 20.49$, $p < .001$). The slope factor was significant and positive ($\hat{\beta}_{SLOPE} = 4.55$, $p < .001$) with a nonsignificant variance ($\hat{\psi}_{SLOPE} = 1.73$, $p = .092$). The significant mean latent growth factors indicated that the rate of improvement in math ability increased over time. The significant variance around the intercept factor demonstrated varying levels of math skills at the start of the study.

Based on the rule of thumb, when the slope variance is not statistically significant, the inclusion of covariates likely increases power to detect slope variability, as a function of the
covariates (Muthén, 2013). Therefore, as part of the preliminary analysis, a conditional latent
growth model for math ability was included with gender as a predictor, controlling for age,
mother’s education and language status. Although the influence of gender on the
development of math skills was not the focus of the current study, this aspect of the math
latent growth model was noted in the preliminary analysis. There was no statistically
significant association between gender and the intercept factor of math ability. This suggests
that boys and girls had similar levels of math ability at the start of the study. There was a
statistically significant association between gender and the slope factor of math ability. This
result indicated boys demonstrated greater improvement in math ability compared to girls
over time.

Next, the bivariate latent growth model for behavioural self-regulation and math
ability was examined to determine whether children’s growth in behavioural self-regulation
paralleled growth in math ability. Figure 5 provides a visual representation of the bivariate
latent growth model. Of interest in the current study are the correlations between the linear
latent growth factors for behavioural self-regulation and early math ability which are
depicted by the double-headed arrows.
The conditional bivariate latent growth model accounted for the background variables, including age, gender, mother’s education and language status. The preliminary analysis suggested that the presence of the covariates did not influence the strength of the correlations in any substantial manner. The results presented in Table 7 show that the slope factors for the trajectories of theoretical interest were not significantly correlated ($r_{SLOPES} = .19$, $p = 0.287$). This statistically nonsignificant finding indicates the growth trajectories for math ability and behavioural self-regulation were not parallel. However, the intercept growth

---

2 The correlations between the latent growth factors for behaviour regulation and early math ability in the unconditional model were moderate for the intercepts ($r_{INTERCEPTS} = .73, p < .001; r_{SLOPES} = .22, p = .197$).
factors were positively and moderately correlated ($r_{INTERCEPTS} = .64, p < .001$). This result suggests that higher levels of behavioural self-regulation were associated with higher levels of math skills at the start of the study, compared to children who had lower levels of behavioural self-regulation.

Table 7

*Correlations between growth parameters for behavioural self-regulation and math skills*

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. HTKS - Intercept</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. HTKS - Slope</td>
<td>-.81**</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. NKT - Intercept</td>
<td>.64**</td>
<td>-.36*</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>4. NKT - Slope</td>
<td>-.08</td>
<td>.19</td>
<td>-.62**</td>
<td>-</td>
</tr>
</tbody>
</table>

*Note. HTKS = Head-Toes-Knees-Shoulders; NKT = Number Knowledge Task.*$p < .05, **p < .001$ Parameter estimate is significantly different from zero.
CHAPTER 5
DISCUSSION

The first goal of the current study was to examine whether the rate of growth in behavioural self-regulation was the same or different in kindergarten boys and girls over a three-year period, using a latent growth modelling approach. Results from the direct assessments showed that all children improved over time and girls and boys had similar growth rates. The second goal was to investigate whether the trajectories of growth in behavioural self-regulation and early reading skills were correlated. The latent growth model for this analysis showed both trajectories were positively and significantly correlated on initial status and growth. Similarly, the third goal tested whether the growth trajectories in behavioural self-regulation and math skills were correlated. Positive and significant correlations were evident on the initial status in both constructs but growth was not correlated. This chapter provides a discussion of the results for the three aforementioned goals, implications of the research results for policy, practice and future research, as well as the limitations associated with the research results, and concluding remarks.

5.1 Gender and growth in behavioural self-regulation

In general, children made positive gains in self-regulation between kindergarten and early elementary school similar to previous reports (McClelland et al., 2006; Wanless et al., 2016). On an individual level, children differed in behavioural self-regulation at the start of the study and growth over time. These findings are consistent with previous research suggesting a positive and upward growth trend in self-regulation during this time period (Center on the Developing Child at Harvard University, 2011; McClelland et al., 2006;
McClelland et al., 2014; Raffaelli et al., 2005). In terms of influences on development, there were no meaningful gender effects on either initial levels of behavioural self-regulation or growth over time. That is, girls and boys demonstrated similar rates of improvement. These findings are consistent with results from several other longitudinal studies that have found comparable trends in the developmental trajectories of boys and girls (Cameron Ponitz et al., 2008; Wanless et al., 2016; Yamamoto & Imai-Matsumura, 2017).

There are a number of plausible explanations for the absence of gender differences. First, potential gender differences may not necessarily be apparent when assessed with an objective measure, as is the case in the current study. Unlike teacher ratings based on perceptions of day-to-day classroom behaviour that typically show a bias towards rating girls higher than boys, the HTKS directly taps individual behavioural self-regulation on a single occasion with adult instruction. Both measures provide valuable information, but given the small to moderate correlations between the measures each may capture a different aspect of behavioural self-regulation (Lonigan et al., 2017; Toplak et al., 2013). Second, of the few studies within this area, there is evidence demonstrating mixed findings concerning gender similarities and differences on the same task (i.e., HTKS). These varied results may be partly due to cultural differences across sample settings, particularly in relation to parent and teacher expectations and scaffolding practices for the development of self-regulatory behaviour. For example, of the small number of cross-cultural studies in this area, one study attributed the absence of gender differences on the HTKS task in a Chinese sample of children to the Confucian values (i.e., solidarity and harmony with others) held in the Chinese culture that require all children to regulate their behaviour in accordance with the
needs of others, especially parents and teachers, thereby allowing them more opportunities to practice behavioural regulation in accordance with group norms, regardless of gender (Wanless et al., 2013). This notion was contrasted in the aforementioned study with a U.S. sample of children from a cultural setting focused on autonomy, self-interest and separateness where girls’ stronger behavioural regulation skills were attributed to a difference in gender norms and more opportunities to practice behavioural regulation (e.g., sociodramatic play). More studies are clearly needed to better understand the influence of cultural background on the development of behavioural self-regulation (Jaramillo, Rendón, Muñoz, Weis, & Trommsdorff, 2017; McClelland et al., 2010). Finally, it is possible that gender differences in the regulation of behaviour are not large enough to detect in kindergarten and early elementary school children and become more pronounced in later grades (Cameron Ponitz et al., 2008; Gestsdottir et al., 2014). Gender beliefs and behaviour are influenced by socialization processes and cognitive development, and the extent of these influences can vary depending on a child’s social experiences and developmental status (Bussey & Bandura, 1999). That said, future longitudinal studies should investigate age-related changes in gender development and the influence of these changes on trajectories of growth in behavioural self-regulation, as they are unclear from the existing literature.

Consistent with other studies, in the current study, maternal education levels were predictive of growth in children’s behavioural self-regulation (Gestsdottir et al., 2014; Matthews et al., 2009; Montroy et al., 2016; Ponitz et al., 2009; Wanless et al., 2016). Children with mothers who had acquired a university education developed behavioural regulation skills at a faster rate compared to children whose mothers did not. There are a few
possible reasons for this finding. First, maternal education may influence parent beliefs and behaviour about the way children learn and develop. Higher levels of education tend to reflect parent profiles associated with higher levels of maternal warmth, responsiveness as well as language-rich and cognitively stimulating home environments, compared to mothers with lower levels of education (Guttentag et al., 2006). Parenting profiles associated with more educated mothers may provide important supports and guidance for the development of self-regulation in children (Bernier et al., 2010; Grolnick & Farkas, 2002; NICHD Early Child Care Research Network, 2005; von Suchodoletz, Trommsdorff, & Heikamp, 2011). Second, maternal education is often used as a proxy for family socioeconomic status (Bradley & Corwyn, 2002; Hoff et al., 2002) and a higher socioeconomic status has been associated with greater availability of educational resources (e.g., books and informal learning opportunities) to support the development of children’s self‐regulation (Brooks-Gunn & Duncan, 1997; Evans, 2004) as well as lower levels of stress within the family home (Blair & Raver, 2012).

5.2 Growth in early reading, math and behavioural self-regulation skills

Overall, children in the current study demonstrated positive gains in early reading ability from kindergarten to Grade 2; while there were similarities in growth trends, there was substantial variability in children’s individual scores in kindergarten and growth rates, after accounting for background variables. The positive association between the developmental trajectories for behavioural self‐regulation and early reading ability was statistically significant. That is, kindergarten children with higher initial levels of behavioural regulation also demonstrated stronger initial early reading proficiency compared to children
with weaker behavioural regulation. Moreover, children who demonstrated greater improvement in behavioural regulation over the growth trajectory also showed significantly greater improvements in early reading ability, compared to children who developed behavioural regulation skills at a slower rate. These findings accord well with previous research studies that have found concurrent (Becker et al., 2014; Schmitt et al., 2014; von Suchodoletz et al., 2013; von Suchodoletz et al., 2015) and longitudinal associations between reading-related skills and behavioural regulation (Burrage et al., 2008; Lonigan et al., 2017; McClelland et al., 2007; Montroy et al., 2016; Montroy et al., 2014; Wanless et al., 2016), controlling for relevant sociodemographic variables across diverse samples. A plausible explanation for this finding is that emergent reading involves a period of knowledge acquisition (e.g., letter recognition, names, and sounds, spelling, punctuation, word meanings) that places demands on cognitive skills associated with behavioural regulation and this process continues until the knowledge has been mastered and becomes more automatized and less reliance is placed on top-down control processes associated with executive functions as children mature (Blair & Razza, 2007). It is possible that the TERA reading assessment in the current study tapped cognitive processes associated with behavioural self-regulation such that it required effort from the emergent readers, across the growth trajectory, to integrate and coordinate cognitive processes in order to identify letters and sounds, decipher words and their meaning, and connect different parts of text to draw inferences (Birgisdóttir, Gestsdóttir, & Thorsdóttir, 2015; Oakhill & Cain, 2012). In addition, it is possible that children with stronger behavioural self-regulation developed better reading skills as a result of having better learning-related skills, compared to their peers, such as being more skillful
with following and remembering the teacher’s instructions, staying on task for the required
duration, ignoring distractions, integrating existing and newly acquired knowledge, and
sustaining motivation to complete a task (Lonigan et al., 2017; Montroy et al., 2014).

Kindergarten children in the current study demonstrated variability in individual
levels of initial math scores but overall they showed improvement over the growth trajectory
into Grade 2, after accounting for background variables. Results from the dual trajectory
analysis showed children’s initial skill levels in math and behavioural self-regulation were
positively associated. These results are consistent with other studies that have shown
concurrent associations between behavioural self-regulation and early math skills (Becker et
al., 2014; Lan et al., 2011; Schmitt et al., 2014; von Suchodoletz et al., 2013). Similar to the
discussion about strengths in behavioural self-regulation and early reading skills, it seems
possible that higher initial levels of behavioural regulation in kindergarten provides children
with stronger in-class learning-related skills (e.g., staying on task, ignoring distractions,
integrating new information with existing information, and remaining engaged and
motivated) that allows them better learning opportunities and consequently stronger
performance on math-related tasks (Garon et al., 2008; Lonigan et al., 2017; McClelland et
al., 2014). Having strengths in both behavioural self-regulation and math skills in
kindergarten may set children on a path towards continued improvement in subsequent
grades, as prior math skills support later math skills (e.g., the ability to count is first learned
and then automatized, which supports performance on more complex tasks; see Aunola et al.,
2004). Investigation of the joint trajectories revealed no significant association between rates
of improvement in math and behavioural self-regulation from kindergarten to Grade 2. Only
one other known study has investigated the relation between growth in behavioural self-regulation and math in kindergarten children. Contrary to the findings of the current study, Schmitt et al. (2017) found correlated growth between math and behavioural self-regulation (i.e., an executive function construct comprised of multiple measures including the HTKS task). However, they administered the Applied Problems subtest of the Woodcock Johnson Psycho-Educational Battery-III Tests of Achievement (WJ-III; Woodcock, McGrew, & Mather, 2001) which perhaps placed a heavier emphasis on language skills compared to the math assessment used in the current study (Montroy et al., 2014; Skibbe, Hindman, Connor, Housey, & Morrison, 2013; Wanless et al., 2016). Therefore, the difference in research findings could be attributed to the extent to which language skills play a role in the math measures and HTKS task (Montroy et al., 2014).

5.3 Implications for practice, research and policy

The current study builds on previous research that has used the HTKS task as an objective and direct measure of behavioural self-regulation in young children and made several contributions to the small number of longitudinal research studies in this area that have used a growth modelling approach. This study contributes to the growing body of literature pointing to the importance of supporting the development of behavioural regulation in kindergarten as well as elementary school children and suggests that the primary focus of such supports may not necessarily need to be based on gender categorizations. In addition, this study underscores the important role that children’s behavioural self-regulation skills play in supporting their development of reading and math skills from kindergarten to early elementary school. That said, the current study has several practical implications.
First, potential gender similarities in the early development of behavioural self-regulation suggest separate instructional practices may not necessarily need to be geared towards a specific gender. Educators can provide effective support for the development of behavioural self-regulation by observing each child’s classroom behaviour and scaffolding that behaviour in individual ways. One way educators might accomplish this is to understand self-regulation from a practical standpoint and be attuned to individual differences by recognizing when children demonstrate this skill (or when they do not) within the classroom context (Ontario Ministry of Education, 2016). Theoretical and empirical evidence suggests that play-based learning strategies can support children’s development and learning, including self-regulation, social competence, math and literacy (Fesseha & Pyle, 2016; Pyle, Poliszczuk, & Danniels, 2018; Pyle, Prioletta, & Poliszczuk, 2018). In a play-based program children are exposed to learning and problem solving through self-initiated activities and teacher guidance, although depending on how play-based is defined the extent of the educators involvement may vary (e.g., child-led, teacher-led or guided play). To obtain a better understanding about how children are progressing, a future consideration for education policy is the identification of an indicator that specifically measures self-regulation outcomes in kindergarten and early elementary school children and research studies to investigate growth trajectories against academic performance.

Second, mother’s education is a well-established predictor of family socio-economic status and in the current study it emerged as a stronger predictor of growth in behavioural self-regulation compared to gender. More highly educated mothers typically have greater access to educational resources to support children’s development of self-regulation
compared to less educated mothers (Brooks-Gunn & Petersen, 1983). Moreover, higher educational attainment is also likely associated with more child-centred beliefs about how children learn and develop, and how parenting behaviour reflects those beliefs (Guttentag et al., 2006). For example, through a child-centred parenting approach, parents provide children with warm responsive interactions in a reduced stress environment characterized by learning experiences that scaffold development of their self-regulatory skills through directing, instructing and maintaining engagement (Center on the Developing Child at Harvard University, 2011; Guttentag et al., 2006). The current study provides preliminary results regarding the influence of early contexts on developmental trajectories of self-regulation and further underscores the importance of parent education and awareness concerning developmental outcomes. Future research should examine the direct influence of particular parenting behaviour on differences in children’s development of regulatory behaviour and associations with academic performance (Grolnick & Farkas, 2002; Montroy et al., 2016).

Third, given mounting evidence pointing to the contribution of behavioural self-regulation to reading- and math-related skills, educational policies that encourage the continuity of instructional practices that foster self-regulatory development may be more effective at reducing the achievement gap, as opposed to policies aimed at promoting these skills only prior to first grade. Furthermore, teacher training and professional development programs that embed self-regulation into pedagogical knowledge and practicums may help better equip teachers to promote children’s self-regulated learning (Hur, Buettner, & Jeon, 2015; Peeters et al., 2014). Although the investigation of classroom and teacher characteristics is beyond the scope of the current study, it is noteworthy that similar to the
suggestion that maternal educational attainment and related child-centred beliefs influence children’s developmental outcomes, it seems possible that teachers’ educational attainment and training as well as their beliefs can also affect their style of instructional practice and how they interact with students (Hur et al., 2015; Mashburn et al., 2008; Rimm-Kaufman et al., 2009). For example, teachers with progressive and democratic, as opposed to traditional and authoritarian, views about children’s learning process tend to implement classroom instructional practices that promote children’s ability to self-regulate by offering opportunities to practice these skills and learning through inquiry and imaginative play in diverse settings (Hur et al., 2015; Ontario Ministry of Education, 2016). Furthermore, self-regulated teachers are more likely to promote children’s self-regulation as they may have a better understanding about particular learning and teaching strategies that allow them to model self-regulated learning strategies (Gordon, Dembo, & Hocevar, 2007; Tillema & Kremer-Hayon, 2002). Teachers’ beliefs about how children learn have been shown to be significantly and positively linked to children’s self-regulation and academic achievement (Hur et al., 2015; Rimm-Kaufman et al., 2009). Thus, given the importance of self-regulation in academic performance, future research should examine the role of teachers’ own self-regulatory capacities on students’ self-regulated learning behaviour and the association with their academic performance (Peeters et al., 2014).

Lastly, findings from the current study provide preliminary evidence that language comprehension may play an important role in the development of behavioural self-regulation and performance on the HTKS task and as such this might be a factor to control for in analyses in future studies.
In recent years, programs such as Ontario’s full-day kindergarten program offer a curriculum that focuses on the development of children’s self-regulatory skills and other skills related to health and well-being that support learning using a developmentally responsive child-centred approach that is play-based and involves problem-solving experiences (Ontario Ministry of Education, 2013, 2016). The program is led by an educator team that includes a certified teacher and early childhood educator and emphasizes the importance of respectful and warm relationships, play and inquiry for learning, educator-child co-learning (learning from one another), and the need for educators to reflect on their instructional style of practice independently and with other educators (Fesseha & Pyle, 2016). There are other well-known educational approaches such as Tools of the Mind and Montessori as well as targeted games and activities that are utilized to help children develop self-regulatory skills (Diamond, 2012); however, future studies should be conducted to investigate the specific components of program curriculum and instructional practices that can potentially facilitate development of this important skill and its causal impacts on reading and math outcomes (Blair, 2017; Lonigan et al., 2017).

5.4 Study limitations

Results from the current study suggest that growth in behavioural self-regulation measured on an objective assessment, from kindergarten to Grade 2, is not differentiated based on gender and relates to children’s reading and math skills in kindergarten as well as improvements in reading related skills into Grade 2. However, there are several key limitations that must be noted. First, although the sample was fairly diverse, it is nonetheless difficult to generalize the study to the provincial level (i.e., Ontario) as rural and Indigenous
communities were not included in the study. The sample consisted of children from a diverse range of ethnic backgrounds and families who resided in predominantly middle- to lower-income areas. This provided the current study with a sample representative of many urban areas across the province of Ontario. However, future studies may benefit from using more heterogeneous samples. Second, the current study utilized one measure of behavioural regulation based on a single direct observation of behaviour typically required in classroom and school settings. Parent and teacher ratings of children’s behavioural regulation are measures that can also provide valuable information as they are based on multiple observations about behaviour across a wide range of situations over different time points. Although ratings are prone to observational bias, future studies should incorporate multiple measures of behavioural regulation to round out the assessment of the complex and multidimensional nature of this construct (McClelland et al., 2010). Doing so would elucidate what aspect of behavioural regulation is being measured (Lonigan et al., 2017). Similarly, future studies should explore multiple measures of specific math and reading components to obtain a more comprehensive understanding of the relationship between math, reading and behavioural self-regulation since associations can vary depending on what is being measured and what factors are accounted for in the analyses (Schmitt et al., 2017). Lastly, the influence of teachers’ instructional practices and classroom context on the development of behavioural regulation, reading and math outcomes was not explored but will be an important area for future studies to explore. Although the latent growth modelling approach utilized in the current study does not determine whether behavioural regulation predicts or is causally related to the development of reading and math ability or what the
effects of other factors such as parenting practices or classroom instruction are on
development, this is the only known study that has examined growth trajectory correlations
between children’s behavioural regulation based on direct assessments, reading and math
ability from kindergarten to Grade 2.

5.5 Conclusion

In summary, the current study found that kindergarten boys and girls shared similar rates
of improvement in behavioural self-regulation based on an objective assessment, as they
progressed through early elementary school. The absence of gender differences suggests that
the HTKS task might measure a different aspect of behavioural self-regulation compared to
other types of assessments such as observer rating scales. This result also suggests that
educators should provide scaffolding in an individualized manner to effectively support
children’s development of self-regulation during this period of time, rather than adopting
gender-specific instructional practices. Future studies should utilize multiple measures to
round out the assessment when investigating the influence of such demographic factors on
development over time. The current study provides preliminary evidence of a positive
association between behavioural self-regulation, reading and math in kindergarten as well as
improvements in both behavioural self-regulation and reading over the growth trajectory.
This finding highlights the importance of a pedagogical approach that optimizes the
development of these important learning-related skills in addition to enhancing early
academic abilities; such an approach may be the most effective to help children succeed in
school. Future studies should follow-up on correlational analyses with causal models to
elucidate the link between improvements across these developmental domains.
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