Université de Montréal

Kindergarten Classroom Engagement Skills: The Road to Academic Success in Elementary School

par
Caroline Fitzpatrick

École de psychoéducation
Faculté des arts et des sciences

Thèse présentée à la Faculté des arts et des sciences
en vue de l'obtention du grade de Ph.D.
en psychoéducation

2 Août, 2011

Université de Montréal
Faculté des études supérieures et postdoctorales

Cette thèse intitulée:

Kindergarten Classroom Engagement Skills:
The Road to Academic Success in Elementary School

Présentée par :
Caroline Fitzpatrick

a été évaluée par un jury composé des personnes suivantes :

_____, président-rapporteur
Linda Pagani, directeur de recherche
_____, membre du jury
_____, examinateur externe
_____, représentant du doyen de la FES

Résumé

Les caractéristiques de l'enfant à la maternelle prédisent le succès des transitions à travers les premières années scolaires ainsi que la poursuite académique à l'âge de 22 ans. Les habiletés en mathématiques et langagières à la maternelle sont étroitement liées au rendement scolaire. Cependant, il est également important de tenir compte du rôle de l'autocontrôle et de la maîtrise de soi dans la réussite académique. Spécifiquement, la capacité de suivre des instructions et travailler de manière autonome pourrait faciliter l'adaptation des enfants en milieu scolaire. La présente thèse examine la valeur potentielle de cibler l'engagement scolaire à la maternelle, sous forme d'orientation vers la tâche, pour améliorer l'ajustement académique des enfants au cours du primaire. Dans une première étude, nous avons examiné si l'engagement scolaire à la maternelle est associé à un meilleur niveau de réussite scolaire et d'ajustement psychosocial à la quatrième année du primaire. Nos résultats suggèrent que les habitudes de travail dès l'entrée à l'école représentent des prédicteurs robustes du rendement académique quatre ans plus tard. Un plus haut niveau d'engagement prédit également moins de comportements externalisés et de victimisation par les pairs en quatrième année. Ces résultats sont demeurés significatifs suite au contrôle statistique des habilités en mathématique, langagières et socio-émotionnelles des enfants ainsi que de facteurs de risques familiaux. Dans une deuxième étude, nous avons examiné l'origine de l'engagement scolaire au primaire. Ceci nous a permis d'observer que le niveau de contrôle cognitif des enfants d'âge préscolaire représente un prédicteur significatif de l'engagement scolaire à la maternelle. Ces résultats suggèrent l'existence d'une continuité développementale du contrôle cognitif de la petite enfance à la maternelle, et que celle-ci pourrait servir de base pour le développement de bonnes habitudes de travail au primaire. Finalement dans une troisième étude, nous avons effectué des analyses centrées sur la personne et avons identifié trois sous-groupes d'enfants dans notre échantillon. Les résultats obtenus indiquent des trajectoires d'engagement bas, moyen et élevé respectivement, au primaire. Le faible contrôle cognitif et les facteurs de risques familiaux ont prédit l'appartenance à la trajectoire d'engagement

faible. Dans l'ensemble, les résultats de ces trois études soulignent l'importance de tenir compte de l'engagement dans les évaluations de la maturité scolaire à la maternelle. Cette recherche pourrait également informer le développement de programmes d'interventions préscolaires visant à augmenter la préparation scolaire ainsi que la réduction des écarts au niveau de la réussite académique des enfants.

Mots-clés : Engagement scolaire; réussite académique, ajustement psychosocial, contrôle cognitive

Abstract

How children begin school is an important predictor of their eventual academic attainment. Although kindergarten knowledge of numbers and vocabulary represent robust indicators of children's readiness to learn at school entry, theory and research suggest that self-directed learning skills are also important for helping children meet the challenges of the elementary school classroom. In the present thesis, three papers examine the potential benefit of targeting classroom engagement skills in terms of task-orientation and industriousness to improve children's academic outcomes. In Paper 1, kindergarten classroom engagement skills were found to predict later academic performance and psychosocial adjustment. These results remained significant even after adjusting for kindergarten mathematics, verbal, and attention skills and established child and family risk factors. Paper 2 addresses the origins of classroom engagement and shows that early childhood cognitive control skills represent robust predictors of school entry classroom engagement skills. These findings suggest that developmental continuity in cognitive control may culminate in better school entry engagement skills. Finally in Paper 3, person-centered analyses were used to identify three subgroups of children showing low, moderate, and high patterns of engagement across elementary school. Belongingness to the low engagement trajectory was predicted by early childhood cognitive control skills and parental risk factors. Taken together these results underscore the importance of considering classroom engagement skills in school readiness assessments. This research also has

implications for the development of early interventions designed to bolster school readiness in order to circumvent later academic and social impairments.

Keywords: Classroom engagement; academic achievement; psychosocial adjustment; cognitive control

Table of Content

List of Tables

List des figures

Acknowledgements

I take great pleasure in thanking Linda Pagani, without whom this thesis would not have been possible. It has been an honour to work side by side with her on this project for which she has provided endless support, patience, and guidance over the course of my studies. I am tremendously grateful for her generosity and insight, which have allowed me to learn, grow, and develop passion and enthusiasm for the topic I study. I am also heartily thankful to all the follow students, professors, and collaborators who have helped me over the course of this project.

During the writing of this thesis I was funded by a doctoral scholarship from the FQRSC and bursaries from the GRES and the École de psychoéducation of the Université de Montréal. I am very grateful for this financial support.

"Our progress as a nation can be no swifter than our progress in education. The human mind is our fundamental resource".

-John F. Kennedy

CHAPTER 1

General Introduction

Introduction

Making sure that the next generation of citizens, workers, and caregivers benefit from a basic education remains at the forefront of societal concerns. Accordingly, the Québec Ministry of Education holds the mission of providing all children with the opportunity to acquire skills that will help them develop into contributing members of society (MELS, 2010). In addition to representing an important objective from a social policy standpoint, maximizing the educational qualifications of each individual child also figures prominently on the economic agenda. Cost-benefit analysis research has highlighted the tremendous economic burden of underachievement and high school dropout, which represent 11.7% in the province of Québec (Bowlby, 2005; Levin, Belfield, Muennig, & Rouse, 2007; MELS, 2011). In light of aging population demographics, the province of Québec particularly depends on individual reinvestment in order to support social programs for the next generation. In order to develop efficient intervention strategies aimed at improving high school completion, it remains important to identify modifiable child and family characteristics which can be targeted to bring about improvement in student achievement.

The process leading to high school dropout originates early on in children's academic trajectories. For instance child characteristics in kindergarten forecast successful academic trajectories and persistence through high school completion (Entwisle, Alexander, & Olson, 2005). One way to increase academic proficiency is thus to help children begin school fit for the challenges they will face throughout their educational journey. School readiness, refers to child maturity and the ability to negotiate classroom

demands upon transitioning to formal schooling. Over the past half century, there has been growing concern over the idea that children need to be well prepared at school entry in order to prevent them from falling behind (High & The Committee on Early Childhood, Adoption, and Dependant Care and Council on School Health, 2008; Tramontana, Hooper, & Selzer, 1988; Zuckerman & Halfon, 2003). A lot of research has been allocated to identifying what children need to know in order to succeed early in school (Duncan et al., 2007; Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010; Pagani, Fitzpatrick, Archambault, & Janosz, 2010; Romano, Babchishin, Pagani, & Kohen, 2010). What has been less clear is how child investment and effort in learning play a role in successful school adjustment. In the present review, we propose a model of school readiness that addresses the unique contribution of self-directed learning behavior to children's academic potential.

School Readiness

Interest and perspectives on school readiness have simultaneously emerged across academic disciplines. For economists, identifying which early capabilities predict achievement and employment potential represents an important investment from a human capital perspective (Duncan et al., 2007; Heckman, 2006; Murnane, Willett, & Levy, 1995). Underachievement especially represents a costly social problem (Knudsen, Heckman, Cameron, & Shonkoff, 2006). Medical practitioners have emphasized the importance of school readiness from a population health perspective, drawing attention to the relationship between educational attainment and later health, morbidity, and mortality (Fiscella & Kitzman, 2009; Freudenberg & Ruglis, 2007). Furthermore, pediatric perspectives have proposed more integrative and contextual definitions of school readiness. That is, in

addition to individual characteristics some have argued that schools and communities also need to be involved in supporting children through a successful transition (High & The Committee on Early Childhood, Adoption, and Dependant Care and Council on School Health, 2008; Zuckerman & Halfon, 2003). Finally, policy makers propose that international goals should include universal school readiness and proficiency upon school entry. Such reasoning is behind the highly publicized "No child Left Behind" act adopted in the United States.

In retrospect, research on school readiness has been driven by the immediate needs of social policy more so than carefully constructed theory. This may be due to the influence of economic production models and the demand for policy makers to increase the overall quality of education to solve urgent social problems. Nevertheless, there are several theoretical and empirical considerations which should be taken into account in methodological and conceptual approaches to school readiness.

School entry coincides with an important transition in children's cognitive development. According to Piaget (1956), an important cognitive shift occurs around the age of 6 which serves as the basis for complex thinking and cognitive processing. One implication of Piaget's stage-driven theory of development is that only cognitively mature children will be able to acquire classroom lessons demanding more complex mental operations. Conversely, less cognitively mature children may experience difficulty in school. Cognitive neuroscience research also suggests that important stage-like changes in child cognition emerge during the preschool period (Feldman, 2009; Marcovitch & Zelazo, 2009; Zelazo & Frye, 1998). For instance, in response to rapid brain development during

the first years of life, children become much more proficient at using focused attention and working memory to solve problems (Feldman, 2009; Garon, Bryson, & Smith, 2008; Marcovitch & Zelazo, 2009). These improvements in attention and working memory in early childhood forecast children's subsequent use of inhibitory control which emerges later in the preschool years (Feldman, 2009). Consequently, by school entry children are generally capable of exercising effortful control over behavior and delayed gratification in the pursuit of goals (Mischel, Shoda, & Rodriguez, 1989).

According to neurocognitive theories, a window of relative plasticity is also likely to help children more easily acquire new behavior, knowledge, and skills during early childhood. The remarkable success of carefully designed preschool interventions programs supports the existence of a developmentally sensitive period for learning (Diamond, Barnett, Thomas, & Munro, 2007; Gormley, Phillips, & Gayer, 2008; Heckman, 2006). Although theories of plasticity do not suggest that new learning cannot occur outside of this period, they do suggest that a stronger environmental "push" may be needed outside of this timeframe to bring about improvement in children's cognitive and social skills. Because interventions that occur later in childhood and adolescence usually require more resources, they are viewed as less cost-effective (Heckman, 2006; Knudsen et al., 2006).

Duncan's School Readiness Model

A resounding theme across school readiness research is that being prepared for school at kindergarten plays a role in how one will fare later on. How one begins school then predicts rewards or consequences for individuals, their families, and society at large. Children who begin their academic journey on solid ground experience more academic

success in primary school (Duncan et al., 2007). In contrast, children who experience difficulty early on are more likely to embark on a course of academic underachievement associated with an increased risk of dropping out of school (Alexander, Entwisle, & Dauber, 1993; Alexander, Entwisle, & Horsey, 1997). Youth who decide to dropout of high school are then more likely to experience poorer health and engage in risky and antisocial behaviors including unprotected sexual intercourse, substance use and abuse, and involvement in criminal activity (Ellickson & McGuigan, 2000; Freudenberg & Ruglis, 2007; Hargreaves et al., 2008). Understanding what skills contribute to successful school experiences is therefore an important step for helping both children and their families achieve their maximum potential.

In a large scale international study of school readiness, Duncan et al. (2007) provide evidence that skills in math, reading, as well as attention are important predictors of later academic achievement. Though previously hypothesized as important contributors to school adjustment (Ladd, Birch, & Buhs, 1999), child classroom behaviors such as aggression, prosocial skills, and anxiety, were not statistically significant. A major conclusion from these findings is that child behaviors carry less weight in facilitating academic success than early intellectual skills.

The findings of Duncan and colleague have been replicated using a French Canadian sample (Pagani et al., 2010). Surprisingly, even though the replication presented methodological improvements over the original piece, a remarkable similarity in effect sizes was observed in both studies. Going beyond the Duncan et al. model, learning-related behaviors in terms of classroom engagement reflecting task-orientation and effortful control

were addressed as additional outcomes. Kindergarten math and attention skills predicted second grade classroom engagement. This study did not address the origins of classroom engagement, as such the role of kindergarten learning-related skills for school readiness remains to be examined. In particular it would be interesting to examine if engaged kindergarten students fare better later in elementary school.

Limits of Duncan's Model

Because of its large sample size and methodological rigour, the above Duncan model (2007) has become a benchmark in school readiness research. Despite its empirical usefulness it does present four important limitations. First, a general finding of research using this model is that kindergarten entry behaviors with the exception of attention problems are not predictive of later success. This conclusion should be interpreted with caution since the authors only assessed a restricted range of mostly negative or problematic child behaviors. It would have been equally if not more informative to examine productive student classroom behavior, such as task orientation and industriousness as opposed to child internalizing (i.e., anxiety) and externalizing (i.e., physical aggression) problems. A second limitation of Duncan's model is that only academic success was considered as a pertinent outcome of interest. However, it is plausible that school readiness forecasts future adjustment in multiple spheres of child functioning. Furthermore, children need to develop a variety of competencies, including positive psychosocial skills and strong work habits on the road to high school completion and successful transition to adulthood. For these reasons, in the present thesis, a holistic set of child functioning indicators are examined as outcomes of school readiness. A third limitation of Duncan's model is that it does not help

us understand the origins of children's successful adjustment to school. Understanding this developmental chain of events is essential to maximize preschool intervention and prevention strategies. Finally, Duncan's model did not examine the existence of individual differences in academic outcomes over time. In a population of typically developing children, the existence of subgoups that follow different developmental courses is likely (Bergman, Magnusson, & El-Khouri, 2003; Magnusson, 1998; Richters, 1997). As such, it is important to take into account the possibility of heterogeneity in children's developmental patterns of learning-related behavior throughout elementary school.

Reevaluating and expanding definitions of school readiness can help us better identify children at risk of future academic problems. Reliable school readiness models can also be used in the development of head start programs for preschoolers. Thus, to achieve universal school proficiency starting in the first grade, it is important to ensure that our definition of school readiness encompasses a broader range of skills that support child learning and adaptive psychosocial functioning across development.

Classroom Engagement and School Readiness

Even though knowledge of numbers and vocabulary explain a lot of the variance in achievement, they leave out a theoretically meaningful self-determining component. In order to be successful in the classroom, children also need to develop strong learning skills (Bierman et al., 2008; Fredricks, Blumenfeld, & Paris, 2004). In particular, the ability to plan, adapt, and self-organize are important to sustain child participation and learning in the classroom.

From a sociological perspective, positive-work habits and the willingness to conform to rules and instructions in the childhood learning context are important because they are akin to the skills required for success in the adult workplace. A review of literature in sociology, conducted by Farkas, (2003) suggests that adults who possess a combination of cognitive skills, conscientiousness, and focused work habits, developed from birth through adolescence, experience greater occupational and personal success. Such learning skills reflect, respect for authority, initiative, task-orientation, and the ability to follow rules and procedures and are consistent with the definition of classroom engagement.

Moreover, an interest in child learning behavior is also consistent with Quebec's educational reform policy. The acquisition of reading, writing, and mathematics skills remain components of child performance. However, the ability to get along and cooperate with fellow students, follow rules and instructions, and work autonomously has been integrated within the grading schemes used to evaluate performance in elementary school students.

Recently, the importance of engagement reflecting commitment and persistence toward learning and academic goals has received attention as a promising target for interventions aimed at reducing student dropout and poor academic achievement (Fredricks et al., 2004; Janosz, Archambault, Morizot, & Pagani, 2008). A chief benefit of studying engagement resides in the intuitively appealing notion that engagement is directly related to learning, as well as in the idea that engagement, unlike IQ or family socio-demographics, is malleable and amenable to change (Fredricks et al., 2004).

Though the concept of engagement has been defined and operationalized in a number of ways in the education literature, commonalities across studies include a definition of engagement as a reflection of the person-environment fit (Fredricks et al., 2004). In this light, an individual's ability to benefit from instruction and be successful in school may be less dependent on how much they know at school entry than on their mastery of skills that favor adaption to the norms and demands of the classroom. For example, children who demonstrate self-directed behavior that favors learning and involvement in the classroom are likely to be more successful and illicit more positive reactions from teachers (Eccles et al., 1993). Children with these favorable characteristics are likely to be rewarded for their behavior by teachers, which can further reinforce positive classroom behavior in the future (Skinner & Belmont, 1993). From a contextual or systemic approach, changes in engagement are therefore likely to arise through interventions that target relevant characteristics of the child and their environment, or both.

In order for individuals to successfully adapt to their environment, they must be able to regulate their own states and exercise effortful control over behavior. Engagement skills, defined in terms of the ability to demonstrate persistence, task-orientation, and compliance in the learning context, are thus likely to represent outcomes of cognitive control skills. Three central components of cognitive control, or executive functions, are the inhibition of inappropriate responses, working memory, and attentional control (Garon et al., 2008; Miyake et al., 2000). These skills which are governed by the prefrontal cortex play an important role in sustaining children's goal directed behavior in the classroom (Barkley, 1997; Blair & Diamond, 2008). Indeed, to be successful in the classroom,

children must inhibit unfavorable behaviors, use working memory to solve problems and answer questions, and exercise control over attention in order to remain responsive to changing instructions and contextual constraints.

On one hand, strong cognitive control and self-regulatory skills have been linked to better academic achievement and psychosocial functioning in school aged children. Foremost is the link between executive function and math performance (Blair & Razza, 2007; Bull & Scerif, 2001; Butterworth, Varma, & Laurillard, 2011; Cirino, 2010; Sabbagh, Xu, Carlson, Moses, & Lee, 2006). Other research suggests a strong link between cognitive control and writing skills (Altemeier, Abbott, & Berninger, 2008; Altemeier, Jones, Abbott, & Berninger, 2006). Furthermore, preschool children who are better able to exert effortful control to delay gratification score higher on cognitive achievement tests several years later in adolescence (Mischel et al., 1989).

Children who are experiencing difficulty in the area of cognitive self-regulation are also at risk of impairments in psychosocial and interpersonal domains. Eisenberg and colleagues (2001) have shown that 4 to 8-year-old children who experience difficulties in effortful control are more likely to display internalizing and externalizing problems in later childhood. Similarly, children who display unstable or low levels of cognitive control (i.e., the ability to resist distractions and temptations) between the ages of 5 and 10 subsequently show more elevated trajectories of externalizing problems (Zhou et al., 2007). Finally, children who demonstrate low levels of effortful control self-report more delinquency and convictions by age 21 (Henry, Caspi, Moffitt, Harrington, & Silva, 1999).

Research employing a person-centered approach suggests that school aged children diagnosed with ADHD are more likely to show multiple impairments in academic, social, behavioral, and emotional domains (Lee, Lahey, Owens, & Hinshaw, 2008). This is not surprising given that poor cognitive control represents a central impairment in ADHD (Barkley, 1997) Furthermore, in a sample of adolescents, ADHD symptoms were associated with impairments in expressive, receptive, and written communication ability, as well reductions in the ability to engage in social interactions, be responsible, and show sensitivity towards others (Clark, Prior, & Kinsella, 2002).

In addition to laboratory-based assessments, observational measures of child cognitive control in naturalistic contexts also predict more favorable academic outcomes. First grade students who participate and are more involved in the classroom tend to do better on fourth grade academic measures (Alexander et al., 1993). Kindergarten task-orientation and persistence have been shown to explain the relationship between early aggressive and prosocial behaviors and first grade math and reading achievement (Normandeau & Guay, 1998). Duncan et al. (2007) found that teacher-ratings of poor attention control represent key components of school readiness that reliably forecasts later academic success above and beyond a large set of child and family characteristics. Teacher-ratings of attention problems can also explain unexpected trajectories of academic failure (Pagani et al., 2008). Finally, later on in adolescence, student self-control explains the gender gap in achievement (Duckworth & Seligman, 2005).

In summary, classroom engagement is likely to depend on the fit between children's characteristics and the demands of the environment. Children's ability to self-regulate and

exercise cognitive control can enhance their ability to adapt to the demands of the school environment by facilitating the pursuit of effortful behavior. Both objectively measured cognitive control skills and learning-related behaviors reflective of cognitive control reliably predict future academic performance. Some research has shown that cognitive control also predicts socio-emotional adjustment, in particular with regards to the control of problematic externalizing behavior. In the next section we expand some of the theoretical underpinnings of classroom engagement.

Theoretical Perspectives

According to Russian developmental psychologist Lev Vygotsky (1987), the ability to exercise cognitive control, and remain engaged, depends on children's ability to master and eventually internalize speech. More specifically, the development of childhood self-control skills involves a developmental progression from the use of "outloud", non-specific language to the use of "private" internalized language to guide goal directed behavior (Vygotsky, 1987). This process is believed to occur within an "open system", which suggests interactions with the environment can facilitate children's acquisition of private speech and eventually self-control (Cicchetti, 1984). Once children are capable of internalizing speech, they can more efficiently use language to give themselves instructions during the performance of complex problems, persist in the face of distractions, regulate emotional responses, and inhibit inappropriate behaviors in the classroom.

The American sociologist Erik Erikson's notion of industriousness, which refers to children's ability to learn skills required for participation in adult society, is consistent with the present conceptualization of engagement. According to Erikson's theory of identity

development (1950), the period from age 6 to 11 is characterized by environmental and social demands upon the child to develop strong work habits and industriousness. Some children may fail to develop such skills because of inadequate school readiness and cognitive control. These children in turn are may be at risk of experiencing poor achievement and feelings of inadequacy or inferiority, which may manifest themselves as psychosocial adjustment problems later in life. In line with this view, others have argued that children who experience difficulty adjusting to the demands of the kindergarten classroom are likely to develop perceptions of themselves as incompetent, which can undermine future academic adjustment (Blair & Diamond, 2008). Furthermore, early school failure that results in grade retention is associated with persistent academic and psychosocial problems toward emerging adolescence (Pagani, Tremblay, Vitaro, Boulerice, & McDuff, 2001).

Finally, it is interesting to note that child engagement is related to American criminologist Travis Hirshi's notion of self-control and social bonds (Gottfredson & Hirschi, 1990). According to his Social Control Theory, children who are engaged in school, and invest time and effort in completing their work and attaining good grades, are unlikely to become involved in delinquent behaviors. In contrast, poor attachments and bonds with others such as peers and teachers and reduced involvement with conventional institutions such as schools are believed to erode individual self-control. Low self-control, in turn, is believed to mediate future involvement in antisocial and deviant behavior (Moffitt & Henry, 1989; Wright, Caspi, Moffitt, & Silva, 1999).

One recent empirically driven conceptualization from educational science has been useful in advancing our understanding of the nature and potential usefulness of engagement as an indicator of school readiness. Based on a thorough review of the education literature, Fredericks et al. (2004) conclude that engagement is a multifaceted concept with emotional, cognitive, and behavioral components. As a result, this definition can help organize a wider range of behaviors, which if targeted can improve academic performance. Furthermore, this distinction can guide the development of more refined risk profiles for children at risk of poor academic achievement and dropout. When broken down into affective, behavioral, cognitive components, high school engagement trajectories are reliable predictors of high school student's eventual attainment and high school completion (Archambault, Janosz, Fallu, & Pagani, 2009; Janosz et al., 2008).

One weakness of this model is that while emotions, cognition, and behavior are likely to be dynamically related, their interconnection is not directly addressed in Frederick's model. For example, behavioral engagement defined as commitment to finishing work on time is dependent on cognitive engagement, which involves the effortful mobilization of cognitive and attentional resources to accomplish a goal. Furthermore, cognitive and behavioral engagement are both likely to rely on emotional engagement since the experience of negative affect can interfere with classroom learning (Blair & Diamond, 2008). Frederick's also fails to address the role of development in academic engagement. For example, their model ignores the role that cognitive and emotional self-regulation and neurological development play in school adjustment. In particular, brain development in the prefrontal cortex is responsible for the performance of actions that require effortful control

over automatic responses and environmentally triggered behaviors (Barkley, 1997). As such, deficits in the ability to exercise self-control and pursue goal directed behavior are likely to be at least partially the result of less than optimal frontal lobe functioning (Marsh, Gerber, & Peterson, 2008; Tsujimoto, 2008).

Blair and Diamond (2008), describe school entry competence as the result of multiple interacting child and family level systems (e.g. gene expression, parenting, cultural norms). These interrelations are described as interacting and dynamic because similar risk factors are likely to give rise to different outcomes according to their context. For example, Blair and Diamond make excellent reference to the case of the catechol-*O*-methytransferase [*COMT*] gene whose common expression is associated with better cognitive control and executive functioning. In particular, this gene tends to result in higher levels of dopamine in the prefrontal cortex. Approximately 25% of individuals possess a variant of this gene which leads to faster clearing of dopamine in the prefrontal cortex. This genotype is associated with poorer performance on cognitive control tasks. However, more dopamine in the prefrontal cortex also makes individuals more responsive to stress. As a result, individuals who possess the variant of this gene, resulting in lower levels of dopamine in the prefrontal cortex, are expected to perform better on cognitive tasks under conditions of moderate stress. In contrast, this scenario is reversed for the majority of children under non stressful conditions (Blair & Diamond, 2008).

Blair and Diamond's model also helps clarify a mechanism through which emotional and cognitive process can mutually influence each other and ultimately classroom behavior. That is, cognitive control skills are described as both influencing

emotional outcomes, as when children inhibit feelings of frustration, and as being influence by them, as when anxiety impairs concentration. It is also hypothesized that both optimizing arousal and positive affect, much like reducing negative emotions, can improve academic performance. For example, mild levels of test anxiety are likely to benefit cognitive performance (Lupien, Maheu, Tu, Fiocco, & Schramek, 2007).

Interestingly, in Duncan's school readiness study, behavioral problems were not related to later achievement. One way to interpret this finding is that kindergarten socio-emotional problems do not bare on early academic performance once variance associated with attention regulation is taken into account. As such, it is likely that the observed association between behavior problems and achievement are due to underlying difficulties with attention regulation and control (Blair, 2002).

In sum, converging theory and research suggest that productive learning behaviors represent important indicators of school readiness. Definitions of engagement have been useful in clarifying the range of behaviors that can be measured as indicators of engagement (Fredricks et al., 2004). Finally, Blair and Diamond's developmental model has enhanced our understanding of the potential dynamic interplay of emotional and cognitive processes in children's regulation of classroom engagement.

Academic Performance: Is achievement all that matters?

Achievement outcomes have represented a singular focus in much of the school readiness literature. Nevertheless, in addition to forecasting academic outcomes, kindergarten classroom engagement skills are also likely to predict adaptive psychosocial functioning in later childhood. The omission of psychosocial outcomes in school readiness

research is also surprising given that social and interpersonal skills are key ingredients for success throughout schooling and eventually in the labor market (Almlund, Duckworth, Heckman, & Kautz, 2011; Heckman, 2007).

Neurocognitive theories link cognitive control to emotional-regulation, impulse control, and the pursuit of effortful and goal directed behavior (Barkley, 1997). As such, early manifestations of productive work habits in the form of engagement are likely to be related to children's long-term psychosocial adjustment. Children who show poor engagement in the classroom are also likely to develop more conflictual relations with teachers. Poorly regulated disruptive children are then more likely to undermine group functioning, experience social rejection, and develop poor academic motivation (Chen, Huang, Chang, Wang, & Li, 2010; Vitaro, Brendgen, Larose, & Tremblay, 2005). In contrast, children who are capable of remaining engaged in the classroom are also more likely to possess enough cognitive control to successfully inhibit inappropriate emotional responses and direct attention away from negative emotions.

Examining children's holistic development also makes sense for practical reasons. Children need to develop a variety of competencies, including positive psychosocial skills and strong work habits on the road to high school completion and successful transition to adulthood. Non cognitive or social skills, not typically measured by ratings of achievement, remain important predictors of how children will fare in their future personal and professional relationships. In the workplace, adults who develop more positive interpersonal orientations are likely to achieve more occupational success, even once their cognitive ability is taken into account (Almlund et al., 2011; Farkas, 2003; Heckman,

2007). As a result, to benefit societal investment, a public educational system should help students prepare for their future roles as citizens, workers, parents, and health-care users. In this light, the usefulness of a school readiness model could benefit from its ability to predict positive psychosocial skills in addition to academic achievement in math and reading.

Early Predictors of Engagement

Theory and empirical research suggest the importance of assessing productive learning behavior as an indicator of school readiness. To date, few studies have empirically addressed the developmental origins of such behavior, represented by classroom engagement in this thesis (Shonkoff & Phillips, 2000). Given the importance of cognitive control in the pursuit of goal-directed behavior (Barkley, 1997), it is likely that early childhood cognitive development forecasts school entry engagement. One possibility is that developmental continuity exists in cognitive control ability from the early preschool years to age 5, culminating in better classroom engagement at school entry. From an intervention perspective, better understanding this developmental chain remains an important goal for enhancing school readiness in at risk children.

Furthermore, as suggested by ecological theories of child development (Bronfenbrenner, 1986; Vygotsky, 1987), it is likely that the development of cognitive control is influenced by children's early environment and experience with caretakers. In particular, supportive parenting that is aimed at helping children sustain attention during activities is likely to help children develop strong attention control skills (Belsky, Pasco Fearon, & Bell, 2007; Razza, Martin, & Brooks-Gunn, 2010). Additional family

characteristics such as maternal stress and social support might also influence the development of positive learning-related behavior at school entry (Razza et al., 2010). High levels of maternal stress are related to an increased incidence of attention problems in middle childhood (Barry, Dunlap, Cotten, Lochman, & Wells, 2005). As a result, it would be informative to examine whether mothers experience of stress and social support during the preschool years are associated with poor classroom engagement skills at school entry.

Person-Centered Approaches

Duncan's model employed a variable-centered approach. While this approach is useful for identifying relationships between variables of interest, it does not inform us about how individuals in a population relate to each other, or whether there are specific groups of people that evolve differently over time. In light of the probability of individual difference over the course of development, it is useful to examine whether it is possible to identify subgroups of individuals who differ in their patterns of engagement. Furthermore, in Duncan's model, the relations between predictors and outcomes were only examined through the lens of multiple regressions. As a result, it is not possible to assess whether children show stable or varying levels of engagement over the course of elementary school. Such information is complimentary to that obtained from linear variable-centered models and helps refine and better tailor intervention efforts toward specific at-risk groups of children.

The Present Research

Current research on school readiness has been useful in identifying early skills which reliably forecast achievement. However they have ignored the importance of neurocognitive functioning in terms of attentional and cognitive control in the classroom. Past research has also been narrow in its conceptualization of academic success as strictly achievement-based. This thesis comprises three articles that aim to develop the idea that classroom engagement represents an easily measured and robust indicator of school readiness.

Paper 1. The objective of the first paper is to assess the added benefit of considering classroom engagement in school readiness assessments. The hypothesis is that better classroom engagement in kindergarten will predict better academic achievement and psychosocial functioning in the fourth grade.

Paper 2. Given the importance of productive learning behavior for academic success, a second objective is to examine whether early childhood cognitive control is associated with better school entry learning skills. Preschoolers who score higher on a task of working memory are expected to show more learning engagement at school entry.

Paper 3. The objective in Paper 3 is to investigate the possibility that individual differences in child trajectories of classroom engagement exist over the course of elementary school. We will also evaluate how early child and parental factors predict trajectory membership. The hypothesis is that early childhood attentional control, warm, consistent parenting, and maternal social support and lower levels of stress, will be associated with higher levels of child engagement across elementary school.

Control Variables

As a person-environment fit indicator, classroom engagement is likely to reflect a wide range of environmental, familial, and psychological influences. For these reasons, characteristics of children and their families are likely to confound the hypothesized relationships. To reduce this possibility, in Papers 1 and 3, we take into account child kindergarten math and reading skills and behavior problems to better estimate the relationship between our hypothesized predictor and outcome variables (Duncan et al., 2007; Pagani et al., 2010). In Paper 2, to reduce confounding and bias in our results, we estimate the relation between early childhood working memory and subsequent classroom engagement while controlling for child verbal and non-verbal intellectual skills. Furthermore, because a number of bio-psycho-social factors can play a role in cognitive development, we also control for child weight for gestational age, sleep, and temperament (Aarnoudse-Moens, Weisglas-Kuperus, Goudoever, & Oosterlaan, 2009; Barkley, 1997; Blair, Granger, & Razza, 2005; Buckhalt, El Sheikh, & Keller, 2007; Ednick et al., 2009). Finally in all studies we control for family socio-demographic characteristics and child gender. Disadvantage and family risk are associated with child adjustment problems during the transition to early schooling (Heckman, 2006; High, 2008; Shonkoff & Phillips, 2000) and the development of externalizing problems (Slopen, Fitzmaurice, Williams, & Gilman, 2010). Boys tend to be less well prepared at school entry (Lemelin & Boivin, 2007), exhibit higher levels of externalizing behavior (Miner & Clarke-Stewart, 2008). They also show poorer patterns of academic self-discipline and engagement in high school (Archambault et

al., 2009; Duckworth & Seligman, 2006). For these reasons all analyses in the present papers are estimated above and beyond presumably confounding variables.

Article 1-Predicting Academic and Psychosocial Adjustment from Kindergarten Engagement Skills

Author contributions

Caroline Fitzpatrick and Linda Pagani designed the study. Caroline Fitzpatrick conducted the analyses and took the lead in writing the paper. Linda Pagani edited the manuscript and participated in the interpretation of the data.

Predicting Academic and Psychosocial Adjustment from Kindergarten Engagement Skills

Caroline Fitzpatrick, Linda Pagani

Université de Montréal, GRES

Short title: Classroom Engagement and Later Adjustment

Key words: Classroom engagement; School readiness, Academic achievement; Psychosocial adjustment

Address for correspondence:

Caroline Fitzpatrick
École de psychoéducation
90 Vincent D'Indy
Montreal, Québec, Canada
H2V 1S9
514-343-0760

Abstract

Objective: Child learning skills have traditionally been neglected as important requisite skills for children entering kindergarten. In this paper, we consider a novel dimension of school readiness by examining prospective associations between early classroom engagement skills, reflecting cognitive control and self-organization, and later academic adjustment in emerging adolescence.

Methods: Kindergarten teachers rated classroom engagement skills of 960 children from the Québec Longitudinal Study of Child Development. Outcomes measured at 10 years old include a direct assessment of mathematics achievement and fourth grade teacher-ratings of academic achievement, teacher-child conflict, inattention, victimization, proactive and indirect aggression, and antisocial behavior in the classroom.

Results: Multiple regression analyses revealed that kindergarten classroom engagement skills were associated with better fourth grade math test scores (Unstandardized $\beta = 2.09$, 95% CI between 1.36 and 2.81) and teacher-rated academic success (Unstandardized $\beta = .41$, 95% CI between .19 and .63). Early classroom engagement also predicted less teacher-child conflict (Unstandardized $\beta = -.57$, 95% CI between -1.01 and -.13), inattention (Unstandardized $\beta = -1.54$, 95% CI between -.85 and -2.23), victimization (Unstandardized $\beta = -.49$ % CI between -.96 and -.01), proactive and indirect aggression (Unstandardized $\beta = -.69$, 95% CI between -1.28 and -.10 and Unstandardized $\beta = -.64$, 95% CI between -1.04 and -.25, respectively), and antisocial behavior (Unstandardized $\beta = -.89$, 95% CI between -1.27 and -.51) in fourth grade.

Conclusions: Easily measurable, context-based assessments of cognitive control and focus represent robust components of children's readiness to learn at school entry.

Predicting Academic and Psychosocial Adjustment from Kindergarten Engagement Skills

Because of its potential for identifying children at risk of academic difficulty, developing a reliable, cost-effective assessment of kindergarten school readiness remains a priority for professionals interested in child health, well-being, and development.[1-3] Child preparedness at school entry forecasts later academic achievement[4] and high school completion[5] which in turn forecast individuals lifelong earning potential, occupational success, and health outcomes.[6,7] Consequently, an important step in reducing educational disparities is to identify a comprehensive set of skills that benefit children's long-term school performance. Although math and reading skills explain a lot of the variance in achievement, they leave out a meaningful self-determining component. That is, children also need to develop the capacity to become engaged, self-directed learners if they are to benefit from instruction and persist toward high school graduation.[8,9]

Time spent on task and participation in the classroom can maximize learning opportunities.[9] Moreover children's ability to remain focussed in the classroom is likely to be influenced by individual differences in self-regulation skills. In particular, cognitive control skills, which represent important mechanisms of self-regulation, allow individuals to override automatic responses in favor of deliberate and effortful behavior. [10-12] A number of studies suggest that child cognitive control can benefit academic performance and facilitate the transition from kindergarten through the early elementary school years.[10-12] In addition to facilitating academic performance, cognitive control is also associated with the development of moral reasoning and interpersonal skills during childhood.[13,14] In contrast, poor cognitive control predicts more antisocial behavior and externalizing problems in later childhood and adolescence.[15]

Much of the research on cognitive control and later school outcomes has featured laboratory-based measures of executive function. While such assessments promise accuracy and methodological rigor, they are not easily implemented on a broader population-based scale. Furthermore, they do not inform us about the importance of effortful behavior outside of controlled conditions. As important outcomes of cognitive control, task-orientation in the classroom could therefore represent a promising component of school readiness.

The ability to concentrate and remain engaged in the classroom may represent a useful indicator of child contextual application of cognitive control skills.[16-17] For children to sustain their focus and task orientation in the classroom, they must inhibit the urge to attend to distracting stimuli in order to complete effortful, goal-relevant tasks. For example, children may be expected to inhibit the urge to listen to disruptive classmate comments in order to concentrate on teacher instructions.

A number of studies in education, economics, sociology, and psychology suggest that teacher ratings of classroom work habits are important for later achievement. Positive learning behaviors in the form of task-orientation predict academic achievement in 8 and 9 year-olds beyond the contribution of IQ.[18] Preschool children characterized by a positive orientation to learning experience more academic success in kindergarten than their less engaged counterparts.[19] Later on in adolescence, student self-discipline outdoes IQ in predicting academic success.[8] Finally, Ivy League undergraduates, elite military cadets, and spelling bee finalists who demonstrate grit defined by the ability to exert a consistent effort over time, tend to succeed more, regardless of their IQ.[20] While all of these studies have examined the relationship between productive work habits and academic performance, none has addressed the potential contribution of classroom engagement as a kindergarten school readiness indicator.

While classroom engagement skills relate directly to one's academic potential, theory and research suggest they might also predict positive psychosocial functioning in later childhood. Because the ability to pursue goal-directed behavior is indicative of cognitive control, better engaged students might also be better at inhibiting aggressive or antisocial behavior.[14,15,21] Furthermore, children who do not follow teacher instructions and who are unable to cooperate during learning activities may be at risk of rejection by their peers. As a behavioral outcome of cognitive control, classroom engagement might therefore be associated with child externalizing behavior and peer victimization.

Traditionally models of school readiness have exclusively focused on academic achievement as outcomes.[4,22] While useful, a single indicator cannot provide a comprehensive picture of how well children are adjusting to the school environment. A sole focus on achievement also overlooks the range of skills children must acquire to become contributing members of society.[17] As such, indentifying school entry skills, which can forecast a wider range of adaptive behaviors, would be useful to maximize prevention and intervention efforts.

Extending previous school readiness research, the present study seeks to evaluate the added benefit of considering classroom engagement skills in school readiness assessments. We also include a wider range of outcomes indicative of positive child functioning. Because the following characteristics have been linked to both school readiness and later achievement and psychosocial adjustment we also account for the potential confounding effect of child baseline and family background characteristics.[4] The hypothesis is that better classroom engagement skills in kindergarten will predict more favorable child adjustment outcomes in later elementary school.

Methods

Participants

Participants were randomly selected at birth from a stratified sample of 2837 born in the province of Québec Canada between 1997 and 1998 as a part of the Quebec Longitudinal Study of Child Development (QLSCD 1998-2010). At the inception of the study when children were 5 months old, 93 children were deemed ineligible and 172 were untraceable due to incorrect coordinates. Of the 2572 remaining children, 14 were unreachable and 438 refused participation. Thus, 2120 5-month-old infants were eligible for follow-up, representing 82% of the eligible target population. Children were followed annually from 5 months to the second grade. A subsequent wave was collected two years later when children where in fourth grade. Parents provided informed consent at each data collection wave. Teachers also gave informed consent for the school-age waves. Participants were included in this IRB approved study if they had complete data on teacher ratings of kindergarten classroom engagement. 968 teachers provided informed consent. Of these 960 provided data on child kindergarten classroom engagement (mean age = 74 months, SD = 3.05). Outcomes were measured in the spring of fourth grade (mean age 121.83 months, *SD*= 3.11).

Attrition

Retained and non-retained participants were compared. Attrition analyses suggest that children with incomplete data on classroom engagement (N=960) compared to non retained children from the original sample (N=1160) were more likely to come from single parent families (x = .72 vs. .77), $t(1937) = 2.12$, $p < .05$, experienced more family functioning problems at 17 months (x= 1.32 vs. 1.20), $t\ (1940) = 2.18$, $p < .05$, and had less educated mothers (x= .78 vs. .83), $t\ (2216) = 2.42$, $p < .05$. Compared to participants with incomplete data at the grade 4

follow up, retained participants at grade 4 were more engaged at kindergarten, ($\bar{x}$ = 2.72 vs 2.66, $t(958) = 2.74$, $p > .01$, were less physically aggressive, ($\bar{x}$ =.77 vs 1.11, $t(958) = 2.74$, $p > .01$, and scored higher on kindergarten receptive vocabulary and number knowledge tests, ($\bar{x}$ = 83.04 vs 78.06, $t(922) = 4.42$, $p > .001$ and $\bar{x}$ =13.55 vs. 12.99), $t(939) = 2.59$, $p > .01$, respectively).

Because missing data could be predicted by covariates in our sample, it was reasonable to assume that data was missing at random (MAR).[23] In order to reduce bias due to differential attrition, multiple imputations were performed on dependent and control variables. Our imputation model contained all the variables from our analytic model. Imputation was conducted using NORM statistical software. This method uses an estimation maximization algorithm to estimate missing data based on the conditional distribution of the variables estimated from available data.[24]

Measures

Independent Variable

Classroom Engagement. Kindergarten teachers rated 7 items of classroom engagement from 1 (never), to 3 (always). A mean classroom engagement score was computed for each participant from the following items:[17,25] Follows rules and instructions; Follows directions; Listens attentively; Completes work on time; Works autonomously; and Works neatly and carefully; and Works and plays cooperatively with other children (alpha = .92). Confirmatory factor analysis was performed to examine how well a 1 factor model accounted for our 7-item classroom engagement scale. Model fit was good suggesting that the items capture a single latent factor (CFI=.98; TLI= .97; RMSEA=.069; SRMR=.034; alpha=.94).

Dependent Variables

Math Achievement. Children completed the Canadian Achievement Test *CAT*/2 with a trained examiner at the end of grade 4. This test evaluates the four basic mathematical operations: addition, subtraction, multiplication, and division. Questions involve the application of operations to whole numbers.

Academic Achievement. Fourth-grade teachers rated child success in *Math, Reading,* and *Spelling* from: Near the top of the class (coded as 2); Above the middle of class (coded as 1); In the middle of the class (coded as 0); Below the middle of the class (coded as -1); or Near the bottom of the class (coded as -2). An overall mean was computed across all subjects (alpha = .89). Because writing skills have been omitted as outcomes in prior school readiness research, they are also considered separately.[4,17]

Teacher-Child Conflict. Teachers rated their relationship with the child (This child and I always seem to be struggling with each other; This child easily becomes angry with me; Dealing with this child drains my energy; and When this child is in a bad mood, I know we are in for a long and difficult day, alpha = .83)[26] from 1 (definitely does not apply) to 5 (definitely applies).

Child Behavior. Teachers also completed parts of the Social Behavior Questionnaire[27,28] pertaining to classroom behavior: *Inattention* (3 items: Was easily distracted; Was inattentive; and Was unable to concentrate, could not pay attention for long, α = .91); *Indirect Aggression* (3 items: When mad at someone, said bad things behind the other's back; When mad at someone, became friends with another as revenge; and When mad at somebody, tried to get others to dislike that person, α= .88); *Proactive Aggression* (3 items: Encouraged other children to pick on a particular child; Tried to dominate other children; and Scared other children to get he/she wanted, α= .88); *Victimization* (3 items: Was called names by other children; Was hit or pushed

by other children; and Was made fun of by other children, α =.77); and *Antisocial Behavior* (6 items: Bragged about accomplishments; Used or conned others; Did not seem to feel guilty after misbehaving; Engaged in risky or dangerous behaviors; Was unconcerned about the feelings of others; and Did not keep promises, α = .80). All items were rated on a Likert scale from 1 (never or not true) to 3 (often or very true).

Control Variables

Child Characteristics. Parents reported child sex. The number knowledge Test (NKT-abridged version) and Peabody Picture Vocabulary Test (PPVT) were administered individually by trained professionals at the end of kindergarten. The NKT tests basic knowledge of numbers.[29] In order to assess vocabulary knowledge children completed the PPVT, French adaptation.[30] The French version has been standardized and is highly correlated with other French vocabulary and intelligence tests.

Attention Problems. Kindergarten teachers reported on child presence of attention problems in the classroom using the Hyperactive Behavior sub-scale from the SBQ. Items include: Could not sit still, Was restless and hyperactive; Has trouble sticking to any activity; Could not stop fidgeting; Was impulsive, acted without thinking; Had difficulty waiting for his or her turn; and Could not settle down to do anything for more than a few moments, α = .91.

Behavioral Problems. Kindergarten teachers also assessed child behavioral adjustment at 74 months using the SBQ. Kindergarten behavior measures include: *Emotional Distress* (i.e., Seemed to be unhappy or sad, alpha = .79); *Physical Aggression* (i.e., Hit, bit or kicked other children, alpha = .85); and *Prosocial Behavior* (i.e., Tried to help someone who had been hurt, alpha = .85). In the interest of parsimony, an index of behavior problems was created. A score of 1 was attributed to the child if they displayed physical aggression and/or emotional distress

scores one standard deviation above the sample mean. A score of 1 was also given to children who scored 1 standard deviation bellow the sample mean on prosocial behavior. By summing across each dichotomized behavior score, an index was derived for each child.

Family Characteristics. When children were 5 and 17 months, mothers provided data on child and family variables that could possibly influence academic achievement prior to school entry. Family variables include maternal education in terms of 1 (high school diploma) or 0 (no high school diploma), family configuration coded as being either 0 (intact) or 1 (non-intact), and family functioning (i.e., "planning family activities is difficult because we misunderstand each other" or "we avoid discussing our fears or concerns"), where lower levels of the variable are associated with less family functioning problems.[31]

Baseline Kindergarten Controls. When children were 74 months old, kindergarten teachers provided ratings of child indirect and proactive aggression, victimization, and antisocial behavior using the SBQ.

Data Analytic Strategy

A series of ordinary least-squares regressions estimate achievement and psychosocial functioning in elementary school from kindergarten classroom engagement skills. Control variable are entered simultaneously in the analysis in order to reduce bias in the estimation of regression coefficients. In order to better isolate the influence of classroom engagement on later behavior problems (indirect aggression, proactive aggression, victimization and antisocial behavior) we employ a residual change regression design which involves controlling for baseline measures of the dependent variable in kindergarten.

Results

Descriptive statistics are presented in Table 1. The mean classroom engagement score was $\bar{x} = 2.68$. Girls (coded as 0) were more engaged in the classroom ($\bar{x} = 2.76$ vs. $\bar{x} = 2.60$, $t(958) = 6.91$ $P < .001$) than boys (coded as 1). Children from single parent families also scored lower on classroom engagement (x= 2.69 vs. 2.62, $t(958)=2.13$, P=.034). Because there was a high correlation between classroom engagement and attention problems (r = -.620), we examined the VIF and tolerance indicators to assess the presence of multicolinearity. In all models, these indicators suggested non-problematic levels of colinearity

Academic Outcomes

As shown in Table 2, a one unit increase in scores on the classroom engagement scale predicted better math scores, (Unstandardized β = 2.09, 95% CI between 1.36 and 2.81), overall academic achievement (Unstandardized β = .41, 95% CI between .19 and .63), and achievement in writing, (Unstandardized β = .51, 95% CI between .25 and .77). Each unit increase in kindergarten classroom engagement also corresponded to less teacher-child conflict (Unstandardized β = -.57, 95% CI between -1.01 and -.13) and less inattention (Unstandardized β = -1.54, 95% CI between .85 and 2.23).

Psychosocial Outcomes

Table 3 reports significant results pertaining to the relationship between school entry classroom engagement and psychosocial adjustment. Unit increases in child classroom engagement scores were associated with less indirect and proactive aggression, (Unstandardized β = -.69, 95% CI between -1.28 and -.10) and (Unstandardized β = -.64, 95% CI between -1.04 and -.25) respectively, less victimization by peers (Unstandardized β = -.49 % CI between -.96

and -.01), and less antisocial behavior (Unstandardized β = -.89, 95% CI between -1.27 and -.51).

Post Hoc Analyses

Because sex was a significant predictor of many of the later outcomes, we conducted host hoc interaction analyses. We found no significant sex X classroom engagement interactions in the prediction of subsequent academic and psychosocial adjustment outcomes.

Discussion

School entry marks an important transition in the lives of children as they experience their first steps into formal society. This important event coincides with the emergence of more complex and purposeful forms of thinking.[32-34] These improvements in cognitive control are likely to contribute to engagement and task-orientation by enhancing child ability to resist the temptation to shift focus to something novel, easier, or more pleasant.

The purpose was to examine the relationship between kindergarten classroom engagement skills and a comprehensive set of adjustment indicators in the fourth grade. Our findings suggest that a cost-effective easy to use checklist completed by teachers can reliably predict children at academic and psychosocial risk. As expected, better kindergarten work habits predicted greater academic achievement and less inattention and teacher-child conflict three years later. These prospective relationships remained predictive after controlling for concurrent child cognitive skills and pre-existing family characteristics.

Task-orientation and persistence appear to play a key role both in the completion of unfamiliar standardized tests that require improvisation and the assimilation of curriculum and lessons transmitted in the classroom. In prior studies, deriving correct answers in mathematics has been shown to hinge on a constellation of effortful control skills. These include children's

ability to focus attention on task relevant information, implement working memory to update and keep information "on-line" during problem solving activities, and exercise inhibition to avoid responding to non-relevant aspects of a given problem.[12, 13] Writing performance, which includes effective punctuation, spelling, and composition, also requires similar processing skills. Better engaged children also showed less signs of inattentiveness, even when kindergarten attention problems were taken into account. This finding suggests that showing dedication and autonomy during work and the ability to remain focused and avoid distractions may both draw upon the same skills. More specifically, we could argue that these two variables are associated because they represent different behavioral manifestations of underlying cognitive control. Last, lower scores on engagement in kindergarten predicted more teacher-child conflict above and beyond baseline academic, attention, and behavior problems. Much like employers in adult workplaces, teachers are likely to be sensitive to children who habitually violate classroom norms and fail to follow procedures and rules. It is also noteworthy that teacher-reported classroom engagement was prospectively associated with conflictual relations between the same students and their fourth grade teachers. That is, children with lower scores on persistent, task-oriented, and autonomous classroom behavior in kindergarten were more likely to have strained relationships with their teachers four years later. Taken together these findings provide some evidence that engagement skills are associated with academic adjustment across multiple spheres.

On a psychosocial note, kindergarten classroom engagement predicted less indirect and proactive aggression, antisocial behavior, and victimization, even while controlling for prior levels of each behavior in kindergarten. Children who had difficulty following directions and rules were especially likely to engage in instrumental forms of aggression such as expressing anger toward their teachers, spreading rumors about their friends, showing little concern for the

feelings of others, and intimidating other children for personal gain. Being teased or bullied was also inversely predicted by classroom engagement reflecting the tendency for victims to be both victims and perpetrators.[35] These associations are consistent with prior research which has shown a link between poor academic performance and psychosocial risk in later childhood.[36] Children who perform less well in school are likely to develop more stress and frustration. Consequently, such feelings can undermine child social cognitive processing during interactions with peers. In addition, poor engagement skills are likely to reflect poorer attention and inhibitory skills, which remain important contributors of later antisocial behavior.[15,21] The association between engagement and psychosocial adjustment is also consistent with previous findings suggesting that cognitive control ability is related to the emergence of theory of mind and false belief understanding.[12,13] Diminished classroom engagement in kindergarten may thus predict social-cognitive impairment because it is associated with a certain amount of executive dysfunction.

The work of Blair and Diamond also sheds light on why engaged children may experience better psychosocial adjustment in later childhood. According to these authors, children's ability to regulate their emotional states is likely to play an important role in school entry competence.[37] Maladaptive levels of emotionality have been shown to undermine engagement by interfering with cognitive control processes. For example, children who experience higher levels of anger and frustration to emotion-eliciting stimuli may have difficulty concentrating in the classroom setting and may be more prone to aggressive behavior. Children who experience higher levels of negative emotionality are also more likely to be excluded from peer groups.[35] The experience of learning and social challenges is then likely to influence children's self-perceptions and level of confidence about their ability to successfully cope with academic and social challenges. As a result, being unable to follow instructions and cooperate with fellow students at the start of

school may eventually set the course for long term maladaptive academic and psychosocial functioning.

The correlational nature of this study represents a limit as it prevents us from inferring causality. However, in order to reduce the possibility of third variable bias, baseline measures of outcomes, as well as relevant child and family characteristics were included to prospectively control for some of the variance explained by confounding factors. As well, the use of a longitudinal design allows us to determine the temporal precedence of our independent variable. The coefficients in the present study range from small (.09) to moderate (.25). From a cumulative risk perspective, our results are important given the notion that even low levels of underachievement and problem behavior add up to significant social costs, when projected on a population basis.[38]

From a social policy standpoint the results of the present study have the potential to be useful. Since most children attend kindergarten the prevention of future learning and behavioral difficulties may be introduced through easily implemented early screening by teachers. Productive work habits appear to play a role in achievement beyond the contribution of IQ.[8] While IQ is relatively stable classroom engagement is malleable and amenable to interventions. Indeed, preschool programs whose curricula are designed to improve cognitive control can help children improve their academic skills, moral reasoning, and social competence.[39-41] Future research should therefore examine the benefit of promoting classroom engagement skills in remedial education programs as a means of reducing educational and mental health disparities at school entry.

References

1. High PC . School readiness. *Pediatrics.* 2008;121:e1008-1015.

2. Zuckerman B, Halfon N. School readiness: an idea whose time has arrived. *Pediatrics*. 2003; 111:1433-1436.

3. Schor EL. The future pediatrician: promoting children's health and development. *J Pediatr.* 2007;151 S11-S16.

4. Duncan et al. School readiness and later achievement. *Dev Psych.* 2007;43:1428-1446.

5. Entwisle DR, Alexander KL, Olson LS. First grade and educational attainment by age 22: a new story. *Am J Sociol.* 2005;110:1458-1502.

6. Freudenberg N, Ruglis J. Reframing school dropout as a public health issue. *Prev Chron Dis.* 2007;4:1-12.

7. Heckman JJ. The economics, technology, and neuroscience of human capability formation. *Proc Nat Acad Sci.* 2007;104:13250-13255.

8. Duckworth AL, Seligman MEP. Self-discipline outdoes IQ in predicting academic performance of adolescents. *Psych Sci.* 2005;16:939-944.

9. Fredricks JA, Blumenfeld PC, Paris AH. School engagement: potential of the concept, state of the evidence. *Rev Edu Res.* 2004;74:59-109.

10. Altemeier L, Abbott R, Berninger V. Executive functions for reading and writing in typical literacy development and dyslexia. *J Clin Exp Neuropsych.* 2008;30:588-606.

11. Altemeier L, Jones J, Abbott R, Berninger V. Executive functions in becoming writing readers and reading writers: note taking and report writing in third and fifth graders. *Dev Neuropsych.* 2006;29:161-173.

12. Blair C, Razza RP. Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Dev.* 2007;78:647-663.

13. Sabbagh MA, Xu F, Carlson SM, Moses LJ, Lee K. The development of executive functioning and theory of mind: a comparison of Chinese and US preschoolers. *Psych Sci.* 2006;17:74-81.

14. Martel MM, Nigg JT, Wong MM, et al. Childhood and adolescent resiliency, regulation, and executive functioning in relation to adolescent problems and competence in a high-risk sample. *Dev Psychopathol.* 2007;19:541-563.

15. Moffitt TE, Henry B. Neuropsychological assessment of executive functions in self-reported delinquents. *Dev Psychopathol.* 1989;1:105-118.

16. Bierman KL, Nix RL, Greenberg MT, Blair C, Domitrovich CE. Executive functions and school readiness intervention: Impact, moderation, and mediation in the Head Start REDI program. *Dev Psychopathol.* 2008;20:821-843.

17. Pagani LS, Fitzpatrick C, Archambault I, Janosz M. School readiness and later achievement: a French Canadian replication and extension. *Dev Psych.* 2010;46:984-994.

18. McKinney JD, Mason J, Perkerson K, Clifford M. Relationship between classroom behavior and academic achievement. *J Ed Psych.* 1975;87:198-203.

19. McWayne CM, Fantuzzo JW, McDermott PA. Preschool competency in context: an investigation of the unique contribution of child competencies to early academic success. *Dev Psych.* 2004;40:633-645.

20. Duckworth AL, Peterson C, Matthews MD, Kelly DR. Grit: perseverance and passion for long-term goals. *J Person Soc Psych.* 2007;92:1087-1101.

21. MacDonald V, Achenbach T. Attention problems versus conduct problems as 6-year predictors of signs of disturbance in a national sample. *J Am Acad Child Adolesc Psychiatry.* 1999;38:1254-1261.

22. Heckman JJ. Skill formation and the economics of investing in disadvantaged children. *Science.* 2006;312:1900-1902.

23. Graham WJ. Missing data: Making it work in the real world. *Ann Rev Psych*. 2009; 60: 549-576.

24. Schafer JL. Multiple imputation: a primer. *Stat Met Med Res.* 1999;8:3-15.

25. Pagani LS, Fitzpatrick C, Barnett TA, Dubow E. Prospective associations between early childhood television exposure and academic, psychosocial, and physical well-being by middle childhood. *Arch Pediatr Adolesc Med.* 2010;164:425-431.

26. Pianta RC, Steinberg MS. Teacher-child relationships and the process of adjusting to school. *N Dir Child Dev.*1992;57:61-80.

27. Tremblay RE, Loeber R, Gagnon C, Charlebois P, Larivée S, LeBlanc M. Disruptive boys with stable and unstable high fighting behavior patterns during junior elementary school. *J Abnorm Child Psych.* 1991;19:285-300.

28. Pagani LS, Tremblay RE, Vitaro F, Boulerice B, McDuff P. Effects of grade retention on academic performance and behavioral development. *Dev Psychopathol.* 2001;13:297-315.

29. Okamoto Y, Case R. Exploring the microstructure of children's central conceptual structures in the domain of number. *Mono Soc Res Child Dev.* 1996;61(1-2):27-58.

30. Dunn LM, Thériault-Whalen CM, Dunn LM, eds. *Peabody Picture Vocabulary Test-revised: French adaptation*. Toronto, ON: Psycan; 1993.

31. Epstein NB, Baldwin LM, Bishop DS. The McMaster family assessment device. *J Mar Fam Ther.* 1983;9:171-180.

32. Piaget J, Inhelder B. *The Child's Conception of Space*. London: Routledge and Kegan Paul; 1956.

33. Garon N, Bryson SE, Smith IM. Executive function in preschoolers: a review using an integrative framework. *Psych Bull.* 2008;134:31-60.

34. Marsh R, Gerber AJ, Peterson BS. Neuroimaging studies of normal brain development and their relevance for understanding childhood neuropsychiatric disorders. *J Am Acad Child Adolesc Psychiatry.* 2008;47:1233-1251.

35. Crick NR, Dodge KA. Social information-processing mechanisms in reactive and proactive aggression. *Child Dev.* 1996;67:993-1002.

36. Miles SB, Stipek D. Contemporaneous and longitudinal associations between social behavior and literacy achievement in a sample of low-income elementary school children. *Child Dev*. 2006; 77:107-117.

37. Blair C, Diamond A. Biological processes in prevention and intervention: the promotion of self-regulation as a means of preventing school failure. *Dev Psychopathol.* 2008;20:899-911.

38. Currie J, Stabile M. Child mental health and human capital accumulation: the case of ADHD. *J Health Econ.* 2006;25:1094-1118.

39. Thorell LB, Lindqvist S, Bergman Nutley S, Bohlin G, Klingberg T. Training and transfer effects of executive functions in preschool children. *Dev Sci.* 2009;12:106-113.

40. Diamond A, Barnett WS, Thomas J, Munro S. Preschool program improves cognitive control. *Science.* 2007;318:1387-1388.

41. Lillard A, Else-Quest N. The early years: evaluating Montessori education. *Science.* 2006;313:1893-1894.

Table 1. Descriptive Statistics for Independent, Dependent, and Control Variables

	M (SD)	Min	Max	N
Independent Variables (74 months)				
Classroom Engagement	2.68 (.37)	.1.14	3.00	960
Dependent Variables (120 months)				
Math Calculation	14.82 (3.45)	0	20	960
Overall Achievement	.36 (1.11)	-2	2	960
Writing	.21 (1.24)	-2	2	960
Teacher-Child Conflict	.99 (1.81)	0	10	960
Inattention	3.43 (3.14)	0	10	960
Proactive Aggression	.82 (1.69)	0	10	960
Indirect Aggression	1.52 (2.40)	0	10	960
Victimisation	1.13 (1.98)	0	10	960
Antisocial Behavior	.95 (1.62)	0	10	960
Child and family Controls				
Number Knowledge (74 months)	13.22 (3.28)	3	18	960
Receptive Vocabulary (74 months)	80.16 (17.23)	12	130	960
Attention Problems (74 months)	2.60 (2.51)	0	10	960
Proactive Aggression (74 months)	1.06 (1.91)	0	10	960
Indirect Aggression (74 months)	1.08 (2.03)	0	10	960

Table 1 (continued). Descriptive Statistics for Independent, Dependent, and Control Variables.

	M (SD)	Min	Max	N
Child and family Controls (continued)				
Antisocial Behavior (74 months)	1.06 (1.63)	0	9.17	960
Victimization (74 months)	.84 (1.41)	0	8.33	960
Behavior Problems (74 months)	.52 (.74)	0	3	960
Sex (1 = boy, 0=girl)	.47 (.50)	0	1	960
FC (1=non intact,17 months)	.25 (.44)	0	1	960
ME (1=high school diploma)	.87 (.34)	0	1	960
Family Functioning (17 months)	2.43 (1.56)	0	8.06	960

FC= family configuration; ME = maternal education

Table 2. *Standardized Regression Coefficients Reflecting the Relationship Between Kindergarten Classroom Engagement and Fourth Grade Academic Outcomes*

Independent Variables	Math Achievement	Overall Achievement	Writing Achievement	Inattention	Teacher-Child Conflict
Classroom engagement	.23 (.37)***	.14 (.11) ***	.15 (.13)***	-.18 (.35) ***	-.12 (.21)**
Attention problems	.02 (.05)	-.03 (.02)	-.05 (.02)	.16 (.05) ***	.22 (.03)***
Number knowledge	.33 (.03)***	.35 (.01) ***	.26 (.01) ***	-.14 (.03) ***	-.04 (.02)
Receptive vocabulary	.08 (.01)*	.21 (.002) ***	.18 (.002)***	-.01 (.01)	.04 (.003)
Behavior problems	.00 (16)	-.01 (.05)	.00 (.06)	.05 (.15)	.10 (.09) **
Sex	.06 (.20) *	-.06 (.06)*	-.17 (.07) ***	.09 (.19) **	.08 (.11)*
FC (0=intact, 1=non intact)	-.11 (.22)***	-.08 (.07) **	-.05 (.08)	.10 (.21)**	.04 (.12)
ME (1=high school diploma)	.07 (.29)*	.06 (.09) *	.07 (.10) *	-.03 (.27)	-.11 (.16)**
Family functioning	-.03 (.06)	.01 (.02)	.02 (.02)	.02 (.06)	.01 (.03)
Adjusted R Squared	.28	.35	.28	.20	.18

Note. Standard Errors are presented in parentheses. Asterices represent probability: *** $P < .001$, ** $P < .01$, * $P < .05$. FC=family configuration. FC= family configuration; ME = maternal education.

Table 3 *Standardized Regression Coefficients Reflecting the Relationship Between Kindergarten Classroom Engagement and Fourth Grade Psychosocial Adjustment.*

Independent Variables	Indirect Aggression	Proactive Aggression	Victimization	Antisocial Behavior
Classroom engagement	-.11 (.30) *	-.14 (.20) **	-.09 (.24)*	-.20 (.19)***
Attention problems	.11 (.04) **	.01 (.03)	.10 (.04)*	.04(.03)
Number knowledge	-.02 (.03)	.03 (.02)	-.04 (.02)	.01 (.17)
Receptive vocabulary	.01 (.01)	.05 (.003)	-.01 (.004)	.05(.03)
Behavior problems	.03 (.13)	.00 (.09)	.06 (.11)	-.03 (.09)
Sex	-.08 (.17) *	.04 (.11)	.09 (.13)**	.06 (.10)
FC (0=intact, 1=non intact)	.02 (.18)	.00 (.12)	.03 (.15)	.03 (.12)
ME (1=high school diploma)	-.11 (.24) **	-.07 (.16) *	-.04 (.19)	-.07 (.15)*
Family functioning	.03 (.05)	.04 (.03)	.04 (.04)	.00 (.03)
Kindergarten Baseline Controls				
Indirect Aggression	.13 (.04)***	_____	_____	_____
Proactive Aggression	_____	.24 (.03)***	_____	_____
Victimization	_____	_____	.01 (.05)	_____
Antisocial Behavior	_____	_____	_____	.23 (.04) ***
Adjusted R Squared	.08	.10	.09	.13

Note. Standard Errors are presented in parentheses. Asterices represent probability: *** $P <$ .001, ** $P <$ .01, * $P <$ .05. FC= family configuration; ME = maternal education.

Article 2-Do Toddler Working Memory Skills Predict School Entry Classroom Engagement?

Author contributions

Caroline Fitzpatrick and Linda Pagani designed the study. Caroline Fitzpatrick planned and conducted the analyses and took the lead in writing the paper. Linda Pagani edited the manuscript, participated in the interpretation of the data.

Do Toddler Working Memory Skills Predict School Entry Classroom Engagement?

Caroline Fitzpatrick, Linda Pagani, Tracie A. Barnett

Université de Montréal, GRES

Short title: Working memory and Classroom Engagement

Key words: Classroom engagement; School readiness, working memory; Number knowledge, Receptive vocabulary

Address for correspondence:

Caroline Fitzpatrick
École de psychoéducation
90 Vincent D'Indy
Montreal, Québec, Canada
H2V 1S9
514-343-0760

Abstract

Converging findings in psychology, neuroscience, education, and economics suggest that child persistence in learning represents an important determinant of academic success during the school years. Nevertheless, the developmental origins of productive learning behaviors are not well understood. Some findings suggest that executive function skills may be developmental precursors to learning-related behaviors. The present study examines how toddler working memory skills predict subsequent classroom engagement at school entry. Participants are 1824 children from the Quebec Longitudinal Study of Child Development. Children were individually assessed on working memory at age 29 and 41 months, using the Imitation Sorting Task. When children were 74 months of age, kindergarten teachers rated classroom engagement and trained examiners assessed number knowledge and receptive vocabulary. Multiple regression analyses revealed a prospective association between early working memory scores and later classroom engagement, *standardized* β = .066, 95% CI between .003 and .130, number knowledge, .134 (95% CI between .079 and .190) and receptive vocabulary and .060 (95% CI between .007 and .113). These results were above and beyond child sex, verbal and nonverbal intellectual skills, and socioeconomic status. The findings propose a robust, easily accessible, and cost effective assessment method of early childhood executive function for the development of early childhood interventions that improve school readiness.

Do Toddler Working Memory Skills Predict School Entry Classroom Engagement?

The economic, social, and health benefits of identifying early childhood precursors of school readiness cannot be overstated. Children who enter kindergarten prepared to learn are at a clear academic advantage and are more likely to complete high school (Duncan et al., 2007; Entwisle, Alexander, & Olson, 2005; Pagani, Fitzpatrick, Archambault, & Janosz, 2010; Vitaro, Brendgen, Larose, & Tremblay 2005). The preschool years also represent a period of remarkable brain plasticity and sensitivity to environments and experiences (Knudsen, Heckman, Cameron, & Shonkoff, 2006; Marsh, Gerber, & Peterson, 2008; Shonkoff & Phillips, 2000). Identifying skills in the first years of life, which predict later achievement thus opens the door to better understanding lifelong learning and informs the implementation of cost effective early interventions (Heckman, 2007, Heckman, 2006).

Early literacy and number knowledge represent robust indicators of how children will fare from kindergarten onward (Duncan et al., 2007; Pagani et al., 2010). Nonetheless, a growing body of research from the fields of education and sociology provide compelling evidence that productive work-habits and behaviors in the classroom can independently forecast academic attainment above and beyond IQ (Duckworth & Seligman, 2005; McKinney, Mason, Perkerson, & Clifford, 1975; Normandeau & Guay, 1998). Strong classroom learning skills also promise less crime participation, teenage pregnancy, smoking and elicit drug use, and interpersonal conflict later in life (Bowles, Gintis, & Osborne, 2001; Heckman, 2007; Heckman, Stixrud, & Urzua, 2006).

Productive learning behaviors are likely to represent outcomes of proper executive function (Diamond, Barnett, Thomas, & Munro, 2007; Pagani et al., 2010). These higher

order thinking skills are mediated by the prefrontal cortex and are essential for the accomplishment of effortful and goal-directed behavior (Koechlin & Summerfield, 2007). In the classroom, executive function is likely to support productive learning behaviors by helping children hold information online during problem solving tasks, efficiently direct attention to relevant stimuli, and suppress automatic responses in favor of thoughtful action.

Working memory is a component of executive functions that operates to keep relevant information on-line during problem solving activities (Repovs & Baddeley, 2006). Other core executive function skills include inhibition and attentional control (Garon, Bryson, & Smith, 2008; Miyake et al., 2000). In adulthood, scores on working memory tests are associated with better fluid intelligence and cognitive processing (Conway, Kane, & Engle, 2003). Unlike other intellectual skills, adult working memory predicts performance on novel tasks with which no prior experience or training is provided.

Though a majority of executive function research has addressed outcomes in adults, child and adolescent performance on working memory tests account for their own variance in math and reading achievement (Blair & Razza, 2007; Gathercole, Tiffany, Briscoe, & Thorn, 2005). At approximately 29 months, children begin to demonstrate increases in their ability to sustain focused attention and use working memory to solve problems (Garon et al., 2008; Marsh et al., 2008). Despite clear age-related improvements in working memory over the preschool period, naturally occurring individual differences among children remain relatively stable (Alp, 1994). It logically follows that working memory skills in infancy and childhood might culminate in better engagement at school entry.

Youth who demonstrate task-persistence, self-discipline, and autonomous learning in the classroom are more likely to experience positive academic and social outcomes later on (Blair & Razza, 2007; Duckworth, Peterson, Matthews, & Kelly, 2007; Fredricks, Blumenfeld, & Paris, 2004; McWayne, Fantuzzo, & McDermott, 2004). Nevertheless, the developmental origins of engaged learning behavior at school remain unclear. It would be of great practical and theoretical benefit to examine whether measurable executive function skills in toddlers predict classroom engagement and academic achievement over the long-term.

In toddlers older than 2, working memory has generally been assessed through span tasks, in which the objective is for the child to keep information on-line during a short delay (for a review see Garon, 2008). More specifically, experimenters typically present a series of words, objects, or locations to children. They are then asked to recall the series. The number of objects kept in mind reflects individual differences in working memory storage capacity. In the present study, we employ the Imitation Sorting Task which assesses children's recall capacity for increasingly larger sets of objects. This task was specifically selected because of its validity and reliability for measuring working memory in very young children (Alp, 1994).

Examining child skills at the end of kindergarten is of particular interest given that children who have difficulty meeting the demands of the kindergarten classroom are at greater risk of subsequent academic problems (Duncan et al., 2007; Pagani et al., 2010). Children's level of competence at school entry is also associated with long-term academic attainment such as high school completion (Alexander, Entwisle, & Horsey, 1997) and

personal success (Heckman, 2006). Therefore, using longitudinal birth-cohort data, the purpose of this study is to examine the prospective association between early working memory and later school entry outcomes. Our hypothesis is that better working memory skills at 35 months will predict better kindergarten classroom engagement and academic performance.

Methods

Sample

Participants were 1824 children from the Québec Longitudinal Study of Child Development (QLSCD) with complete data on a test of working memory at 29 and 41 months. Follow-up occurred in the spring of kindergarten (at age 74 months, *SD*= 3.11). This sample originates from a randomly selected, stratified sample of 2837 infants born between 1997 and 1998 in the province of Quebec, Canada. At the inception of its longitudinal component, 93 children were deemed ineligible and 172 were untraceable due to incorrect coordinates. Of the 2572 remaining children, 14 were unreachable and 438 refused participation. For the early childhood phase, 2120 5-month-old infants were thus deemed eligible for follow-up at 17 and 29 months, representing 82% of the eligible target population defined by the birth cohort. This sampling procedure resulted in 2120 children once active informed parental consent was obtained. Of these, 39% were firstborn. From school entry onward informed consent was obtained from parents and teachers.

Measures: Independent Variable (Working memory)

Children completed the Imitation sorting Task (Alp, 1994) at 29 and 41 months with trained examiners. In a validation study of the this measure, children who were

retested 3 weeks later showed high levels of consistency in their scores (r = .80). The same children also retained their original rank when retested 6 months later (r =.75, Alp 1994). The observed stability in scores over several weeks offers construct validity, suggesting that observed scores are likely to reflect underlying working memory ability rather than learned responses. This measure was also significantly correlated with age, which is consistent with the idea that age-related maturational changes underlie developmental changes in information processing ability.

To meet the feasible and practical requirements for the present large scale longitudinal study, the amount of trials afforded per level and of toys administered per trial was reduced in the Imitation sorting Task. This resulted in a reduced time of administration. In the modified version, the experimenter first places the objects (ex.: toy animals, puzzle pieces, eating utensils, vehicles) into two canisters. The objective of the task is for children to correctly reproduce the demonstrated sequence by placing the correct toy in the correct canister. Before beginning, the experimenter first ensures that the child is capable of imitating the act of placing a single toy into the correct canister. At the start of each trial, the examiner places each toy in front of the child. The examiner then names each object, attracting the child's attention to it before placing the object into one of the canisters. Toys are then removed from the canister and placed in front of the child. Objects are placed in a predetermined manner so that toys that are to be sorted together are not placed directly next to each other. The examiner then asks the child to place the objects in the canisters. At each level of difficulty the child has one trial to correctly sort the objects into the canisters. At 29 months children completed four trials of increasing difficulty. At 41 months an additional

level of difficulty was added. Successful completion at Level 1 involved correctly sorting two toys in one canister, and a third in the other. At level 2, children were asked to sort 2 toys in each canister. At level 3, children sorted 3 objects in one canister and 2 in another. Finally, at level 4 children were asked to sort 3 objects in one canister and 3 in another. Children received one point for each level completed. Partial credit was not provided for partially completed sequences. However, children received full credit as long as they recreated the demonstrated grouping of toys and placed them into the same canister. That is, children were not required to follow the same order or sort the toys in the same canister as the experimenter since the objective is for the child to recreate the modelled subsets. A total score is then computed. In order to reduce measurement error, we computed a mean score from total scores at 29 and 41 months.

The sample mean (SD) working memory score (reflecting the mean of scores at 29 and 41 months) was 1.20 (.74) and ranged between 0 and 3.5. The mean working memory scores for girls and boys were 1.24 (.72) and 1.15 (.69) respectively. Scores on the working memory task were also examined according to socioeconomic status. Children in the bottom, middle, and highest tertile of socioeconomic status had mean scores of 1.11 (.68), 1.18 (.69), and 1.29 (.73) respectively. Ranges did not differ according to gender or socioeconomic status.

At the 29 month assessment n = 371 (20.3%) of obtained a score of 0, n = 949 (51.9%) obtained a score of 1, n = 430 (23.6%) obtained a score of 2, and n = 77 (4.2%) obtained a score of 3. At the 41 month follow-up, n = 515 (29%) of children obtained a

score of 0, n = 507 (29.4%) obtained a score of 1, n = 450 (26.1%) obtained a score of 2, n = 207 (12%) obtained a score of 3, and n = 43 (2.5%) obtained a score of 4.

Measures: Dependent Variables

Classroom Engagement. Kindergarten teachers rated 7 items of classroom engagement from 1 (*never*) to 3 (*always)*: Follows rules and instructions; Follows directions; Listens attentively; Completes work on time; Works autonomously; Works and plays cooperatively with other children; and Works neatly and carefully. From these items, a mean classroom engagement score (ranging from 1 to 3) was then computed for each participant. Confirmatory factor analysis was performed to examine how well a 1 factor model accounted for our 7-item classroom engagement scale. Model fit was good suggesting that the items capture a single latent factor (CFI=.98; TLI= .97; RMSEA=.069; SRMR=.034). Reliability was assessed by computing Cronbach's alpha on the 7-items in our sample of 891 children for whom data was available on classroom engagement. This scale has been used in previous studies on child development (Pagani et al., 2010; Pagani, Fitzpatrick, Barnett, & Dubow, 2010).

Academic Achievement. The Number Knowledge Test (NKT) was administered to assess basic knowledge of numbers (Okamoto & Case, 1996). The version adjusted for 5-year-olds measures: Knowledge of the number sequence from one to ten; Knowledge of the one to one correspondence in which a sequence is mapped onto objects being counted; Understanding the cardinal value of each number; Understanding the generative rule which relates adjacent cardinal values; and Understanding that each successive number represents a set which contains more objects. Children also completed the most recent version of the

Peabody Picture Vocabulary Test (PPVT, Dunn, Thériault-Whalen, & Dunn, 1993) to assess vocabulary knowledge. This test consists of 175 vocabulary items that increase in difficulty throughout the test. Its French translation has been standardized and is highly correlated with other French vocabulary and intelligence tests (Dunn et al., 1993).

Measures: Control Variables

Parents and direct assessments provided data on many child and family characteristics that could potentially confound the relationship between working memory ability and later classroom engagement. Trained examiners assessed nonverbal intellectual skills when children were 41 months using the Block Design subtest of the Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R, Wechsler, 1991). This subtest, which assesses visual perception of the spatial relationships of objects, has been shown to correlate well with general IQ. Each child score is standardized by children's precise age (mean=6.20 with range between 0 and 24). At 41 months, trained examiners also assessed child receptive vocabulary (mean= 30 with range between 2 and 91) using the most recent version of the Peabody Picture Vocabulary Test adapted for 3-year-olds (PPVT-French adaptation, Dunn & Thériaut 1990). Weight-for-gestational age was calculated from child weight and length of pregnancy derived from birth records. Scores were standardized by gender and weeks of pregnancy using Canadian norms (Kramer et al., 2001).

When children were between 5 and 17 months, parents reported child sex, hours of continuous sleep, number of months breastfed, and family configuration (0=intact vs 1=non intact) family functioning ("planning family activities is difficult because we

misunderstand each other" or "we avoid discussing our fears or concerns") where lower levels of the variables are associated with less family functioning problems (Epstein, Baldwin, & Bishop, 1983). Parents also reported child age in months at the completion of the first working memory task. Socioeconomic status was derived from mother and father reports of income, occupational prestige, and level of education (for details see Willms & Shields, 1996). Socioeconomic status scores represent means across all available time points between 5 and 74 months.

Finally, mothers reported on two dimensions of child temperament using the Infant Characteristic Questionnaire (Bates, Freeland, & Lounsbury, 1979). *Difficult temperament* was measured using 6 items: How easy or difficult is it for you to calm or soothe your child when he/she is upset; How many times per day on average does your child get fussy and irritable; How much does he/she cry or fuss in general; How easily does he/she get upset; and How changeable is your child's mood. Each score was rated on a 7-point Likert scale ranging from 1 (easy temperament) to 7 (difficult temperament). *Unpredictable temperament* was measured by 4 items: How does he/she typically respond to a new person; How does he/she typically respond to being in a new place?; How well does he/she adapt to things (such as new people or new places); and How well does he/she adapt to new experiences (such as new playthings, new foods, new persons, etc.). Each score was also rated on a 7-point Likert scale from1 (predictable temperament) to 7 (unpredictable temperament). Cronbach alphas were .71 and .70 for difficult and unpredictable temperaments, respectively. For each dimension a mean was computed with scores brought back to a scale ranging from 0 to 10. Dichotomous scores were then derived with scores

above the 70th percentile on each dimension coded as 1 and scores below the 70th percentile coded as 0. A sum reflecting temperament problems was then computed from dichotomized scores on the difficult and unpredictable temperament scales.

All of the measured control characteristics have been shown to influence our predictor and outcome variables (Bartels, van Beijsterveldt, & Boomsma, 2009; Bernier, Carlson, & Whipple, 2010; Caspi & Silva, 1995; High & the Committee on Early Childhood, Adoption, and Dependent Care and Council on School Health, 2008; Raizada, Richards, Meltzoff, Kuhl, 2008; Ribas-Fito, Julves, Torrent, Grimalt, & Sunyar, 2007; Touchette et al., 2007).

Data Analytic Strategy

Our objective is to model the relationship between early childhood working memory and kindergarten classroom engagement and achievement. To reduce omitted variable bias, we begin by estimating a regression model that includes a large set of variables identified by the literature as likely confounders of the relationship between our predictor and outcome variables. We conducted multiple regression using M-plus software (Muthén, Kaplan, & Hollis, 1987). A final, more parsimonious model that omits non-significant covariates will be estimated and reported in the results.

Incomplete Data

This IRB approved study required a substantial amount of data from several sources and ages. A majority of children from our final analytic sample of individuals with complete data on working memory had complete data on receptive vocabulary (1658 = 91%) and non-verbal intellectual skills (1678,92%) at 41 months. Over 99% of our sample

had data available on the following variables: weight-for–gestational-age; breastfeeding; temperament; family functioning; sleep; and family configuration. Finally, all children had available data on socioeconomic status, maternal age, and child age in months. Complete outcome variable data was available for n=891 (49%) of children for classroom engagement, n=1078 (59%) of children for receptive vocabulary, and n=1099 (60%) of children for number knowledge at kindergarten. T-tests were conducted using SPSS software to compare the 1824 retained cases with working memory data at 29 and 41 months and the 296 unretained cases from the original sample (N = 2120) at age 5 months on the baseline control variables. Results revealed that children in the retained sample had less family functioning problems between the ages of 5 and 17 months, ($\bar{x}$ =1.48 vs. 1.89) $t(2106) = -5.23$, $p < .000$ and had lower socioeconomic status ($\bar{x}$ = .02 vs. -.16 $t(2093) = 2.74$, $p < .01$. A second attrition analysis (N=1824) comparing children with complete and incomplete kindergarten classroom engagement data on demographic measures revealed some differences. Compared to the unretained sample, children in our retained sample in kindergarten were more likely to come from intact families ($\bar{x}$ = .23 vs. .28), t (2116) = -2.58 , $p < .05$, had less family functioning problems ($\bar{x}$ = 1.48 vs. 1.89), t (2106) =-5.29 , $p < .001$, and had more participants whose mothers had completed high school ($\bar{x}$= .82 vs. .78), t (2113) = 2.52, $p < .05$. There were no differences between samples on working memory scores, child birth weight, age in months, number of months breastfed, duration of sleep, temperament problems, and maternal age.

We imputed missing data on covariates using NORM multiple imputations program (Schafer, 1999). By drawing values from the conditional distribution of the variables, NORM uses an iterative method based on EM algorithm to impute missing data, depending on the available and valid observations from the original data. Missing kindergarten outcome data was not replaced and was dealt with in the regression analyses using a full information maximum likelihood approach in Mplus. This method retains individuals with missing outcome data as part of the analytic sample, thus reducing attrition bias. More specifically, maximum likelihood estimation takes into account the pattern of missing data in the observed sample when estimating parameters. Along with multiple imputation, full information maximum likelihood estimation is statistically and methodologically advantageous compared with pairwise deletion and simple imputation (Muthén, Kaplan, & Hollis, 1987; Worthke, 2000).

Results

Descriptive statistics are reported in Table 1. Table 2 depicts correlations between our predictor and outcome variables. Gaussian diagrams revealed a reasonably linear relationship between our key variables, allowing us to assume no major departure from multivariate normality, linearity, and homoscedasticity (Cohen, 1968; Tabachnick et al., 2001). Our aim is to reliably estimate the relationship between preschooler working memory and kindergarten entry classroom engagement. To best isolate an unbiased estimation of the link in question we simultaneously account for control characteristics.

In an initial regression we entered our predictors and all available control variables simultaneously. Child age, temperament, sleep, weight-for-gestational age, months

breastfed, family functioning and configuration, and maternal age did not significantly contribute to the variance in the model (results presented in Annex A). In order to increase parsimony, these variables were thus omitted from the final model in Table 3. Our final model therefore included working memory, verbal and nonverbal intellectual skills, socioeconomic status, and sex. Children who scored one standard deviation higher on the working memory task scored .076 standard deviation units higher on the classroom engagement scale (95% CI between .012 and .140). A one standard deviation increase in working memory scores also corresponded to .134 (95% CI between .079 and .190) and .060 (95% CI between .007 and .113) standard deviation unit increases on the number knowledge and receptive vocabulary tests, respectively. Results remained significant after controlling for verbal and nonverbal intellectual skills, sex, and socioeconomic status. Sex explained most of the variance in classroom engagement, but was unrelated to academic achievement outcomes.

As controls, child receptive vocabulary, nonverbal intelligence, and socioeconomic status made their own unique contributions to predicting kindergarten classroom engagement, number knowledge, and receptive vocabulary scores. A one standard deviation increase in nonverbal intelligence and receptive vocabulary test scores corresponded to .088 (95% CI between .020 and .157) and .104 (95% CI between .038 and .169) standard deviation unit increases on the classroom engagement scale, respectively. Being a girl and having a higher socioeconomic status predicted .202 (95% CI between .141 and .262) and .143 (95% CI between .078 and .209) standard deviation unit increases in kindergarten classroom engagement, respectively. Early receptive vocabulary predicted

.416 standard deviation unit increases in kindergarten receptive vocabulary scores (95% CI between .365 and .468) and .158 standard deviation unit increases in number knowledge (95% CI between .100 and .216). Nonverbal IQ was also prospectively associated with both academic skills; as it predicted .076 standard deviation unit increases in receptive vocabulary (95% CI between .020 and .133) and .152 standard deviation unit increases in in number knowledge (95% CI between .093 and .212). Finally, higher socioeconomic status was prospectively associated with .143 standard deviation unit increases in classroom engagement (95% CI between .078 and .209), .120 standard deviation unit increases in receptive vocabulary (95% CI between .065 and .174), and .189 standard deviation unit increases in number knowledge (95% CI between .132 and .246).

Because sex was the greatest predictor of classroom engagement, we further examined the possibility that the relationship between working memory and classroom engagement may differ for boys and girls. To address this possibility we conducted post hoc analyses in which we regressed classroom engagement scores on the interaction term composed of sex and working memory scores. Analyses revealed no significant working memory by sex interactions. This precluded any gender-based strategies for analysis.

Discussion

The integration of concepts from the field of cognitive neuroscience with child development, learning, and education has stimulated interest in considering the brain in the classroom (Gabrieli, 2009; Meltzoff, Kuhl, Movellan, & Sejnowski, 2009). In the present study, we found that in typically developing children, toddler working memory can reliably forecast persistent, focused, and goal-directed behavior in kindergarten. In addition, we

found a prospective association between early childhood working memory and school entry math and reading achievement. Furthermore, our observed results remained significant after statistically controlling for the contribution of socioeconomic status and both verbal and nonverbal intellectual skills. As such, our findings suggest a link between a measure of toddler frontal lobe functioning and their subsequent ability to navigate the demands of the classroom at kindergarten entry.

Interestingly, being a girl was the most important positive predictor of kindergarten classroom engagement. These results are consistent with evidence from Duckworth and Seligman (2006) which suggests a tendency toward better academic performance and self-discipline by adolescent girls compared to boys. Other research has shown that teenage girls are less likely than boys to exhibit maladaptive patterns of student engagement that results in high school dropout (Janosz, Archambault, Morizot, & Pagani, 2008). On one hand, this can be explained by possible brain-driven sex differences in cognitive-control in the face of distracters during effortful activity (Huster, Westerhausen, and Herrmann, 2011). One the other hand, an environmentally-driven perspective suggests sex differences in focussed and disciplined work behavior may originate in early childhood sex segregation in play patterns. During the preschool years, children spontaneously organise themselves in same-sex play groups (Maccoby & Jacklin, 1987). Participation in male versus female play groups is associated with the development of different skills. For example, boys tend to be more involved in activities which develop motor and physical prowess while girls tend to engage in games and activities which require communication, cooperation, and problem

solving. Given that they are likely to develop different skills within their respective peer groups, boys and girls may show different levels of classroom engagement at school entry.

Children who develop better working memory from early childhood to school entry may find it easier to keep instructions and procedures in mind during the completion of classroom tasks. Indeed, the capacity to maintain more information in memory has been shown to facilitate cognitive processing by "freeing up" attention and inhibitory control functions (De Fockert, Rees, Frith, & Lavie, 2001). In adults, working memory and attention skills appear to be linked through a common mechanism. Neuroimaging research indicates that attention and working memory share overlapping activation across neural networks (LaBar, Gitelman, Parrish, & Mesulam, 1999). More recently, a study revealed that activation in brain regions associated with attentional control predicts working memory performance. These results are consistent with the hypothesis that attention plays a gate-keeping role during working memory tasks by favoring the encoding of task-irrelevant information. Research has not examined these processes in very young children facing real life situational demands. However, prior research has established that early childhood attention skills are important for subsequent academic performance and classroom engagement (Duncan et al., 2007; Pagani et al., 2010). Research also suggests a strong link between sustained attention skills and subsequent math and verbal achievement (Blair & Razza, 2007; Butterworth, Varma, & Laurillard, 2011; Cirino, 2010; Sabbagh, Xu, Carlson, Moses, & Lee, 2006).

While working memory skills appear to reliably and uniquely contribute to future school readiness, it may also be the case that these skills represent developmental markers

of underlying cognitive functioning. For example, the task in the present study is likely to have indirectly accessed attentional and inhibitory skills as well working memory (Baillargeon, Pascual-Leone, & Roncadin, 1998). These cognitive skills in turn are likely to have played a role in the development of productive learning behavior in the youngest of primary school students. In order to better understand the importance of early executive function to later school entry learning behavior it would be informative to examine the added benefit of including child assessments of inhibition and attention-shifting skills (Marcovitch & Zelazo, 2009; Blair & Razza, 2007).

Several limitations merit discussion. First, the relative contribution of working memory in the prediction of classroom engagement was less important than that of socioeconomic status and measured verbal and nonverbal intellectual skills. Most of the studies in which cognitive control or IQ explained more variance in achievement than IQ were conducted with older children (Duckworth & Seligmen, 2005). The importance of such self-directed skills may therefore become more apparent in later elementary and high school grades as child autonomy increases and the ability to organize one's own behavior becomes an increasingly important determinant of academic performance. As such, future research should seek to examine how early working memory skills influences the development of classroom engagement over the course of elementary and high school. Finally, given that our methodology is based on a natural experiment afforded by a prospective longitudinal design, it is not possible to determine with certainty any causal features of the prospective association observed between working memory and classroom engagement. Nonetheless, assessing executive function skills in preschoolers may be

advantageous for identifying children at risk of experiencing early academic difficulties, regardless of whether or not these skills are causally related to classroom learning behavior.

From a population health perspective, allocating more resources to understanding the development of persistence and autonomy in learning in young children is seriously warranted (Shonkoff & Phillips, 2000). Future generations of workers are especially likely to face economic conditions that require flexible thinking and problem solving skills (Knudsen et al., 2006). Furthermore, high levels of underachievement and drop out remain costly for both the individual and society (Currie & Stabile, 2006; Levin, Belfield, Muennig, & Rouse, 2007). As such, a better understanding of the chain of developmental events leading up to strong school entry learning skills represents an important outcome in its own right (Knudsen et al., 2006).

The present results may have certain practical implications for the implementation of early childhood interventions designed to bolster school readiness. Toddlers whose parents encourage autonomous behavior score higher on tests of executive function one year later (Bernier, Carlson, & Whipple, 2010). In contrast, children with less supportive families characterized by overt conflict, aggression, neglect, and a lack of warmth, are likely to demonstrate poorer emotional and self-regulatory control later in adolescence and adulthood (Repetti, Taylor, & Seeman, 2002). As such, strategies that target early parental practices may help young children develop better cognitive control by the time they begin school.

Early childhood executive function skills appear to be amenable to intervention. Children and adults who train on working memory tasks have shown transfer effects on

untrained cognitive tests such as fluid intelligence and attention (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008; Thorell, Lindqvist, Bergman Nutley, Bohlin, & Klingberg, 2009). This finding is promising as it suggests that working memory can be sharpened to bring about improvements in cognitive performance. Educational enrichment programs have also successfully enhanced executive function in 4- and 5-year olds (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008; Diamond et al., 2007; Lillard & Else-Quest, 2006). In particular, experimental evaluations strongly suggest the effectiveness of *Tools of the Mind* and Montessori preschool curricula toward improving child executive function.

While our observed effect sizes are modest, small disparities in academic ability at school entry are likely to snowball into larger differentials in achievement over time (Blair & Diamond, 2008). During the preschool years, brain growth occurs at an unparalleled rate resulting in structural changes that chart a developmental course for the capacity to store and manipulate information, pay attention, and exercise cognitive control (Marsh et al., 2008). As such, we propose that assessing working memory in preschool batteries may represent a promising avenue for identifying children at risk future academic difficulty.

References

Alexander, K. L., Entwisle, D. R., & Horsey, C. S. (1997). From first grade forward: Early foundations of high school dropout. *Sociology of Education, 70*, 87-107.

Alp, I. E. (1994). Measuring the size of working memory in very young children: the imitation sorting task. *International Journal of Behavioral Development*, *17,* 125-141.

Baillargeon, R., Pascual-Leone, J & Roncadin, C. (1998). Mental-attentional capacity : does cognitive style makes a difference? *Journal of Experimental Child Psychology,70,* 143-166.

Bates, J. E., Freeland, C. A. B., & Lounsbury, M. L. (1979). Measurement of infant difficultness. *Child Development*, *50,* 794-803.

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

Bierman, K. L., Nix, R. L., Greenberg, M. T., Blair, C., & Domitrovich, C. E. (2008). Executive functions and school readiness intervention: Impact, moderation, and mediation in the Head Start REDI program. *Development and Psychopathology, 20*, 821-843.

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

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

Bowles, S., Gintis, H., & Osborne, M. (2001). The determinants of earnings: a behavioral approach. *Journal of Economic Literature, 39*, 1137-1176.

Butterworth, B., Varma, S., & Laurillard, D. (2011). Dyscalculia: from brain to education. *Science, 332*, 1049-1053.

Caspi, A., & Silva, P. (1995). Temperamental qualities at age three predict personality traits in young adulthood: longitudinal evidence from a birth cohort. *Child Development*, *66,* 486-498.

Cirino, P. T. (2010). The interrelationships of mathematical precursors in kindergarten. *Journal of Experimental Child Psychology, 108,* 713-733.

Cohen, J. (1968). Multiple regression as a general data-analytic system. *Psychological Bulletin, 70*, 426-443.

Conway, A., Kane, M., & Engle, R. (2003). Working memory capacity and its relation to general intelligence. *Trends in Cognitive Sciences, 7*, 547-552.

Currie, J., & Stabile, M. (2006). Child mental health and human capital accumulation: the case of ADHD. *Journal of Health Economics, 25*, 1094-1118.

De Fockert, J., Rees, G., Frith, C., & Lavie, N. (2001). The role of working memory in visual selective attention. *Science, 291*, 1803-1806.

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science, 318*, 1387-1388.

Duckworth, A. L., Peterson, C., Matthews, M. D., & Kelly, D. R. (2007). Grit: perseverance and passion for long-term goals. *Journal of Personality and Social Psychology, 92*, 1087-1101.

Duckworth, A. L., & Seligman, M. E. P. (2006). Self-discipline gives girls the edge: Gender in self-discipline, grades, and achievement test scores. *Journal of Educational Psychology, 98*, 198-208.

Duckworth, A. L., & Seligman, M. E. P. (2005). Self-discipline outdoes IQ in predicting academic performance of adolescents. *Psychological Science, 16*, 939-944.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., et al. (2007). School readiness and later achievement. *Developmental Psychology, 43*, 1428-1446.

Dunn, L. M., The´riault-Whalen, C. M., & Dunn, L. M. (1993). *Échelle de vocabulaire en images Peabody: Adaptation franc¸aise du Peabody Picture Vocabulary test-revised: Manuel pour les formes A et B [French adaptation of the Peabody Picture Vocabulary Test Revised: Manuals for Forms A and B*]. Toronto, Canada: Psycan.

Entwisle, D. R., Alexander, K. L., & Olson, L. S. (2005). First grade and educational attainment by age 22: a new story. *American Journal of Sociology, 110*, 1458-1502.

Epstein, N. B., Baldwin, L. M., & Bishop, D. S. (1983). The McMaster Family Assessment Device. *Journal of Marital and Family Therapy, 9*, 171-180.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: potential of the concept, state of the evidence. *Review of Educational Research, 74*, 59-109.

Gabrieli, J. (2009). Dyslexia: a new synergy between education and cognitive neuroscience. *Science, 325*, 280-283.

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: a review using an integrative framework. *Psychological Bulletin, 134*, 31-60.

Gathercole, S., Tiffany, C., Briscoe, J., & Thorn, A. (2005). Developmental consequences of poor phonological short term memory function in childhood: a longitudinal study. *Journal of Child Psychology and Psychiatry, 46*, 598-611.

Graham, W. J. (2009). Missing data: making it work in the real world. *Annual Review of Psychology, 60*, 549-576.

Heckman, J. J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science, 312*, 1900-1902.

Heckman, J. J. (2007). The economics, technology, and neuroscience of human capability formation. *Proceedings of the National Academy of Sciences, 104*, 13250-13255.

Heckman, J. J., Stixrud, J., & Urzua, S. (2006). The effects of cognitive and noncognitive abilities on labor market outcomes and social behavior. *Journal of Labor Economics, 24*, 411-482.

High, P. C., & the Committee on Early Childhood, Adoption, and Dependent Care and Council on School Health. (2008). School readiness. *Pediatrics*, *121*, 1008–1015.

Huster, R. J., Westerhausen, R., & Herrmann, C.S. (2011). Sex differences in cognitive control

are associated with midcingulate and callosal morphology. *Brain Function & Structure, 215,* 225-235

Jaeggi, S. M., Buschkuehl, M., Jonides, J., & Perrig, W. J. (2008). Improving fluid intelligence with training on working memory. *Proceedings of the National Academy of Sciences, 105*, 6829-6833.

Janosz, M., Archambault, I., Morizot, J., & Pagani, L. S. (2008). School engagement trajectories and their differential predictive relations to dropout. *Journal of Social Issues, 64*, 21-40.

Knudsen, E. I., Heckman, J. J., Cameron, J. L., & Shonkoff, J. P. (2006). Economic, neurobiological, and behavioral perspectives on building America's future workforce. *Proceedings of the National Academy of Sciences, 103*, 10155-10162.

Koechlin, E., & Summerfield, C. (2007). An information theoretical approach to prefrontal executive function. *Trends in Cognitive Sciences, 11*, 229-235.

Kramer, M., Platt, R., Wen, S., Joseph, K., Allen, A., Abrahamowicz, M., et al. (2001). A new and improved population-based Canadian reference for birth weight for gestational age. *Pediatrics, 108*, e35.

LaBar, K., Gitelman, D., Parrish, T., & Mesulam, M. (1999). Neuroanatomic overlap of working memory and spatial attention networks: a functional MRI comparison within subjects. *Neuroimage, 10*, 695-704.

Levin, H., Belfield, C., Muennig, P., & Rouse, C. (2007). The Costs and Benefits of an Excellent Education for all of America's Children. Teacher's College, New York.

Lillard, A., & Else-Quest, N. (2006). The early years: Evaluating Montessori education. *Science, 313*, 1893-1894.

Maccoby, E. E., & Jacklin, C. N. (1987). Sex segregation in childhood. In H. W. Reese (Ed.), *Advances in Child Development and Behavior* (pp. 239-287). Orlando: Academic Press.

Marcovitch, S. & Zelazo, P. D. (2009). A hierarchical competing systems model of the emergence and early development of executive function. *Developmental Science, 12*, 1-25.

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

McKinney, J. D., Mason, J., Perkerson, K., & Clifford, M. (1975). Relationship between classroom behavior and academic achievement. *Journal of Educational Psychology, 87*, 198-203.

McWayne, C. M., Fantuzzo, J. W., & McDermott, P. A. (2004). Preschool competency in context: an investigation of the unique contribution of child competencies to early academic success. *Developmental Psychology, 40*, 633-645.

Meltzoff, A. N., Kuhl, P. K., Movellan, J., & Sejnowski, T. J. (2009). Foundations for a new science of learning. *Science, 325*, 284-288.

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

Muthén, B., Kaplan, D., & Hollis, M. (1987). On structural equation modeling with data that are not missing completely at random. *Psychometrika, 52*, 431-462.

Normandeau, S., & Guay, F. (1998). Preschool behavior and first-grade school achievement: the mediational role of cognitive self-control. *Journal of Educational Psychology, 90*, 111-121.

Okamoto, Y., & Case, R. (1996). Exploring the microstructure of children's central conceptual structures in the domain of number. *Monographs of the Society for Research in Child Development*, 61, 27–58.

Pagani, L. S., Fitzpatrick, C., Archambault, I., & Janosz, M. (2010). School readiness and later achievement: a French Canadian replication and extension. *Developmental Psychology, 46*, 984-994.

Pagani, L. S., Fitzpatrick, C., Barnett, T. A., & Dubow, E. (2010). Prospective associations between early childhood television exposure and academic, psychosocial, and physical well-being by middle childhood. *Archives of Pediatrics and Adolescent Medicine, 164*, 425-431.

Raizada, R. D. S., Richards, T. L., Meltzoff, A., Kuhl, P.K. (2008). Socioeconomic status predicts hemispheric specialisation of the left inferior frontal gyrus in young children. *Neuroimaging, 40*, 1392-1403.

Repetti, R. L., Taylor, S. E., & Seeman, T. E. (2002). Risky families: family social environments and the mental and physical health of offspring. *Psychological Bulletin, 128*, 330-366.

Repovs, G., & Baddeley, A. (2006). The multi-component model of working memory: explorations in experimental cognitive psychology. *Neuroscience, 139*, 5-21.

Ribas-Fitó, N., Júlvez, J., Torrent, M., Grimalt, J.O. and Sunyer, J. (2007). Beneficial effects of breastfeeding on cognition regardless of DDT concentrations at birth. *American Journal of Epidemiology, 166*, 1198-1202.

Sabbagh, M. A., Xu, F., Carlson, S. M., Moses, L. J., & Lee, K. (2006). The development of executive functioning and theory of mind: A comparison of Chinese and US preschoolers. *Psychological Science, 17*, 74-81.

Schafer, J. L. (1999). NORM: Multiple imputation of incomplete multivariate data under a normal model [Version 2]. Retrieved from http:// www.stat.psu.edu/_jls/misoftwa.html

Shonkoff, J., & Phillips, D. (2000). *From Neurons to Neighbourhoods: The Science of Early Childhood Development*. Washington: DC: National Academy Press.

Tabachnick, B., Fidell, L., & Osterlind, S. (2001). *Using Multivariate Statistics*. Boston: Allyn and Bacon.

Thorell, L. B., Lindqvist, S., Bergman Nutley, S., Bohlin, G., & Klingberg, T. (2009). Training and transfer effects of executive functions in preschool children. *Developmental Science, 12*, 106-113.

Touchette, E., Petit, D., Séguin, J.R., Boivin, M., Tremblay, R.E., Montplaisir, J.Y. (2007). Associations between sleep duration patterns and behavioral/cognitive functioning at school entry, *Sleep, 30*, 1213-1239.

Vitaro, F., Brendgen, M., Larose, S., & Tremblay, R. E. (2005). Kindergarten disruptive behaviors, protective factors, and educational achievement by early adulthood. *Journal of Educational Psychology, 97*, 617-629.

Wechsler D. (1991) *Wechsler Intelligence Scale for Children, Third Edition*. San Antonio: The Psychological Corporation.

Willms, J. D., & Shields, M. (1996). A measure of socioeconomic status for the National Longitudinal Study of Children. Report prepared for Statistics Canada.

Worthke, W. (2000). Longitudinal and multigroup modeling with missing data. In T. Little, K. Schnabel & J. Baumert (Eds.), *Modeling Longitudinal and Multilevel Data: Practical Issues, Applied Approaches, and Specific Examples* (pp. 219-240). Hillsdale, NJ: Erlbaum.

Table 1. *Descriptive Statistics for Dependent, Independent, and Control Variables*

Variable	*Mean (SD)*	*Min*	*Max*	*N*
Classroom engagement (74 months)	2.68 (.37)	1.29	3.00	891
Number knowledge (74 months)	13.29 (3.23)	3	18	1099
Receptive vocabulary (74 months)	115.18 (16.82)	40	160	1078
Working memory (29 and 41 months)	1.20 (.74)	0	3.50	1824
Non-verbal IQ (41 months)	6.20 (3.82)	0	24.00	1824
Receptive vocabulary (41 months)	30 (14.53)	2	91	1824
Sex	.50 (.50)	0	1	1824
Socioeconomic Status (5 months)	.00 (.69)	-2.84	3.66	1824
Child age (in months)	29.06 (.47)	28.00	32.00	1824
Temperament problems (17 months)	.46 (.62)	0	2	1824
Hours of continuous sleep (17 months)	6.87 (1.64)	1.00	11.00	1824
Weight-for-gestational age	1.97 (.18)	1.0	2.0	1824
Months breastfed (17 mo)	3.75 (4.57)	0	18	1824
Family functioning (5-29 mo)	1.48 (1.20)	0	10	1824
Family configuration (5-29 mo)	.26 (.44)	0	1	1824
Maternal age (5-mo)	29.31 (5.22)	16.40	44.40	1824

Table 2. Intercorrelations between working memory scores and kindergarten classroom engagement, number knowledge, and receptive vocabulary skills.

	1	2	3	4
Predictor				
1.Working memory	---	.151 ***	.214***	.150***
Kindergarten Outcomes				
2. Classroom engagement		---	.340***	.253***
3. Number knowledge			---	.386***
4. Receptive vocabulary				---

Note. *** $p < .001$.

Table 3. Standardized regression coefficients and 95% confidence intervals depicting the relationship between toddler working memory skills and later school readiness

	Classroom engagement	Number Knowledge	Receptive vocabulary
Working memory	.076 (.012-.140)*	.134 (.079-.190)***	.060 (.007-.113)*
Receptive vocabulary	.104 (.038-.169)**	.158 (.100-.216)***	.416 (.365-.468)***
Non-verbal IQ	.088 (.020-.157)*	.152 (.093-.212)***	.076 (.020-.133)**
Socioeconomic status	.143 (.078-.209)***	.189 (.132-.246)***	120 (.065-.174)***
Sex (1=male, 2=female)	.202 (.141-.262)***	-.024 (-.078-.031)	-.028 (-.080-.024)
R Squared	.126	.167	.259

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

Annex A

Independent Variables	Classroom Engagement	Number Knowledge	Receptive Vocabulary
Working memory	.078 (.017-.142)*	.134 (.079-.190)***	.057 (.004-.110)*
Sex	.199 (.138-.259)***	-.023 (-.078-.031)	-.027(-.078-.025)
Non verbal IQ (41 mo)	.085 (.017-.154)*	.153 (.094-.213)***	.071 (.014-.127)*
Receptive vocabulary (41mo)	.103 (.037-.169)**	.156 (.097-.215)***	.415 (.363-.466)***
Socioeconomic status (5-65 mo)	.111 (.038-.184)**	.174 (.111-.237)***	.120 (.060-.180)
Child age in months	-.014 (-.075-.046)	-.008(-.063-.046)	-.028(-.080-.023)
Temperament problems (17 mo)	.019(-.044-.081)	.010 (-.045-.065)	-.029 (-.081-.023)
Continuous Sleep (17 mo)	.053 (-.009-.116)	.015 (-.040-.070)	.043 (-.009-.094)
Weight for gestational age	-.031 (-.092-.030)	-.040 (-.093-.014)	-.022 (-.072-.027)
Months breastfed (17 mo)	.022 (-.044-.088)	.024 (-.034-.081)	-.027 (-.081-.028)
Family functioning (5-29 mo)	-0.032 (-.098-.033)	-.037 (-.095-.020)	-.084 (-.139--.030)**
Family configuration (5-29 mo)	-.009 (-.077-.058)	-.023 (-.081-.035)	.034 (-.021-.089)
Maternal age (5 mo)	.033 (-.033-.099)	-.022 (-.081-.037)	-.052 (-.108-.003)
Adjusted R square	.132	.173	.276

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

Article 3-Child and Parent Predictors of Patterns of Classroom Engagement in Elementary School

Author contributions

Caroline Fitzpatrick and Linda Pagani designed the study. Caroline Fitzpatrick and Tracie Barnett collaborated in conducting the analyses. Caroline Fitzaptrick took the lead in writing the paper. Linda Pagani and Tracie Barnett edited the manuscript and participated in the interpretation of the data.

Predicting Academic and Psychosocial Adjustment from Kindergarten Engagement Skills

Caroline Fitzpatrick, Linda Pagani, & Tracie A. Barnett

Université de Montréal, GRES

Short title: Classroom Engagement and Later Adjustment

Key words: Classroom engagement; School readiness, Academic achievement; Psychosocial adjustment

Address for correspondence:

Caroline Fitzpatrick
École de psychoéducation
90 Vincent D'Indy
Montreal, Québec, Canada
H2V 1S9
514-343-0760

Abstract

Individual differences in how children behave in the classroom predict later achievement above and beyond intellectual talent. Understanding the evolution of engagement in learning throughout childhood represents an important step in reducing academic underachievement and drop out. Our objective is to examine how child and family level factors predict subsequent developmental trajectories of engagement through elementary school. A population-based birth cohort was follow from birth to grade 4 (N=1589). Elementary school teachers provided ratings of child classroom engagement reflecting task-orientation and self-organization in kindergarten and grades 1 through 4. Growth mixture modelling identified high, moderate, and low trajectories of classroom engagement. Child preschool working memory skills and impulsivity, and maternal hostility, low social support, and stress predicted greater odds of belonging to the low versus the high trajectory. Child impulsivity and maternal hostility and stress also distinguished between the low and moderate engagement trajectories. These results remained significant after controlling for child sex, intellectual skills and socioemotional skills, family configuration, and socioeconomic status. Distinct patterns of classroom engagement can be reliably observed from kindergarten onward. Unlike IQ, classroom engagement is amenable to change and thus can be targeted for intervention. Our results suggest that developing early childhood interventions aimed at improving child attention control and reducing family risk factors may increase child adjustment in elementary school.

Predicting Academic and Psychosocial Adjustment from Kindergarten Engagement Skills

The current economic burden of underachievement and high school dropout remains high and demands that we increase our understanding of which children may be at risk of experiencing poor academic attainment (Heckman, 2006; Levin, Belfield, Muennig, & Rouse, 2007). In the United States, 20% of males and 15% of females do not complete high school by age 20 while in Canada, 10% of young adults have not completed their high school education by age 24 (Bowlby, 2005). Because less well educated individuals pay fewer taxes, consume more social and health care services, and are more likely to get involved in criminal activities, the lifetime cost of each high school dropout is over 200,000 dollars (Levin et al., 2007).

A growing body of literature suggests that strong work habits and the ability to remain focused on classroom tasks favor early academic success and persistence through high school completion (Breslau et al., 2010; Duckworth & Seligman, 2005; Fredricks, Blumenfeld, & Paris, 2004; McWayne, Fantuzzo, & McDermott, 2004; Pagani et al., 2008). For these reasons, professionals interested in the prevention of school dropout have become increasingly interested in student engagement, which refers to student commitment and persistence in the academic environment. Indeed, adolescent work habits explain twice as much variance in academic achievement as IQ (Duckworth, Peterson, Matthews, & Kelly, 2007; Duckworth & Seligman, 2005). Furthermore, individual differences in learning flexibility and adaptability enhance and mediate the acquisition of new skills in a variety of academic, interpersonal and work-related contexts (Heckman, Stixrud, & Urzua,

2006; Knudsen, Heckman, Cameron, & Shonkoff, 2006). As such, because they are narrowly related to achievement, it is important to better understand the evolution of learning disposition across childhood.

Research suggests that the processes leading up to high school dropout can be traced all the way back to kindergarten (Entwisle, Alexander, & Olson, 2005; Vitaro, Brendgen, Larose, & Tremblay, 2005). Children who are better prepared in kindergarten are more likely to experience academic success and show higher engagement in elementary school (Duncan et al., 2007; Pagani et al., 2008). In the youngest of elementary school students, teacher assessments of student ability to remain focused and follow instructions is also associated with more academic success, better teacher-child relations, and more positive relations with peers (Ladd, Birch, & Buhs, 1999; McWayne et al., 2004; Normandeau & Guay, 1998). Furthermore, when surveyed about the student characteristics they favor most, characteristics reflecting student compliance and self-control are among the most common teacher responses (Rimm-Kaufman, Pianta, & Cox, 2000). For these reasons, it remains important to identify early childhood factors that contribute to the development of classroom engagement in the elementary school classroom.

Sociologists have long been aware of the importance of developing strong productive work habits reflecting industriousness in middle childhood. According to Erikson (1950), the ability to acquire strong working skills during elementary school represents a crucial step in children's development of a positive self-concept and sense of competence. Failure to achieve industriousness at this stage is expected to undermine children's self-esteem and adjustment in later childhood and adolescence. In line with this

hypothesis, early elementary school failure has been associated with poorer child mental health and achievement outcomes several years later (Pagani, Tremblay, Vitaro, Boulerice, & McDuff, 2001).

Active engagement toward learning depends on child ability to self-regulate and exercise willful control over emotional and cognitive processes (Blair 2002). For example, in the classroom, children may need to inhibit feelings of anxiety in order to maximize their performance during tests, and challenging academic tasks. In addition, child performance depends on a constellation of cognitive control or executive function skills, which contribute to the achievement of self-directed, effortful behavior by helping individuals mobilize attentional resources. From the first years of life, children begin to show rudiments of inhibition, attention, and working memory ability, which represent the core components of cognitive control (Best & Miller, 2010; Marsh, Gerber, & Peterson, 2008). By the time children enter school, neurocognitive development in the prefrontal brain areas leads to improvements in children's ability to exhibit self-control over cognitive and emotional processes in the interest of goal pursuits. As a result, most kindergarten students are capable of sustaining concentration and focus in their learning environment (Marsh et al., 2008).

Although biological maturation plays an important role in setting the course of neurocognitive trajectories, cognitive control skills also depend on early contexts and experiences. In particular, evidence suggests that aversive and hostile environments can impede the development of brain regions responsible for the control of attention and may lead to lifelong disruptions in psychological and physiological regulation systems (Lupien,

Maheu, Tu, Fiocco, & Schramek, 2007; Repetti, Taylor, & Seeman, 2002; Rutter & O'Connor, 2004). In more favorable conditions, toddlers whose parents' encourage autonomous behavior are more likely to show better cognitive control skills one year later (Bernier, Carlson, & Whipple, 2010). Furthermore, research employing animal models suggests that naturally occurring variations in early maternal warmth and care can influence neural development and even alter genetic expression (Bredy, Humpartzoomian, Cain, & Meaney, 2003; Liu, Diorio, Day, Francis, & Meaney, 2000; Liu et al., 1997). Hence, both positive and adverse rearing practices are likely to shape child neurocognitive development.

The healthy development of children is likely to be influenced not only by their immediate experiences with parents, but also by the family's broader socio-environmental context (Bronfenbrenner, 1986). For example, parents' experience of stress outside the home can have an influence on the quality of care children receive. While children are not directly exposed to parents' work and social environments, these distal contexts or "exosystems" can influence the amount of cognitive and affective resources that are available to parents for childcare (Burchinal, Follmer, & Bryant, 1996). If parental exosystems occasion the experience of stress in excess of coping capacity, symptoms of strain may arise (Spector & Jex, 1998). In certain cases, enduring stress that leads to emotional, physical, and mental exhaustion can lead to parental burnout akin to what is observed in professional caregivers (Schieve, Blumberg, Rice, Visser, & Boyle, 2007). For example, research conducted with professionals in the caretaking professions suggests that emotional burnout can compromise the quality of care that is delivered to patients, in particular because of increased cynicism and reduced emotional involvement towards

caregiving tasks (Maslach, 2003; Maslach & Leiter, 2008). This literature also suggests that the availability of social support may serve to improve mental health, by increasing the number of resources available to individuals (Burchinal et al., 1996). In sum, because they influence adult well-being, parental stress and social support may also play a role in the cognitive development and eventual school competence of children.

Typically developing children show heterogeneity in their patterns of change over time. Nonetheless, much of the research on school readiness has been conducted under the assumption that children follow one general developmental pathway. A limit of this approach is that it can lead us to overlook meaningful diversity that exists within a population (Magnusson, 1998; Richters, 1997). Person-centered approaches allow us to identify discrete subgroups that follow distinct developmental patterns and which display individual differences in risk for developmental difficulty. Thus the identification of non-normative developmental pathways is of particular interest for intervention and prevention research. Because it allows us to model our data while accounting for possible heterogeneity and non-linearity in the data, we therefore apply a person-centered approach to the study of patterns of classroom engagement in elementary school.

The current study

Identifying dispositions in early childhood that are subsequently related to successful academic adjustment is useful for informing the implementation of preschool intervention programs. Furthermore, decisions about whether and to what extent early school readiness interventions should include the family remains to be addressed. The present study examines the relationship between early child and parental characteristics

during the preschool years and subsequent developmental patterns of classroom engagement from school entry to fourth grade. We attempt to isolate the direct influence of early childhood cognitive control and parental practices and context on classroom engagement trajectories. We hypothesize that better cognitive control will be associated with high and sustained classroom engagement throughout elementary school. In turn, we expect that children whose mothers report more hostile and less warm and consistent discipline will display more maladaptive patterns of classroom engagement. Finally, we hypothesize a similarly unfavorable outcome for children whose parents report more stress and less social support. A number of factors are likely to confound the relationship between our predictor variables and subsequent trajectories of engagement (High, 2008; Ladd et al., 1999; Mezzacappa, 2004; Pagani, Fitzpatrick, Archambault, & Janosz, 2010). To reduce confounding in the present study we therefore include measures of child sex, math and reading skills, behavioral adjustment, family configuration, and socioeconomic status.

Methods

Participants

The Quebec Longitudinal Study of Child Development (QLSCD 1998-2010) represents a birth cohort randomly selected from a stratified sample of 2837 children born in the province of Québec Canada between 1997 and 1998. At the inception of the longitudinal component of this public data set coordinated by the Institut de la Statistique du Québec, 93 children were deemed ineligible and 172 were untraceable due to incorrect coordinates. Of the 2572 remaining children, 14 were unreachable and 438 refused participation. Thus, for its early childhood phase, 2120 5-month-old infants were deemed eligible for follow-up, representing 82% of the eligible target population defined by the

birth cohort. Of these, 39% were firstborn. Parents provided informed consent at each data collection wave. Children and teachers also gave informed consent for the school-age phase. Participants were included in this IRB approved study if they had least one valid classroom engagement score between kindergarten and fourth grade, at 74 and 122 months respectively, (N=1589).

Outcome Measure

Classroom Engagement Trajectories. Teachers rated classroom engagement in the spring of kindergarten and grades 1, 2 and 4 using a 7-item scale (average Cronbach alpha of all four assessments = .92): Works and plays cooperatively with other children; Follows rules and instructions; Follows directions; Listens attentively; Completes work on time; Works autonomously; and Works neatly and carefully. Potential responses ranged from 1 (never) to 3 (always) in kindergarten and 1 (never) to 5 (always) in grades 1, 2, and 4. Higher scale scores indicate a higher degree of classroom engagement. Classroom engagement scores were standardized prior to the estimation of trajectories. Confirmatory factor analysis was performed to examine how well a 1 factor model accounted for our 7-item classroom engagement scale. Model fit was very good suggesting that the items capture a single latent factor (CFI=.98; TLI= .97; RMSEA=.069; SRMR=.034). This measure of learning-related behavioral disposition is substantively indicative of productivity, effortful control, and task-orientation in the classroom (Pagani et al., 2010; Pagani, Fitzpatrick, Barnett, & Dubow, 2010).

Child Predictors

Preschool Attentional Control Skills. Children completed the IST at 29 and 41 months (Alp, 1994) with trained examiners. This task is designed to measure working memory ability in preschool age children, and has demonstrated good test-retest reliability and construct-validity. At each session, children sat on the floor, facing the examiner. At the beginning of each of the 3 sets, the examiner first placed toys into two transparent canisters. A red or black band identified each canister. The objective of the task was for children to correctly reproduce the demonstrated sequence by placing the correct toy in the correct canister. Before beginning, the examiner first ensured that the child was capable of imitating the act of placing a single toy into the correct canister. At 29 months, children sorted from two to four toys. Successful completion at Level 1 involved correctly sorting two toys in one canister, and a third in the other. At level 2, children were asked to sort two toys in each canister. At level 3, children sorted three toys in one canister and two in another. At the 41 month assessment, children were asked to sort between three and six toys and an additional level of difficulty was added. Children received one point for every level completed. A level is considered complete if children succeed in sorting the correct toys in the correct canister. A total score was then computed. In order to reduce measurement error, we computed a mean score from total scores at 29 and 41 months.

Impulsivity. When children were 53 and 65 months, parents completed a 9-item subscale from the Social Behavior Questionnaire (SBQ, Tremblay et al., 1991). Items were rated from 1 (often or very true) to 3 (never or not true) and include: Could not sit still, was restless and hyperactive; Has trouble sticking to any activity; Could not stop fidgeting; Was

impulsive, acted without thinking; Had difficulty waiting for his or her turn; Could not settle down to do anything for more than a few moments; Was easily distracted; Was inattentive; and Was unable to concentrate, could not pay attention for long, $\alpha = .91$). Means at 53 and 65 months were averaged. Higher scores indicate more impulsivity.

Parenting Context Predictors

When children were 53 and 65 months, mothers provided information about parenting practices, stress, and social support. Maternal Hostility was measured using the PACOTIS (Boivin et al., 2005). Mothers responded to 7 items related to hostile coercive parenting: I have gotten mad with my child because he said or did something they were not supposed to; I have raised my voice, scolded, or shouted at my child when he/she misbehaved; I have lost my temper with my child while punishing them; I have used corporal punishment when my child misbehaved; and I have hit my child when they were particularly difficult, alpha= .74. Items were rated on a 5-point scale where higher scores reflect more hostile parenting.

Maternal warmth refers to the amount of affection and pleasure mothers express during interactions with their child. Items include: My child and I have spent time talking, playing, or focusing attention on each other just for fun for 5 minutes or more; I have done something special with my child that they enjoy; I engage in sports, hobbies, or play games with my child: I calmly discuss the problem when my child brakes the rules or misbehaves; and I Describe alternative ways of behaving that are acceptable when my child breaks the rules or misbehaves. Items were rated from 1 (never) to 5 (often).

Parental discipline reflects use of consistent discipline with the child. Items include: When I told my child they would get punished if they did not stop doing something, and they kept doing it, I punished them; My child has gotten away with things that should have been punished; My child has gotten out of a punishment when their mind was really set on it; After being disciplined, my child ignores the punishment; and When my child misbehaves, I ignore it or do nothing. Items were rated on a 5 point Likert scale from 1 (never) to 5 (always).

Maternal stress. Mothers were asked about their general level of daily stress over the past 12 months using a Likert scale ranging from 1 (never) to 5 (always). Higher scores reflect higher levels of stress. Items include: I felt I had to rush to get everything done each day; By the time supper time arrived, I was physically exhausted; and I felt I had enough time for myself (reverse coded) alpha= .75.

Social support. Finally mothers reported perceived social support when children were 53 months using 3 items adapted from the ASSI (Barrera & Garrison-Jones, 1992). Mothers rated each item on a Likert scale from 1 (strongly agree) to 4 (strongly disagree): I have family and friends that help me feel safe, secure, and happy; There is someone I trust whom I would turn to for advice if I were having a problem; and There are people I can count on in an emergency, alpha= .87. Means were transformed to a scale ranging from 1 to 10 with higher scores reflecting higher levels of social support.

Control variables

Child Characteristics. The Number Knowledge Test (NKT, abridged version) was administered individually to children by trained examiners to test basic knowledge of

numbers (Okamoto & Case, 1996). The NKT adapted for testing in 4 year-olds measures: Knowledge of the number sequence from one to ten; Knowledge of the one to one correspondence in which a sequence is mapped onto objects being counted; understanding the cardinal value of each number; Understanding of the generative rule which relates adjacent cardinal values; and Understanding that each successive number represents a set which contains more objects. The Peabody Picture Vocabulary Test (PPVT, French adaptation, (Dunn, Thériault-Whalen, & Dunn, 1993) was also administered by trained examiners to test vocabulary knowledge. This test consists of 175 vocabulary items which increase in difficulty throughout the test. The French version has been standardized by Dunn et al. (1993) and is highly correlated with other French vocabulary and intelligence tests.

Parents provided data on additional child and family variables that could possibly influence the key variables in this study. These include child sex and behavioral adjustment : Emotional distress (6 items: Seemed to be unhappy or sad; Was not as happy as other children; Has no energy was feeling tired, Cried a lot; Had trouble enjoying him/herself; and Is unable to make decisions, alpha = .79) and Prosocial behavior (3 items: Tried to help someone who had been hurt; Comforted a child (friend, brother or sister) who was crying or upset; and Helped other children (friends, brother or sister) who were feeling sick, alpha = .85). Items were scored such that a higher value on the scale would indicate a higher degree of the factor. The SBQ represents a good predictor of future psychosocial adjustment and school success (Dobkin, Tremblay, Masse, & Vitaro, 1995; Pagani et al., 2001). All measures reflect means of the 53 and 65 month assessments. Family controls

include socio-economic status (derived from maternal and paternal education, income, and occupational prestige) and family configuration (intact or not).

Data Analytic Strategy

Our interest is in modeling the relationship between child and family characteristics prior to kindergarten entry and their relation to subsequent trajectories of classroom engagement from kindergarten through grade 4. We used Growth Mixture Modeling to estimate distinct intercepts and slopes for groups with unique patterns of the variable of interest. Model selection was based on fit indices and ability to account for meaningful diversity in the data (Richters, 1997). We first generated a one-group linear model; to which a 2 group model was compared. Models with additional group were then tested sequentially against two, three, and four group models. We repeated the same process with higher order growth terms. Based on our criteria, a three group quadratic growth model was favored based on fit indices and ability to model distinct subgroups within the population. Participants were assigned to the group for which they had the highest estimated posterior probability.

We next examine the prospective associations between early childhood attentional control and parenting characteristics and subsequent classroom engagement trajectories. In order to reduce the possibility of competing explanations and minimize the possibility of omitted variable bias our equations account for concurrent and pre-existing child and family control characteristics. The results bear upon the adjusted model, estimated with polytonous logistic regressions (using SPSS).

$$CE_{iTRAJ} = a1 + ß1\ ATT_{iPRESC} + ß2\ PAR_{iPRESC} + \gamma 1 CHILD_i + \gamma 2\ FAM + e_i$$

Where CE_{itraj} represents the elementary school trajectory of classroom engagement, ATT represents early measures of child attentional control skills, PAR represents parental factors, and FAM_i and $CHILD_i$ represent family and child control variables for each individual $child_i$. Finally, a_1 and e_i represent the constant and the stochastic error term, respectively.

Missing data

Missing data on classroom engagement between kindergarten and fourth grade were dealt with during the estimation of trajectories using full information maximum likelihood methods in Mplus (Muthén, Kaplan, & Hollis, 1987). Because missing data predictors and covariates could be predicted from variables in the analytical mode, we conducted multiple imputations under the assumption that data were missing at random (Graham, 2009). Imputations were conducted using NORM multiple imputation software (Schafer, 1999). By using an iterative method based on an EM algorithm, NORM draws values from the conditional distribution of the variables, which are estimated based on available and valid observations from the original data set (for technical details Schafer, 1999).

Results

Using Mplus, Growth Mixture Modeling was applied to classroom engagement scores on the basis of four measurement times between kindergarten and fourth grade. Parameters were obtained by maximum likelihood estimation using an expectation maximization algorithm (Muthén et al., 1987). As reported in Table 2, the Akaike information criterion, Bayesian information criterion, sample size adjusted Bayesian

information criterion, and loglikelihood indices favored a 3 group quadratic solution. Entropy for this model was .71 and was slightly higher than observed for the other models. The fit criteria for this three-group model was good (AIC = 10823.94 and SSBIC= 10870.01) corresponding to a Low (9%, of which 26% = girls and 74% = boys); Medium (19%, of which 44% = girls and 56% = boys), and High trajectory (72%, of which 57% = girls and 43% = boys). The average posterior class probabilities for the low, medium, and high trajectories were .90, .74, and .83 respectively. The posterior mean fitted and observed values for the trajectories in primary school are illustrated in Figure 1.

Table 2 reports the relationship between child and family predictors and profiles of classroom engagement during primary school, while controlling for child and family-level confounders. All odds ratios are interpreted using 'low engagement' as the reference group (omitted group). A one point increase in the working memory scores was associated with a 35% greater odds of belonging to the high engagement group (95% CI=1.003-1.827). A one point increase on the impulsivity scale in turn was associated with a 43% reduction in the probability of belonging to the high engagement group (95% CI=.598-.761).

Maternal hostility and stress were independently associated with 27 and 44% reduced chances of belonging to the high engagement group. Finally mother reported social support was associated with 20% greater odds of belonging to the high engagement group. Scores of impulsivity were also associated with a 14% decrease in the probability of membership to the moderate (versus low) engagement group while maternal hostility and stress predicted a 22 and 30% decrease in the probability of being in the moderate engagement group.

Discussion

In the present study we observed naturally occurring clusters of children that followed distinct patterns of learning-related behavior over time. In our sample of typically developing elementary school students, stable differences were observed between children depicting high, moderate, and low levels of task orientation and classroom focus as early as kindergarten. Furthermore, these individual differences appear to remain stable all the way through to the fourth grade.

Preschoolers who were better able to keep information in working memory and showed lower levels of impulsivity were more likely to remain organized and follow rules and procedures throughout elementary school. These associations remained significant even after child math and reading skills and family socio-economic status were taken into account. Our results therefore suggest that eventual group differences in child engagement depend on the development of attentional and cognitive control skills during the preschool years (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008; Pagani et al., 2010).

As expected, children whose mothers reported more hostile parenting in early childhood were at greater risk of adopting lower patterns of engagement. The children's experience of a cold and hostile environment during the formative years of life can undermine neurocognitive development (Lupien et al., 2007; Repetti et al., 2002). In particular, attentional controls skills, which are necessary for concentration and engagement in the classroom, are highly dependent on brain development during the preshool years. Harsh parenting has been shown to increase cortisol reactivity in preschool aged children, even after genetic influences are taken into account (Ouellet-Morin et al., 2008). In turn,

poor patterns of cortisol reactivity can interfere with child ability to self-regulate and adapt to early schooling (Blair & Diamond, 2008). Future research should thus address whether the association between hostile parenting and child ability to remain engaged in the classroom are explained by cortisol reactivity, and whether child genotype plays a moderating role in this relationship.

Surprisingly, early childhood parental warmth and consistent use of discipline were not statistically associated with subsequent patterns of engagement. Our results are also consistent with a recent study in which both poor, and nearly poor children's sustain attention skills were predicted by maternal of hostility but not maternal warmth (Razza, Martin, & Brooks-Gunn, 2010). Taken together, these findings suggest that in the absence of high levels of adversity, "good enough" parenting may be sufficient for promoting healthy development in human offspring (Scarr, 1992). Another possibility is that specific features of positive parenting, unmeasured in the present study, are likely to have a favorable influence on the development of attentional control. Specifically, parenting that enhances child autonomy may facilitate engagement by contributing to the development of child self-sustained attention skills (Bernier, 2010).

More distal factors such as parental levels of stress and social support were also related to children's ability to remain on task and follow directions in the classroom. These findings relating the larger ecological context of the family with child trajectories of school engagement make sense from a sociological perspective (Bronfenbrenner, 1986; Krieger, 1994). Stress and low social support are likely to reduce the amount of psychological and social resources that are available to mothers and as a result may compromise caregiving

(Ensor & Hughes, 2010). Through playtime and reciprocal interactions parents foster learning environments that help prepare children for more formal learning that takes place in the classroom (Bernier, Carlson, & Whipple, 2010; Mezzacappa, 2004). As a result, parents who experience elevated stress and low social support may have more difficulty providing children with the types of environments that are cognitively enriching.

Several limitations merit discussion. For one, we observed how naturally occurring individual differences influence subsequent patterns of learning related skills in elementary school. As a result, we cannot determine with certainty the presence of a causal relationship between our predictor variables and outcome variables. Nevertheless, we are confident that we included a number of relevant confounders including child math and verbal skills, and socioeconomic status. As in most longitudinal studies, attrition also represents a limit of the present research. This compromises our ability to generalize with absolute accuracy the present findings to the general population. To reduce the influence of selection bias on our results, we performed multiple imputations, which help to maintain the relationship structure between variables in the midst of attrition (Graham, 2009).

The economics of early intervention dictate that the most promising interventions take place in the preschool years when child brain architecture is sensitive to experiences (Heckman, 2006). Furthermore, because attentional control skills represent a significant predictor of achievement among children from low-income backgrounds, targeting attention skills in predominantly disadvantaged populations is likely to represent a useful strategy for redressing social disparities at school entry (Razza et al., 2010). Several programs have shown that attention and cognitive control skills can be successfully targeted

in disadvantaged children (Diamond, Barnett, Thomas, & Munro, 2007; Lillard & Else-Quest, 2006). For example, the school-based Tools of the Mind educational program is grounded in Vygotskian theory and involves training preschool teachers to scaffold children's learning with the aim of improving cognitive control and classroom learning behavior. Randomized controlled trials have demonstrated the effectiveness of its curriculum for promoting, attention, executive functions, and academic achievement with preschool age children from disadvantaged neighborhoods (Diamond et al., 2007).

The skills children bring with them on the first day of school are shaped prior to school entry through a confluence of individual child and contextual factors (Shonkoff & Phillips, 2000). Accordingly, we propose that school readiness interventions be expanded to take into account the early caretaking environment in addition to child skills. Some of the family level factors observed in our study may be more resistant to change (parental stress). Others are likely to be modifiable through interventions (social support, parental practices). Prior studies have highlighted the added benefit of providing support to parents as a means of improving child school readiness (Mendelsohn et al., 2011).

In the present study we observed stability in the trajectories of child engagement from school towards emerging adolescence. These behaviors represent productive work habits indicative of self-control and discipline and predict achievement and psychosocial adjustment in childhood and later on in adulthood (Heckman, 2007). This observed stability in children's disposition towards learning in elementary school can be interpreted as the natural course of engagement in the absence of formal intervention. Because several preschool programs have been successful in boosting child cognitive control, attention, and

involvement in learning, we propose that classroom engagement be targeted in the early elementary school years to improve academic performance.

References

Alp, I. E. (1994). Measuring the size of working memory in very young children: The Imitation Sorting Task. *International Journal of Behavioural Development,17*, 125-141.

Barrera, M., & Garrison-Jones, C. (1992). Family and peer social support as specific correlates of adolescent depressive symptoms. *Journal of Abnormal Child Psychology, 20*, 1-16.

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

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

Bierman, K. L., Nix, R. L., Greenberg, M. T., Blair, C., & Domitrovich, C. E. (2008). Executive functions and school readiness intervention: Impact, moderation, and mediation in the Head Start REDI program. *Development and Psychopathology, 20*, 821-843.

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

Boivin, M., Pérusse, D., Dionne, G., Saysset, V., Zoccolillo, M., Tarabulsy, G. M., . . . Tremblay, R. E. (2005). The genetic environmental etiology of parents' perceptions

and self assessed behaviours toward their 5 month old infants in a large twin and singleton sample. *Journal of Child Psychology and Psychiatry, 46*, 612-630.

Bowlby, G. (2008). Provincial drop-out rates:trends and consequences. *Labor Force Survey*, from http://www.statcan.gc.ca/pub/81-004-x/2005004/8984-eng.htm#b. Accessed 1 July, 2011.

Bredy, T., Humpartzoomian, R., Cain, D., & Meaney, M. (2003). Partial reversal of the effect of maternal care on cognitive function through environmental enrichment. *Neuroscience, 118*, 571-576.

Breslau, N., Breslau, J., Peterson, E., Miller, E., Lucia, V., Bohnert, K., & Nigg, J. (2010). Change in teachers' ratings of attention problems and subsequent change in academic achievement: a prospective analysis. *Psychological Medicine, 40*, 159-166.

Bronfenbrenner, U. (1986). Ecology of the family as a context for human development: Research perspectives. *Developmental Psychology, 22*, 723-742.

Burchinal, M. R., Follmer, A., & Bryant, D. M. (1996). The relations of maternal social support and family structure with maternal responsiveness and child outcomes among African American families. *Developmental Psychology, 32*, 1073-1083.

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science, 318*, 1387-1388.

Dobkin, P. L., Tremblay, R. E., Masse, L. C., & Vitaro, F. (1995). Individual and peer characteristics in predicting boys' early onset of substance abuse: A seven-year longitudinal study. *Child Development*, *66,*1198-1214.

Duckworth, A. L., Peterson, C., Matthews, M. D., & Kelly, D. R. (2007). Grit: Perseverance and passion for long-term goals. *Journal of Personality and Social Psychology, 92*, 1087-1101.

Duckworth, A. L., & Seligman, M. E. P. (2005). Self-discipline outdoes IQ in predicting academic performance of adolescents. *Psychological Science, 16*, 939-944.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., . . . Brooks-Gunn, J. (2007). School readiness and later achievement. *Developmental Psychology, 43*, 1428-1446.

Dunn, L. M., The´riault-Whalen, C. M., & Dunn, L. M. (1993). *Échelle de vocabulaire en images Peabody: Adaptation française du Peabody Picture Vocabulary test-revised: Manuel pour les formes A et B [French adaptation of the Peabody Picture Vocabulary Test Revised: Manuals for Forms A and B*]. Toronto, Canada: Psycan.

Ensor, R., & Hughes, C. (2010). With a little help from my friends: maternal social support, via parenting, promotes willingness to share in preschoolers born to young mothers. *Infant and Child Development, 19*, 127-141.

Entwisle, D. R., Alexander, K. L., & Olson, L. S. (2005). First grade and educational attainment by age 22: a new story *American Journal of Sociology, 110*, 1458-1502.

Erikson, E. H. (1950). *Childhood and society*. New York: Norton.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*, 59-109.

Graham, W. J. (2009). Missing data: making it work in the real world. *Annual Review of Psychology, 60*, 549-576.

Heckman, J. J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science, 312*, 1900-1902.

Heckman, J. J. (2007). The economics, technology, and neuroscience of human capability formation. *Proceedings of the National Academy of Sciences, 104*, 13250-13255.

Heckman, J. J., Stixrud, J., & Urzua, S. (2006). The effects of cognitive and non-cognitive skills on labor and behavioral outcomes. *Journal of Labor Economics, 24*, 411-482.

High, P. C. (2008). School readiness. *Pediatrics, 121*, e1008-e1015.

Knudsen, E. I., Heckman, J. J., Cameron, J. L., & Shonkoff, J. P. (2006). Economic, neurobiological, and behavioral perspectives on building America's future workforce. *Proceedings of the National Academy of Sciences, 103*, 10155-10162.

Krieger, N. (1994). Epidemiology and the web of causation: has anyone seen the spider? *Social Science & Medicine, 39*, 887-903.

Ladd, G., Birch, S., & Buhs, E. (1999). Children's social and scholastic lives in kindergarten: Related spheres of influence? *Child Development, 70*, 1373-1400.

Levin, H., Belfield, C., Muennig, P., & Rouse, C. (2007). *The costs and benefits of an excellent education for all of America's children*. New York: Teacher's College.

Lillard, A., & Else-Quest, N. (2006). The early years: Evaluating Montessori education. *Science, 313*, 1893-1894.

Liu, D., Diorio, J., Day, J. C., Francis, D. D., & Meaney, M. J. (2000). Maternal care, hippocampal synaptogenesis and cognitive development in rats. *Nature Neuroscience, 3*, 799-806.

Liu, D., Diorio, J., Tannenbaum, B., Caldji, C., Francis, D., Freedman, A., . . . Meaney, M. J. (1997). Maternal care, hippocampal glucocorticoid receptors, and hypothalamic-pituitary-adrenal responses to stress. *Science, 277*, 1659-1662.

Lupien, S. J., Maheu, F., Tu, M., Fiocco, A., & Schramek, T. E. (2007). The effects of stress and stress hormones on human cognition: Implications for the field of brain and cognition. *Brain and Cognition, 65*, 209-237.

Magnusson, D. (1998). The logic and implications of a person-oriented approach. In R. B. Cairns, L. R. Bergman & J. Kagan (Eds.), *Methods and models for studying the individual*. Thousand Oaks: Sage.

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

Maslach, C. (2003). Job burnout. *Current Directions in Psychological Science, 12*, 189-192.

Maslach, C., & Leiter, M. P. (2008). Early predictors of job burnout and engagement. *Journal of Applied Psychology, 93*, 498-512.

McWayne, C. M., Fantuzzo, J. W., & McDermott, P. A. (2004). Preschool competency in context: an investigation of the unique contribution of child competencies to early academic success. *Developmental Psychology, 40*, 633-645.

Mendelsohn, A. L., Huberman, H. S., Berkule, S. B., Brockmeyer, C. A., Morrow, L. M., & Dreyer, B. P. (2011). Primary care strategies for promoting parent-child interactions and school readiness in at-risk ramilies: The Bellevue Project for early language, literacy, and education success. *Archives of Pediatrics and Adolescent Medicine, 165*, 33-41.

Mezzacappa, E. (2004). Alerting, orienting, and executive attention: Developmental properties and sociodemographic correlates in an epidemiological sample of young, urban children. *Child Development, 75*, 1373-1386.

Muthén, B., Kaplan, D., & Hollis, M. (1987). On structural equation modeling with data that are not missing completely at random. *Psychometrika, 52*, 431-462.

Normandeau, S., & Guay, F. (1998). Preschool behavior and first-grade school achievement: The mediational role of cognitive self-control. *Journal of Educational Psychology, 90*, 111-121.

Okamoto, Y., & Case, R. (1996). Exploring The Microstructure of children's central conceptual structures in the domain of number. *Monographs of the Society for Research in Child Development, 61*, 27-58.

Ouellet-Morin, I., Boivin, M., Dionne, G., Lupien, S. J., Arsenault, L., Barr, R. G., . . . Tremblay, R. E. (2008). Variations in heritability of cortisol reactivity to stress as a

function of early familial adversity among 19-month-old twins. *Archives of General Psychiatry, 65*, 211.

Pagani, L. S., Fitzpatrick, C., Archambault, I., & Janosz, M. (2010). School readiness and later achievement: a French Canadian replication and extension. *Developmental Psychology, 46*, 984-994.

Pagani, L. S., Fitzpatrick, C., Barnett, T. A., & Dubow, E. (2010). Prospective associations between early childhood television exposure and academic, psychosocial, and physical well-being by middle childhood. *Archives of Pediatrics and Adolescent Medicine, 164*, 425-431.

Pagani, L. S., Tremblay, R. E., Vitaro, F., Boulerice, B., & McDuff, P. (2001). Effects of grade retention on academic performance and behavioral development. *Development and Psychopathology, 13*, 297-315.

Pagani, L. S., Vitaro, F., Tremblay, R., McDuff, P., Japel, C., & Larose, S. (2008). When predictions fail: The case of unexpected pathways toward high school dropout. *Journal of Social Issues, 64*, 175-194.

Razza, R. A., Martin, A., & Brooks-Gunn, J. (2010). Associations among family environment, sustained attention, and school readiness for low-income children. *Developmental Psychology, 46*, 1528.

Repetti, R. L., Taylor, S. E., & Seeman, T. E. (2002). Risky families: Family social environments and the mental and physical health of offspring. *Psychological Bulletin, 128*, 330-366.

Richters, J. E. (1997). The Hubble hypothesis and the developmentalist's dilemma. *Development and Psychopathology, 9*, 193-229.

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

Rutter, M., & O'Connor, T. G. (2004). Are there biological programming effects for psychological development? Findings from a study of Romanian adoptees. *Developmental Psychology, 40*, 81-94.

Scarr, S. (1992). Developmental theories for the 1990s: Development and individual differences. *Child Development, 63*, 1-19.

Schafer, J. L. (1999). Multiple imputation: a primer. *Statistical methods in medical research, 8*, 3-15.

Schieve, L. A., Blumberg, S. J., Rice, C., Visser, S. N., & Boyle, C. (2007). The relationship between autism and parenting stress. *Pediatrics, 119*, S114-S121.

Shonkoff, J., & Phillips, D. (2000). *From neurons to neighbourhoods: The science of early childhood development*. Washington: DC: National Academy Press.

Spector, P. E., & Jex, S. M. (1998). Development of four self-report measures of job stressors and strain: Interpersonal conflict at work scale, organizational constraints scale, quantitative workload inventory, and physical symptoms inventory. *Journal of Occupational Health Psychology, 3*, 356-367.

Tremblay, R. E., Loeber, R., Gagnon, C., Charlebois, P., Larivée, S., & LeBlanc, M. (1991). Disruptive boys with stable and unstable high fighting behavior patterns

during junior elementary school. *Journal of Abnormal Child Psychology, 19*, 285-300.

Vitaro, F., Brendgen, M., Larose, S., & Tremblay, R. E. (2005). Kindergarten disruptive behaviors, protective factors, and educational achievement by early adulthood. *Journal of Educational Psychology, 97*, 617-629.

Table 1. Growth Mixture Models of Developmental Patterns of Engagement with Linear and Quadratic Growth Terms.

	Growth mixture model			
Fit indices	2 Class linear	2 Class quadratic	3 Class linear	3 Class quadratic
AIC	11037.02	10957.30	10935.04	10823.94
BIC	11101.470	11048.61	110515.60	10936.73
SSBIC	11063.35	10994.60	10967.95	10870.01
Entropy	.76	.73	.74	.71
Loglikekihood	-5506.51	-5461.66	-5452.52	-5390.97

AIC= Akaike information criterion; BIC= Bayesian information criterion; SSBIC = sample size adjusted Bayesian information criterion.

Figure Caption.

Figure 1. Classroom engagement trajectories from kindergarten to grade 4.

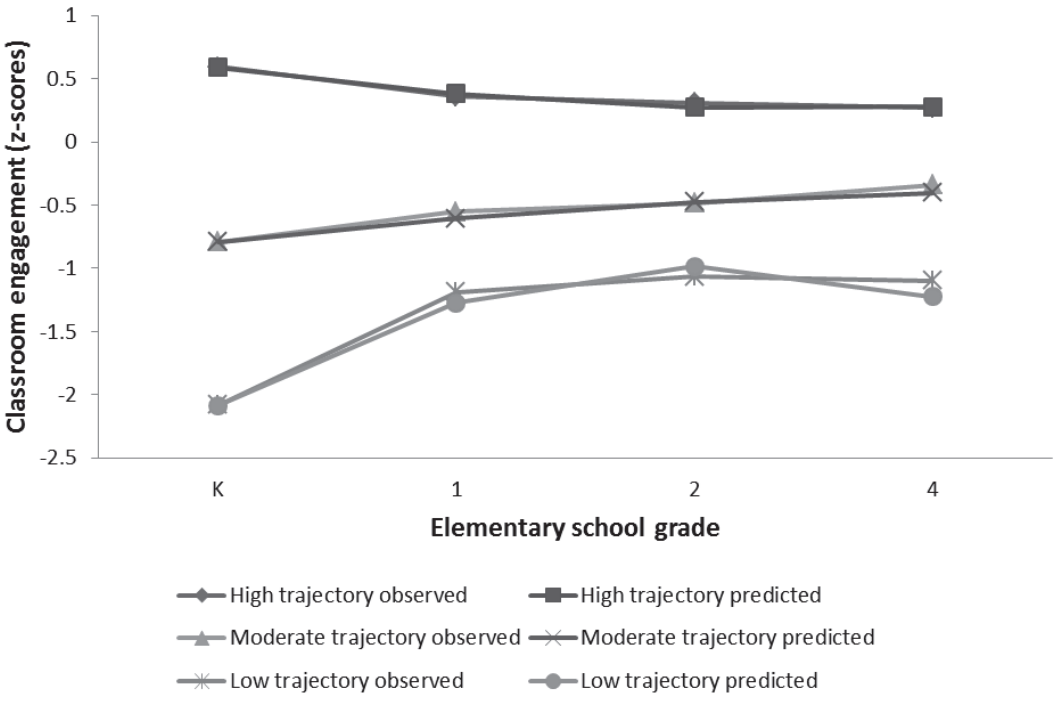
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
Classroom engagement (z-scores)
K
1
2
4
Elementary school grade
High trajectory observed
High trajectory predicted
Moderate trajectory observed
Moderate trajectory predicted
Low trajectory observed
Low trajectory predicted

Table 2. *Descriptive statistics of independent, dependent, and control variables*

	M (SD)	Min	Max
Classroom Engagement			
Kindergarten	2.68 (.37)	1.14	3.00
Grade 1	4.04 (.69)	1.09	5.00
Grade 2	4.02 (.67)	1.82	5.00
Grade 4	3.99 (.68)	1.73	5.00
Predictors			
Working memory	1.20 (.70)	0	3.5
Impulsivity	3.76 (1.80)	0	10
Maternal hostility	2.93 (1.06)	0	7.75
Maternal stress	2.69 (.67)	1	5
Social support	9.09(1.38)	3.33	10
Maternal warmth	6.24 (.98)	2	9.50
Maternal discipline	7.16 (1.44)	1.75	10
Control variables			
Sex	.48 (.50)	0	1
Number knowledge	65.27 (19.13)	2	120
Receptive vocabulary	9.24 (4.16)	0	22
Emotional distress	1.90 (1.28)	0	7.5
Prosocial skills	6.41 (2.36)	0	10
Family configuration	.26 (.44)	0	1
Socioeconomic status	.05 (1.00)	-2.60	3.66

Table 3. Independent predictors of classroom engagement trajectories class membership

	High vs. Low Trajectory (N=1151)	Moderate vs. Low Trajectory (N=297)
	AOR (95%CI)	AOR (95% CI)
Working memory	1.35 (1.003-1.827)*	1.12 (.810-1.549)
Impulsivity	.675 (.598-.761)***	.862 (.760-.979)*
Parental Characteristics		
Maternal hostility	.722 (.596-.876)**	.781 (.635-.960)*
Maternal stress	.680 (.496-.932)*	.639 (.454-.899)*
Social support	1.199 (1.047-1.367)*	1.146 (.992-1.324)
Maternal discipline	.936 (.812-1.08)	.971 (.833-1.132)
Maternal warmth	.923 (.752-1.133)	.981 (.787-1.223)
Cox et Snell	.174	

Models include child sex, prosocial skills, emotional distress, math and reading skills, family configuration, and socioeconomic status. Asterices represent probability: *** $p < .001$, ** $p < .01$, * $p < .05$. AOR = Adjusted odds ratio.

"*That some achieve great success, is proof to all that others can achieve it as well.*"

-Abraham Lincoln

"Chaque enfant qu'on enseigne est un homme qu'on gagne"

-Victor Hugo

CHAPTER 2

General Discussion

Children's ability to follow directions, work autonomously, and remain focused in the classroom setting represent useful indicators of their preparedness to meet the demands of formal schooling which begins in the first grade. In Paper 1, kindergarten classroom engagement skills predicted later achievement and psychosocial adjustment. Engagement skills may be related to these later outcomes because they facilitate adaptation to the academic and social demands of the early school environment. They are also likely to reflect underlying individual differences in cognitive control skills which play an important role in helping individuals adjust to novel challenges. In Papers 2 and 3, the contribution of early childhood cognitive control to school entry classroom engagement was assessed. Our results suggest a robust relationship between toddler working memory and attention skills and subsequent behavioral disposition toward learning in the kindergarten classroom. Finally in Paper 3, we show that individuals appear to follow either stable high, moderate, or low trajectories of engagement over the course of elementary school. In the same study, early childhood cognitive control skills and parental characteristics predicted these developmental pathways. Taken together, the present findings suggest that targeting classroom engagement represents a promising strategy for enhancing academic achievement and adjustment.

Overall, the findings regarding the predictive value of classroom engagement are important for several reasons. Academic achievement tends to stabilize in the middle of elementary school. Youth who are experiencing difficulty in primary school are then more likely to follow a path leading to underachievement and high school dropout (Alexander et al., 1993). Dropping out of high school is subsequently associated with a cascade of risks

that can impede wellbeing throughout the life course. For example, the decision to dropout of high school increases the risk of lifelong poverty (Card, 1999), poorer health (Freudenberg & Ruglis, 2007), and antisocial life-course trajectories (Henry et al., 1999). Kindergarten measures that forecast achievement in the fourth grade thus represent useful tools for identifying children at risk of lifelong adjustment problems.

Paper 1 also showed that children who have difficulty remaining engaged during learning activities are more likely to develop negative relationships with teachers. Elementary school teachers in particular spend a lot of time with the same children, for whom they play a role as both a nurturer and educator. Teacher's expressions of warmth/closeness or anger/conflict over the course of a school year are thus likely to shape children's school and learning experience. In particular, much like good parenting skills, teacher warmth and structure are likely to enhance child outcomes; whereas, conflictual relations with teachers are likely to undermine child well-being at school (Baker, 2006; Brendgen, Wanner, & Vitaro, 2006; Hamre & Pianta, 2001).

Students with poor cognitive and self-regulatory control may be especially at risk of developing less than optimal relations with teachers. Theoretically, this dynamic can have important repercussions. For one, teachers may be less inclined to exert effort and provide guidance to challenging students. Second, once established, teacher expectations of their students can influence later student achievement, even when past performance is taken into account (Rosenthal & Jacobson, 1968). Negative teacher-child relationships are thus likely to steer children toward less positive learning trajectories (Rimm-Kaufman, La Paro, Downer, & Pianta, 2005).

Children who were less engaged in the classroom were more likely to use aggressive and antisocial behavior while interacting with fellow students. They were also more likely to experience rejection by their peers. From a prevention perspective, these findings are of concern given that elementary school students who perpetrate proactive acts of aggression are at an elevated risk of following a course characterized by involvement in later criminal and antisocial behavior (Nagin & Tremblay, 1999). Furthermore, children who present externalizing problems are more likely to be excluded from their peer group (Ladd et al., 1999; Vitaro et al., 2005). Disruptive children in particular are more likely to experience rejection or victimization, especially if the larger social group labels them as "unpopular". In contrast, children who show lower levels of behavioral problems are likely to develop more supportive relations with peers. Children who are better able to inhibit aggressive behaviors are then more likely to be included in classroom activities, which can increase school liking and access to social and academic learning opportunities.

Papers 2 and 3 provide evidence that early childhood cognitive control is a robust predictor of engagement in elementary school. These findings suggest that early interventions that strengthen attentional control and working memory, two important mechanisms of learning, can significantly improve school readiness. Furthermore, in Paper 3, we show that parental characteristics can influence childhood engagement trajectories. These observed associations relating the larger family ecology to child learning outcomes suggest the importance of providing support to at risk-families in order to reduce academic underachievement.

Historically, schooling policies have functioned primarily to ensure a steady inflow of workers to fuel the labor market (Lillard, 2005). For efficiency purposes, children were asked to assimilate large amounts of knowledge passively from teachers. In this context, little emphasis has been placed on problem solving, creativity, and autonomous learning. Classrooms, teaching styles, and curricula were standardized with a one size fits all formula. While this form of classroom arrangement is well suited for its intended purpose of developing workers for the industrial market, social and technological transformations over the past century have changed the nature of working conditions. For this reason, the "factory model" of learning can be seen as increasingly ill-suited for current market characteristics which favor workers that are skilled learners, capable of flexible problems solving skills (Knudsen, Heckman, Cameron, & Shonkoff, 2006). Traditional kindergarten classrooms are likely to be especially inefficient for the promotion of flexible learning and classroom engagement in young children during a developmental period that favors creativity.

Prevention and Intervention Programs

Interventions and curricula that target preschool children represent promising avenues for increasing school readiness and adjustment throughout childhood (Heckman, 2006). Few programs to date have been designed to specifically improve cognitive control and classroom engagement in preschool aged children. Nonetheless, *Tools of the Mind* preschool program (Bodrova & Leong, 2007), Montessori Education (Lillard & Else-Quest, 2006) and the REDI program (Bierman, Domitrovich, et al., 2008; Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008) have shown positive effects on cognitive control

and classroom learning behavior. As well, some programs have included a self-regulation components within larger objectives (e.g., Webster-Stratton, 2001). Finally, several programs have addressed specific subsets of attention skills over short periods of time (Klingberg, Forssberg, & Westerberg, 2002; Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005). In the following sections these programs will be reviewed in order identify the most promising interventions for enhancing student's classroom engagement.

Tools of the Mind

According to Lev Vygotsky's social learning theory, children's acquisition of new skills occurs most efficiently in the context of social interactions. Specifically, social interactions are seen as facilitating learning through a process referred to as scaffolding. This process involves a more experienced teacher facilitating child acquisition of knowledge by providing graded assistance to children within the "zone of proximal development." As previously discussed, an important outcome of social learning is children's development of self-regulation. For example, through meaningful interactions with caretakers children become increasingly skilled at using private speech to guide their behavior. The ability to give oneself instructions in order to plan and control one's actions is especially important for the accomplishment of self-controlled behavior.

The *Tools of the Mind* program was developed by educational psychologists Bodrova & Leong (1996) and was inspired by Vygotsky's theory of development (1987). The objective of this program is to improve cognitive control in the form of self-regulation, metacognition, cognitive flexibility, and working memory in children with the aim of facilitating goal-directed planning, problem solving, and learning. An important component

of this program involves teacher scaffolding and children's use of speech, or constructive self-talk to facilitate cognitive control (Bodrova & Leong, 2007). For example, teachers can help children develop metacognition or "thinking about thinking" by prompting children to share how they solved a problem or why they chose one course of action over another. Children also develop self-regulation skills by engaging in activities with peers. For example, in one game, one child plays the role of the "checker" whose role is to monitor (out loud) the work of their partner as they attempt to complete a task. As children become increasingly skilled at monitoring the work of others, teachers can modify the task by asking children to switch from monitoring the work of others to monitoring their own work during a problem solving task. This exercise is designed to help children internalize speech and language to help them regulate their own behavior.

Children also work on inhibitory control, by participating in a game called *Graphics Practice.* During this game, children draw different kinds of marks while music is played. They must then stop on a determined cue. Finally, children also develop working memory and cognitive control by engaging in dramatic play. For example, during dramatic play, children are asked to play a role, thus requiring them to update and keep in working memory information that is relevant to their scenario. Furthermore, as children interact with others, they must also use attentional control and flexibility in order to help them adapt and rethink their role in light of new developments.

The effectiveness of *Tools* has been demonstrated with 5 year olds from disadvantaged neighborhoods (Diamond, Barnett, Thomas, & Munro, 2007). Specifically, when compared to controls, children randomly assigned to follow Tools curriculum

performed better on executive function tests one year later. Unfortunately there are no data available on the effectiveness of this program from non-disadvantaged children. As such, in order to better understand the potential benefit of implementing this program on a wider scale, replications with more heterogeneous population-based samples are necessary. Nevertheless, this program remains promising in light of its effectiveness and ease of implementation within the preschool environment.

Montessori Education

Montessori educational systems were designed to target social and academic skills in children from disadvantaged backgrounds (Lillard, 2005). An evaluation of this program suggests its effectiveness in promoting cognitive control, moral development, and learning skills. Characteristics of this program include mixed-aged classrooms, student-directed learning activities, and long periods of uninterrupted play (Bodrova & Leong, 2007). As in *Tools of the Mind*, children in Montessori classrooms spend much of their time engaged in self-directed learning activities which require autonomy, creativity, and self-control. These effortful control skills represent important foundations for the development of strong classroom engagement skills.

The effectiveness of this program has been measured by comparing two groups of preschool-aged children who were, or were not, granted access to a Montessori classroom through a random lottery. Though all the participants self-selected themselves for Montessori education, the randomized lottery suggests that differences between these groups reflect differences in the education they received during one year of preschool. Results of the evaluation indicate that relative to controls, Montessori children scored

higher on math problem solving and phonological awareness by the end of kindergarten (Lillard & Else-Quest, 2006). In addition, Montessori 5-year olds scored higher on tests of executive functioning, moral reasoning, and were less likely to show aggressive behavior.

REDI Preschool Intervention Program

The REDI prevention program involves research-based curricula and instructional strategies which were developed with the specific aim of improving children's cognitive control skills. The contents of this program have been integrated within larger school readiness interventions such as Head Start (Bierman et al., 2008). The objective is for children to improve their self-regulatory skills in terms of cognitive and emotional control by listening to stories, playing with puppets, and role playing in the classroom. In addition teachers are provided with training session and supervision to help them develop positive classroom management skills, appropriate praise, warm involvement, emotional coaching, and problem-solving dialogue.

Two randomized controlled studies indicate that the present program implemented in the classroom setting can increase children's working memory, inhibitory control, and attentional set-shifting (Bierman et al., 2008; Bierman et al., 2008). Furthermore, children who participated in this program also showed improvements in learning engagement. As in the other interventions, a weakness of the original version of the REDI program is the absence of a parental component. However, in order to increase the dosage of this program, an enriched version that includes a parental component, has been developed and has demonstrated favorable results (Bierman et al., 2008).

The Incredible Years Program

The goal of this exemplary program is to reduce conduct problems in children. This intervention was not directly concerned with the improvement of children's cognitive control skills. However, the *Incredible Years* does include modules that target productive classroom behavior (Webster-Stratton, Jamila Reid, & Stoolmiller, 2008).

Both teachers and parents deliver the child component of this program. Guidance is provided to teachers and parents through training videos, manuals, and participation in discussion groups. The child component is administered via multiple mediums including videos, selected readings, collaborative learning exercises, games, and the completion of supervised homework exercises. Learning-related skills are targeted by teachers who encourage students to listen and raise their hand in class. They also help students develop good concentration skills by showing them how to avoid interference in the classroom and by teaching them to take time to check over their work.

Parents help to transmit the program curriculum by learning positive discipline skills. By learning productive parenting strategies, parents are better able to monitor, set limits, establish learning routines, and avoid using criticism. These skills are believed to help children develop better self-regulatory skills and classroom competence. Interestingly, the benefit of including a parental component is supported by the results of Paper 3 where hostile parenting was associated with lower levels of classroom engagement throughout elementary school.

The strengths of the present program include its inclusion and integration of child, parent, and teacher components and its thoughtfully designed training materials, which can be adapted to individuals from different cultural contexts. Randomized control group

studies have demonstrated the effectiveness of *The Incredible Years Program* (Webster-Stratton et al., 2008). Program participation is associated with reductions in teacher-rated problem behaviors and increased academic achievement in at risk-children. What remains to be examined is whether parental and teacher training in positive discipline strategies enhances the effectiveness of preschool programs designed to improve classroom engagement skills.

Additional Programs

Though the following programs are small in scope, they describe training interventions which are likely to help strengthen children's ability to sustain focus and concentration in the classroom. They also suggest that relatively brief, child-focused, training interventions can lead to significant improvements in attention and cognitive control. The contributions of the following studies are thus useful for the development of specific modules to be included within larger scope interventions.

Working Memory Training Program. Klingberg et al. (2002) examined the efficacy of a program designed to improve child attention skills by targeting working memory. The exercises in this program are computer-based and involve training on visual-spatial, and backward-digit and letter span tasks. Over the course of 20 days participants showed improvement in attention in the form of improved reasoning ability and scores on the Stroop-tasks. Participants also showed improvement's on Raven's progressive matrices. One limit of this program is that it was tested in a sample of 5-7 year olds diagnosed with ADHD. Nonetheless, in the same study, the findings were replicated with adults without ADHD. As such, given its effectiveness with a non-clinical adult sample, it is possible that

this program can be adapted to benefit non-ADHD preschool-aged children. Furthermore, the relative simplicity of implementation of the computer exercises and the positive results of the current trial suggest that the inclusion of these exercises can enrich larger scope classroom engagement intervention programs.

Attention Training Intervention. The objective of Rueda and colleagues (2005) original training program was to help prepare monkeys for space flight. By adapting the content of this program for children, the authors found positive effects of their specific training exercises on subsequent attention skills in 4- to 6-year-olds. Furthermore, these effects were observed above and beyond the influence of genetic factors, which are known to explain a lot of the variance in cognitive control (Barnes, Dean, Nandam, O'Connell, & Bellgrove, 2011). Training sessions were held over 9 days on three modules targeting attention: stimulus anticipation and discrimination, and conflict resolution. Participants performed tasks on a computer to fulfill their training on each module. For stimulus anticipation, children learned to anticipate the movement of a duck on a computer screen. For stimulus discrimination, children selected a previously viewed portrait from a group of portraits. Finally, for conflict resolution, children performed a Stroop-like task where they were asked to identify which of two sets contained more elements. Conflict was introduced by presenting a smaller set made up of larger digits (a set of 3 number 9s) versus a larger set of smaller digits (a set of 9 number ones). Evaluations showed that children who underwent the training improved their conflict resolution skills and showed improvements in attention and intelligence relative to controls (Rueda et al., 2005). As in the previous program, long-term research should evaluate the sustainability of the effects over time.

Furthermore, it would be useful to determine whether the improvement in attention observed in this program translate into better task-orientation and focus in the classroom.

Summary

In sum, specific cognitive control training programs have been successful in targeting, inhibitory control, cognitive flexibility, planning, reasoning, working memory, and attention skills in preschool aged children. These skills represent pre-requisites for behavioral regulation, task-orientation, persistence, and focus in the classroom. That is, while no program has comprehensively targeted classroom engagement as their primary focus, programs which have addressed specific components of cognitive control in young children have generally lead to improvements in the ability to remain on task in the classroom.

The success of interventions, such as *Tools of the Mind* and *Montessori*, which are administered mainly by teachers, is promising. Many preschool and elementary school teachers report facing challenges in the classroom due to child behavior problems and low self-regulatory skills. Indeed, poor self-regulation on the behalf of children is a factor that contributes to growing rates of teacher burnout (Hastings & Bham, 2003). Not surprisingly, when surveyed about the student characteristics they favor most, student compliance, attentiveness, sitting still, and listening are among the most common teacher responses (Rimm-Kaufman, Pianta, & Cox, 2000). As such, programs and curriculum that are easy to administer and which aim to improve engagement are likely to be met with enthusiasm by teachers.

One limitation of current intervention programs (with the exception of the REDI and Incredible Years) is the absence of parental components. A continued collaboration with parents may further improve the outcomes of promising interventions, especially in light of the findings that early family characteristics are likely to play an important role in the development of school readiness (Mendelsohn et al., 2011). Furthermore, as suggested by the findings of Paper 3, children may benefit from continued support in the home, and the added involvement of their parents in educational interventions. Another limitation highlighted in the present review is that most programs did not follow up on the long-term sustainability of their results. Better understanding the durability of these effects can help inform decisions over how and when to implement these programs. It can also inform the introduction of possible booster components. In sum, preschool intervention programs which include training exercises organized into modules that target cognitive control and self-regulation appear promising for improving classroom engagement. Furthermore, it would be ideal for programs to include complementary and mutually reinforcing child, parent, and teacher components.

Conclusion

The current crisis in education demands that we increase our ability to understand which skills, if targeted, are likely to bring about improvements in children's academic performance, high school completion, and eventual productivity in the workplace. Three studies suggested that classroom engagement, which refers to the ability to work autonomously and follow directions, predicts later academic performance and psychosocial adjustment, even while adjusting for kindergarten math and verbal skills, and family risk

characteristics. Results also suggested a robust association between working memory ability at age 3 and kindergarten classroom engagement skills. Finally, individual differences in engagement were observed over the course of elementary school suggesting that children presenting cognitive and familial risks in early childhood are more likely to show low engagement across the grade school years.

Upon merging scholarship in the fields of education and cognitive neuroscience, we propose that productive work habits in the classroom are likely to represent ecological manifestations of cognitive control skills. Such skills help individuals suppress automatic and less effortful responses in favor of more deliberate and thoughtful actions (Diamond, 2006). Furthermore, from an educational perspective, engagement represents an important mechanism of achievement because it is directly related to being on task and following directions in the classroom (Fredricks et al., 2004).

An examination of the outcomes and antecedents of classroom engagement also support a conceptualization of engagement as a contextual manifestation of cognitive control. For one, better classroom engagement was predictive of academic and psychosocial adjustment, both of which have also been shown to rely on cognitive and emotional regulation. Second, measures of working memory and impulsivity in Papers 2 and 3 were predictive of classroom engagement skills. This relationship was robust and revealed no mediation by intellectual skills and socioeconomic factors.

From a policy standpoint the present findings are promising. First, cognitive control appears to play a role in achievement beyond that of IQ and socioeconomic status. Second, research on cognitive control is generally conducted in a controlled laboratory setting.

However, studying engagement in the classroom setting, as observed by teachers can help us understand how children's actual contextual application of effortful control is related to later outcomes. Third, in addition to being related to academic outcomes classroom engagement skills, reflecting cognitive control, are also likely to contribute to better psychosocial and interpersonal adjustment. Finally, research suggests that classroom engagement skills are malleable and amenable to interventions. How children begin their educational journey has important repercussions on their academic experience, and eventual quality of life. The current review provides evidence that assessing classroom engagement skills can help identify at-risk children. This represents an important step to ensure that all children have the opportunity to start school on the right foot and experience success to their full potential.

References

Aarnoudse-Moens, C., Weisglas-Kuperus, N., Goudoever, J., & Oosterlaan, J. (2009). Academic achievement, behavioral problems and executive function in very preterm and/or very low birth weight children: A meta-analysis. *Acta Pædiatrica, 124*, 717-728.

Alexander, K. L., Entwisle, D. R., & Dauber, S. L. (1993). First-grade classroom behavior: Its short-and long-term consequences for school performance. *Child Development, 64*, 801-814.

Alexander, K. L., Entwisle, D. R., & Horsey, C. S. (1997). From first grade forward: Early foundations of high school dropout. *Sociology of Education, 70*, 87-107.

Almlund, M., Duckworth, A. L., Heckman, J. J., & Kautz, T. (2011). Personality psychology and economics. In E. A. Hanushek, S. Machin & L. Wößmann (Eds.), *Handbook of the economics of education*. Amsterdam: Elsevier.

Altemeier, L., Abbott, R., & Berninger, V. (2008). Executive functions for reading and writing in typical literacy development and dyslexia. *Journal of Clinical and Experimental Neuropsychology, 30*, 588-606.

Altemeier, L., Jones, J., Abbott, R., & Berninger, V. (2006). Executive functions in becoming writing readers and reading writers: Note taking and report writing in third and fifth graders. *Developmental Neuropsychology, 29*, 161-173.

Archambault, I., Janosz, M., Fallu, J. S., & Pagani, L. S. (2009). Student engagement and its relationship with early high school dropout. *Journal of Adolescence, 32*, 651-670.

Baker, J. (2006). Contributions of teacher-child relationships to positive school adjustment during elementary school. *Journal of School Psychology, 44*, 211-229.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin, 121*, 65-94.

Barnes, J. J. M., Dean, A. J., Nandam, L. S., O'Connell, R. G., & Bellgrove, M. A. (2011). The Molecular genetics of executive function: Role of monoamine system genes. *Biological Psychiatry,69*, e127-e143.

Barry, T. D., Dunlap, S. T., Cotten, S. J., Lochman, J. E., & Wells, K. C. (2005). The influence of maternal stress and distress on disruptive behavior problems in boys. *Journal of the American Academy of Child & Adolescent Psychiatry, 44*, 265-273.

Belsky, J., Pasco Fearon, R. M., & Bell, B. (2007). Parenting, attention and externalizing problems: Testing mediation longitudinally, repeatedly and reciprocally. *Journal of Child Psychology and Psychiatry, 48*, 1233-1242.

Bergman, L. R., Magnusson, D., & El-Khouri, B. (2003). *Studying individual development in an interindividual context: A person-oriented approach*. Mahwah, NJ: Erlbaum.

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

Bierman, K. L., Nix, R. L., Greenberg, M. T., Blair, C., & Domitrovich, C. E. (2008). Executive functions and school readiness intervention: Impact, moderation, and mediation in the Head Start REDI program. *Development and Psychopathology, 20*, 821-843.

Blair, C. (2002). School readiness: Integrating cognition and emotion in a neurobiological conceptualization of children's functioning at school entry. *American Psychologist, 57*, 111-135.

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

Blair, C., Granger, D., & Razza, R. P. (2005). Cortisol reactivity is positively related to executive function in preschool children attending Head Start. *Child Development, 76*, 554-567.

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

Bodrova, E., & Leong, D. (2007). *Tools of the mind: The Vygotskian approach to early childhood education.* New York: Merrill/Prentice Hall.

Bowlby, G. (2008). Provincial drop-out rates:trends and consequences. *Labor Force Survey*, from http://www.statcan.gc.ca/pub/81-004-x/2005004/8984-eng.htm#b. Accessed 1 July, 2011.

Brendgen, M., Wanner, B., & Vitaro, F. (2006). Verbal abuse by the teacher and child adjustment from kindergarten through grade 6. *Pediatrics, 117*, 1585-1598.

Bronfenbrenner, U. (1986). Ecology of the family as a context for human development: Research perspectives. *Developmental Psychology, 22*, 723-742.

Buckhalt, J. A., El Sheikh, M., & Keller, P. (2007). Children's sleep and cognitive functioning: race and socioeconomic status as moderators of effects. *Child Development, 78*, 213-231.

Bull, R., & Scerif, G. (2001). Executive functioning as a predictor of children's mathematics ability: Inhibition, switching, and working memory. *Developmental Neuropsychology, 19*, 273-293.

Butterworth, B., Varma, S., & Laurillard, D. (2011). Dyscalculia: From brain to education. *Science, 332*, 1049-1053.

Card, D. (1999). The causal effect of education on earnings. in O. Ashenfelter and D. Card, eds. *The handbook of labor economics* (pp.1801-1864). Amsterdam: North Holland Publishing Company.

Chen, X., Huang, X., Chang, L., Wang, L., & Li, D. (2010). Aggression, social competence, and academic achievement in Chinese children: A 5-year longitudinal study. *Development and Psychopathology, 22*, 583-592.

Cicchetti, D. (1984). The emergence of developmental psychopathology. *Child Development, 55*, 1-7.

Cirino, P. T. (2010). The interrelationships of mathematical precursors in kindergarten. *Journal of Experimental Child Psychology, 108,* 713-733.

Clark, C., Prior, M., & Kinsella, G. (2002). The relationship between executive function abilities, adaptive behaviour, and academic achievement in children with externalising behaviour problems. *Journal of Child Psychology and Psychiatry, 43*, 785-796.

Diamond, A. (2006). The early development of executive functions. In E. Bialystock & F. I. M. Craik (Eds.), *Lifespan cognition: Mechanisms of change* (pp. 70–95). Oxford, England: Oxford University Press.

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science, 318*, 1387-1388.

Duckworth, A. L., & Seligman, M. E. P. (2005). Self-discipline outdoes IQ in predicting academic performance of adolescents. *Psychological Science, 16*, 939-944.

Duckworth, A. L., & Seligman, M. E. P. (2006). Self-discipline gives girls the edge: Gender in self-discipline, grades, and achievement test scores. *Journal of Educational Psychology, 98*, 198-208.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., . . . Brooks-Gunn, J. (2007). School readiness and later achievement. *Developmental Psychology, 43*, 1428-1446.

Eccles, J. S., Midgley, C., Wigfield, A., Buchanan, C. M., Reuman, D., Flanagan, C., & MacIver, D. (1993). Development during adolescence: The impact of stage-environment fit on young adolescents' experiences in schools and in families. *American Psychologist, 48*, 90-90.

Ednick, M., Cohen, A. P., McPhail, G. L., Beebe, D., Simakajornboon, N., & Amin, R. S. (2009). A review of the effects of sleep during the first year of life on cognitive, psychomotor, and temperament development. *Sleep, 32*, 1449-1458.

Eisenberg, N., Cumberland, A., Spinrad, T. L., Fabes, R. A., Shepard, S. A., Reiser, M., . . . Guthrie, I. K. (2001). The relations of regulation and emotionality to children's

externalizing and internalizing problem behavior. *Child Development, 72*, 1112-1134.

Ellickson, P. L., & McGuigan, K. A. (2000). Early predictors of adolescent violence. *American Journal of Public Health, 90*, 566-572.

Entwisle, D. R., Alexander, K. L., & Olson, L. S. (2005). First grade and educational attainment by age 22: A new story. *American Journal of Sociology, 110*, 1458-1502.

Erikson, E. H. (1950). *Childhood and society*. New York: Norton.

Farkas, G. (2003). Cognitive and noncognitive traits and behaviors in stratification processes. *Annual Review of Sociology, 29*, 541-562.

Feldman, R. (2009). The development of regulatory functions from birth to 5 years: Insights from premature infants. *Child Development, 80*, 544-561.

Fiscella, K., & Kitzman, H. (2009). Disparities in academic achievement and health: the intersection of child education and health policy. *Pediatrics, 123*, 1073-1080.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*, 59-109.

Freudenberg, N., & Ruglis, J. (2007). Reframing school dropout as a public health issue. *Preventing Chronic Disease, 4*, 1-12.

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin, 134*, 31-60.

Grissmer, D. K., Grimm, K. J., Aiyer, S. M., Murrah, W. M., Steele, J. S. (2010). Fine motor skills and early comprehension of the world: Two new school readiness indicators. *Developmental Psychology, 46,* 1008-1017.

Gormley Jr, W. T., Phillips, D., & Gayer, T. (2008). Preschool programs can boost school readiness. *Science, 320*, 1723-1724.

Gottfredson, M. R., & Hirschi, T. (1990). *A general theory of crime*. Stanford: Stanford University Press.

Hamre, B., & Pianta, R. (2001). Early teacher–child relationships and the trajectory of children's school outcomes through eighth grade. *Child Development, 72*, 625-638.

Hargreaves, J. R., Morison, L. A., Kim, J. C., Bonell, C. P., Porter, J. D. H., Watts, C., . . . Pronyk, P. M. (2008). The association between school attendance, HIV infection and sexual behaviour among young people in rural South Africa. *Journal of Epidemiology and Community Health, 62*, 113-119.

Hastings, R., & Bham, M. (2003). The relationship between student behaviour patterns and teacher burnout. *School Psychology International, 24*, 115-127.

Heckman, J. J. (2006). Skill formation and the economics of investing in disadvantaged children. *Science, 312*, 1900-1902.

Heckman, J. J. (2007). The economics, technology, and neuroscience of human capability formation. *Proceedings of the National Academy of Sciences, 104*, 13250-13255.

Henry, B., Caspi, A., Moffitt, T. E., Harrington, H. L., & Silva, P. A. (1999). Staying in school protects boys with poor self-regulation in childhood from later crime: A

longitudinal study. *International Journal of Behavioral Development, 23*, 1049-1073.

High, P. C. & the Committee on Early Childhood, Adoption, and Dependent Care and Council on School Health. (2008). School readiness. *Pediatrics*, 121, e1008-e1015.

Janosz, M., Archambault, I., Morizot, J., & Pagani, L. S. (2008). School engagement trajectories and their differential predictive relations to dropout. *Journal of Social Issues, 64*, 21-40.

Klingberg, T., Forssberg, H., & Westerberg, H. (2002). Training of working memory in children with ADHD. *Journal of Clinical and Experimental Neuropsychology, 24*, 781-791.

Knudsen, E. I., Heckman, J. J., Cameron, J. L., & Shonkoff, J. P. (2006). Economic, neurobiological, and behavioral perspectives on building America's future workforce. *Proceedings of the National Academy of Sciences, 103*, 10155-10162.

Ladd, G. W., Birch, S. H., & Buhs, E. S. (1999). Children's social and scholastic lives in kindergarten: Related spheres of influence? *Child Development, 70*, 1373-1400.

Lee, S. S., Lahey, B. B., Owens, E. B., & Hinshaw, S. P. (2008). Few preschool boys and girls with ADHD are well-adjusted during adolescence. *Journal of Abnormal Child Psychology, 36*, 373-383.

Lemelin, J. P., & Boivin, M. (2007). *Success starts in grade 1: The importance of school readiness.* Quebec Longitudinal Study of Child Development *(QLSCD 1998-2010)* 4, Institut de la Statistique du Québec.

Levin, H., Belfield, C., Muennig, P., & Rouse, C. (2007). *The costs and benefits of an excellent education for all of America's children*. New York: Teacher's College.

Lillard, A. (2005). *Montessori: The science behind the genius*. New York: NY: Oxford University Press.

Lillard, A., & Else-Quest, N. (2006). The early years: Evaluating Montessori education. *Science, 313*, 1893-1894.

Lupien, S. J., Maheu, F., Tu, M., Fiocco, A., & Schramek, T. E. (2007). The effects of stress and stress hormones on human cognition: Implications for the field of brain and cognition. *Brain and Cognition, 65*, 209-237.

Magnusson, D. (1998). The logic and implications of a person-oriented approach. In R. B. Cairns, L. R. Bergman & J. Kagan (Eds.), *Methods and models for studying the individual*. Thousand Oaks: Sage.

Marcovitch, S., & Zelazo, P. D. (2009). A hierarchical competing systems model of the emergence and early development of executive function. *Developmental Science, 12*, 1-18.

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

Mendelsohn, A. L., Huberman, H. S., Berkule, S. B., Brockmeyer, C. A., Morrow, L. M., & Dreyer, B. P. (2011). Primary care strategies for promoting parent-child interactions and school readiness in at-risk families: The Bellevue Project for early language,

literacy, and education success. *Archives of Pediatrics and Adolescent Medicine, 165*, 33-41.

Miner, J. L., & Clarke-Stewart, K. A. (2008). Trajectories of externalizing behavior from age 2 to age 9: Relations with gender, temperament, ethnicity, parenting, and rater. *Developmental Psychology, 44*, 771-786.

Ministry of Educaction, Leisure, and Sports. (2010). L'obtention d'un diplôme au secondaire: secteur des jeunes et des adultes. http://www.mels.gouv.qc.ca/. Accessed 1 July, 2011.

Mischel, W., Shoda, Y., & Rodriguez, M. I. (1989). Delay of gratification in children. *Science, 244*, 933-938.

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

Moffitt, T. E., & Henry, B. (1989). Neuropsychological assessment of executive functions in self-reported delinquents. *Development and Psychopathology, 1*, 105-118.

Murnane, R. J., Willett, J. B., & Levy, F. (1995). The growing importance of cognitive skills in wage determination. *The Review of Economics and Statistics, 77*, 251-266.

Nagin, D., & Tremblay, R. E. (1999). Trajectories of boys' physical aggression, opposition, and hyperactivity on the path to physically violent and nonviolent juvenile delinquency. *Child Development*, *70*, 1181-1196.

Normandeau, S., & Guay, F. (1998). Preschool behavior and first-grade school achievement: The mediational role of cognitive self-control. *Journal of Educational Psychology, 90*, 111-121.

Pagani, L. S., Fitzpatrick, C., Archambault, I., & Janosz, M. (2010). School readiness and later achievement: A French Canadian replication and extension. *Developmental Psychology, 46*, 984-994.

Pagani, L. S., Tremblay, R. E., Vitaro, F., Boulerice, B., & McDuff, P. (2001). Effects of grade retention on academic performance and behavioral development. *Development and Psychopathology, 13*, 297-315.

Pagani, L. S., Vitaro, F., Tremblay, R., McDuff, P., Japel, C., & Larose, S. (2008). When predictions fail: The case of unexpected pathways toward high school dropout. *Journal of Social Issues, 64*, 175-194.

Piaget, J. & Inhelder, B. (1956). *The child's conception of space*. London: Routledge and Kegan Paul.

Razza, R. A., Martin, A., & Brooks-Gunn, J. (2010). Associations among family environment, sustained attention, and school readiness for low-income children. *Developmental Psychology, 46*, 1528-1542.

Richters, J. E. (1997). The Hubble hypothesis and the developmentalist's dilemma. *Development and Psychopathology, 9*, 193-229.

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

Rimm-Kaufman, S. E., La Paro, K. M., Downer, J. T., & Pianta, R. C. (2005). The contribution of classroom setting and quality of instruction to children's behavior in kindergarten classrooms. *The Elementary School Journal, 105*, 377-394.

Romano, E., Babchishin, L., Pagani, L. S., Kohen, D. (2010). School readiness and later achievement: Replication and extension using a nationwide Canadian survey. *Developmental Psychology, 46,* 995-1007.

Rosenthal, R., & Jacobson, L. (1968). Pygamlion in the calssroom. *The Urban Review*, *3,* 16-20.

Rueda, M. R., Rothbart, M. K., McCandliss, B. D., Saccomanno, L., & Posner, M. I. (2005). Training, maturation, and genetic influences on the development of executive attention. *Proceedings of the National Academy of Sciences, 102*, 14931-14936.

Sabbagh, M. A., Xu, F., Carlson, S. M., Moses, L. J., & Lee, K. (2006). The development of executive functioning and theory of mind: A comparison of Chinese and US preschoolers. *Psychological Science, 17*, 74-81.

Shonkoff, J., & Phillips, D. (2000). *From neurons to neighbourhoods: The science of early childhood development*. Washington: DC: National Academy Press.

Skinner, E., & Belmont, M. (1993). Motivation in the classroom: Reciprocal effects of teacher behavior and student engagement across the school year. *Journal of Educational Psychology, 85*, 571-571.

Slopen, N., Fitzmaurice, G., Williams, D. R., & Gilman, S. E. (2010). Poverty, food insecurity, and the behavior for childhood internalizing and externalizing disorders. *Journal of the American Academy of Child & Adolescent Psychiatry, 49*, 444-452.

Tramontana, M., Hooper, S., & Selzer, S. (1988). Research on the preschool prediction of later academic achievement: A review. *Developmental Review, 8*, 89-146.

Tsujimoto, S. (2008). The prefrontal cortex: Functional neural development during early childhood. *The Neuroscientist, 14*, 345-358.

Vitaro, F., Brendgen, M., Larose, S., & Tremblay, R. E. (2005). Kindergarten disruptive behaviors, protective factors, and educational achievement by early adulthood. *Journal of Educational Psychology, 97*, 617-629.

Vygotsky, L. S. (1987). *Thinking and speech*. In L. S. Vygotsky, R. W. Rieber (Series Eds.), & A. S. Carton (Vol Ed.). The collected works of L. S. Vygotsky, Vol. 1.: Problems in general psychology (N. Minick, Trans.). New York: Plenum.

Webster-Stratton, C., Jamila Reid, M., & Stoolmiller, M. (2008). Preventing conduct problems and improving school readiness: Evaluation of the Incredible Years teacher and child training programs in high-risk schools. *Journal of Child Psychology and Psychiatry, 49*, 471-488.

Wright, B. R. E., Caspi, A., Moffitt, T. E., & Silva, P. A. (1999). Low self-control, social bonds, and crime: social causation, social selection, or both? *Criminology, 37*, 479-514.

Zelazo, P. D., & Frye, D. (1998). Cognitive complexity and control: II. The development of executive function in childhood. *Current Directions in Psychological Science*, *7,* 121-126.

Zhou, Q., Hofer, C., Eisenberg, N., Reiser, M., Spinrad, T. L., & Fabes, R. A. (2007). The developmental trajectories of attention focusing, attentional and behavioral persistence, and externalizing problems during school-age years. *Developmental Psychology, 43*, 369-384.

Zuckerman, B., & Halfon, N. (2003). School readiness: an idea whose time has arrived. *Pediatrics*. 111, 1433-1436.