happy
educated
active
healthy

Predicting Academic Achievement in Fourth Grade from Kindergarten Cognitive, Behavioural and Motor Skills[I, 1]

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QLSCD 1998-2010 in brief

This fascicle is based on data from the *Québec Longitudinal Study of Child Development* (QLSCD 1998-2010) which is being conducted by the Institut de la statistique du Québec (Québec Institute of Statistics) in collaboration with various partners (listed on the back cover). The goal of this study is to gain a better understanding of the trajectories which, during early childhood, lead to children's success or failure in the education system.

The target population of the QLSCD comprises children (singleton births) born to mothers residing in Québec in 1997-1998, with the exception of those whose mother, at the time of the child's birth, were living in certain administrative regions of the province (Nord-du-Québec, Terres-Cries-de-la-Baies-James and Nunavik) or on Indian reserves. Certain children were also excluded because of constraints related to the sample frame or major health problems. The initial sample eligible for longitudinal monitoring comprised 2,120 children. The children were monitored annually from the age of about 5 months to 12 years, when they finished elementary school. A round of data collection was conducted this year (2011), with most of the children now in their first year of high school (Secondary 1).

The QLSCD employs a variety of data collection instruments to gather data on the child, the person most knowledgeable of the child (PMK), her or his spouse/partner (if applicable), and the biological parent(s) not residing in the household (if applicable). During each data collection round, the child is asked to participate in a variety of activities designed to assess development. As of the 2004 round, the child's teacher is also being asked to respond to a questionnaire covering various aspects of the child's development and adjustment to school. Further information on the methodology of the survey and the sources of data can be accessed on the website of the QLSCD (also known as "I Am, I'll Be"), at www.iamillbe.stat.gouv.qc.ca.

In Canada, taxpayers spend more per capita on providing basic education compared to the United States. Nevertheless, our school dropout rates remain comparatively high. This predicts a host of social, health, and economic problems. Canadians depend upon individual contributions in the form of tax dollars to support social programs for future generations. The situation is timely considering looming population demographics that forecast a decline in the proportion of the population that is of working-age and a marked increase in that of seniors (Institut de la statistique du Québec, 2009; Statistics Canada, 2010). Consequently, we need to maximize the potential of each child who will eventually be entering the labour market.

One way to do this is to improve a person's chances of obtaining a high school diploma. The process leading to high school dropout by age 20 can be judiciously traced to kindergarten. In fact, child characteristics in kindergarten predict successful transitions in the early grades, which significantly forecast academic attainment by age 22 (Entwisle, Alexander and Olson, 2005). For these reasons, we ought to examine how such characteristics in the early years forecast later academic standing. Thus, ensuring all children are ready to learn at school entry remains an international preoccupation because of the eventual socioeconomic and health implications (Duncan et al., 2007; Heckman, 2006; High and the Committee on Early Childhood Adoption and Dependent Care and Council on School Health, 2008).

In addition to possessing basic skills, being prepared for school also implies an inclination and enthusiasm for classroom learning. Such characteristics at school entry play an important role in future academic success. Indeed, there is clinical consensus in both medicine and social science that adequate cognitive, physical, and socio-emotional skills and a positive outlook on learning represent effective developmental features of school readiness at school

entry (High and the Committee on Early Childhood Adoption and Dependent Care and Council on School Health, 2008). In recent years researchers have focused on developing an effective and coherent conceptual and measurement model of school readiness (Janus and Offord, 2007; Lemelin and Boivin, 2007). At the end of the day, gaining a better understanding of certain skills in kindergarten that predict future academic achievement can have an economic impact. An effective and efficient model can result in accurate assessments, early identification, and more focused preventive interventions.

Gaining a better understanding of school readiness also remains germane to public health policies on child development for a number of reasons. Youth who do not achieve the developmental milestone of finishing high school have greater chances of living in poverty and leading less productive lives (Desrosiers and Robitaille, 2006; Heckman, 2006). Such consequences become intergenerational when dropouts become parents (Evans, 2004). Low parental education, especially in mothers, is associated with providing a less stimulating and less than optimal family environment for raising children (Duncan and Brooks-Gunn, 1997; Repetti, Taylor and Seeman, 2002). In contrast, attainment of a high school diploma is associated with the acquisition of better health attitudes, behaviours, and dispositions (Chen, Matthews and Boyce, 2002; Lynch, Kaplan, and Salonen, 1997). Freudenberg and Ruglis (2007) have persuasively argued that if we reduced the number of high school dropouts, a host of lifestyle risks and outcomes would be reduced across the existing and unborn populations. From a population health perspective (Kindig and Stoddart, 2003), this means that children should do well academically in their early years of attending school in order to do well later (Heckman, 2006).

Duncan et al.: The "What matters most" project

A recent consortium, led by an economist, inquired about which kindergarten characteristics matter most in predicting later academic achievement (Duncan et al., 2007). The resulting research endeavour implemented a model involving six international data sets, comprising approximately 36,000 children from Québec, England, and the United States. Meta-analysis of the results of the six data sets revealed that kindergarten skills in mathematics, and to a lesser extent reading, were the most powerful predictors of later primary school achievement in both first and third grade. Interestingly, early mathematics skills showed the most power in predicting later mathematics and reading achievement. In fact, precursor mathematics skills predicted later reading better than precursor reading skills. Surprisingly, with the exception of attention problems, behavioural (aggression, opposition) and emotional adjustment as well as social skills in kindergarten had no significant influence on later achievement, even among children presenting numerous teacher-reported symptoms of internalizing and externalizing behaviours. Similar results using QLSCD data were observed by Lemelin and Boivin (2007) in their study of school readiness and academic performance in Grade 1.

Although Duncan's trailblazing study has its merits, it should be indicated that its Québec sample comprised only disadvantaged children in Montreal (Duncan et al., 2007). Therefore, corroborating Duncan's findings with a more representative, Québec-wide sample is warranted. The Duncan study leaves unanswered questions about how school readiness might influence other forms of achievement such as classroom engagement. Classroom engagement skills include school readiness characteristics that are important because they are analogous to the productive work behaviours and habits that employers value in adults (Bowles, Gintis, and Osborne, 2001; Pagani et al., 2010a). According to a review of the literature in Farkas (2003), adults who possess a combination of cognitive skills and focused work habits, developed from birth through adolescence, experience greater occupational success. Finally, the Duncan study did not consider motor skills as an additional component of school readiness, even though research suggests they are predictive of later academic achievement (Tramontana, Hooper and Selzer, 1988).

Indeed, the importance of motor skills had been emphasized in much of the literature prior to the conclusions of the National Educational Goals Panel (1991) on school readiness. Nevertheless, they have somehow remained absent from public policy and research, even though as recent as the late 1980s, research was supporting the conclusion that physical skills, especially fine motor skills, predict later achievement (Tramontana, Hooper and Selzer, 1988). Yet, clinical studies have replicated the association (Sandler et al., 1992; Sortor, Od and Kulp, 2003). First, an association has been observed between motor skill problems and learning capacities (Geuze et al., 2001; Missiuna et al., 2007). Worsening the prognosis is an overlap between behavioural and motor disorders (Harvey and Reid, 2003; Kadesjö and Gillberg, 2001; Kaplan and Wilson, 1998). Furthermore, motor deficits have also been associated with specific language impairments in school-aged children (Gaines and Missiuna, 2007; Hill, 2001; Webster et al., 2005). Finally, it is noteworthy that locomotion also figures prominently in both Piagetian theory (Piaget and Inhelder, 1956) and the Perry Preschool High/Scope Program (Hohmann and Weikart, 2002; Nores et al., 2005).

Using data from the *Quebec Longitudinal Study of Child Development* (QLSCD, see the box entitled *QLSCD 1998-2010 in brief*), this study replicated and extended the Duncan et al. model by investigating the impact of children's cognitive, behavioural and motor skills in kindergarten on their overall success level in fourth grade, including their achievement in mathematics, reading, writing, and science. We also examined how school readiness in kindergarten contributes to students' school and classroom engagement in the fourth grade. Such skills operationalized in terms of task orientation, perseverance, and autonomy have been shown to influence achievement, above and beyond that of IQ (Duckworth and Seligman, 2005; McKinney et al., 1975).

Data source and analytical method

We conducted seven separate multiple linear regression analyses to estimate to what extent kindergarten cognitive, behavioural and motor skills are associated with teacher-rated academic performance and school and classroom engagement in Grade 4.[3] Classroom engagement was assessed using several questions pertaining to task orientation, following rules, and perseverance. School engagement here refers to the perceived importance of school for the child (see the appendix for a detailed list of the variables). All models included the same independent and control variables and differed only in terms of the outcome variable.

The data were based on responses to various QLSCD questionnaires. Measurements of academic performance and school engagement were derived from responses to the Self-Administered Questionnaire for the Teacher (SAQT) in the 2008 round when the children were in Grade 4. The independent variables were based on responses to the SAQT and direct tests conducted on the children in the 2004 round when they were finishing kindergarten. The independent variables were the following: number knowledge, receptive vocabulary,[4] hyperactive behaviour, gross motor skills, fine motor skills, locomotion, and object control. Finally, each of the seven regression models took into account certain child and family characteristics as control variables likely to be associated with academic achievement in fourth grade, namely the child's sex, age in months, presence of physical aggressivity symptoms or emotional problems as assessed by the kindergarten teacher, as well as maternal education and family structure and functioning when the child was very young (High and the Committee on Early Childhood Adoption and Dependent Care and Council on School Health, 2008). No multicolinearity problem was detected.

It should be noted that the SAQT had a lower response rate compared to other QLSCD questionnaires. Using this instrument at different times and in combination with other questionnaires likely contributed to lowering the number of respondents. Multiple imputation was conducted by the ISQ on certain variables to maximize the number of respondents that could be included in the analyses. When this operation was completed, the analysis involved 610 children out of the approximate 2,000 having participated in the 1998 round and eligible for longitudinal monitoring. However, the data were weighted, thereby allowing the results to be generalized to the target population of the QLSCD. Many variables were accounted for in the weighting procedure and given the longitudinal nature of the survey, we have considerable information on non-respondents. Therefore the weights are quite precise and the risk of bias was minimized. The complex sample design of the survey was also taken into account in calculating the precision of the estimates.

It is important to emphasize that because of the small number of respondents included in the analyses, it is possible that the models lack statistical power and therefore certain associations could not be established. In addition, children who arrived in Québec after their birth were excluded from the QLSCD, though they form part of the same age cohort of the initial sample.[5]

Results

As we can see in Tables 1 and 2, kindergarten mathematics skills as measured by the Number Knowledge Test (NKT) were significantly associated with all 5 outcome measures of academic achievement as well as classroom and school engagement (as reported by the fourth grade teachers). In turn, language skills (receptive vocabulary), as measured by the Peabody Picture Vocabulary Test (PPVT), significantly explained all the variables related to academic achievement, but not those of classroom and school engagement. Hyperactive behaviours were inversely associated with all measures of later academic achievement in Grade 4 (with the exception of science) as well as school and class engagement, as reported by the teachers. Noteworthy is that fine motor skills were significantly associated with success in reading, writing, and overall achievement as well as classroom engagement, even after controlling for other kindergarten skills (see Tables 1 and 2). In addition, locomotion scores were positively associated with writing achievement and classroom engagement.

Also worth mentioning is the significant negative association between gross motor skills and school engagement. Children who had better coordination seemed to have a higher risk of lower school engagement, as assessed by their teachers. Object control skills (i.e., catching or kicking a ball) were not significantly associated with any of the outcome measures or school engagement.

The results of this study were compared with those obtained by Duncan et al. (2007) and certain similarities were observed. In both studies, kindergarten mathematics skills (NKT), hyperactive behaviours (referred to as attention problems in Duncan et al.) and receptive language skills (PPVT) were all strongly associated with teacher-rated achievement in Grade 4. Moreover, early receptive language as assessed in kindergarten predicted later reading skills in both studies.

In the following section we elaborate on the associations observed between kindergarten school readiness skills and measures of academic performance in fourth grade. Results pertaining to school engagement are also discussed.

Number knowledge and receptive vocabulary

The QLSCD data revealed that number knowledge in kindergarten was not only predictive of future achievement in mathematics but also in other areas assessed such as reading. Receptive vocabulary was also predictive of academic performance in most other subjects in Grade 4. Early mathematics ability constitutes the foundation of conceptual, procedural, and problem-solving skills (Okamoto & Case, 1996). These skills are likely to underlie subsequent child performance in increasingly complex reading and math tasks (Cirino, 2010). The importance of core precursor skills in number knowledge demonstrated in our study is quite noteworthy, as most early childhood programs in the past have placed more emphasis on precursors to reading than mathematics. This might serve as a reminder of the importance of also focusing on mathematics skills in early childhood development.

> **Number knowledge and receptive vocabulary in kindergarten were associated with academic performance in all subjects in Grade 4.**

Table 1
Models measuring associations between skills in kindergarten and teacher-assessed academic performance in Grade 4 in various subjects and overall, Québec, from 1998 to 2008[1]

	Mathematics	Reading	Writing	Science	Overall
	β	β	β	β	β
Number knowledge	0.11[†††]	0.11[†††]	0.11[†††]	0.08[†††]	0.11[†††]
Receptive vocabulary	0.01[††]	0.01[†]	0.01[†]	0.01[†††]	0.01[†]
Hyperactive behaviours	−0.09[†††]	−0.07[††]	−0.08[†††]	−0.04	−0.09[†††]
Gross motor	−0.08	−0.07	−0.06	−0.03	−0.04
Fine motor	0.06	0.10[†]	0.11[††]	0.00	0.08[†]
Locomotion	0.01	0.02	0.02[†]	0.00	0.01
Object control	0.00	0.00	0.01	0.00	0.00
	R^2				
	0.30	0.27	0.30	0.22	0.61

1. Results of multiple linear regression analyses. For more details, see Footnote 3.

Note: Thresholds: †: 0,05; ††: 0,01; †††: 0,001. Models adjusted for children's age in months, sex, physically aggressive behaviours and emotional distress in kindergarten, as well as maternal education, family structure and functioning when the children were 5 or 17 months of age (see Appendix).

Source: Institut de la statistique du Québec, QLSCD 1998-2010.

Table 2
Models measuring associations between skills in kindergarten and teacher-assessed school and class engagement in Grade 4, Québec, from 1998 to 2008[1]

	Classroom engagement	School engagement
	β	β
Number knowledge	0.03[†††]	0.04[†††]
Receptive vocabulary	0.00	0.00
Hyperactive behaviour	−0.08[†††]	−0.05[†††]
Gross motor	−0.05	−0.05[†]
Fine motor	0.06[††]	0.03
Locomotion	0.01[†]	0.01
Object control	0.01	0.00
	R^2	
	0.36	0.24

1. Results of multiple linear regression analyses. For more details, see Footnote 3.

Note: Thresholds: †: 0,05; ††: 0,01; †††: 0,001. Models adjusted for children's age in months, sex, physically aggressive behaviours and emotional distress in kindergarten, as well as maternal education, family structure and functioning when the children were 5 or 17 months of age (see Appendix).

Source: Institut de la statistique du Québec, QLSCD 1998-2010.

Hyperactive behaviours

Our findings remind us once again how attention problems in kindergarten may be negatively associated with later academic achievement. Attention problems here refer to hyperactive behaviours assessed by the kindergarten teacher when the children were 6 years old. In a recent publication using QLSCD data, Cardin et al. (2011) demonstrated a gradient between hyperactivity/inattention symptoms in children from 3.5 to 8 years of age and academic achievement in Grade 2. Duncan et al. (2007) had found that greater skills in attention in kindergarten predicted better academic achievement in Grade 3, even when other kindergarten skills were taken into account. Moreover, a recent prospective study from kindergarten to age 21 years also suggests the importance of persistent effortful control in the classroom (Pagani et al., 2008). When left unregulated, teacher-rated attention problems throughout elementary school predicted cases of unexpected high school dropout even for low-risk males and females (Pagani, et al., 2008). These findings echo earlier work which showed the long-term impact of early attention related to inhibitory control processes on later adolescent scholastic performance, social competence, and adaptation to stress and frustration (Mischel, Shoda and Rodriguez, 1989; Shoda, Mischel and Peake, 1990).

Interestingly, attention ability figures prominently as a precursor and correlate of mathematics and literacy skills in kindergarten (Blair and Razza, 2007). In recent research using the *Montreal Longitudinal Experimental Preschool Study* data, kindergarten attention skills were shown to be more strongly associated with pre-mathematics than with receptive language skills (Pagani et al., 2009). In fact, kindergarten attention skills predicted later mathematics skills as well as kindergarten mathematics skills themselves.

During early childhood, "there is rapid growth and development in frontal and prefrontal brain regions which are recruited for the effortful control of attention" (Blair, 2002). Attention skills continue to develop in middle childhood (Posner and Rothbart, 2000). Developmental improvements in attention foster inhibition of impulsive responses and promote delay of gratification processes (Kochanska, Murray and Harlan, 2000). The suppression of competing and often less effortful responses in the service of a higher goal such as learning academic material requires effortful control. This is likely the reason why attention and its associated factors partially mediate the relationship between cognitive ability and academic achievement (Duckworth and Seligman, 2005). Our results, combined with those of the larger, original study, point to the value of targeting attention skills for early intervention. There is recent evidence that attention, and its associated inhibitory control of executive function processes, are indeed responsive to intervention during preschool and kindergarten (Diamond et al., 2007; Lillard and Else-Quest, 2006).

> **Even when other kindergarten skills are taken into account, hyperactive behaviours were associated with lower academic performance in most subjects.**

Motor skills

Although not considered in the Duncan et al. (2007) study, fine motor skills showed positive associations with later reading and writing performance as well as overall academic performance. Locomotion skills in kindergarten were also positively associated with later writing performance. The association between fine motor skills and later academic performance is not surprising, because the execution of many cognitive tasks requires fine motor skills such as the ability to control one's hands during writing or one's eyes for word tracking during reading tasks (Grissmer et al., 2010).

Based on a synthesis of neuroanatomical and clinical research findings, certain authors have proposed a more intricate and bi-directional relationship between cognitive and motor skills (Grissmer et al., 2010). First, brain areas that specialize in motor control show activation during the execution of certain cognitive tasks. In turn, areas associated with cognitive control show activation during the execution of complex, effortful motor tasks. Second, during sensorimotor development, neurons are recruited from the prefrontal cortex to improve child adaptation and control. In later childhood, these cerebral structures have been shown to play a role in learning by supporting cognitive control during learning tasks.

Our findings highlight the unique contribution of motor skills as a possible early factor in predicting later achievement. Thus, motor skills often acknowledged in research on clinical populations as being associated with poor attention and linguistic skills, appear to be worthy of more consideration than they have received in the past, especially given that they are responsive to early intervention.

> **Fine motor skills in kindergarten were associated with future academic performance in writing and reading.**

Classroom and school engagement as measures of academic achievement

We expanded the concept of academic achievement in fourth grade by including teacher-rated classroom and school engagement. As a learning-related behavioural construct, children's classroom engagement can be defined as behavioural dispositions when approaching and undertaking school-related tasks (McDermott, Mordell, and Stoltzfus, 2001). Such dispositions, related to productivity, "include but are not limited to attentiveness, persistence, flexibility, reflectivity, strategic problem-solving, response to novelty and error, preoccupation with effectiveness, motivation, and attitudes toward learning" (Duckworth and Seligman, 2006). The prospective associations we found between kindergarten attention characteristics and later classroom engagement fit very well within this learning-related behavioural framework. The association between early mathematics skills and later classroom engagement is not unexpected given certain critical links between emerging executive function and mathematics skills during the preschool period (Blair, 2002). We would also highlight the positive association between kindergarten fine motor and locomotion skills and later classroom engagement. However, school entry gross motor skills were negatively associated with fourth grade school engagement, measured by teacher assessment of the importance ascribed to school by the children. This finding might be explained by the fact that children who are better coordinated may be at risk of liking school less because movement and athletic activities tend to occupy less and less time in later elementary grades, and predominantly cognitive skills are required for academic success in these higher grades.

> **Certain cognitive and behavioural skills in kindergarten can not only predict academic performance as such, but also classroom and school engagement.**

Conclusions

In this fascicle, we replicated the model of school readiness described in Duncan et al. (2007), expecting to validate its fundamental components in children attending Grade 4 in the province of Québec. The QLSCD provides an excellent opportunity to validate Duncan's results. Indeed, even when including various other characteristics in the model, our results support the findings of Duncan et al. (2007). Kindergarten cognitive skills, namely receptive vocabulary and number knowledge, as well as hyperactive behaviours, are associated with academic achievement by the end of fourth grade – cognitive skills positively, and hyperactive behaviours negatively. These findings were observed in all subjects assessed – writing, reading, mathematics and science. One exception was that no association was observed between hyperactive behaviours and later achievement in science.

Our findings also suggest that motor skills make a unique contribution to later child literacy (reading and writing) and overall academic performance. Finally we also showed that certain cognitive (e.g. number knowledge), behavioural, and motor skills in kindergarten were positively associated with later classroom and school engagement in Grade 4. In contrast, hyperactive behaviours predicted lower levels of classroom and school engagement in Grade 4.

Although the control variables provided a means of capturing the unique contribution of each predictor skill, our findings should be interpreted in the context of several limitations. First, the analyses could not address how subgroups of individuals, for example, boys and girls, differed in terms of school readiness or academic achievement. Second, we examined a certain number of variables related to academic achievement independently of one another. In future research, it would be productive to examine how the various outcomes may be interrelated. Third, fourth grade is not that far up the academic ladder. But because academic achievement tends to stabilize beyond the early elementary years (Alexander and Entwisle, 1998), our window in time can be interpreted as a window of opportunity for prevention. However, it will be incumbent in future research to analyze the relative importance of school readiness compared to other factors in the school trajectories of children as they grow up to develop higher skill levels and autonomy. For example, other studies have shown that aggressive behaviour and lack of social skills in kindergarten are negatively associated with school engagement later in childhood, which in turn predicts whether or not a child will complete high school (Véronneau et al., 2008). Knowing when these factors take precedence over school readiness factors will help improve the timing and focus of strategies designed to increase the chances of children being academically successful. Finally, we cannot exclude possible biases associated with the low response rate of the SAQT and the fact that certain coefficients partially translate the effect of characteristics not entered into the model. Despite these limitations, many of the findings obtained by analyzing the QLSCD data were similar to those of the study conducted by Duncan et al. (2007).

For a multitude of reasons, including sociodemographic and economic trends, early childhood education is increasingly viewed as a relatively inexpensive preventive intervention against psychosocial maladjustment and academic underachievement. The findings presented in this fascicle show that school readiness can be considered a confluence of cognitive, attention regulation and motor skills. The results also suggest that kindergarten skills are not only associated with school achievement as such, but also with school and classroom engagement, i.e. behavioural dispositions when approaching and undertaking school-related tasks. Since student engagement is known to influence later academic achievement (Duckworth and Seligman, 2005; McKinney et al., 1975; Véronneau et al., 2008), we recommend that it be included in future research on academic success and encourage other researchers to conduct more in-depth studies on the associations among student engagement, school readiness and academic achievement in general.

Appendix

Description of the variables used in the regression models

Independent variables (measured in late kindergarten)

1. Cognitive Skills

1A. Number Knowledge. The Number Knowledge Test (NKT) administered individually to the children was an abridged version of the test developed by Robbie Case (Okamoto and Case, 1996). It measures the child's degree of familiarity with basic notions of arithmetic such as counting, adding, and subtracting, as a function of age. The test includes a variety of tasks used to assess knowledge and understanding of (1) the number sequence from one to ten; (2) the one-to-one correspondence in which a sequence is mapped onto objects being counted; (3) the cardinal value of each number; (4) the generative rule that relates adjacent cardinal values; and (5) successive numbers which represent progressively more items than the previous ones. All the skills measured by the NKT constitute performance predictors for arithmetic. The test comprises a number of levels and terminates when the child has committed three consecutive errors.

1B. Receptive Vocabulary. The Peabody Picture Vocabulary Test (PPVT) (Dunn, Thériault-Whalen, and Dunn, 1993) administered individually in English or French, provided a means of assessing receptive vocabulary, which is a good predictor of academic achievement (Lemelin and Boivin, 2007) and future reading skills (Duncan et al., 2007). This test comprises practice images, followed by 170 other images in order of increasing difficulty. The starting point depends on the child's age. The results were standardized; the tables of norms differed according to the French or English version of the test administered to the child (see Desrosiers and Ducharme, 2006). Results of the PPVT are strongly correlated with language sub-scales in intelligence tests (Dunn and Dunn, 1997).

2. Hyperactive Behaviours

The children's kindergarten teachers filled out a questionnaire in which they were asked to assess various aspects of the children's development. The six questions on hyperactivity behaviours were taken from the *Ontario Child Health Study* (OCHS) and the *Longitudinal and Experimental Study of Low Socio-Economic Status Boys in Montréal* (*ÉLEM*). The teachers were asked to indicate at what frequency the child 1) could not sit still, was restless and hyperactive; 2) was easily distracted, had trouble sticking to any activity; 3) could not stop fidgeting; 4) was impulsive, acted without thinking; 5) had difficulty waiting for his or her turn in games; and 6) could not settle down to do anything for more than a very short period of time. Response choices were the following: 1) Never or not true; 2) Sometimes or somewhat true; 3) Often or very true. Based on responses to these questions, scores were calculated and then reduced to a scale ranging from 0 to 10 ($\alpha = 0.89$).

3. Motor skills

3A. Gross Motor. This aspect was assessed by the kindergarten teachers. The items were taken from the *Early Development Instrument* (EDI) developed by Janus and Offord (2007). Teachers were asked if, in their opinion, the child was well-coordinated (i.e., moves without running into or tripping over things) (Yes/No). They were also asked to rate the child's ability to climb stairs and his/her overall physical development. Response choices for the two aforementioned questions were: 1) Excellent; 2) Good; 3) Average; 4) Poor; 5) Very poor. Based on these responses, scores were assigned to a scale ranging from 0 to 10 ($\alpha = 0.68$).

3B. Fine Motor. The kindergarten teachers were also asked to assess other aspects of the child's development, namely his/her "Proficiency at holding a pen, crayons, or a brush" and "Ability to manipulate objects." These two items were also taken from the EDI and had the same response choices as the two questions on gross motor skills. Based on responses to these items, scores were calculated on a scale ranging from 0 to 10 ($\alpha = 0.88$).

3C. Locomotion Skills. When the children were in kindergarten, trained interviewers administered the *Test of Gross Motor Development* (TGMD; Ulrich, 2000) to assess the child's locomotion skills (i.e., running, side shuffle). During this test, interviewers first demonstrate an action. After this the child repeats the action twice. The child is given one point for every correct action, and a total for the subtest is calculated by summing the scores for each action.

3D. Object Control. When the children were in kindergarten, trained interviewers also administered the TGMD for object control (i.e., catching, kicking a ball). The procedures for testing and rating were the same as for the locomotion skills.

Outcome variables (measured in Grade 4)

1. *Academic Achievement*. Fourth grade teachers rated academic achievement in *1A-mathematics, 1B-reading, 1C-writing, 1D-science* and *1E-overall achievement*. Response choices were (a) Near the top of the class; (b) Above the middle of the class, but not at the top; (c) In the middle of the class; (d) Below the middle of the class, but above the bottom; or (e) Near the bottom of the class. Based on responses to these questions, five continuous variables were constructed with values from -2 to 2 (optimal academic achievement).

2. *Classroom Engagement*. Eleven items pertaining to task orientation, compliance and persistence were asked of the Grade 4 teacher and used to create a scale. Eight of them were drawn from the EDI (Social Competence Domain) (Janus and Offord, 2007): "Works and plays cooperatively with other children;" "Follows rules;" "Follows instructions;" "Follows directions;" "Listens attentively;" "Completes work on time;" "Works independently;" and "Works neatly and carefully." The three other items, namely "Puts a lot of effort into his/her work;" "Participates in class" and "Asks questions if he/she does not understand" came from cycle 3 of *National Longitudinal Survey of Children and Youth* (NLSCY). Response choices for the first eight questions were: 1) Often or very true; 2) Sometimes or somewhat true; 3) Never or not true. For the three other questions, five responses were possible: 1) Never; 2) Rarely; 3) Sometimes; 4) Often; 5) Always. Based on responses to all these questions, scores were calculated on a scale ranging from 1 to 5 ($\alpha = 0.93$) (Pagani et al., 2010a; Pagani et al., 2010b).

3. School Engagement. Finally, teachers provided ratings of child school engagement in response to an item pertaining to the importance of school to the child, with responses ranging from 3 ("Very important") to 1 ("Of little importance").

Control Variables

Certain child and family characteristics likely to be associated with achievement in Grade 4 were integrated into the various models as control variables. Child characteristics were 1) *sex*; 2) *age in months* (2004 round, kindergarten), and ratings by the kindergarten teacher of 3) *emotional distress* and 4) *physical aggression* (scores on a scale from 0 to 10). Family characteristics included in the models were 1) *maternal education* (based on the 1998 round when the children were approximately 5 months old and coded as 1=high school diploma, 0=no high school diploma); 2) *family functioning* (mean of standardized scores ranging from 0 to 10 for the 1998 and 1999 rounds when the children were 5 and 17 months old); and 3) *family structure* (based on data from the 1998 round when the children were 5 months old and coded as 0=intact two-parent family or 1=other). For more details on the sources and construction of the variables, access the QLSCD website at: http://www.iamillbe.stat.gouv.qc.ca.

Notes

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2. Linda S. Pagani is Professor at the École de psychoéducation, Researcher in the *Groupe de recherche sur les environnements scolaires* (GRES) (Research Group on School Environments), and Researcher at the Centre de Recherche du CHU-Mère-Enfant Sainte-Justine (Mother-Child Research Centre at Sainte-Justine Children's Hospital) of the Université de Montréal. Caroline Fitzpatrick is a doctoral candidate at the École de psychoéducation of the Université de Montréal. Luc Belleau is a statistician at the Institut de la statistique du Québec. Michel Janosz is Professor at the École de psychoéducation of the Université of Montréal, Director of GRES and was responsible for the evaluation team of the *New Approaches, New Solutions* (NANS) intervention strategy.

3. This type of analysis is designed to ascertain whether a particular variable or set of variables can explain a significant part of the dependent variable's variation – in this case, academic performance in various subjects, overall performance and school and classroom engagement. In Tables 1 and 2, R^2 represents the proportion of variation of the dependent variable that is explained by the set of variables entered in the model. A given skill is considered to be associated with the outcome variable when the beta or coefficient (β) is significant.

4. Other names for this can be found in the literature, such as "passive vocabulary," "word recognition," etc.

5. Based on data from the *Régie de l'assurance maladie du Québec* (Québec Health Insurance Board), the Institut de la statistique du Québec estimates that approximately 10% of children who were 10 years of age on July 1, 2008 were born outside of Quebec (Source: Institut de la statistique du Québec, based on the *Fichier d'inscription des personnes assurées* [Registry of Insured Persons] of the aforementioned *Régie*, 2008).

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