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Early childhood working memory forecasts high school dropout risk

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ABSTRACT

Individual differences in cognitive control contribute to academic success, engagement, and persistence toward long-term goal achievement. In a prior study, we found that preschool working memory, a component of cognitive control, predicts kindergarten academic competence and classroom engagement. In the present study, we assess whether preschool working memory contributes to high school dropout risk at age 13. Participants are 1824 children from the Quebec Longitudinal Study of Child Development who were individually assessed at ages 2.5 and 3.5 on working memory using the Imitation Sorting Task. Dropout risk, representing an index, comprised of grade retention history and concurrent school performance and engagement, was measured in spring of grade 7. We used logistic regression to estimate dropout risk from early childhood working memory while controlling for verbal and non-verbal IQ, socioeconomic status, and sex. A one point increase in children's working memory skills predicted a 26% reduction in the odds of being in the high risk group for dropout. Higher socioeconomic status and intellectual skills also predicted lower high school dropout risk. Individual differences in preschool working memory may contribute to early detection of later high school dropout risk. These results suggest the importance of further developing early effective interventions aimed at strengthening cognitive control in children.

1. Introduction

In North America, the proportion of youth who do not finish high school remains high, ranging from 15 to 26% within Canada and the United States (MELS, 2011; Levin, Belfield, Muennig, & Rouse, 2007). As a demographic, high school dropouts pose a tremendous economic and social burden on tax payers because they earn lower salaries, remain unemployed for longer, and spend more time on welfare as adults (Bowlby, 2005; Levin et al., 2007). Youth who do not complete high school also engage in more lifestyle and health risks over their life course (Gase, Kuo, Coller, Guerrero, & Wong, 2014; Hahn et al., 2015). As a result, current dropout rates indicate that many youth are entering adult life at a significant disadvantage.

Being able to identify youth showing precursor signs of dropping out can represent an important step in preventing this social problem before it occurs. Using a composite scale combining academic performance, prior grade retention, and school engagement, researchers have successfully identified 12 year-old students at greater risk of eventually dropping out by age 21 (Archambault, Janosz, Fallu, & Pagani, 2009; Janosz, Le Blanc, Boulerice, & Tremblay, 2000; Janosz, LeBlanc, Boulerice, & Tremblay, 1997). Furthermore, research has examined what characteristics of 7 year old students and their families contribute to dropout risk by the age of 12 (Janosz et al., 2013). Little research has explored how early childhood risk factors might be associated with later dropout risk.

Research suggests that high school dropout represents a gradual process of disengagement that occurs over several years (Archambault et al., 2009; Wang & Fredricks, 2014). There is also evidence that the processes leading to high school disengagement begin as early as kindergarten (Alexander, Entwisle, & Horsey, 1997; Janosz et al., 2013). Specifically, academic difficulties and problems regulating school engagement behaviors in early primary school have been found to forecast not completing high school by age 21 (Alexander et al., 1997). Moreover, persistent attention problems as early as kindergarten predict dropout at age 21 in low risk students. That is, students who do not display the typical risk profile of having previously experienced grade retention, living in a single parent household, and having a mother that did not complete high school (Pagani et al., 2008).

Individual differences in cognitive control among children are likely to play an important role in forecasting later dropout risk since they account for academic performance, engagement behavior, and the ability to pursue long-term goals (Bierman, Nix, Greenberg, Blair, &

Abbreviations: QLSCD, Quebec Longitudinal Study of Child Development; IST, Imitation Sorting Task.

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Domitrovich, 2008; Fitzpatrick, McKinnon, Blair, & Willoughby, 2014; Mischel, Shoda, & Rodriguez, 1989). Cognitive control refers to a set of functions which allow individuals to exercise willful regulation of their behavior and attentional resources and resist the temptation to give into impulses (Garon, Bryson, & Smith, 2008). As a result, it is plausible that poorly controlled children experience more challenges at school which eventually contribute to their risk of dropout by adolescence.

Cognitive control is related to the broader self-regulatory construct of self-control, a characteristic that is associated with academic performance during adolescence once IQ and socioeconomic status are statistically controlled (Duckworth, 2011; Heckman & Kautz, 2012). In a more recent study, childhood differences in self-control predicted leaving school by age 16 (Moffitt et al., 2011). Finally, poor cognitive control is related to a constellation of maladaptive behaviors with peers and teachers that tend to disrupt academic adjustment (Clark, Prior, & Kinsella, 2002; Jacobson, Williford, & Pianta, 2011; Lee, Lahey, Owens, & Hinshaw, 2008).

Working memory is a component of cognitive control which involves manipulation and tracking of incoming information, thus allowing children to retain it on-line during problem solving activities and monitor on-going tasks (Brydges, Reid, Fox, & Anderson, 2012). When measured with an Imitation Sorting Task, working memory predicts kindergarten success and classroom engagement (Fitzpatrick & Pagani, 2012). Similarly, others have found that preschool working memory forecasts achievement by the end of elementary school (Bull, Espy, & Wiebe, 2008). Although environments help enhance the development of these skills, individual differences in cognitive control more generally, and working memory more specifically tend to remain relatively stable across the lifespan in the absence of formal interventions (Casey et al., 2011; Friedman, Miyake, Robinson, & Hewitt, 2011; Klingberg, 2010; Weintraub et al., 2013). Consequently, we are interested in examining whether this component of cognitive control can help us predict high school dropout before it occurs.

The purpose of the present study is to use longitudinal birth cohort data to examine whether working memory skills from ages 3.5 to 4.5 are prospectively associated with dropout risk at age 13, which corresponds to grade 7. Working memory can be reliably measured as early as 3 years of age (Alp, 1994; Wiebe, Espy, & Charak, 2008). We control for verbal and non-verbal intellectual skills, sex, and socioeconomic disadvantage, to reduce their potential as confounders in the relationship (Battin-Pearson et al., 2000; Bushnik, Barr-Telford, & Bussiere, 2004; MELS, 2011; Moffitt et al., 2011). We expect that children scoring higher on early childhood assessments of working memory will face a lower risk of dropout by the end of their first year of middle school.

2. Methods

2.1. Sample

Participants are 1824 children from the Quebec Longitudinal Study of Child Development (QLSCD) with complete data on an assessment of working memory administered at 29 and 41 months. Our sample originates from a randomly selected, stratified sample of 2837 infants born between 1997 and 1998 in the province of Quebec, Canada. From the inception this longitudinal study, 93 children were ineligible and 172 were untraceable because their coordinates were incorrect. From the remaining 2572 children, 14 were unreachable and 438 refused participation. The sampling procedure resulted in 2120 children once informed parental consent was obtained, representing 82% of the eligible population from the original birth cohort. For the first early childhood phase of this study, 2120 5-month-old infants were consequently eligible for follow-up at age 2.5. Of these children, 39% were firstborn. In the school-aged waves, informed consent was obtained from teachers and from children.

2.2. Measures

2.2.1. Independent variable: working memory at ages 2.5 and 3.5

Children were administered the Imitation Sorting Task (Alp, 1994) by trained examiners. The reliability and validity of this test for measuring early childhood working memory and attention have been published elsewhere (Alp, 1994; Fitzpatrick & Pagani, 2012). During this task, the experimenter first places the objects (e.g., toy animals, puzzle pieces, eating utensils, vehicles) into two canisters. The objective of the task is for children to 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 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 age 2.5, children completed four trials of increasing difficulty. At age 3.5, 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 full credit (one point) as long as they correctly recreated the demonstrated grouping of toys and placed them into the same canister. Because the objective is for the child to recreate the modeled subsets, children were not required to follow the same order or sort the toys in the same canister as the experimenter to get full credit. Partial credit was not provided for incomplete sequences.

In order to reduce measurement error, we computed a mean score from total scores at 29 and 41 months. Scores ranged from 0 to 3 at age 2.5 and from 0 to 4 at age 3.5. Working memory scores (mean of scores at 29 and 41 months) therefore ranged from 0 to 3.5. The sample mean (standard deviation) working memory score, reflecting the mean of scores at 29 and 41 months, was 1.20 (.74). The mean working memory scores for girls and boys were 1.24 (.72) and 1.15 (.69), respectively.

2.2.2. Outcome variable (Dropout Prediction Index at age 13)

In spring 2011 when students were in grade 7, students self-reported their academic standing using a 7-item computerized questionnaire which assessed academic performance, grade retention, and school engagement: (1) During this school year, what is your average mark in English Language?; (2) During this school year, what is your average mark in mathematics?; (3) Have you ever repeated an entire school year?; (4) Do you like school?; (5) In terms of your school marks, how would you rate yourself compared with other students of your age at your school?; (6) How important is it for you to get good marks?; and (7) Based on your own wishes, how far do you plan to go in school?. These data generated an index with good validity for predicting school dropout (Archambault & Janosz, 2009). The distribution of this variable was positively skewed (skew = 1.80, SE = .073). The frequency distribution is shown in Fig. 1. We therefore dichotomized this variable to reflect a natural break in the distribution at the 84th percentile. Thus 202 (11.1%) children (58% male) were identified at risk of dropout by grade 7. Our selected cut-off point allowed us to reach a specificity level of 68% and a sensitivity of 76% which means that our dichotomization allowed us to be effective in correctly classifying students at risk of dropout. Furthermore, all alternative cut-offs provided significant results of similar magnitude. Because of sample attrition, 1234 students had