



Kindergarten self-control mediates the gender reading achievement gap: A population-based cohort study

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ABSTRACT

Could superior self-control explain the gender difference in reading achievement favoring girls? To test this idea, we drew on a unique population-based sample ($N = 11,336$) where self-control was measured in kindergarten using a multimethod battery of assessments. Girls showed substantially higher levels of self-control in kindergarten ($\beta = 0.47$) and outperformed boys on standardized tests of reading achievement in third/fourth grade ($\beta = 0.20$). Further, kindergarten self-control prospectively predicted reading achievement throughout elementary school ($\beta = 0.37$). Connecting these findings, our mediation analyses revealed that the female self-control advantage in kindergarten could account for subsequent gender differences in reading achievement. Our results suggest that early gender differences in self-control may represent a key pathway through which gender disparities in reading skills, vocabulary knowledge, and reading comprehension occur.

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1. Introduction

Reading skills are vital for proficiency across subjects and childhood reading ability is a key predictor of literacy, educational attainment, and socioeconomic status in adulthood (Ritchie & Bates, 2013). Whilst school-age girls and boys differ little on general intelligence (Halpern & LaMay, 2000), girls tend to outperform boys on tests of reading achievement (Lietz, 2006). Estimates from large-scale studies suggest that gender disparities in reading ability are meaningful in magnitude (e.g. $d = 0.19$ – 0.42 ; Lietz, 2006; Lynn & Mikk, 2009; Reilly, Neumann, & Andrews, 2019), persist throughout formal schooling and college, and are near universal in nature. Girls have been found to outperform boys on tests of reading achievement from kindergarten and show faster growth in reading achievement throughout elementary school (Wei, Liu, & Barnard-Brak, 2015). Further, the female advantage in reading achievement appears to increase from elementary school to middle school and remains substantial (e.g. $d = 0.32$ – 0.42) throughout high school (Lynn & Mikk, 2009; Reilly et al., 2019).

Although the emergence of a female advantage in reading ability has been well documented, explanations for this phenomenon remain uncertain. Debate on potential contributing factors has

focused on the influence of intrinsic gender differences (e.g. in reading impairment and language maturation) and social and cultural beliefs (e.g. gender-stereotyping, parental and teacher expectations) (Reilly et al., 2019). Whilst these distal factors likely contribute, few studies have investigated the possibility that the notable female advantage in self-control evident from as early as 24 months (Anderson & Whitaker, 2018; Duckworth & Seligman, 2006; Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006) may explain subsequent gender disparities in reading performance.

Self-control is a domain-general term that captures the capacity to voluntarily regulate behavioral, emotional, and attentional impulses to accomplish valued goals including academic achievement. Teachers single out the ability to regulate attention and emotion as crucial to facilitating teaching and learning (Blair & Raver, 2015). For instance, in a national survey of kindergarten teachers the majority of respondents endorsed self-controlled behaviors such as being able to sit still and pay attention, being able to take turns, follow directions, and not being disruptive, as crucial to school readiness (Heaviside & Farris, 1993). An accumulation of empirical evidence indicates that early childhood self-control is a valuable predictor of school readiness, adjustment, duration of schooling, and academic attainment (Blair & Raver, 2015; Duckworth, Taxer, Eskreis-Winkler, Galla, & Gross, 2019; Moffitt et al., 2011).

In classroom settings self-control may foster reading achievement by enabling children to focus on and then recall vocabulary

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and language instruction, stay on task, and cope with frustration during challenging assignments. Further, in school settings children must inhibit potentially disruptive behaviors and emotional expressions in order to maintain positive student-teacher relations and learn effectively (Duckworth et al., 2019). Outside of the classroom self-control may allow children to resist or avoid momentarily gratifying activities (e.g. time on media devices, daydreaming) to pursue activities congruent with improving reading achievement (e.g. independent reading and study, completing vocabulary and language homework). Perhaps for these reasons, individual differences in self-control have also been shown to forecast reading achievement throughout childhood (e.g. Matthews, Marulis, & Williford, 2014).

Established gender differences in self-control favoring girls (e.g. Else-Quest et al., 2006) can explain why females earn higher classroom grades than males (Duckworth & Seligman, 2006; Matthews et al., 2014). However, while prior studies have examined the role of self-control in explaining gender differences in academic achievement, it remains unclear whether the female advantage in self-control can account for the emergence of the gender gap in reading achievement. We suggest that this is because existing studies have been curtailed by three key limitations: (i) combining measures of self-control with other individual difference measures (e.g. interpersonal skills) so that the specific contribution of trait self-control cannot be distinguished (DiPrete & Jennings, 2012), (ii) relying on small and/or non-representative samples rather than samples representative of the underlying population – the gold standard for evaluating gender differences in achievement (Duckworth & Seligman, 2006; Matthews, Ponitz, & Morrison, 2009; Matthews et al., 2014; Reilly et al., 2019), and (iii) not examining reading achievement separately from other domains of achievement such as mathematics and science (e.g. Duckworth & Seligman, 2006) where pronounced sex differences are less evident (Reilly, Neumann, & Andrews, 2015).

In the current study, we therefore drew on a unique nationally representative study where the specific role of trait self-control in contributing to the emergence of the female advantage in reading achievement was examined.

2. Methods

2.1. Sample

This study used data from the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11 (ECLS-K:2011) cohort, a nationally representative longitudinal study of children in public and private schools in the US. The sample is designed to provide representative estimates of students enrolled in kindergarten in the fall of the 2010–2011 school year and the most up-to-date survey data on the educational achievement of US elementary school students. In this study, we examined data collected in the fall and spring of kindergarten (2010–2011) and the spring of third and fourth grades (2014–2015). Our analytical sample consisted of children with available self-control and reading achievement data from kindergarten who completed at least one reading achievement assessment in third and fourth grade ($N = 11,336$).

2.2. Measures

2.2.1. Self-control

Our measure of children's self-control consisted of a combination of parent and teacher questionnaire ratings and a direct behavioral assessment administered by ECLS-K:2011 field staff. We integrated multiple methods and rating perspectives in order to provide a more complete and reliable assessment of kinder-

garten self-control than possible using any single assessment approach. In total, five assessments were repeated in the fall and spring of kindergarten and the integrated self-control measures corresponded closely between time-points ($r = 0.7$, $p < 0.001$). All ten assessments of self-control administered during kindergarten were standardized and combined to form a single highly reliable composite measure (Cronbach's $\alpha = 0.82$).

To produce our composite self-control scale we utilized the well-validated Children's Behavior Questionnaire (CBQ)–Short Form (Putnam & Rothbart, 2006) and assessed self-control using the effortful control subscales (i.e. *Inhibitory Control* and *Attentional Focusing* subscales) as in prior studies (e.g. Duckworth, Tsukayama, & Kirby, 2013). Kindergarten teachers rated whether individual children typically displayed a series of behaviors considered to reflect the ability to suppress inappropriate responses when given instructions or in novel situations (Putnam & Rothbart, 2006; Tourangeau et al., 2018). For example, teachers were asked to indicate whether the child “can easily stop an activity when s/he is told ‘no.’” or “can wait before entering into new activities if s/he is asked to”. Teachers rated the degree to which each of twelve items represented the child's behavior in different situations over the past six months using a 7-point scale ranging from “extremely untrue” to “extremely true”. Scores were averaged across items and ranged from 1 to 7 (inhibitory control: $M = 5.00$, $SD = 1.19$; attentional focusing: $M = 4.85$, $SD = 1.21$) and scale scores showed good reliability in both the fall and spring of kindergarten (Cronbach's $\alpha > 0.8$).

We also incorporated parent and teacher ratings of each child's self-control in fall and spring of kindergarten assessed using a modified version of the Social Skills Rating System – a widely used inventory of child behavior (SSRS; Gresham & Elliott, 1990). Specifically, both parents and teachers completed the four-item *Self-Control* subscale of the Social Rating System (SRS) which gauged the child's ability to control his/her behavior (e.g. frequency throws tantrums, argues). Parents and teachers rated how often the child displayed each characteristic using a four-point frequency scale from 1 “never” to 4 “very often” and responses were coded so that higher scores indicated better self-control ($M = 3.00$, $SD = 0.45$). The *Self-Control* subscale showed good reliability in both fall and spring kindergarten assessments (Cronbach's $\alpha \geq 0.7$).

Finally, we drew on the Dimensional Change Card Sort (DCCS) a set-shifting measure that captures the higher-order cognitive processes involved in self-regulation (e.g. keeping rules in mind, exercising inhibitory control to override an established response pattern). The DCCS has shown good test-retest reliability and convergent and discriminant validity (Beck, Schaefer, Pang, & Carlson, 2011; Tourangeau et al., 2018). The task requires that children sort 22 test cards into target trays according to rules that change during the task, requiring the children to refocus attention to a new sorting dimension and override the natural tendency to respond in the same way as previously. DCCS performance was scored as the sum of correct responses across 18 trials and ranged from 0 to a maximum of 18 ($M = 14.71$, $SD = 2.48$).

2.2.2. Reading achievement

Our primary outcome was a direct assessment of children's reading achievement administered individually by trained ECLS-K:2011 field staff. To maximize the sample size, we combined highly correlated ($r = 0.85$, $p < 0.001$) test scores from the third and fourth grade reading assessments and included participants who had completed both assessments or a single assessment. In addition, our lagged dependent variable model incorporated scores from the standardized reading assessment conducted in the fall of kindergarten ($r = 0.58$ with third/fourth grade reading achievement).

The reading achievement tests were designed specifically for the ECLS-K:2011 and aimed to assess children's knowledge and skills in reading at a level appropriate to their age. The test developers drew on current curriculum standards, the National Assessment of Educational Progress (NAEP) 2009 Reading Framework, input from development and education experts, and the reading framework and existing content from the 1998–99 ECLS-K study. Extensive consultation with curriculum experts coupled and psychometric analysis were used to ensure that floor and ceiling effects were avoided and a constant level of relative difficulty was maintained throughout assessments rounds (Tourangeau et al., 2018).

The reading achievement tests measured basic reading skills (e.g. phonological awareness, letter and sound recognition, familiarity with print, common word recognition), vocabulary knowledge (e.g. expressive and receptive vocabulary), and reading comprehension (e.g. identify information located in a text, make inferences and draw conclusions). The reading assessments contained items primarily relating to basic skills in the kindergarten assessment and the item content was more heavily weighted towards vocabulary knowledge and reading comprehension in the third and fourth grade assessments. To increase efficiency, rather than administering all test items to all children, children were routed to items of different levels of difficulty depending on their demonstrated ability. We utilized item response theory (IRT) based scale scores which estimated the total number of items a child would have correctly answered if administered all possible questions.

2.2.3. Covariates

Our control variables were participant age, ethnicity/race (White, Black, Hispanic, Asian, Other race), whether English was the main language spoken in the home (yes/no), and annual household income (from 1 = \$5000 or less, to 18 = \$200,001 or more).

In addition, we included measures of kindergarten social skills and emotional difficulties in our robustness tests in order to isolate the role of self-control. In the fall and spring of kindergarten teachers rated each child's social skills using the four-item *Interpersonal Skills* subscale of the SRS and parents rated their child's social skills using the three-item *Social Interaction* subscale of the SRS (e.g. skills in forming and maintaining friendships, comforting or helping other children). In addition, teachers completed the four-item *Internalizing Problems* subscale (e.g. the presence of anxiety, loneliness, sadness) from the teacher SRS and parents completed the four-item *Sad/Lonely* subscale (e.g. feelings of sadness, loneliness, low self-esteem) from the parent SRS. Subscale scores were stan-

dardized and the four social skills and four emotional difficulties measures were combined to form composite scales which showed acceptable reliability (Cronbach's $\alpha \geq 0.6$).

2.3. Analytical strategy

Missing covariate data ($\leq 3\%$ of cases) were handled using full-information maximum likelihood (FIML) estimation, where all available cases are used to supplement the information lost due to incomplete data. Participants were nested within schools and we therefore used multilevel modelling to correct standard errors for clustering. A non-parametric bootstrap was used to estimate bias-corrected bootstrap standard errors and 95% confidence intervals using 10,000 bootstrap samples. We also applied NCES-constructed sampling weights to account for differential sampling probabilities and response patterns in all analyses.

In our regression analyses we first examined the relationship between (female) gender and scores on our composite measure of self-control. Next, we analyzed the association between gender and self-control in kindergarten and reading achievement test scores. All analyses were adjusted for participant age in kindergarten, ethnicity/race, primary language spoken in the home, and household income.

Our mediation analyses relied on establishing an association between child gender and self-control (path *a*) which, in turn, explained variation in the dependent variable, reading achievement levels (path *b*). The indirect effect (path *a* \times *b*) was then estimated and concluded to be statistically significant at the 0.05 level if the 95% bootstrap confidence intervals did not include zero.

We conducted two additional analyses to ensure the robustness of our findings. First, we tested whether the role of self-control was attenuated when measures of social skills and emotional difficulties in kindergarten were entered alongside self-control in a parallel multiple mediation model. Second, we examined whether self-control mediated the relationship between gender and reading achievement at follow-up in a lagged dependent variable model where reading achievement scores in kindergarten were adjusted for.

3. Results

Table 1 displays the sample characteristics in kindergarten and self-control and reading achievement scores for the full sample and for males and females separately. On average participants were aged 5.63 in the fall of kindergarten and the majority of the sample were White (51.8%). Males and females differed minimally in terms

Table 1
Participants' Characteristics in the Early Childhood Longitudinal Study, Kindergarten Class of 2010–2011 (ECLS-K:2011) Cohort (N = 11,336).

	Males (N = 5804)	Females (N = 5532)	Total (N = 11,336)
Age (fall of kindergarten)	5.65 (SD = 0.38)	5.60 (SD = 0.36)	5.63 (SD = 0.37)
Race/ethnicity			
White (%)	52.0	51.6	51.8
Black (%)	11.5	11.2	11.4
Hispanic (%)	27.5	27.0	27.2
Asian (%)	4.0	4.9	4.5
Other race (%)	5.0	5.3	5.1
English primary language spoken (%)	81.5	81.5	81.5
Household income ^a	10.69 (SD = 5.55)	10.77 (SD = 5.55)	10.73 (SD = 5.55)
Reading achievement in third/fourth grade ^b	−0.10 (SD = 1.07)	0.11 (SD = 0.91)	0.00 (SD = 1.00)
Reading achievement in kindergarten ^b	−0.05 (SD = 1.02)	0.05 (SD = 0.97)	0.00 (SD = 1.00)
Self-control in kindergarten ^b	−0.23 (SD = 1.02)	0.24 (SD = 0.92)	0.00 (SD = 1.00)
Internalizing problems ^b	0.03 (SD = 0.96)	−0.03 (SD = 1.04)	0.00 (SD = 1.00)
Interpersonal skills ^b	−0.17 (SD = 1.02)	0.18 (SD = 0.95)	0.00 (SD = 1.00)

^a Measured in kindergarten and ranging from 1 = \$5000 or less, to 18 = \$200,001 or more.

^b Standardized to have a mean of 0 and standard deviation of 1 across the full sample.

of age, race/ethnicity, and income as expected in a population-based sample. Females scored 0.47 standard deviations (SD) higher than males on our composite self-control measure and 0.21 SD higher on third/fourth grade tests of reading achievement at follow-up, as shown in Table 1. The correlations between all study variables are detailed in Table S1.

Adjustment for sociodemographic factors did not notably impact the magnitude of gender disparities in self-control ($\beta = 0.47$, $SE = 0.02$, $p < 0.001$) and reading achievement ($\beta = 0.20$, $SE = 0.02$, $p < 0.001$) identified in our univariate analyses. Individual differences in self-control measured in 2010–2011 positively predicted reading achievement in third/fourth grade in 2014–2015 ($\beta = 0.37$, $SE = 0.02$, $p < 0.001$). The strength of the association between self-control and reading achievement did not differ by gender indicating that the gender reading achievement gap was unlikely to be attributable to gender differences in the strength of the contribution of self-control to reading test scores.

3.1. Mediation analyses

In contrast, higher levels of self-control among girls had strong explanatory power in accounting for the gap in reading performance. Including kindergarten self-control in our fully adjusted regression model reduced the female advantage in reading achievement in third/fourth grade from 0.20 to 0.03 SD, as shown in Table 2. Further, after adjustment for self-control levels in kindergarten the direct effect of gender on reading achievement was not statistically significantly different from zero. Formal mediation analyses confirmed the existence of a statistically significant indirect effect of (female) gender on reading achievement through self-control ($\beta = 0.17$, $SE = 0.01$, $p < 0.001$). Further, inspection of the 95% CI for the indirect effect (lower 0.15 to upper 0.19) suggested that self-control acted as a mediator.

4. Robustness tests

The explanatory power of self-control was unaffected by adjustment for interpersonal skills and internalizing behavior problems in kindergarten, as shown in Table 2. Our lagged dependent variable model showed that girls scored higher than boys on reading achievement at follow-up after adjustment for reading levels in kindergarten. In line with our main analyses, we found a statistically significant indirect effect of gender on reading achievement from kindergarten to third/fourth grade occurring through self-control ($\beta = 0.11$, $SE = 0.01$, $p < 0.001$) that explained almost three-quarters of the gender reading gap, as shown in Table 2. Finally, the explanatory role of self-control was evident in mediation models that did not adjust for socio-demographic covariates (without adjustment for kindergarten reading: $\beta = 0.21$, $SE = 0.01$, $p < 0.00$; with adjustment for kindergarten reading: $\beta = 0.11$, $SE = 0.01$, $p < 0.001$).

5. Discussion

Prior research has demonstrated that higher self-control enables girls to exert the sustained effort needed (e.g. completing homework, project assignments, and classroom activities) to earn better classroom grades than boys (Duckworth & Seligman, 2006). The academic consequences of trait self-control have been extensively investigated. However, prior research has not provided a strong test of whether superior trait self-control gives girls an academic 'edge' in reading achievement.

In a longitudinal study of 11,336 individuals we show that girls exhibited higher levels of self-control in kindergarten (Else-Quest et al., 2006; Moffitt et al., 2011) and reading achievement in third/fourth grade of elementary school (Reilly et al., 2019). Further, individual differences in self-control were of critical importance in forecasting reading achievement throughout elementary school (Matthews et al., 2014). Connecting these findings our mediation analyses revealed that the initial female advantage in self-control could account for the subsequent gender gap in reading achievement.

This study advances prior work (e.g. DiPrete & Jennings, 2012; Duckworth & Seligman, 2006; Matthews et al., 2009, 2014) by demonstrating that the superior self-control of girls appears to confer an academic advantage that extends beyond classroom grades to standardized tests of reading achievement. The explanatory power of self-control demonstrated in this study contrasts with previous findings (e.g. Matthews et al., 2009, 2014), perhaps because of our reliance on data drawn from a nationally representative sample (Reilly et al., 2019) and our ability to isolate the role of gender differences in self-control (DiPrete & Jennings, 2012).

5.1. Limitations and future directions

This study is limited in four key respects. First, we focus on a kindergarten sample from the United States and additional research is therefore needed to demonstrate the generalizability of the study findings. We anticipate that kindergarten self-control, where rigorously assessed, will yield similar sustained academic benefits for girls in other age-groups and non-US countries where children engage in formal education from an early age. Second, while we could demonstrate that self-control appears to play a role in explaining the gender reading achievement gap, we did not identify the potential mechanisms (e.g. reading motivation, academic engagement) connecting early gender differences in self-control to subsequent disparities in reading performance. Third, our mediation model was limited in its reliance on self-control examined at a single time-point. Multi-wave longitudinal analyses assessing changes in self-control as a function of gender and changes in reading achievement following changes in self-control may shed further light on this relationship. Finally, our study does not consider the role of early socialization experiences. It remains possible that early-life self-control may connect diver-

Table 2
Kindergarten Self-Control (2010–2011) as a Mediator of the Relationship between Gender and Reading Achievement (2014–2015) (N = 11,336).

Path	β^a	95% CI	+ Socioemotional covariates		+ Kindergarten reading ability	
			β^b	95% CI	β^c	95% CI
Total effect (female => reading achievement)	0.20	[0.17–0.24]	0.20	[0.17–0.24]	0.15	[0.11–0.18]
Direct effect (female => reading achievement)	0.03	[–0.01–0.07]	0.03	[–0.004–0.07]	0.04	[0.01–0.08]
Indirect effect (female => reading achievement via self-control)	0.17	[0.15–0.19]	0.17	[0.15–0.18]	0.11	[0.09–0.12]
Effect ratio (indirect/total effect)	0.85		0.85		0.73	

^a Model adjusts for demographic factors (age, ethnicity/race, English main language spoken in the home, and household income).

^b Model includes further adjustment for kindergarten interpersonal skills and internalizing problems.

^c Model includes further adjustment for kindergarten interpersonal skills and internalizing problems and reading achievement test scores.

gent socialization experiences to the emergence of gender disparities in reading achievement.

In conclusion, this study suggests that gender differences in self-control may represent a key pathway through which gender disparities in reading skills, vocabulary knowledge, and reading comprehension occur. Because self-control is malleable, the present findings highlight the potential of preschool self-regulation interventions programmes in promoting academic achievement (Corcoran, Cheung, Kim, & Chen, 2019; Pandey et al., 2018), and particularly for boys in helping narrow the gender gap in reading.

Author contributions

All authors contributed to the study concept and conceived the analytic strategy. M. Daly executed the analytic strategy. All authors contributed to drafting the manuscript and approved the final version of the manuscript for submission.

Declaration of Competing Interest

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jrp.2019.103881>.

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