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Title: Examining the Contribution of Self-Regulation and Executive Function Skills to School Readiness and Longer-Term Achievement Gaps: A Replication and Extension in Statewide and National Datasets.

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Self-regulation in early childhood encompasses higher-order executive function processes and lower-order emotional responses that enable children to navigate the classroom environment. Although self-regulation and executive functions are overlapping constructs, self-regulation represents a broad assessment of children's ability to call upon executive function processes in order to meet contextual demands. Prior research has demonstrated the utility of teacher-rated classroom self-regulation and individually-assessed executive functions through evidence of their independent associations with academic achievement. Yet, the unique contribution of these skills to achievement gaps are largely unknown. The two studies in this dissertation establish the roles of individual executive function skills and classroom self-regulation for school readiness gaps and longer-term achievement among two particularly vulnerable subgroups of children: students from economically disadvantaged families and English-language learners (ELLs). Acknowledging the importance of replication for the robustness of scientific results across contexts, questions were addressed using Oregon's statewide kindergarten assessment data (OKA) and data from the most recent cohort of the Early Childhood Longitudinal Study – Kindergarten (ECLS-K). Study 1 estimated the kindergarten and third grade achievement gaps among economically disadvantaged students and ELLs nationally and in Oregon and investigated whether these gaps could be partially explained by classroom self-regulation skills, individual executive functions, or both. Results uncovered only slight differences in the magnitude of achievement gaps experienced by children in Oregon when compared to children nationally. Classroom self-regulation significantly explained school readiness gaps for economically disadvantaged children and ELLs nationally and in Oregon. Furthermore, after accounting for classroom self-regulation skills, individual executive functions significantly explained achievement gaps for both groups in kindergarten and third grade nationally. Study 2 investigated whether classroom self-regulation skills, executive functions skills, or both could compensate for the negative effects of economic disadvantage being of ELL status on kindergarten and third grade academic achievement. Results revealed compensatory effects of classroom self-regulation on third grade academic achievement among economically disadvantaged students and ELLs nationally. Furthermore, having strong attentional flexibility and working memory served as additional protective factors for third achievement nationally. Together, the results from these studies expand our knowledge on the specificity and generalizability of developmental processes across subgroups and contexts. Implications for targeted interventions developed to close achievement gaps and recommendations for the selection of statewide kindergarten assessments are discussed.

Examining the Contribution of Self-Regulation and Executive Function Skills to School Readiness and Longer-Term Achievement Gaps: A Replication and Extension in Statewide and National Datasets

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Jennifer K. Finders, Author

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Examining the Contribution of Self-Regulation and Executive Function Skills to School Readiness and Longer-Term Achievement Gaps: A Replication and Extension in Statewide and National Datasets

Examining the Contribution of Self-Regulation and Executive Function Skills to School Readiness and Longer-Term Achievement Gaps: A Replication and Extension in Statewide and National Datasets

Children enter kindergarten with widely varying skills and knowledge (Zill & West, 2001; West, Denton, & Reaney, 2000). Referred to as school readiness, the cognitive and behavioral competencies of children at the start of school are well known indicators of short- and long- term academic success (Duncan et al., 2007). Major socioeconomic inequalities in school readiness place children from economically disadvantaged families and English-language learners (ELLs) at risk of falling behind their peers throughout schooling (Aikens & Barbarin, 2008; Genesee, Lindholm-Leary, Saunders & Christina, 2005; Duncan & Magnuson, 2011; Reardon & Portilla, 2016; Lesaux, 2012; Sirin 2005). The increased demands of kindergarten and the relentless achievement gaps have motivated efforts to monitor children's progress in school and identify how various skills at kindergarten entry matter for academic trajectories (e.g., Caemmerer & Keith, 2015; Rabiner, Godwin, & Dodge, 2016). While most evidence on school readiness gaps is based on academic assessments, recently there has been a shift in focus to gaps in self-regulation skills and executive functions processes because they are assumed to provide the foundation for learning (Li, Riis, Ghazarian, & Johnson, 2017; Little, 2017; Magnuson & Duncan, 2016; McClelland, Acock, & Morrison, 2006; McClelland, Morrison, & Holmes, 2000).

Self-regulation and executive functions are related and overlapping constructs, but self-regulation skills are often measured within contexts, such as within the classroom environment, and therefore represent a broader assessment of children's ability to call upon specific executive function processes to meet classroom demands (McClelland & Cameron, 2012). Furthermore, there is evidence that classroom self-regulation skills are distinct from executive functions because they uniquely contribute to academic achievement (Fuhs, Farran, & Turner Nesbitt, 2015; Lipsey, Turner Nesbitt, Farran, Dong, Fuhs, & Wilson, 2017). Yet, there is currently a lack of research investigating the extent to which individual executive function skills and classroom self-regulation skills in kindergarten independently explain achievement gaps over time (e.g., Morgan, Farkas, Hillemeir, Hun, & Maczuga, 2018). The interactive nature of development raises the possibility that different processes could lead to remarkedly similar achievement gaps among ELLs and economically disadvantaged students, or the same processes could lead to vastly different achievement gaps between ELLs and economically disadvantaged students (Thelen & Smith, 1998; Duncan, Magnuson, & Votruba-Drzal, 2017).

This dissertation includes two studies that establish the roles of individual executive function skills and classroom self-regulation for school readiness gaps and longer-term achievement. Acknowledging the importance of replication for the robustness of scientific results across contexts (Duncan, Engel, Claessens, & Dowsett, 2014), these relations were examined using Oregon's statewide kindergarten assessment data (OKA) and data from the most recent cohort of the Early Childhood Longitudinal Study – Kindergarten (ECLS-K). The first study describes the gaps in school readiness skills and third grade academic achievement due to economic disadvantage and being of ELL status in Oregon and nationally, and investigates the extent to which individual executive function skills and classroom self-regulation are responsible for explaining these gaps in kindergarten and third grade. The second study examines whether individual executive function skills and classroom self-regulation at kindergarten entry can compensate for the effects of economic disadvantage and being of ELL status on academic achievement in kindergarten and third grade. The results of this dissertation provide evidence of the homogeneity and heterogeneity of developmental processes across contexts and have implications for efforts aimed at reducing achievement gaps as well as how states assess school readiness.

Theoretical Perspective

This study is grounded in a developmental systems framework. A developmental systems approach recognizes processes of development at multiple levels of analysis, with attention to individual variation in child characteristics and a child's environment (Cairns & Cairns, 2006). Advances in developmental systems thinking have shaped an understanding of school readiness (Carlton & Winsler, 1999). Children are often viewed as being ready to enter school when they can intentionally regulate their behaviors in ways that help them to sustain engagement with learning activities (Blair & Raver, 2015). Yet, these skills do not develop automatically as a result of individual maturation – they require rich and stimulating experiences, including the provision of sensitive and nurturing caregiving in early childhood (Blair, 2002; Fay-Stammbach, Hawes, & Meredith, 2014). From this perspective, the child is considered a dynamic system that is developing within numerous biological and environmental contexts of influence. Thus, school readiness can be conceptualized by children's interactions with resources in their immediate environments, and it is through supportive relationships in a complex system that children develop higher-order academic, language, and cognitive competencies (Mashburn & Pianta, 2006).

Developmental researchers argue that what happens early in life has a disproportionally large impact on later life outcomes relative to other experiences (Duncan, Yeung, Brooks-Gunn, & Smith, 1998; Duncan, Magnuson, Kalil, & Ziol-Guest, 2012; Heckman, 2006; Shonkoff & Phillips, 2000). During the first few years, the brain develops extremely rapidly with more than one million new neural connections being formed every second (Center for the Developing

Child, 2009). By kindergarten, the development of higher-order cognitive processes slows (Shonkoff & Phillips, 2000). Within the context of low-resourced environments, such as poverty, children may not receive adequate high-quality inputs from their interactions, and in turn, the biological system can interfere with the development of children's ability to manage contextual demands (Blair, 2010; Blair & Raver, 2012). In a developmental systems framework, both the stress response processes and the more general development of brain circuitry are implicated as mechanisms driving the effects of poverty and related environments on children (G. Duncan et al., 2017). Therefore, the early childhood period is a crucial window of opportunity when the developing system is open to influence and minor adjustments to the child's environment or within the child can have long-term implications for developmental trajectories (McClelland, Geldhof, Cameron, & Wanless, 2015).

Indeed, research suggests that poverty-related gaps in achievement are accompanied by differences in brain structure and function, as well as differences in skills that are important for learning (Farah et al., 2006; Hair, Hanson, Wolfe, & Pollak, 2015). Since executive function processes are directly tied to brain development, it is hypothesized that socioeconomic gaps in academic abilities at school entry can be partially attributed to the effects of poverty on children's development of executive function skills (Raver, Blair, & Willloughby, 2013). These pathways may be similarly disrupted among young children from families for whom English is a second language because the majority of ELLs also come from low-income backgrounds (Quirk, Nylund-Gibson, & Furlong, 2013). However, a more comprehensive model of developmental offers the possibility that children from diverse backgrounds may interact with their environments in ways that generate multiple underlying processes of school readiness.

The vulnerability of school readiness skills also suggests that processes leading to their development are malleable (Diamond & Lee, 2011; Diamond, 2013). This plasticity is best represented through intervention findings. In particular, there has been an increased focus on self-regulation skills in school readiness research (Blair, 2002). For example, interventions designed to boost self-regulation among low-income children have also been demonstrated to improve early academic achievement (Zhai, Raver, & Jones, 2012), with evidence of more pronounced effects among low-income ELLs (Schmitt, McClelland, Tominey, & Acock, 2015). These findings suggest that interventions may be successful in raising the academic readiness of children facing risk because they target the development of malleable skills that are fundamental to master in order to promote later achievement (e.g., Bailey, Duncan, Odgers, & Yu, 2016).

In addition, the equifinality and multifinality principles of developmental systems theories assert that adaptive development can be reached from a diversity of pathways and experiencing similar adverse events does not necessarily culminate in the same outcomes for each individual (Cichetti & Rogosch, 1996; Cichetti & Tucker, 1994). Multifinality specifies that developmental processes may share the same starting point but reach diverse outcomes and equifinality suggests that different developmental processes may lead to any given outcome. In other words, children can enter school with the same background characteristics (e.g., from low-resourced environments) but take divergent trajectories based on the complex matrix of individual traits, experiences, and sociocultural influences. This suggests that risk factors, such as poverty and speaking a primary language other than English, are probabilistic and they do not always affect children in the same ways (G. Duncan et al., 2017). Indeed, some children are more resilient to adversity than others. Keeping these principles of development in mind, this study investigated whether the mechanisms underlying achievement gaps are different among

ELLs and children from economically disadvantaged families, and if the same compensatory factors positively support school readiness and longer-term achievement for both at-risk groups.

School Readiness Domains

Although kindergarten was once considered the setting where children learned how to be ready for formal schooling (Gracey, 1975), children entering kindergarten today must be able to regulate their behaviors and emotions, problem solve and reason, focus and pay attention, remember complex rules and information, and simultaneously engage with learning material (Rimm-Kaufman & Pianta, 2000). Successfully navigating the kindergarten environment depends on school readiness, a multi-dimensional construct that describes the set of skills, abilities, and dispositions that children need in order to meet the physical, cognitive, and social demands of the classroom (Mashburn & Pianta, 2006; Pianta et al., 2007). Five dimensions of school readiness are recognized: 1) physical well-being and motor development; 2) social-emotional development; 3) approaches to learning; 4) language and literacy development; and 5) cognition and general knowledge (Snow, 2006). Though all domains are important indicators of children's readiness to learn in school, the cognitive and behavioral aspects of school readiness are among the strongest markers of academic achievement later in life (e.g., Duncan et al., 2007; McClelland et al., 2006; McClelland et al., 2000).

Early academic skills. A plethora of research has documented the strong links between early academic abilities, including math and literacy, and later academic performance (e.g., Duncan et al., 2007). The early numeracy skills that are necessary for the development of basic math skills include counting and cardinality, numerical relations, and arithmetic operations (Jordan, Kaplan, Ramineni, & Locuniak, 2009; Nguyen et al., 2016). A large body of research supports the strong connection between math skills measured at the beginning of kindergarten and third grade academic performance (Byrnes & Wasik, 2009; Davies, Janus, Duku, & Gaskin, 2016). Associations between kindergarten mathematics abilities, including early counting and numeracy skills, and later academic success continue into middle school (Claessens & Engel, 2013; Geary, Hoard, Nugent, & Bailey, 2013) and high school (Watts, Duncan, Siegler, & Davis-Kean, 2014). These relations hold even when other child characteristics and skills are controlled for in models. For instance, math skills in kindergarten, measured as knowing numbers and ordinality, were shown to be more predictive of children's fifth grade reading than reading in kindergarten, even after other academic competencies were accounted for (Claessens, Duncan, & Engel, 2009). In addition, growth in mathematics abilities during the transition to formal school appears to be a robust predictor of later math (Jordan et al., 2009; Watts et al., 2014).

Early literacy skills include oral language, phonological processing, and print knowledge (Whitehurst & Lonigan, 1998). These skills provide an important foundation for success in the early years of formal reading instruction (Catts, Fey, Zhang, & Tomblin, 1999; Lonigan, Burgess, & Anothony, 2000), and are consistent predictors of later academic achievement across studies (Duncan et al., 2007; Sabol & Pianta, 2012). Children who start school with deficits in language and emergent literacy skills are frequently identified as poor readers in elementary school and rarely catch up to their peers, often suffering long-term reading difficulties and underachievement. In one example, children who scored one standard deviation below the mean on literacy skills in kindergarten fell nearly two grade levels behind their peers by the end of third grade (Foster & Miller, 2007). Together, these findings support the importance of early math and literacy for determining children's learning trajectories in elementary school and beyond.

Individual executive function skills. Executive functions are higher-level processes that service goal-oriented behaviors (Diamond, 2013). Three specific executive function processes hypothesized to contribute to children's academic achievement are *working memory* (recalling, storing, and updating information while tracking progress on a task), *attentional flexibility* (focusing attention and shifting between tasks, operations, or mental sets), and *inhibitory control* (stopping an automatic predisposition in favor of a more adaptive response). These cognitive processes are related but also distinct (Friedman & Miyake, 2017; Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000). One confirmatory factor analysis yielded a two-factor structure with all three executive function processes loading onto latent factors of attentional flexibility and working memory (Huizinga, Dolan, & Van der Molen, 2006).

In previous research, attentional flexibility and working memory have been found to uniquely contribute to performance on academic tasks (Bull, Espy, & Wiebe, 2008; Bull & Scerif, 2001; Duncan et al., 2007; Fuhs, Turner Nesbitt, Farran, & Dong, 2014; Sabol & Pianta, 2012; Welsh, Nix, Blair, Bierman, & Nelson, 2010), with the strongest links being those between working memory and subsequent mathematics (Bull et al., 2008; Morgan et al., 2018). The ability to control and sustain attention in kindergarten also predicts achievement and grades in elementary school (Claessens et al., 2009; Duncan et al., 2007; Fuhs et al., 2014; McClelland et al., 2006; Razza, Martin, & Brooks-Gunn, 2012; Stipek & Valentino, 2015). Moreover, early attention has implications for high school graduation (Rabiner et al., 2016) and future educational attainment (Entwisle, Alexander, & Olson, 2005; McClelland et al., 2013).

Classroom self-regulation skills. Self-regulation and executive function skills access common networks in the brain (Hofmann, Schmeichel, & Baddeley, 2012), but self-regulation is often seen as a broader construct that includes higher-order, effortful cognitive skills, including executive function processes, as well as lower-order, automatic responses, such as the regulation of emotions and attention (Blair & Ursache, 2011; McClelland et al., 2015). For the purpose of this paper, self-regulation will be thought of as the manifestation of executive function skills in classroom contexts (McClelland & Cameron, 2012). The majority of teachers identify children's classroom behavior skills as a critical component of kindergarten readiness and early school success (Bassok, Latham, & Rorem, 2016). Teacher ratings of children's self-regulation, in particular, complement direct assessments by measuring executive function skills within context (Cameron, McClelland, Matthews, & Morrison, 2009; McClelland et al., 2006).

Research has demonstrated that children with stronger self-regulation skills in the classroom have better long-term educational outcomes (Li-Grining, Votruba-Drzal, Maldonado-Carreño, & Haas, 2010; McClelland et al., 2006; Vitaro, Brendgen, Larose, & Trembaly, 2005). Although teacher ratings of classroom self-regulation are related to individual executive function processes, they also uniquely predict academic achievement (Fuhs et al., 2015; Lipsey et al., 2017; Schmitt, Pratt, & McClelland, 2014). Therefore, using measures of classroom self-regulation alongside indicators of executive functioning may provide a more comprehensive assessment of a child's ability to recall advanced cognitive skills to meet multiple classroom demands (Duncan, McClelland, & Acock, 2017).

School Readiness Gaps

Overall, children today are entering kindergarten with stronger skills than in previous decades (Baumgartner, 2017). However, achievement gaps have persisted (Bassok, Finch, Lee, Reardon, Waldfogel, 2016; Lee & Burkam, 2002; Reardon & Galindo, 2009). Low-income children and ELLs, in particular, seem to be markedly disadvantaged from the time they enter formal schooling. In Oregon, for instance, kindergarteners from economically disadvantaged family backgrounds perform significantly lower on assessments of math and literacy and are rated as having poorer classroom self-regulation compared to their higher-income peers (Wilson, 2015). The achievement gap is even wider for economically disadvantaged children who are also ELLs (Diaz, 2016). For example, among low-income kindergarteners, non-ELLs identify approximately 25 letters in a minute versus only 16 for ELLs (Diaz, 2016). These trends are consistent with findings from nationally representative datasets and highlight the need to further understand achievement gaps among these vulnerable populations.

Socioeconomic disadvantage. On average, families need an income of about twice the federal poverty threshold to meet their most basic needs (National Center for Children in Poverty, 2017). In the 2010-2011 school year, 48% of kindergarteners lived in households with incomes 200% or below of the poverty threshold (National Center for Education Statistics, 2013). The percentage of economically disadvantaged families in Oregon is similar to the national average. However, Oregon has experienced a steeper increase in child poverty since the Great Recession, making it challenging for educational initiatives to keep up with the educational needs of low-income children prior to kindergarten (Jurjevich & Byerly, 2013).

Poverty represents one of the most powerful predictors of children's school readiness (Brooks-Gunn & Duncan, 1997; Duncan & Magnuson, 2005; Engel, Claessens, Watts, & Stone, 2016; Lee & Burkam, 2002). Generally, household income is more strongly related to cognitive skills than socioemotional outcomes (Brooks-Gunn & Duncan, 1997; Duncan & Magnuson, 2011). Children from high-poverty families enter kindergarten anywhere from a half of a standard deviation to over a full standard deviation behind their well-to-do peers in language, literacy, and math (Chatterji, 2006; Duncan & Magnuson, 2011; Reardon & Portilla, 2016). These differences typically intensify from kindergarten to third grade (Aikens & Barbarin, 2008;

Jordan et al., 2009).

School readiness gaps are also evident in measures of non-academic skills. For instance, Little (2017) uncovered significant disparities in kindergarten executive function skills based on socioeconomic status. In another recent study, children in the lowest income category scored almost a full standard deviation below children in the highest income category on measures of executive function abilities (Li et al., 2017). Low-income children also tend to perform worse than their peers on aspects of attention in early childhood (Dilworth-Bart, Khurshid, & Vandell, 2007). With regards to teacher ratings, there is some evidence that low-income children are more frequently reported as having lower classroom self-regulation (R. Duncan et al., 2017). However, while achievement gaps tend to widen over the elementary years, gaps in executive functions narrow slightly (Little, 2017).

English-language learners. ELLs are generally defined as speaking a primary language other than English in the home while being in the process of learning English (Halle, Hair, Wandner, McNamara & Chien, 2012). ELLs are a growing portion of the student population and currently represent approximately 17% of all entering kindergarteners (National Center for Education Statistics, 2017). This number is closer to 20% in Oregon (Diaz, McClelland, Thomson, & the Oregon School Readiness Research Consortium, 2017). Some estimates suggest that by 2020, the number of preschool-age children using or exposed to a language other than English at home may exceed the number of their peers who speak only English at home (Maxwell, 2013). In the U.S., 71% of languages spoken in the homes of ELLs is Spanish (Ruiz Soto, Hooker, & Batalova, 2015). Latino students are overrepresented in English proficiency programs, particularly in states with a large Hispanic population. In Oregon, for instance, 78% of ELLs in kindergarten identify as Latino and 83% are classified as low-income (Diaz et al., 2017).

Thus, much of the literature has focused on the school readiness gap between low-income, ELL children and monolingual, middle-class children (Castro, Páez, Dicksinon, & Frede, 2011).

The disproportionately large percentage of Latino children living in poverty combined with generally low parental education and limited English proficiency contributes to sizeable school readiness gaps between ELLs and non-ELLs at the start of kindergarten (Castro et al., 2011; Choi, Jeon & Lippard, 2018; Genesee et al., 2005; Lesaux, 2012; Reardon & Galindo, 2009; Swanson, Saez, Gerber, & Leafstedt, 2004; Wanless, McClelland, Tominey, & Acock, 2011). Moreover, although advanced executive function skills have been found in bilingual speakers (Bialystok, 1999; Bialystok & Martin, 2004; Hartanto, Toh, & Yang, 2018), low-income, Spanish-speaking ELLs tend to perform worse on direct assessments of executive function tasks in preschool and kindergarten, even when these assessments are given in Spanish (McClelland & Wanless, 2012). By the end of kindergarten, low-income ELLs score close to one standard deviation below their English-speaking peers on direct assessments of executive function skills (Wanless et al., 2011). However, ELLs are usually rated as having as strong or stronger classroom behavior skills, including self-regulation (Diaz, 2016; De Feyter & Winsler, 2009; Galindo & Fuller, 2010; Halle et al., 2014; Luchtel, Hughes, Luze, Bruna, & Peterson, 2010).

Self-Regulation, Executive Functions, and Longer-Term Achievement Gaps

These early disparities have important implications for longer-term school success. The state of Oregon has the 3rd lowest high-school graduation rate in the nation (National Center for Education Statistics, 2016), accompanied by higher than average rates of childhood poverty and a growing Latino immigrant population (Oregon Community Foundation, 2016; U.S. Census Bureau, 2016). In fact, a recent report documented graduation rates of 68.1% among economically disadvantaged students and 52.9% among English-Language learners in Oregon (Oregon Department of Education, 2017). One major policy lever may be raising the achievement levels of low-income students and students with limited English proficiency early in an attempt influence long-run economic outcomes such as employment and earnings. To illustrate, a noteworthy study documented links between kindergarten test scores and outcomes in adulthood, finding that a one percentile increase in kindergarten test scores was associated with a $94 increase in wage earnings at age 27, controlling for parental characteristics (Chetty, Friedman, Hilger, Saez, Diane, & Yagan, 2011). Understanding how malleable school readiness skills, such as classroom self-regulation and individual executive functions, relate to concurrent and future achievement gaps may provide opportunities to intervene in ways that impact children's life trajectories.

Specifically, researchers have been interested in whether classroom self-regulation and individual executive function skills help to explain achievement gaps (e.g., Fitzpatrick, McKinnon, Blair, & Willoughby, 2014; Morgan, Li, Farkas, Cook, Pun, & Hillemeier, 2017). These studies show how a composite measure of executive function skills, as well as individual assessments of attentional flexibility and working memory, partially mediate the effects of socioeconomic status on math achievement during the early school grades. Inhibitory control skills have also been found to explain math gaps among ELLs in preschool and kindergarten (Choi et al., 2018). Noticeably less literature has focused on classroom self-regulation as an underlying process that may be driving the effects of economic disadvantage and ELL status on academic outcomes over the transition to school (Sektnan, McClelland, Acock, & Morrison, 2010). Given the lack of research in this area, the extent to which classroom self-regulation skills and individual executive functions are uniquely responsible for gaps in math and reading achievement among ELLs and economically disadvantaged students over the early elementary grades is currently unknown.

Another related avenue of research has been to examine whether classroom self-regulation skills and individual executive functions can buffer achievement gaps. Relations between socioeconomic risk and academic achievement have not consistently been shown to significantly vary as a function of classroom self-regulation (Li-Grining et al., 2010; McClelland & Wanless, 2012; Sektnan et al., 2010). However, researchers have found compensatory effects of individual executive functions, such as inhibitory control, among low-income children in preschool (R. Duncan et al., 2017). Furthermore, a recent student demonstrated a weak but significant protective effect of classroom self-regulation for second grade math among children experiencing socioeconomic risk (Morgan et al., 2018). Only one study has investigated the buffering effect of classroom self-regulation skills for longer-term achievement among ELLs (McClelland & Wanless, 2012). Together, these mixed findings across studies underscore a critical gap in the field that, once filled, may lead to a more nuanced understanding of the unique roles that contextually-based classroom self-regulation skills and individually assessed executive functions play in facilitating academic achievement among children facing risk.

Overview of Studies

The studies included in this dissertation answer the call for incorporating external replication into empirical work by determining whether results are robust across measurements and samples (Duncan et al., 2014), and follow recommended practices by attempting to reproduce associations across contexts (Cronbach, 1982). Data from Oregon's statewide kindergarten assessment (OKA) and from the most recent cohort of the Early Childhood Longitudinal Study – Kindergarten (ECLS-K: 2010) were analyzed in order to increase generalizability of developmental processes. These datasets offer similar measures of classroom self-regulation and assessments of early math and literacy at kindergarten entry, permitting comparisons between samples. In addition, the ECLS-K includes measures of children's individual executive function skills in kindergarten, which allowed for the extension of research questions in a nationally representative dataset. Investigating whether classroom self-regulation skills facilitate and combat achievement gaps in local and national contexts for economically disadvantaged students and ELLs may shed light on early patterns of disparities and provide solutions for attenuating longer-term achievement gaps. Furthermore, by extending this work to look at the unique and independent effects of individual executive functions, relevant questions regarding which skills may be most important to measure as markers of school readiness among at-risk populations may be answered.

Overview of study 1. The first study in this dissertation examined the extent to which individual executive function skills and classroom self-regulation explained school readiness and longer-term achievement gaps experienced by economically disadvantaged students and ELLs. Specifically, this study 1) examined the achievement gaps between economically disadvantaged students and non-economically disadvantaged students and between ELLs and non-ELLs in kindergarten and third grade both nationally and in Oregon, 2) investigated whether the achievement gaps experienced by economically disadvantaged students and ELLs in kindergarten and third grade could be partially explained by classroom self-regulation skills, and 3) explored whether individual executive functions could explain any additional variance in kindergarten and third grade achievement gaps nationally after accounting for classroom self-regulation. The achievement gaps experienced by economically disadvantaged students and ELLs were expected to be roughly the same in Oregon as across the nation. Based on previous research, it was anticipated that classroom self-regulation skills would explain a significant portion of the achievement gaps in kindergarten and third grade in Oregon and nationally. Furthermore, executive function skills were expected to explain additional variance in achievement gaps once accounting for classroom self-regulation skills.

Overview of study 2. The second study in this dissertation examined whether relations between economic disadvantage and/or ELL status and academic achievement varied as a function of classroom-based self-regulation or individual executive function skills. Specifically, this study 1) investigated whether having strong classroom self-regulation skills at kindergarten entry could compensate for the negative effects of economic disadvantage being of ELL status on kindergarten and third grade academic achievement, and 2) examined whether individual executive functions, after accounting for classroom self-regulation, serve as additional protective factors for kindergarten and third grade achievement gaps nationally. Classroom self-regulation was expected to compensate for the negative effects of economic disadvantage and being of ELL status on school readiness and third grade math and reading achievement nationally and in Oregon. It was also hypothesized that individual executive function skills at kindergarten entry would compensate for the effects of economic disadvantage and ELL status on school readiness and third grade math and reading achievement after accounting for classroom self-regulation.

Overall, the results from the two studies in this dissertation provide insight into the robustness of developmental processes that underlie achievement gaps experienced by two subgroups of children who are particularly at-risk for starting school behind their more advantaged peers. Specifically, findings highlight the independent and unique contributions of classroom self-regulation and individually assessed executive functions, such as attentional flexibility and working memory, for school readiness and longer-term achievement. By clarifying the relative importance of these malleable skills as children enter kindergarten, early childhood education programs in Oregon and beyond may be more effective in targeting the skills that matter for attenuating longer-term achievement gaps. In addition, the results of these studies have the potential to inform how states select their kindergarten entry assessments.

Explaining School Readiness and Longer-Term Achievement Gaps in Statewide and National Contexts

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Abstract

The present study investigated the achievement gaps experienced by economically disadvantaged students and English-Language learners (ELLs) in kindergarten and third grade and examined the extent to which classroom self-regulation and individual executive functions measured at kindergarten entry explained these gaps over the first few years of schooling. Data from the statewide Oregon Kindergarten Assessment (OKA) and nationally representative data from the Early Childhood Longitudinal Study – Kindergarten cohort of 2011 (ECLS-K) were utilized in an attempt to replicate associations across contexts and measurement tools. Classroom self-regulation consistently explained a moderate portion of the kindergarten math and literacy gaps experienced by economically disadvantaged students and ELLs in Oregon and nationally. In third grade, classroom self-regulation continued to partially explain the effect of economic disadvantage on third grade math and reading in Oregon. Moreover, individual executive function skills explained a large portion of kindergarten and third grade achievement gaps nationally, even after accounting for classroom self-regulation skills. Results highlight the importance of classroom self-regulation for reducing school readiness gaps among economically disadvantaged students and suggest that individual executive function skills such as attentional flexibility and working memory may be most effective in reducing longer-term achievement gaps.

Explaining School Readiness and Longer-Term Achievement Gaps in Statewide and National Contexts

School readiness is generally described as a set of skills, abilities, and dispositions that children need in order to meet the physical, cognitive, and social demands of the kindergarten classroom (Mashburn & Pianta, 2006; Rimm-Kaufman & Pianta, 2000). The cognitive and language aspects of school readiness are among the strongest indicators of academic achievement and educational success later in life (Claessens, Duncan, & Engel, 2009; DiPerna, Lei, & Reid, 2007; Duncan et al., 2007; Rabiner, Godwin, & Dodge, 2016). Deficits in these skills are evident at school entry and place children at-risk for school failure (Aikens & Barbarin, 2008; Crosnoe, Leventhal, Worth, Pierce, & Pianta, 2010; Duncan & Magnuson, 2011; Reardon & Robinson, 2008; Sirin 2005). For example, more than a full standard deviation in math and literacy separates children whose families are in the bottom and top income quintiles in kindergarten (Duncan & Magnuson, 2011; Reardon & Portilla, 2016). Achievement gaps are even greater for economically disadvantaged children who are also English-language learners (Genesee, Lindholm-Leary, Saunders & Christina, 2005; Lesaux, 2012).

The increased demands of kindergarten and the persistent achievement gaps have motivated efforts to monitor children's progress in school and identify how various skills at kindergarten entry matter for academic trajectories. Recently there has been a focus on the roles of executive functions and self-regulation because these skills provide the foundation for learning (Li, Riis, Ghazarian, & Johnson, 2017; Magnuson & Duncan, 2016; McClelland, Acock, & Morrison, 2006; McClelland, Morrison, & Holmes, 2000). Executive functions include a set of higher order cognitive processes that promote goal driven behaviors and self-regulation (Bernier, Carlson, & Whipple, 2010). Although self-regulation and executive functions are related and overlapping constructs (e.g., Kim, Byers, Cameron, Brock, Cottone, & Grissmer, 2016), self-regulation represents a broader assessment of children's ability to call upon executive function processes in order to meet contextual demands (McClelland & Cameron, 2012).

There is evidence that executive functions are one prominent pathway through which economic disadvantage and limited English proficiency influence achievement (Choi et al., 2018; Evans & Rosenabaum, 2008; Fitzpatrick, McKinnon, Blair, & Willoughby, 2014; Turner Nesbitt, Baker-Ward, & Willoughby, 2013). Less research has examined whether classroom self-regulation plays a similar role as executive function skills in explaining achievement gaps in early childhood (Sektnan, McClelland, Acock, & Morrison, 2010). And few studies have sought to tease apart the unique contribution of these skills for academic achievement (Fuhs, Farran, & Turner Nesbitt, 2015; Lipsey, Turner Nesbitt, Farran, Dong, Fuhs, & Wilson, 2017; Schmitt, Pratt, & McClelland, 2014). The lack of research in this area begs the question of whether longer-term achievement gaps among economically disadvantaged students and ELLs can be attributed to poor individual executive functions skills, poor classroom self-regulation, or a combination of both in kindergarten.

The present study examines the extent to which individual executive function skills and classroom self-regulation explain school readiness and longer-term achievement gaps experienced by economically disadvantaged students and English-language learners (ELLs). To increase the generalizability of findings, this study investigates whether the associations are robust to differences in context and measurement by using Oregon's statewide kindergarten assessment data (OKA) and nationally representative data from the most recent cohort of the Early Childhood Longitudinal Study – Kindergarten (ECLS-K: 2010). Disentangling the relative importance of self-regulation and executive function skills for achievement gaps has implications for local and national policy efforts aimed at reducing achievement gaps.

Individual Executive Functions Skills

Executive function skills include three distinct processes that are critically tied to development within the prefrontal cortex during the years prior to kindergarten (Kane & Engle, 2002). *Working memory* refers to the extent to which children can store, recall, and update important information as they track their progress on a given task (Gathercole, Pickering, Ambridge, & Wearing, 2004). *Attentional flexibility* indicates children's ability to focus attention and shift back and forth between multiple tasks, operations, or mental sets (Rueda, Posner, & Rothbart, 2005). *Inhibitory control* describes the ability to stop an automatic response in favor of a more adaptive behavior (Dowsett & Livesey, 2000). Together, executive functions play a key role in facilitating achievement and classroom self-regulation (e.g., Brock, Rimm-Kaufman, Nathansan, & Grimm, 2009).

Executive function processes are both conceptually distinct and overlapping in early childhood (Friedman & Miyake, 2017; Garon, Bryson, & Smith, 2008; Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000). However, measurement impurity causes challenges when assessing individual executive functions because many executive function tasks require a combination of executive function processes (Zelazo, Blair & Willoughby, 2017). When assessed individually, measures of executive function skills tend to be moderately correlated around $r = 0.30$, indicating only partial shared variance and some degree of measurement discrepancy (Willoughby, Blair, & the Family Life Project Investigators, 2016). In the present study, executive function skills are treated as individual processes rather than as a latent construct because it was important to make the distinction between individual cognitive processes and broader executive function abilities, which may have more overlap with contextually-based classroom self-regulation, in order to answer the research questions.

Of the individual executive function skills, working memory and attentional flexibility appear to be particularly important for learning during the elementary years (Best & Miller, 2010). In previous research, these executive function processes have been found to uniquely contribute to performance on academic tasks (Bull & Scerif, 2001; Bull, Espy, & Wiebe, 2008; Duncan et al., 2007; Fuhs, Turner Nesbitt, Farran, & Dong, 2014; Sabol & Pianta, 2012; Welsh, Nix, Blair, Bierman, & Nelson, 2010). Notably, attention skills at school entry are independently predictive of later school success after accounting for other indices of readiness, including cognitive ability (McClelland et al., 2000; McClelland, Acock, Piccinin, Rhea, & Stallings, 2013; Rabiner et al., 2016). Therefore, it should come as no surprise that kindergarten children with deficits in working memory and attentional capacities are more likely to experience reading and mathematics difficulties in first grade than similar kindergarten children without such deficits (Morgan, Li, Farkas, Cook, Pun, & Hillemeier, 2017).

Classroom Self-Regulation Skills

Self-regulation in early childhood can be defined as the control of thoughts, feelings, and behaviors, which requires the coordination of all three executive function processes (McClelland & Cameron, 2012). In school, children must achieve a balance between activating executive function processes and managing their emotional and stress response systems. Researchers therefore argue that self-regulation is a broader construct that demonstrates the feedback between the child's executive function processes and emotion regulation skills within classroom environment (Ursache, Blair, & Raver, 2012).

Teacher ratings of self-regulation are especially popular in early childhood because they are practical, cost-effective, and require little training (Cameron, McClelland, Matthews, & Morrison, 2009). Teacher ratings of classroom self-regulation and direct assessments of executive functions are similarly related to academic outcomes (Allan, Hume, Allan, Farrington, & Lonigan, 2014). However, studies have shown that teacher ratings of classroom self-regulation also independently contribute to academic achievement (Fuhs et al., 2015; Lipsey et al., 2017; McClelland & Cameron, 2012). Furthermore, there is some evidence that teacher ratings of self-regulation are better indicators of literacy skills than direct assessments, which are more strongly related to math skills (Schmitt et al., 2014; von Suchodoletz et al., 2013).

Although direct assessments of executive functions have the advantage of providing an objective assessment of children's regulatory capacities, teacher ratings of classroom self-regulation have the advantage of providing information on the fit between the child and their learning environment. Thus, there is utility in using both direct assessments of executive function skills and teacher ratings of classroom self-regulation as measurement tools for foundational school readiness skills at the start of kindergarten (Fuhs et al., 2015).

School Readiness and Longer-Term Achievement Gaps

Children from low-income families tend to start kindergarten behind their middle-income peers in math skills, such as number knowledge, counting, enumeration, number patterns, and story problems (Jordan, Kaplan, Nabors Oláh, & Locuniak, 2006), and these initial math levels are associated with slower growth in mathematics abilities from first to third grade (Jordan, Kaplan, Ramineni, & Locuniak, 2009). Reading and language skills are also strongly tied to household income in the early years (Aikens & Barbarin, 2008; Chatterji, 2006; Noble, McCandliss, & Farah, 2007). Children from families in poverty enter kindergarten anywhere from a half of a standard deviation to over a full standard deviation behind their well-to-do peers in language and literacy skills (Duncan & Magnuson, 2011), and these early gaps in reading achievement intensify from kindergarten to third grade (Aikens & Barbarin, 2008).

Socioeconomic disparities in academic achievement are also reflected in patterns of self-regulation and executive function skills at kindergarten entry (Li et al., 2017; Little, 2017; Reardon & Portilla, 2016; Wanless, McClelland, Tominey, & Acock, 2011). The relation between family income and working memory emerges early in childhood and appears to persist across middle childhood (Hackman, Gallop, Evans, & Farah, 2015). In addition, low-income children perform worse than their peers on aspects of attention in early childhood and continue to experience attentional deficits throughout the elementary grades (Dilworth-Bart, Khurshid, & Vandell, 2007; Mezzacappa, 2004). With regards to self-regulation, there is some evidence that low-income children are more frequently reported by teachers as demonstrating lower classroom self-regulation (Duncan, McClelland, & Acock, 2017; Rimm-Kaufman, Pianta, & Cox, 2000).

While learning English in the early years, low-income ELLs may also experience considerable deficits in academic achievement (Castro, Páez, Dickinson, & Frede, 2011; Wanless et al., 2011). Findings from a nationally representative dataset demonstrate that students who are not English proficient at the start of kindergarten enter kindergarten over a standard deviation below in math and over a half of a standard deviation below in reading (Reardon & Galindo, 2009). Low-income ELLs, in particular, score lower than their low-income English-speaking peers in literacy and math (Choi et al., 2018; Genesee et al., 2005; Lesaux, 2012). When ELLs enter kindergarten with limited English proficiency, they score significantly lower than their English-speaking peers in reading and math through eighth grade (Halle, Hair, Wandner, McNamara, & Chien, 2012).

Although advanced executive function skills have been found in bilingual speakers (Bialystok, 1999; Bialystok & Martin, 2004; Hartanto, Toh, & Yang, 2018; Morales, Calvo, & Bialystok, 2013), low-income, Spanish-speaking ELLs tend to perform worse on direct assessments of executive function tasks in preschool and kindergarten, even when these assessments are given in Spanish (McClelland & Wanless, 2012; Wanless et al., 2011). There is less literature comparing teacher ratings of self-regulation between ELLs and non-ELLs, but evidence suggests that teachers rate ELLs and non-ELLs similarly on classroom self-regulation in kindergarten (Diaz, 2016; De Feyter & Winsler, 2009; Galindo & Fuller, 2010; Halle et al., 2014; Luchtel, Hughes, Luze, Bruna, & Peterson, 2010). These results are consistent with studies showing that ELLs tend to score similarly as their monolingual English-speaking peers on measures of internalizing and externalizing behaviors in kindergarten (Dawson & Williams, 2008). Together, findings indicate that ELLs may demonstrate as strong self-regulation in the classroom due to their ability to comply with adults' requests (Kochanska, Coy, & Murray, 2001), or based on the fact that they lack complete comprehension of classroom instructions relayed in English.

Explaining Achievement Gaps

Studies taking a developmental systems approach have often emphasized the importance of contextual differences in parenting, home environments, and early learning experiences (Bassok, Finch, Lee, Reardon, & Waldfogel, 2016; Bradley & Corwyn, 2002; Duncan & Brooks-Gunn, 2000; Halle et al., 2012; Li et al., 2017; Linver, Brooks-Gunn, & Kohen, 2002; Mancilla-Martinez & Lesaux, 2011; McLoyd, 1998). However, developmental systems theories provide an explanation for specifying within-child processes that facilitate the effects of economic disadvantage and being of ELL status on school readiness and longer-term academic achievement (Duncan, Magnuson, & Votruba-Drzal, 2017). Because the foundations for learning are biologically and environmentally embedded, researchers have argued that individual executive function skills and classroom self-regulation can be considered building blocks for a range of higher-order concepts (Morrison, Ponitz, & McClelland, 2010). Yet, few studies have examined the unique contribution of executive function skills to the achievement gaps experienced by economically disadvantaged students in kindergarten and first grade (Fitzpatrick et al., 2014; Morgan et al., 2017). For example, Fitzpatrick and colleagues (2014) demonstrated that a composite measure of executive function skills in preschool partially mediated the effects of socioeconomic status on math achievement. These findings were repeated with individual assessments of attentional flexibility and working memory in first grade (Morgan et al., 2017). Among ELLs, working memory was found to contribute to English literacy skills in first grade and inhibitory control was found to explain math achievement in preschool and kindergarten (Choi et al., 2018; Swanson, Saez, Gerber, & Leafstedt, 2004). Conclusions from these studies, however, do not extend to other facets of executive functions, across achievement domains, or over multiple time points in school. Furthermore, less literature has focused on classroom self-regulation as a variable that explains the achievement gaps experienced by economically disadvantaged students and ELLs over the transition to school (Sektnan et al., 2010). Given the lack of empirical work in this area, it is currently unknown whether the same within-child processes during the formative transition to school lead to similar gaps in math *and* reading achievement among ELLs *and* economically disadvantaged students throughout the early elementary grades.

Present Study

The goal of the present study was to examine whether classroom self-regulation skills and/or individual executive function skills contribute to the achievement gaps experienced by economically disadvantaged students and ELLs in kindergarten and third grade. These associations were explored in a statewide dataset and a nationally representative dataset for two purposes. The first was to leverage the extensive battery of assessments that large datasets offer in comparison to local datasets. For example, Oregon's kindergarten assessment (OKA), which includes data on the skills and knowledge of all entering kindergarteners in the state of Oregon, only measures children's classroom self-regulation at the start of kindergarten, while the ECLS-K, which includes comparable information on a sample of kindergarteners around the country, assesses children's classroom self-regulation and individual executive function abilities. Analyzing both datasets renders it possible to investigate questions about the relative contribution of subjective ratings of self-regulation abilities and more objective measures of executive function capacities. Furthermore, the state of Oregon has the 3rd lowest high-school graduation rate in the nation (National Center for Education Statistics, 2016), accompanied by higher than average rates of childhood poverty and a growing Latino immigrant population (Oregon Community Foundation, 2016; U.S. Census Bureau, 2016). The second reason for attempting to replicate results across datasets is the opportunity to examine whether associations are robust to differences in measurement, sample characteristics, and contexts. Three research questions and corresponding hypotheses were explored.

1. **What are the achievement gaps between economically disadvantaged students and non-economically disadvantaged students and between English-language learners and non-English-language learners in kindergarten and third grade in a statewide dataset and a national dataset?**

It was hypothesized that children from economically disadvantaged backgrounds and ELLs would exhibit lower math and literacy skills at kindergarten entry compared to their peers without these risk factors (Kieffer, 2008; Reardon & Portilla, 2016). Furthermore, the gaps in achievement due to economic disadvantage were expected to increase from kindergarten to third grade (Aikens & Barbarin, 2008; Sirin, 2005). There is less existing research examining trends in achievement gaps experienced by ELLs, but in the present study, they were expecting to weaken by third grade due to the fact that English language skills improve over the course of schooling (Kieffer, 2008; Reardon & Galindo, 2009; Roberts & Bryant, 2011). Achievement gaps for economically disadvantaged students and ELLs were expected to be larger in Oregon than nationally because Oregon is at a slightly greater disadvantage in terms of its demographic makeup.

2. **Can the achievement gaps experienced by economically disadvantaged students and English-language learners in kindergarten and third grade be partially explained by classroom self-regulation skills in kindergarten in a statewide dataset and a national dataset?**

It was hypothesized that classroom self-regulation would explain some of the math and reading gaps experienced by economically disadvantaged students in kindergarten and third grade in both datasets. Although ELLs have been shown to demonstrate just as strong classroom self-regulation as non-ELLs, they consistently tend to perform lower than their English-speaking peers on direct assessments of academic achievement (Diaz, 2016; McClelland & Wanless, 2012). Since academic achievement is strongly related to classroom self-regulation among ELLs, accounting for classroom self-regulation skills among ELLs was expected to significantly reduce the achievement gaps at kindergarten and third grade in both datasets.

3. **In a national dataset, after accounting for classroom self-regulation skills, can individual executive function skills explain any of the achievement gaps among economically disadvantaged students and English-language learners in kindergarten and third grade?**

Given prior research documenting the mediating effects of executive functions between sociodemographic risk and academic achievement (e.g., Fitzpatrick et al., 2014; Morgan et la., 2017; Choi et al., 2018), it was hypothesized that kindergarten and third grade achievement gaps would be partially explained by individual executive function skills, even after accounting for classroom self-regulation abilities. Specifically, in the national dataset, individual executive function skills were expected to explain a significant proportion of the math and reading gaps in kindergarten and third grade among economically disadvantaged students and ELLs. This could not be explored in the Oregon dataset because the OKA does not include any direct assessments of executive function skills.

Method

Participants

ECLS-K. The proposed study uses data from the ECLS-K: Class of 2010-2011 and the OKA. The ECLS-K is a nationally representative sample of 17,339 kindergarten children who participated during the 2010-2011 school year, and approximately 13,600 children who were followed into the spring of third grade during the 2013-2014 school year. Children who repeated kindergarten or did not pass the language screener and spoke another language other than Spanish were excluded from the ECLS-K sample (n = 892). Children identified by teachers has having an IEP for special education services in kindergarten were also excluded (n = 750) because of the links between ADHD, learning disabilities, and executive functions (e.g., Biederman et al., 2004; Brocki & Bohlin, 2006). At baseline, the sample was 51% male. Forty-seven percent of the sample had family incomes at or below 200% of the poverty threshold. This is slightly higher than the U.S. Census Bureau estimate of children under 18 who lived in families with incomes 200% or below the poverty threshold in 2010 (44%; National Kids Count, 2017). The sample was fairly diverse in terms of race/ethnicity. A little less than half of the sample was White, non-Hispanic (47%), a quarter of the sample identified as Hispanic (25%), followed by Black (13%), Asian (9%), Mixed Race (4%), Native American (1%), and Pacific Islander (1%). Only 2% of the sample did not pass the English-language screener in kindergarten, indicating Spanish-speaking and limited English proficiency. Ninety-four percent of Spanish-speaking ELLs were also economically disadvantaged.

OKA. The OKA is a statewide effort led by the Oregon Department of Education to gain a snapshot of the skills that Oregon's children have when they enter kindergarten. The OKA dataset includes 34,490 entering kindergarteners in the 2013-2014 school year who had data that could be linked with third grade academic test scores during the 2016-2017 school year. Additional selection criteria prohibited including children who utilized special education services in kindergarten (n = 2,706) for the same reasons as stated in the national dataset. Children who attended schools that provided free or reduced lunch to all students under Provision 2 were also not included (n = 274) because their participation in Provision 2 made it impossible to decipher whether they themselves were experiencing economic disadvantage or whether they simply attended a school with a large proportion of economically disadvantaged students that made them eligible for this benefit. The final sample included 30, 876 children (49% male). Approximately 53% of the sample were eligible to receive either free or reduced lunch during the 2013-2014 kindergarten year (family income at or below 185% of the poverty level). This percentage is similar to the state as a whole for that school year (52%), according to the Oregon Department of Education. In kindergarten, parents reported on children's race/ethnicity. The sample was mostly White, non-Hispanic (63%), followed by Hispanic (24%), Mixed Race (5%), Asian (4%), Black (2%), Native American (1%), and Pacific Islander (1%). Approximately 14%

of the sample were Spanish-speaking and had limited English proficiency in kindergarten. Eighty-nine percent of Spanish-speaking ELLs were also economically disadvantaged.

Procedures

ECLS-K. In the fall of kindergarten and spring of third grade children were directly assessed on cognitive assessments of reading (language use and literacy), mathematics, and executive functions (working memory and attentional flexibility). The study employed a one- or two-stage assessment for kindergarten and third grade achievement measures in which children completed a set of items appropriate for their ability level rather than all items in the assessment. Patterns of right and wrong responses on common items were used to calculate IRT-based ability scores in reading and math that were on the same scale for all children. The IRT score therefore represents an estimate of the number of items a child would have answered correctly given that the child received all items. IRT scoring makes it possible to assess longitudinal gains in achievement even when items on assessments are not identical at both time points. Parent interviews were also conducted in the fall of kindergarten to obtain information about parent and child demographic characteristics. Teachers were asked to fill out a questionnaire in the fall of kindergarten that included questions about how often children exhibited certain social skills and behaviors within the classroom.

OKA. Most children entering a publicly funded kindergarten in the state of Oregon during the 2013-2014 academic school year were included in the de-identified OKA dataset provided by the Oregon Department of Education (ODE). Children were directly assessed on math and literacy measures within the first three weeks of kindergarten. Teachers rated children’s self-regulation in the classroom setting via questionnaire within the first six weeks of the kindergarten school year. In addition, ODE provided child-level demographic variables. The state of Oregon uses Smarter Balanced assessments to measure children's mathematics and English language arts abilities in the spring of third grade after 66% of instruction has been completed. The Smarter Balanced Assessment Consortium has developed a comprehensive assessment system for mathematics and English language arts that is aligned to the Common Core State Standards. To do this, each testing item is based on overall content claims and assessment targets. Smarter Balanced assessments use computer-adaptive software.

Measures

School readiness.

Literacy and reading. The reading assessment developed for the ECLS-K includes questions measuring basic skills (print familiarity, letter recognition, beginning and ending sounds, rhyming words, word recognition), vocabulary knowledge, and reading comprehension (Tourangeau, Nord, Le, Sorongon, Hagerdorn, Daly, & Najarian, 2013). Reading comprehension questions asked children to identify information specifically stated in text (e.g., definitions, facts, supporting details), make complex inferences within and across texts, and consider the text objectively and judge its appropriateness and quality. Possible weighted IRT-based reading scores ranged from 0-83. ELLs were administered the reading assessment in Spanish. The reliability coefficient was calculated based on the variance of repeated estimates of the overall ability estimate for each individual child compared with the total sample variance. For the kindergarten reading assessment, the reliability coefficient is reported in the technical manual as .95 (Tourangeau et al., 2013).

The OKA measures literacy skills with the easyCBM Letter Names and easyCBM Letter Sounds tasks. The Letter Names task assesses children's ability to name the letters of the English alphabet. In this assessment, children are shown a chart with upper- and lower- case letters and are instructed to name as many letters as they can in 60 seconds. At the end of 60 seconds, the testing administrator marks the last letter named and calculates the total number of letters identified correctly to arrive at the child's 'per minute' fluency-based score (Alonzo & Tindal, 2007). Possible scores ranged from 0-100. In previous research, the easyCBM Letter Names showed strong construct validity through its correlation with the DIBELS Letter Naming (r = .86) in a Kindergarten sample (Lai, Alonzo, & Tindal, 2013).

The easyCBM Letter Sounds assessment measures children's' ability to produce common sounds associated with letters of the English alphabet and common digraphs (Lai, Nese, Jamgochian, Alonzo, & Tindal, 2010). Children are shown a chart with letters and digraphs and are instructed to produce as many letter sounds as they can in 60 seconds. At the end of 60 seconds, the testing administrator marks the last letter responded to and calculates the total number of letters sounded correctly to arrive at the child's 'per minute' fluency-based score (Alonzo & Tindal, 2007). Possible scores ranged from 0-100. In previous research, the easyCBM Letter Sounds measure showed moderate construct validity through its correlation with the Initial Sound Fluency tasks (r =.55) in a Kindergarten sample (Lai et al., 2013).

ELLs were administered both EasyCBM literacy measures in English. Scores on Letter Names and Letter Sounds assessments were highly correlated in the OKA dataset (r = .76), consistent with prior work (Lipscomb, Miao, Finders, Hatfield, & Pears, 2018). Furthermore, in Oregon and beyond, floor effects have occurred on letter sounding tasks while ceiling effects have occurred on letter naming tasks (Catts, Petscher, Schatschneider, Sittner-Bridges, & Mendoza, 2009; Tindal, Irvin, Nese, & Slater, 2015; Wagner, Torgesen, & Rashotte, 1994). Therefore, in the current study, children's scores on Letter Names and Letter Sounds were averaged to create a literacy composite score in order to balance these distributions.

Mathematics. The math assessment developed for the ECLS-K was designed to measure skills in conceptual knowledge, procedural knowledge, and problem solving. The assessment consists of questions on number sense, properties, and operations; measurement; geometry and spatial sense; data analysis, statistics, and probability (measured with a set of simple questions assessing children's ability to read a graph); and pre-algebra skills such as identification of patterns (Tourangeau et al., 2013). Most of the items were read aloud to children by the assessor, and children were offered pencil and paper as part of the protocol. ELLs were administered the math assessment in Spanish. Possible weighted IRT-based math scores ranged from 0-75. The reliability coefficient was calculated based on the variance of repeated estimates of the overall ability estimate for each individual child compared with the total sample variance. For the kindergarten math assessment, the reliability coefficient is reported in the technical manual as .92 (Tourangeau et al., 2013).

The OKA measures math skills with the easyCMB math task. The easyCBM assesses children's ability to understand numbers, number systems, relationships among numbers, and meanings of operations (Anderson et al., 2010). Children are shown items that include counting, simple addition, simple subtraction, and recognizing number patterns. The assessment includes two sample items and 16 multiple-choice items. Children point to indicate their choice for a correct response from three possible answers. Children receive a score of 1 for each correct response, and possible scores ranged from 0-16. Unlike literacy, ELLs were administered the math assessment in Spanish. In an examination of construct validity, the correlation between the TerraNova and easyCBM math in the fall of kindergarten was strong ($r = 0.59$; Anderson et al., 2010).

Executive function skills. The ECLS-K includes two direct assessments that tap executive function skills.

Attentional flexibility (DCCS). The Dimensional Change Card Sort (DCCS) assesses children's attentional flexibility (Zelazo, 2006). In the DCCS, children were asked to sort a series of 12 picture cards into one of two trays according to color and then shape. If children correctly sort four of the six cards by shape, then they move on to a third sorting rule that instructed them to sort 6 additional cards by color if the card had a black border or sort by shape if the card did not have a black border. Children received a post-switch score representing the number of cards the child correctly sorted by shape (after switching from sorting by color to sorting by shape) and a border game score representing the number of cards the child correctly sorted when the sorting rule was determined by the presence or absence of a border around the card. Children received a point for each correct sort on 6 items in the post-switch section and 6 items in the border game section. These scores were summed for analyses, with possible scores ranging from 0-12. This version of the DCCS has been shown to be reliable in previous work (Hongwanishkul, Happaney, Lee, & Zelazo, 2005; Zelazo, 2006). The reliability coefficient for the post-switch and border items is Cronbach's $\alpha = 0.98$ in the current study.

Working memory (WJ Numbers Reversed). The Numbers Reversed subtest of the Woodcock-Johnson III Tests of Cognitive Abilities assesses children's working memory (Mather & Woodcock, 2001). In the Numbers Reversed task, children were asked to repeat increasingly long strings of orally presented numbers in reverse order. Children were given 5 two-number sequences, followed by 5 three-number sequences. The sequences became increasingly longer, up to a maximum of eight numbers, until the child floored by answering incorrectly to three consecutive number sequences. Standardized W-scores were used in the analyses, which are normed to account for the child's raw number-right score, age in months, and the language of administration. Possible weighted W-Scores on the Numbers Reversed task ranged from 393-581. The reliability coefficient for the items in the Numbers Reversed task is Cronbach's α = 0.99 in the current study.

Classroom self-regulation skills. The ELCS-K includes a teacher rating of children's self-regulation within the classroom that is derived from the Child Behavior Questionnaire (CBQ; Putnam & Rothbart, 2006). Teachers rated 12 items on a 7-point Likert-type scale to assess the frequency of behaviors exhibited in the classroom (e.g., works independently; easily adapts to changes in routine; persists in completing tasks; and follows classroom rules). The items were averaged for each child, and scores ranged from 0-7 in the current study. The reliability coefficient for the CBQ as reported in the technical manual is Cronbach's α = .87 (Tourangeau et al., 2013).

In the OKA, teachers reported on children's classroom self-regulation using the Child Behavior Rating Scale (CBRS; Bronson, Goodson, Layzer, & Love, 1990). The CBRS is based on the Bronson Social Task and Skill Profile (Bronson, 1991). Teachers rated 10 items using a 5-point Likert-type scale. Items included statements such as "Observes rules and follows directions without requiring repeated reminders" and "Completes tasks successfully." The 10 items for self-regulation were averaged for each individual child. Average self-regulation scores ranged from 1-5 in the current study. In previous work, the self-regulation subscale of the CBRS has been found to be significantly correlated with direct measures of executive function skills, including the DCCS (r = .44; R. Duncan et al., 2017). The reliability coefficient for the self-regulation items of the CBRS is Cronbach's α = 0.97.

Third grade academic achievement.

Mathematics. The same math assessment was administered in third grade by the ECLS-K as in kindergarten and measured skills in conceptual knowledge, procedural knowledge, and problem solving. The testing specifications for the third grade math assessment were based on the same NAEP frameworks developed for the kindergarten math assessment. The task consists of questions on number sense, properties, and operations, measurement, geometry and spatial sense, data analysis, probability, and patterns. Possible weighted IRT-based math scores ranged from 0-135. The reliability coefficient was calculated based on the variance of repeated estimates of the overall ability estimate for each individual child compared with the total sample variance. For the third grade math items, the reliability coefficient is reported in the technical manual as 0.92 (Tourangeau et al., 2018).

The Smarter Balanced math task administered in third grade in Oregon assessed concepts and procedures, problem solving, communicating and reasoning, and modeling/data. Questions were asked in many formats, requiring students to respond to multiple choice items, short answers, matching, and equations. For instance, a sample item in third grade that assesses problem solving abilities may ask: “There are 9 cherry trees. Kim picks 8 cherries from each tree. Kim eats 14 of the cherries she picked. Enter the number of cherries Kim has left”. In the current sample, Smarter Balanced math scores range from 1963-2937 in the spring of third grade. Information on the reliability and validity of the Smarter Balanced English language arts and mathematics assessments can be found in the technical report (Smarter Balanced Assessment Consortium, 2017).

Reading. The same reading assessment was administered in third grade by the ECLS-K as in kindergarten and measured basic skills, such as word recognition, vocabulary knowledge, and reading comprehension. The testing specifications for the third grade reading assessment were based on the same NAEP frameworks developed for the kindergarten reading assessment. Reading comprehension questions asked the child to identify information specifically stated in text (e.g., definitions, facts, supporting details); to make complex inferences within texts; and to consider the text objectively and judge its appropriateness and quality. Possible IRT-based readings scores ranged from 0-141. The reliability coefficient was calculated based on the variance of repeated estimates of the overall ability estimate for each individual child compared with the total sample variance. For the third grade reading items, the reliability coefficient is reported in the technical manual as 0.87 (Tourangeau et al., 2018).

The Smarter Balanced English language arts task administered in third grade in Oregon assessed reading, writing, listening, and research/inquiry skills. For example, a short answer question from the reading subtest requires children to read a passage and answer questions related to what they read. A sample item may ask: “What can the reader infer about the secret the father tells his sons? Include information from the passage in your answer”. In the current study, Smarter Balanced English Language Arts scores range from 2042-2712 in the spring of third grade. Information on the reliability and validity of the Smarter Balanced English language arts and mathematics assessments can be found in the technical report (Smarter Balanced Assessment Consortium, 2017).

Risk factors.

Economic disadvantage. In the ECLS-K, economic disadvantage was measured with a composite variable representing at or below 200% of the federal poverty level. This variable was created from each individual’s household income and household size, as reported by parents in the fall of kindergarten. In 2010, a family of 4 would be considered economically disadvantaged under these criteria if their pooled income fell below $44,100.

In the OKA dataset, children were flagged based on whether they were eligible to receive free lunch (family income at or below 130% of the poverty level) or reduced lunch (family income between 130% and 185% of the poverty level) during the kindergarten year (U.S. Department of Agriculture, 2012). In 2013, a family of 4 would be considered economically disadvantaged under these criteria if their pooled income fell below $43,568.

English-language learner. In the ECLS-K, a composite variable was created that applies to children who did not pass the English language screener and were identified by schools as speaking a non-English language at home (Kieffer, 2010). In the current study, children who were identified as ELLs and whose primary language was Spanish were considered ELLs.

In the OKA, children were officially identified as ELLs by each school district. If parents reported a primary language other than English was spoken in the home, children qualified for an initial language assessment. Children were flagged as ELLs if they did not pass the screener. In the current study, children who were identified as ELLs and whose primary language was Spanish were considered ELLs.

Control variables. Control variables available in the OKA are limited to gender and race/ethnicity in kindergarten. The same control variables were included from the ECLS-K so that the results could be replicated more reliably. Previous research has linked gender (Isaacs, 2012; Matthews, Ponitz, & Morrison, 2009; McCoy & Reynolds, 1999) and race/ethnic minority status (Lee & Burkam, 2002; Little, 2017) to skills at school entry.

Analytic Strategy

An achievement gap is a statistic describing the difference between two distributions on an academic assessment (Ho & Reardon, 2012). To answer the first research question, the achievement gaps were examined by estimating the differences in the central tendencies, or group averages, between economically disadvantaged students and non-economically disadvantaged students and between ELLs and non-ELLs on measures of math and reading (Reardon & Robinson, 2008). These achievement gaps were also expressed in standard deviation units, which is preferable for facilitating comparisons across tests with difference scoring scales (Hedges & Olkin, 1985). Specifically, math and literacy at kindergarten entry, and math and reading in third grade, were regressed on economic disadvantage in kindergarten. The coefficients for economic disadvantage in these models represent the unadjusted achievement gaps due to economic disadvantage. After obtaining the point estimates for the raw achievement gaps due to economic disadvantage, ELL status was added in a subsequent regression model predicting math and literacy in kindergarten, and math and reading in third grade with economic disadvantage. Because the majority of Spanish-speaking ELLs in both samples were also economically disadvantaged, examining the coefficient for ELL status while controlling for income provides a less-biased estimate of the effect of ELL status and better disentangles the magnitude of the ELL gap (Little, 2017; Roberts & Bryant, 2011).

To look at the factors that help to explain achievement gaps, researchers have measured statistically how much of the gap remains after controlling for a host of observed variables (e.g., Duncan & Magnuson, 2005). For example, Elder & Zhou (2017) report that controlling for a small set of observable background characteristics, such as gender, SES, birth weight, and the number of books the child owns, almost makes the entire black-white test score gap, and a majority of the Hispanic-white gap, disappear for kindergarten reading and math assessments. The same approach was followed in the current study by running a set of comparable nested regression models in the national and statewide datasets at both time points. Building on the models for the raw and adjusted achievement gaps, covariates for racial/ethnic minority status and gender were added as predictors of math and reading in kindergarten and third grade for both datasets. In the third grade models, the same kindergarten autoregressive skill was also included as a covariate at this stage. This follows the analytic approach of others who have subsequently controlled for lagged test scores when modeling achievement gaps as a means to partition the variance due to prior skill level (e.g., Fitzpatrick et al., 2014; Choi et al., 2018; Michelmore & Dyrnaski, 2017; Morgan et al., 2017). Finally, to answer the second research question, classroom self-regulation in kindergarten was added as a predictor of math and literacy in kindergarten, and math and reading third grade for both datasets.

To answer the third and final research question, the same set of regression models for the second research questions were run. As a final step, two measures of individual executive function skills (attentional flexibility and working memory) were added in subsequent models in the national dataset only. A complementary approach to Baron & Kenny's (1986) product of the coefficients method (*ab)* analyzes the difference- in- coefficients (*c* - *c'*) before and after adjustment for the intervening variable (Freedman & Schatzkin, 1992). This method was utilized in the current study because the indirect pathways tested by traditional mediation models were not of interest. The results from each regression were stored with the `estimates` command and combined with `suest`. The coefficients for economic disadvantage and ELL status between models with and without self-regulation and executive functions were subsequently compared using adjusted Wald-tests with the `test` command.

Weighting. Data collection in large-scale surveys is typically organized using specialized sampling techniques that include stratification, clustering, and multiple stages of collection. In the ECLS-K, a multi-stage sampling design involved sampling primary sampling units (PSUs) and schools with probabilities proportional to the targeted number of children attending the school. In addition, a cluster design was used which restricted data collection to a limited number of geographic areas and to as few schools as possible in order to maximize costs while achieving precision of estimates. Such equal probability sampling may lead to biased estimates and standard errors in clustered data when samples include unequal probability of selection (Kolenikov, 2010). To account for sampling design, researchers recommend weighting in order to produce point estimates that are representative of the target population (Solon, Haider, & Wooldridge, 2015). Sampling weights are the inverse probabilities of selection. In the current study, the W7C17P_20 weight was applied in all regression analyses using the national dataset, which adjusts for non-response and sampling error associated with child direct assessments in kindergarten and third grade as well as parent questionnaire data collected in the fall or spring of kindergarten (Tourangeau et al., 2018).

Standard errors. Weighting adjustments make inferences about the population parameters more valid but tend to increase the variance of the estimates. Therefore, it is necessary to correct the standard errors for these adjustments when using weighted data. Specifically, for the W7C17P_20 weight, the variance increases by approximately 44% due to weight adjustments (Tourangeau et al., 2018). For complex survey designs, clustered, multistage sampling and the use of differential sampling rates can be accounted for with variance estimation methods such as Taylor Series linearization and Replication. In the current study, replicate weights with the jackknife variance estimator procedure were preferred over Taylor linearization because Taylor Series is unable to estimate standard errors accurately when the number of observations within PSUs is small (Kreuter & Valliant, 2007). In the jackknife method, each survey estimate of interest is calculated for the full sample as well as for each of the replicates. The variation of the replicate estimates around the full-sample estimate is used to estimate the variance for the full sample. Replicate weights for the jackknife method with two PSUs per stratum (JK2) were applied using `jkrweight(W7C17P_21-W7C17P_240) vce(jack) mse`. In the analyses with the ECLS-K, the `svyset` function in Stata was used with the `svy: regress` command to specify sampling design, including probability weights, replicate weights, and jackknife replication in linear regression models. In Oregon, the `nestreg` command with a sandwich estimator specified by `vce(cluster clusterid)` was used to account for non-independence of the child observations within classrooms at both time points.

Results

Descriptive statistics, including means and standard deviations, are presented separately by economic disadvantage and ELL status for both datasets in Tables 1-4. Bivariate correlations for the full sample in each dataset are presented in Tables 5 and 6. For the national dataset, descriptive statistics are included for the unweighted and weighted data, but correlations were run on the weighted data only. Correlations for the national dataset were obtained in Mplus 7 (Muthén & Muthén, 2012) and all remaining data analyses were conducted in Stata 14.0 (Stata Corp, 2015).

Each column in Tables 7 and 8 represent a separate regression model. In Table 7, column (1) indicates the coefficient for economic disadvantage alone, column (2) indicates the coefficient for economic disadvantage once ELL status is accounted for, column (3) indicates the coefficient for economic disadvantage after gender and racial/ethnic minority are accounted for (in third grade it also controls for the autoregressive skill from kindergarten), column (4) indicates the coefficient for economic disadvantage once classroom self-regulation is accounted for, and column (5) indicates the coefficient for economic disadvantage after accounting for individual executive function skills in the national dataset only.

Table 8 reports the coefficients for ELL status with the same sequence of models as were performed for economic disadvantage except that ELL status is never modeled without adjusting for economic disadvantage. Therefore, column (1) indicates the coefficient for ELL status after accounting for economic disadvantage, and so on. Both unstandardized and standardized coefficients are reported in order to facilitate interpretation. All standard errors are robust to design effects including correlation of observations within schools. Wald-tests revealed whether point estimates were significantly different from prior model point estimates. Results from Wald-tests are indicated by the significance stars in Tables 7 and 8.

What are the achievement gaps between economically disadvantaged students and non-economically disadvantaged students and between English-language learners and non-English-language learners in kindergarten and third grade in a statewide dataset and a national dataset?

The achievement gaps due to economic disadvantage were examined in the first set of regression models for each academic outcome in kindergarten and third grade and can be found in column (1) of Table 7. Overall, children who were economically disadvantaged in kindergarten scored between a quarter to just over a third of a standard deviation lower in math and literacy in kindergarten and third grade when compared to children who were not economically disadvantaged in kindergarten[1]. The kindergarten math gap due to economic disadvantage was 0.264 standard deviations in Oregon (*b* = 1.685, *SE* = 0.057) and 0.322 standard deviations nationally (*b* = -7.389, *SE* = 0.155), while the kindergarten literacy score gap was 0.353 standard deviations in Oregon (*b* = 8.866, *SE* = 0.265) and 0.285 standard deviations

[1] In Oregon, these represent raw differences in kindergarten or third grade math and reading between children who were eligible and ineligible to receive subsidized meals in kindergarten. In the national dataset, these represent raw differences in kindergarten or third grade math and reading between children whose household incomes were at or below 200% of the poverty line and above 200% of the poverty line in kindergarten.

nationally (*b* =.-6.409, *SE* = 0.147). By third grade, coefficients for the economic gaps converge between the datasets, narrowing in some cases and widening in others. In Oregon, the math and reading gaps increased by 0.09 standard deviations and 0.01 standard deviations, while nationally, the math gap decreased by 0.02 standard deviations and the reading gap increased by 0.03 standard deviations when compared to kindergarten. These changes resulted in math gaps of 0.343 standard deviations in Oregon (*b* = -56.751, *SE* = 1.801) and 0.304 standard deviations nationally (*b* = -9.182, *SE* = 0.177), and reading gaps of 0.342 standard deviations in Oregon (*b* = -60.354, *SE* = 1.809) and 0.317 standard deviations nationally (*b* = -8.956, *SE* = 0.171) in third grade.

It is important to keep in mind that these are the raw coefficients, not controlling for child characteristics. As indicated by column (2) in Table 7, controlling for children's ELL status significantly reduced math and reading gaps in kindergarten and third grade by approximately 18% in Oregon and 5% nationally. Controlling for children's gender, racial/ethnic minority status, and their same domain prior academic skill also significantly reduced the gaps in Oregon and nationally, as indicated by column (3) in Table 7. However, the kindergarten literacy gap was not significantly reduced by accounting for these background covariates in Oregon (*b* = -7.197, *SE* = 0.255, $p > 0.05$). The proportion of achievement gaps explained by child characteristics for economically disadvantaged students is illustrated in Figure 1.

The achievement gaps due to being of ELL status, after accounting for economic disadvantage, can be found in column (1) of Table 8 for each academic outcome in kindergarten and third grade. Overall, children who were ELLs in kindergarten scored approximately a tenth to a twentieth of a standard deviation lower in math and literacy in kindergarten and third grade when compared to children who were not ELLs in kindergarten[2]. The kindergarten math gap due to being of ELL status was 0.160 standard deviations in Oregon and 0.136 standard deviations nationally, while the kindergarten literacy score gap was 0.227 standard deviations in Oregon and 0.129 standard deviations nationally. By third grade, coefficients for the gaps due to ELL status narrowed in Oregon and nationally. In Oregon, math and reading gaps decreased by 0.02 standard deviations and by 0.05 standard deviations, while nationally, the math gap decreased by 0.04 standard deviations and the reading gap remained relatively unchanged when compared to kindergarten. These changes resulted in third grade math gaps of 0.143 standard deviations in Oregon and 0.095 standard deviations nationally, and reading gaps of 0.174 standard deviations in Oregon and 0.131 standard deviations nationally.

These are not completely unadjusted coefficients because they do take economic disadvantage into account. As indicated by column (2) in Table 8, controlling for children's gender, racial/ethnic minority status, and their same domain prior academic skill significantly reduced math and reading gaps in kindergarten and third grade in both datasets. The proportion of achievement gaps explained by child characteristics for ELLs is represented in Figure 2.

Are the achievement gaps experienced by economically disadvantaged students and English-language learners in kindergarten and third grade partially explained by classroom self-regulation skills in kindergarten in a statewide dataset and a national dataset?

The achievement gaps due to economic disadvantage, adjusting for child characteristics, prior academic skills, and classroom self-regulation, were examined in the fourth set of

[2] In both datasets, these represent raw differences in kindergarten or third grade math and reading between children who were English proficient at the start of kindergarten and children who were Spanish-speaking with limited English proficiency at the start of kindergarten.

regression models for each academic outcome in kindergarten and third grade and can be found in column (4) of Table 7. In Oregon, accounting for classroom self-regulation in the regression models for economic disadvantage significantly reduced math and reading gaps in kindergarten and third grade. In the national dataset, accounting for self-regulation in the regression models only significantly reduced the math and reading gaps in kindergarten (Figure 1). Classroom self-regulation at kindergarten entry explained approximately 12-15% of the school readiness gaps among economically disadvantaged students in Oregon, and 8-12% of the school readiness gaps among economically disadvantaged students nationally. In Oregon, classroom self-regulation measured at kindergarten entry continued to explain approximately 7% of the math gap and 4% of the reading gap experienced by economically disadvantaged students in third grade, but none of the gaps nationally.

The achievement gaps due to being of ELL status, adjusting for child characteristics, prior academic skills, and classroom self-regulation, were examined in the third set of regression models for each academic outcome in kindergarten and third grade and can be found in column (3) of Table 8. In Oregon, accounting for classroom self-regulation in the regression models significantly reduced math and reading gaps in kindergarten, but not in third grade. In the national dataset, accounting for classroom self-regulation in the models only significantly reduced the kindergarten math gap (Figure 2). Classroom self-regulation measured at kindergarten entry explained approximately 3-4% of the school readiness gaps among ELLs in Oregon and 7% of the math gap among ELLs nationally. In Oregon, accounting for classroom self-regulation slightly increased the effect of ELL status on third grade reading, but this increase of 0.006 standard deviations was not practically meaningful. Classroom self-regulation did not explain a significant portion of the math gaps among ELLs in third grade for either dataset.

In a national dataset, after accounting for classroom self-regulation skills, can individual executive function skills explain any of the achievement gaps among economically disadvantaged students and English-language learners in kindergarten and third grade?

In column (5) of Table 7, the achievement gaps due to being economically disadvantaged and adjusting for child characteristics, prior academic skills, classroom self-regulation, and executive function skills were examined in the last set of regression models in the national dataset only. Accounting for attentional flexibility and working memory skills in the regression models significantly reduced math and reading gaps in kindergarten and third grade in the national dataset (Figure 1). Attentional flexibility and working memory skills at kindergarten entry explained 26-27% of the school readiness gaps due to being economically disadvantage and 2-5% of the third grade achievement gaps due to being economically disadvantaged nationally.

In column (4) of Table 8, the achievement gaps due to being of ELL status after adjusting for child characteristics, prior academic skills, classroom self-regulation, and executive function skills were examined in the last set of regression models in the national dataset. Accounting for attentional flexibility and working memory skills in the regression models significantly reduced math and reading gaps in kindergarten, as well as the third grade reading gap in the national dataset (Figure 2). Attentional flexibility and working memory skills at kindergarten entry explained 48-49% of the school readiness gaps due to being of ELL status and 17% of the third grade reading gap nationally. Accounting for individual executive function skills in the model of third grade math increased the gap between ELLs and non-ELLs by approximately 10%.

Discussion

The current study sought to clarify the contribution of classroom self-regulation skills and individual executive functions for school readiness and longer-term achievement gaps experienced by economically disadvantaged students and ELLs in Oregon and nationally. Initial estimates of the achievement gaps demonstrated that, overall, economically disadvantaged kindergarteners in Oregon faced similar challenges during the transition to school as economically disadvantaged kindergarteners across the nation. Specifically, while the math gap due to economic disadvantage in kindergarten was larger nationally than in Oregon, the reading gap was larger in Oregon than nationally. This could reflect the large population of English-language learners who are all mostly economically disadvantaged in Oregon (14%) at kindergarten entry compared to nationally (2%). By third grade, these achievement gaps were comparable across both datasets. This was somewhat inconsistent with the hypothesis that achievement gaps due to economic disadvantage would universally increase over the course of the first few years of schooling in both datasets and may suggest variability in achievement gaps based on measurement and context.

Being of ELL status, after adjusting for economic disadvantage, had a larger effect on achievement in Oregon than nationally for all outcomes. For kindergarten literacy, in particular, this may have been due to the fact that Spanish-speaking ELLs in Oregon were administered the assessment in English unlike the Spanish-speaking ELLs nationally. The gaps due to being of ELL status consistently reduced in both datasets by third grade, with the exception of reading in the national dataset. These findings aligned with a small body of prior research suggesting that as ELLs progress through school, their math and literacy skills improve at a faster rate than their monolingual English-speaking peers (e.g., Choi et al., 2018; Kieffer, 2008; Reardon & Galindo, 2009). Furthermore, it appears that trends in gaps for ELLs are less vulnerable to differences in measurement tools and contexts, as these gaps took on the same pattern between datasets.

Classroom Self-Regulation Skills Explaining Achievement Gaps

As hypothesized, kindergarten classroom self-regulation explained a significant portion of the school readiness gaps across outcomes and between datasets, with the exception of kindergarten literacy among ELLs nationally. This suggests that classroom self-regulation is one potential mechanism through which disparities in math and literacy are manifested at kindergarten entry, regardless of context and measurement. Thus, consistent with hypotheses, the developmental pathways that underlie school readiness in Oregon's kindergarteners appear to be generally the same in a nationally representative sample of kindergartners, with the exception of kindergarten literacy gaps among ELLs in the national dataset. In previous studies, kindergarten literacy has been found to be more strongly linked to classroom self-regulation than math (Schmitt et al., 2014; von Suchodoletz et al., 2013). However, this was the first study to examine the explanatory power of classroom self-regulation for literacy among ELLs specifically. Given that literacy assessments were administered to ELLs in Spanish in the national dataset, it's likely that kindergarten literacy among ELLs is heavily influenced by factors that are not accounted for in the present study, such as Spanish language proficiency (Kieffer, 2008; Winsler, Kim, & Richard, 2014).

In third grade, the results were less consistent between contexts. In line with prior research, kindergarten classroom self-regulation continued to explain the math and reading gaps among economically disadvantaged students in Oregon (Sektnan et al., 2010). In the national dataset, classroom self-regulation did not explain any of the third grade achievement gaps among ELLs or economically disadvantaged students. It's possible that classroom self-regulation at kindergarten entry may have continued to explain the third grade achievement gaps among economically disadvantaged students in Oregon because standardized assessments in Oregon required children to exercise their classroom based self-regulation skills, such as ignoring distractions, paying attention, remembering instructions, and persisting on challenging tasks, more so than the third grade math and reading assessments in the ECLS-K. In the national dataset, once child characteristics, including prior skill levels, were entered into third grade models, the gaps due to economic disadvantage and ELL status were almost negligible. At that point, there was very little variance leftover for classroom self-regulation to explain.

Another potential reason that the third grade gaps in the national dataset were less likely to be explained by children's classroom self-regulation in kindergarten is because scores on similar academic tests in kindergarten and third grade are highly correlated, which may have resulted in the crowding out of other less-related skills, as previous work has also demonstrated (Fitzpatrick et al., 2014). Indeed, studies have shown that test scores in math and reading are relatively stable over the first few years of school (Byrnes & Wasik, 2009; Chatterji, 2006; Claessens & Engel, 2013). It has been less common to examine these associations longitudinally and also control for prior academic skills (Sektnan et al., 2010; Turner Nesbitt et al., 2013). Therefore, these findings may represent conservative estimates of the explanatory power of classroom self-regulation for third grade achievement gaps.

The third grade achievement gaps due to being of ELL status were not consistently reduced after accounting for classroom self-regulation skills in Oregon or nationally. This suggests that differences in third grade achievement between ELLs and non-ELLs in kindergarten may not be accurately reflected by how well teachers think they can meet environmental demands at the start of kindergarten. Additionally, given that classroom self-regulation continued to explain a portion of the third grade math and reading gaps among economically disadvantaged students in Oregon, these findings provide some evidence of variability in developmental processes that underlie longer-term achievement gaps between students experiencing different sociodemographic risk factors. There appears to be something unique about the classroom self-regulation of ELLs that prohibits these skills from explaining their academic performance into third grade. This may result from the relatively weak correlation between ELL status and classroom self-regulation in Oregon (r = -0.07). Perhaps, as previous research has demonstrated, classroom self-regulation in kindergarten is not as strongly differentiated between ELLs and non-ELLs (Diaz, 2016), and therefore, cannot exert a powerful influence on more distal academic outcomes.

Individual Executive Function Skills Explaining Achievement Gaps

As hypothesized, individual executive function skills consistently explained school readiness and longer-term achievement gaps in the national dataset. In fact, attentional flexibility and working memory explained a large proportion of the math and reading gaps in kindergarten and third grade, even after adjusting for teacher-rated self-regulation in the classroom. These findings align with prior work demonstrating that children's ability to remember and follow multi-step instructions, solve problems, and manipulate and apply information at the start of kindergarten has important implications for their academic skills and growth in achievement over the first few years of schooling (Best & Miller, 2010; Bull et al., 2008; Duncan et al., 2007; Morgan et al., 2017). More importantly, the results of this study provide additional evidence that individual executive functions are one distinct mechanism through which achievement gaps for economically disadvantaged students and ELLs are actualized (Fitzpatrick et al., 2014; Choi et al., 2018), and demonstrate that classroom self-regulation skills and individual executive functions measured at kindergarten entry tap different skills in context (R. Duncan et al., 2017; Lipsey et al., 2015). The relative importance of executive function skills for kindergarten and third grade achievement gaps in Oregon, however, could not be examined.

A large portion of the achievement gaps were attributed to child factors in these models, as evident by large reductions in the coefficients for economic disadvantage once gender, racial/ethnic minority status, and in third grade, prior same domain academic skills were included. Math and reading gaps in third grade among economically disadvantaged students, in particular, seemed to be heavily influenced by kindergarten achievement in Oregon and nationally. The largest reduction in gaps occurred for third grade math nationally, where approximately 74% of the math gap among economically disadvantaged students was explained by child characteristics, including prior math. This suggests that math may be an additional mechanism through which achievement gaps are transmitted to children from economically disadvantaged homes, particularly in later grades (Stipek & Valentino, 2015). For instance, researchers argue that high-quality mathematics education may have the dual benefit of teaching math content area and developing executive function processes (Clements, Sarama, & Germeroth, 2016). Alternatively, interventions focusing on executive functions that overlap with math skills, such as planning, may provide an even larger reduction in achievement gaps (Crook & Evans, 2014). Exploring these nuances in future research could lead to important conclusions that currently linger in the field.

Contrary to hypotheses, accounting for attentional flexibility and working memory actually caused the effect of ELL status on third grade math to grow rather than reduce in size. In fact, ELLs were predicted to have stronger third grade math skills than non-ELLs after holding classroom self-regulation and all other covariates constant. The most likely explanation for this finding is a suppresser effect. Specifically, a negative suppresser may have a positive correlation with one or more predictor variable and with the outcome variable, but when entered simultaneously into a regression model, the negative suppresser takes on the opposite sign (e.g., Conger, 1974; Pandey & Elliot, 2010). Given the correlational nature of the analyses, this result should be interpreted with caution.

Limitations and Future Directions

The present study is not without limitations. First and foremost, the results from this study are only correlational, and therefore, cannot support a conclusion as to whether economic disadvantage and ELL status are casually related to school readiness and third grade achievement through classroom self-regulation and executive function processes. While the analyses did account for child characteristics and early skills that are strongly associated with academic outcomes in the early years of schooling (Jacob & Parkinson, 2015), the limitations of administrative data permitted studying the influence of other known factors that are related to poverty and ELL status as well as the outcomes of interest. For example, the quality of the home environment, including cognitive and language stimulation, as well as access to parenting quality and educational investments are all known drivers of achievement gaps (Bassok et al., 2016; Bradley & Corwyn, 2002; Cheadle, 2008; Duncan & Brooks-Gunn, 2000). These environmental factors, while also associated with children’s self-regulation and executive function skills, may be spuriously contributing to the gaps in achievement between lower-income and higher-income peers or ELLs and non-ELLs. Future directions include utilizing quasi-experimental designs, such as propensity score matching and instrumental variable approaches, to rule out omitted variable bias (Schneider, Carnopy, Kilpatrick, Schmidt, Shavelson, 2007).

Following recommendations by Freedman & Schatzkin (1992), the present study analyzed the difference- in- coefficients before and after adjusting for classroom self-regulation skills and individual executive functions in order to explain achievement gaps. In future work, the mediated pathways through classroom self-regulation and individual executive functions could be simultaneously analyzed and compared using structural equation modeling (SEM) framework (Preacher & Hayes, 2008). Doing so would clarify which mechanisms are the strongest for explaining specific academic outcomes for ELLs and economically disadvantaged students, perhaps leading to a more refined conclusions about intervention levers prior to kindergarten entry. In addition, although the *(c – c')* estimates are the same mathematically as the *(ab)* estimates, one limitation of this method is that it is prone to produce higher Type I error rates (Zhang, Zyphur, & Preacher, 2009). Performing product coefficient mediation analysis as a complement to the difference- in- coefficient analysis could add robustness to these findings in the future.

Finally, it is important to note that this study did not formally test whether effect sizes in the Oregon dataset were different from effect sizes in the national dataset, or whether changes in achievement gaps over time were statistically significant. Rather, the goal was to describe the unadjusted gaps prior to running the full battery of nested regression models, as well as to contextualize these disparities and provide a common starting point from which to analyze the role of classroom self-regulation and individual executive functions in reducing achievement gaps. When reliable and valid measures of school readiness exist in multiple datasets, it would be useful to do such comparisons in order to strengthen our knowledge of whether the achievement gaps take on the same trajectories over time and across contexts.

Implications

Overall, the current study has several important implications for science and practice. When randomized experiments are difficult or impossible, researchers often turn to quasi-experimental designs. However, evidence-based policies rest on the ability to replicate results and not just produce statistically significant findings (Miguel et al., 2014). Specifically, when causal conclusions cannot be made, replication may be the only way to verify the reliability of an effect or association (Simons, 2014). Acknowledging the importance of replication for scientific results and for promoting research integrity (Duncan, Engel, Claessens, & Dowsett, 2014), this study produced findings that were robust to context, measures, and sample characteristics. As a result, policy makers should have increased confidence in the generalizability of findings as they make informed decisions on how to close achievement gaps.

Results that may be of particular interest suggest that achievement gaps in Oregon are similarly explained by classroom self-regulatory processes as achievement gaps nationally. Specifically, deficiencies in math and literacy skills among children from economically disadvantaged homes and ELLs appear to be universally tied to the perceptions that teachers have about how well children can navigate the complexity of the classroom environment, regardless of which measures are used to capture these skills. Early childhood educators could help children enter kindergarten more prepared to meet these demands by practicing being able to stay on task, persisting through challenges, working independently, and following instructions. For example, there is evidence that attending even just a few weeks of a kindergarten preparation program focused on practicing classroom self-regulation skills can improve school readiness skills such as math and literacy, and ultimately, ease the transition to kindergarten for low-income children with no prior preschool experience (Duncan, Schmitt, Burke, & McClelland, 2018). Given that children from low-income families have lower rates of preschool enrollment in general (Magnuson & Duncan, 2016), performing a cost-benefit analysis to examine whether short-duration kindergarten preparation programs provide an equal, greater, or added advantage when compared to traditional preschool programs or targeted interventions is an important next step to answering questions that may be relevant to policy makers.

Additionally, the largest effect sizes were observed with respect to individual executive function skills explaining short- and long-term achievement gaps nationally. Although this could not be replicated in Oregon, these results may be used to motivate future directions in the field. For instance, researchers should investigate whether including measures of individual executive function skills in the OKA yields similar findings. Furthermore, it may be worthwhile to examine the role of inhibitory control skills for school readiness and longer-term achievement gaps because, although not a focus of this study, inhibitory control has been found to explain achievement gaps experienced by ELLs (Choi et al., 2018). In addition, the results from this study indicate that child characteristics such as gender, racial/ethnic minority status, and kindergarten achievement overwhelmingly contribute to the achievement gaps in third grade, even more so than classroom self-regulation or individual executive function skills. Teasing apart these influences is imperative for understanding the roots of disparities over the long-run. Certainly, the approach for reducing achievement gaps will differ based on whether gender or racial/ethnic minority status explain the largest proportion of third grade achievement gaps or if prior academic skills are more heavily responsible.

Conclusion

This was the first study to test whether developmental systems theories can be applied to the early achievement gaps experienced by economically disadvantaged students and ELLs in a statewide (e.g., Oregon) and national context. The findings have implications for programs aimed at measuring and reducing achievement gaps. One strength of this study was the ability to compare mechanisms behind school readiness and longer-term achievement gaps across contexts and measures through the replication process. Results that were robust to contexts and measures indicated that, when direct assessments of executive function skills were not available, classroom self-regulation reliably explained school readiness gaps among economically disadvantaged students and ELLs. Where assessments of both classroom self-regulation and individual executive functions were available, the relative importance of classroom self-regulation for longer-term achievement gaps may have been masked by the stability in measurement of academic achievement over time. Together, these findings contribute new evidence that measuring and targeting children's classroom self-regulation skills prior to kindergarten entry may complement traditional approaches that concentrate on improving academic abilities as a means to attenuate school readiness and longer-term achievement gaps (Yen, Konold, & McDermott, 2004).

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Table 1

Descriptive statistics by economic disadvantage (OKA)

	Economically Disadvantaged			**Non-Economically Disadvantaged**		
	N	***M***	***SD***	***N***	***M***	***SD***
K Math	16,190	7.36	2.98	14,602	9.06	3.18
K Literacy	16,035	9.16	10.35	14,557	18.02	13.12
K Self-Regulation	16,069	3.49	0.82	14,397	3.77	0.79
3rd Grade Math	16,132	2403.63	77.25	14,549	2460.52	77.86
3rd Grade Reading	16,111	2393.63	82.29	14,558	2454.20	83.30
English-Language	16,239	0.23	0.42	14,637	0.03	0.18
Female	16,239	0.52	0.50	14,637	0.50	0.50
Racial/Ethnic Minority	16,239	0.50	0.50	14,637	0.24	0.42

Table 2

Descriptive statistics by economic disadvantage (ECLS-K)

	Economically Disadvantaged			Non-Economically Disadvantaged		
Weighted	***N***	***M***	***SD***	***N***	***M***	***SD***
K Math	3,506	31.59	8.19	4,556	38.97	9.52
K Literacy	3,500	49.94	7.45	4,558	56.35	9.97
K Self-Regulation	3,260	4.75	0.95	4,274	5.05	0.93
Attention	3,506	8.09	2.55	4,557	9.05	2.12
Working Memory	3,506	427.43	22.59	4,557	442.79	24.80
3rd Grade Math	3,515	98.06	12.17	4,561	107.24	11.02
3rd Grade Reading	3,514	112.29	11.34	4,560	121.24	10.33
English-Language	3,522	0.04	0.16	4,565	0.00	0.05
Female	3,522	0.50	0.39	4,565	0.49	0.42
Racial/Ethnic Minority	3,522	0.64	0.46	4,564	0.31	0.48
Unweighted	***N***	***M***	***SD***	***N***	***M***	***SD***
K Math	4,867	31.44	10.50	5,863	39.40	11.57
K Literacy	4,859	49.85	9.76	5,867	56.71	12.34
K Self-Regulation	4,570	4.70	1.23	5,510	5.08	1.13
Attention	4,867	8.08	3.27	5,864	9.06	2.58
Working Memory	4,865	427.05	28.78	5,864	443.44	29.78
3rd Grade Math	4,165	98.01	15.46	5,102	107.77	13.16
3rd Grade Reading	4,164	112.03	14.66	5,101	121.81	12.18
English-Language	4,894	0.04	0.20	5,878	0.00	0.05
Female	5,740	0.50	0.50	6,600	0.49	0.50
Racial/Ethnic Minority	5,739	0.66	0.47	6,599	0.35	0.48

Note. ECLS-K estimates weighted by W7C17P_20 using jackknife replicate weights W7C17P_21- W7C17P_240 to adjust standard errors; some subpopulation observations were dropped in weighted estimates due to missing values

Table 3

Descriptive statistics by English-language learner status (OKA)

	English-Language Learner			**Non-English Language Learner**		
	N	***M***	***SD***	***N***	***M***	***SD***
K Math	4,213	6.37	2.77	26,579	8.45	3.17
K Literacy	4,107	3.55	6.00	26,485	14.90	12.61
K Self-Regulation	4,206	3.48	0.81	26,260	3.65	0.82
3^{rd} Grade Math	4,204	2382.96	72.64	26,477	2438.17	81.53
3^{rd} Grade Reading	4,199	2364.86	74.84	26,470	2431.51	86.60
English-Language	4,228	0.89	0.32	26,648	0.47	0.50
Female	4,228	0.53	0.50	26,648	0.51	0.50
Racial/Ethnic Minority	4,228	0.98	0.14	26,648	0.28	0.45

Table 4

Descriptive statistics by English-language learner status (ECLS-K)

	English-Language Learner			**Non-English-Language Learner**		
Weighted	***N***	***M***	***SD***	***N***	***M***	***SD***
K Math	225	21.68	7.65	9,072	35.32	10.11
K Literacy	212	40.53	4.85	9,080	53.19	9.98
K Self-Regulation	220	4.53	1.02	8,440	4.90	1.04
Attention	226	5.51	3.48	9,072	8.60	2.59
Working Memory	226	402.58	17.51	9,071	435.39	26.85
3rd Grade Math	238	88.38	12.83	9,077	102.71	13.31
3rd Grade Reading	237	100.41	11.90	9,078	116.94	12.39
Economic Disadvantage	196	0.92	0.22	7,891	0.46	0.44
Female	238	0.50	0.41	9,092	0.50	0.45
Racial/Ethnic Minority	238	1.0	0.0	9,090	0.47	0.45
Unweighted	***N***	***M***	***SD***	***N***	***M***	***SD***
K Math	290	21.16	8.58	13,941	35.06	11.50
K Literacy	275	40.46	5.79	13,958	52.95	11.39
K Self-Regulation	284	4,56	1.20	12,939	4.88	1.21
Attention	291	5.27	4.23	13,938	8.54	2.99
Working Memory	291	401.00	19.29	13,934	434.66	30.10
3rd Grade Math	278	87.67	15.77	9,934	102.91	14.91
3rd Grade Reading	277	99.56	14.83	9,935	117.14	13.92
Economic Disadvantage	220	0.94	0.24	10,552	0.44	0.50
Female	315	0.49	0.50	13,957	0.50	0.50
Racial/Ethnic Minority	316	1.0	0.06	13,954	0.50	0.50

Note. ECLS-K estimates weighted by W7C17P_20 using jackknife replicate weights W7C17P_21- W7C17P_240 to adjust standard errors; some subpopulation observations were dropped in weighted estimates due to missing values

Table 5

Correlations for all major study variables (OKA)

Variables	1	2	3	4	5	6	7	8	9
1. K Math	-								
2. K Literacy	0.56***	-							
3. K Self-Regulation	0.27***	0.31***	-						
4. 3rd Grade Math	0.52***	0.52***	0.34***	-					
5. 3rd Grade Reading	0.48***	0.54***	0.34***	0.80***	-				
6. Economic Disadvantage	-0.27***	-0.35***	-0.17***	-0.34***	-0.34***	-			
7. English-Language Learner	-0.22***	-0.31***	-0.07***	-0.23***	-0.26***	0.29***	-		
8. Female	-0.03***	0.03***	0.21***	-0.05***	-0.08***	0.03***	0.02**	-	
9. Racial/Ethnic Minority	-0.18***	-0.20***	-0.05***	-0.19***	-0.21***	0.28***	0.50***	0.02***	-

*Note. * p<.05, ** p<.01, *** p<.00; N = 30, 876*

Table 6

Correlations for all major study variables (ECLS-K)

Variables	1	2	3	4	5	6	7	8	9	10	11
1. K Math	-										
2. K Literacy	0.75^{***}	-									
3. K Self-Regulation	0.34^{***}	0.31^{***}	-								
4. K Attention	0.34^{***}	0.28^{***}	0.18^{***}	-							
5. K Working Memory	0.63^{***}	0.53^{***}	0.28^{***}	0.29^{***}	-						
6. 3rd Grade Math	0.68^{***}	0.51^{***}	0.30^{***}	0.32^{***}	0.52^{***}	-					
7. 3rd Grade Reading	0.62^{***}	0.56^{***}	0.34^{***}	0.30^{***}	0.50^{***}	0.70^{***}	-				
8. Economic Disadvantage	-0.32^{***}	-0.28^{***}	-0.13^{***}	-0.16^{***}	-0.25^{***}	-0.31^{***}	-0.32^{***}	-			
9. English-Language Learner	-0.17^{***}	-0.16^{***}	-0.05^{***}	-0.15^{***}	-0.16^{***}	-0.14^{***}	-0.17^{***}	0.13^{***}	-		
10. Female	-0.03^{***}	0.04^{***}	0.22^{***}	0.04^{***}	0.02^{***}	-0.12^{***}	0.10^{***}	0.01^{*}	-0.00	-	
11. Racial/Ethnic Minority	-0.27^{***}	-0.17^{***}	-0.08^{***}	-0.20^{***}	-0.25^{***}	-0.31^{***}	-0.26^{***}	0.33^{***}	0.15^{***}	-0.01	-

Note. ECLS-K estimates weighted by W7C17P_20 using jackknife replicate weights W7C17P_21- W7C17P_240 to adjust standard errors; * $p<.05$, ** $p<.01$, *** $p<.001$

Table 7

Achievement gaps for economically disadvantaged students (OKA and ECLS-K)

	Math								
	OKA				ECLS-K				
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(5)
Kindergarten	-1.685	-1.389***	-1.341***	-1.086***	-7.389	-6.997***	-5.826***	-4.961***	-2.969***
	-0.264	***-0.217***	***-0.210***	***-0.170***	***-0.322***	***-0.305***	***-0.254***	***-0.216***	***-0.129***
	(0.057)	(0.055)	(0.058)	(0.057)	(0.155)	(0.142)	(0.142)	(0.130)	(0.102)
Third Grade	-56.751	-49.913***	-33.204***	-29.109***	-9.182	-8.802***	-2.060***	-2.005	-1.833**
	-0.343	***-0.302***	***-0.201***	***-0.176***	***-0.304***	**-0.292**	***-0.068***	***-0.066***	***-0.061***
	(1.810)	(1.714)	(1.432)	(1.411)	(0.177)	(0.172)	(0.119)	(0.116)	(0.114)

	Literacy/Reading								
	OKA				ECLS-K				
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)	(5)
Kindergarten	-8.866	-7.241***	-7.197	-6.129***	-6.409	-6.065***	-5.587***	-4.732***	-3.077***
	-0.353	***-0.288***	***-0.286***	***-0.244***	***-0.285***	***-0.270***	***-0.248***	***-0.210***	***-0.137***
	(0.265)	(0.242)	(0.255)	(0.248)	(0.147)	(0.139)	(0.135)	(0.130)	(0.105)
Third Grade	-60.354	-51.600***	-27.752***	-25.133***	-8.956	-8.472***	-3.721***	-3.668	-3.217***
	-0.342	***-0.293***	***-0.157***	***-0.143***	***-0.317***	***-0.300***	***-0.132***	***-0.130***	***-0.114***
	(1.809)	(1.666)	(1.299)	(1.290)	(0.171)	(0.169)	(0.144)	(0.146)	(0.142)

Note: standardized coefficients bolded and italicized; standard errors in parenthesis; model 1 includes only economic disadvantage, model 2 adds ELL status, model 3 adds gender, race/ethnicity, and prior academic skill of the same domain (3rd grade only), model 4 adds classroom self-regulation, and model 5 adds executive functions (attention and working memory); ECLS-K estimates weighted by W7C17P_20 using jackknife replicate weights W7C17P_21- W7C17P_240 to adjust standard errors; OKA robust standard errors clustered by classroom; significance stars test equality of coefficients between models; * *p<.05*, ** *p<.01*, *** *p<.001*

Table 8

Achievement gaps for English-language learners (OKA and ECLS-K)

	Math						
	OKA			ECLS-K			
	(1)	(2)	(3)	(1)	(2)	(3)	(4)
Kindergarten	-1.481	-1.267***	-1.203**	-10.867	-9.370***	-8.569*	-3.340***
	-0.160	***-0.137***	***-0.130***	***-0.136***	***-0.117***	***-0.107***	***-0.041***
	(0.077)	(0.089)	(0.090)	(0.521)	(0.509)	(0.504)	(0.479)
Third Grade	-34.232	-14.418***	-14.731	-10.017	0.005***	-0.348	0.814***
	-0.143	***-0.060***	***-0.062***	***-0.095***	***0.000***	***-0.003***	***0.007***
	(2.063)	(2.032)	(2.065)	(0.573)	(0.460)	(0.471)	(0.472)
	Literacy/Reading						
	OKA			ECLS-K			
	(1)	(2)	(3)	(1)	(2)	(3)	(4)
Kindergarten	-8.314	-8.014	-7.748**	-10.096	-9.436***	-9.102	-4.488***
	-0.227	***-0.218***	***-0.211***	***-0.129***	***-0.120***	***-0.116***	***-0.055***
	(0.198)	(0.271)	(0.266)	(0.266)	(0.273)	(0.303)	(0.415)
Third Grade	-44.819	-12.827***	-14.431***	-12.876	-5.622***	-5.708	-3.527***
	-0.174	***-0.050***	***-0.056***	***-0.131***	***-0.054***	***-0.055***	***-0.033***
	(2.017)	(1.997)	(2.022)	(0.413)	(0.499)	(0.497)	(0.515)

Note: standardized coefficients bolded and italicized; standard errors in parenthesis; model 1 includes economic disadvantage and ELL status, model 2 adds gender, race/ethnicity, and prior academic skill of the same domain (3rd grade only), model 3 adds classroom self-regulation, and model 4 adds executive functions (i.e., attention and working memory); ECLS-K estimates weighted by W7C17P_20 using jackknife replicate weights W7C17P_21- W7C17P_240 to adjust standard errors; significance stars test equality of coefficients between models; OKA robust standard errors clustered by classroom*; * p<.05, ** p<.01, *** p<.001*

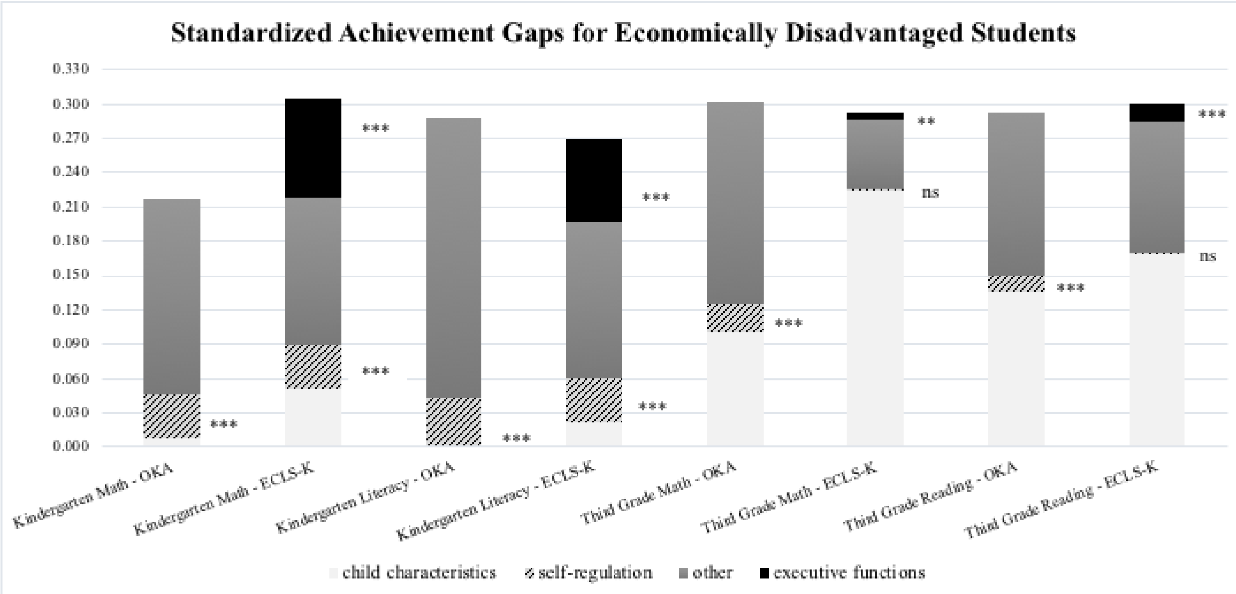

Figure 1. Standardized achievements gaps for economically disadvantaged students explained by self-regulation and executive functions

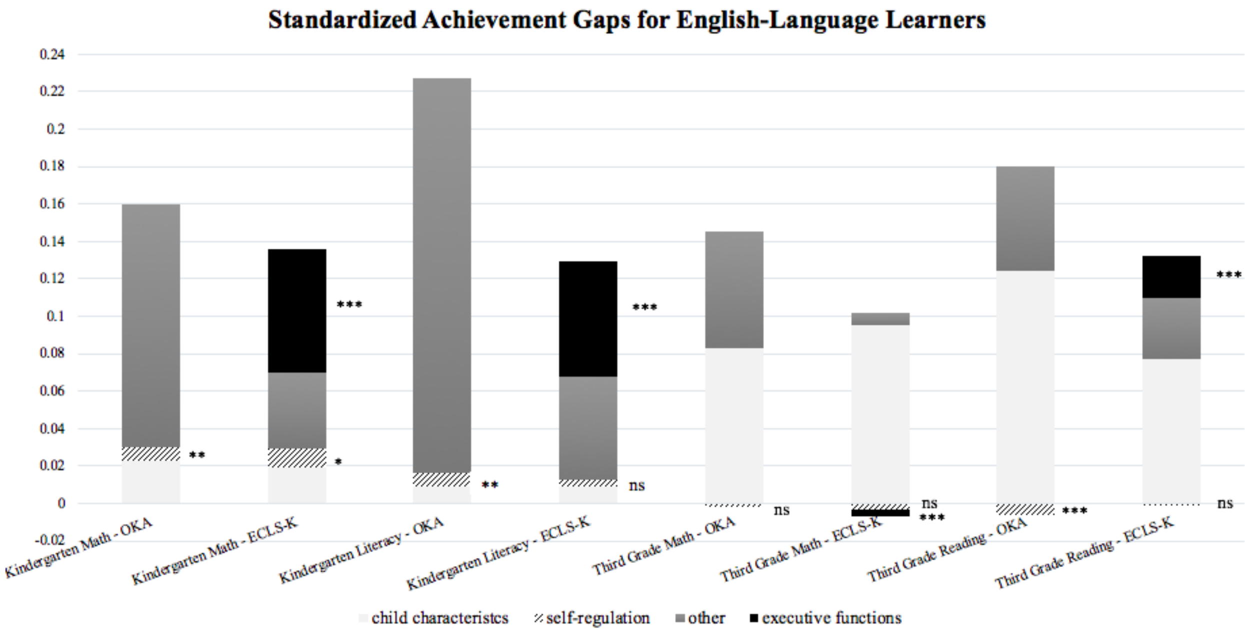

Figure 2. Standardized achievements gaps for English-language learners explained by self-regulation and executive functions

Identifying Compensatory Skills for School Readiness and Longer-Term Achievement Gaps in Statewide and National Contexts

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Abstract

The present study examined the independent compensatory effects of classroom self-regulation and individual executive function skills measured at kindergarten entry for the achievement gaps experienced by economically disadvantaged students and ELLs in kindergarten and third grade. Data from the statewide Oregon Kindergarten Assessment (OKA) and nationally representative data from the Early Childhood Longitudinal Study – Kindergarten cohort of 2011 (ECLS-K) were utilized in an attempt to replicate associations across contexts and measurement tools. Results revealed that having strong classroom self-regulation benefitted the kindergarten math and literacy skills of non-economically disadvantaged students and non-ELLs in Oregon and nationally more so than their disadvantaged peers. However, demonstrating strong classroom self-regulation in kindergarten helped to offset some of the negative effects associated with being economically disadvantaged and of ELL status on third grade achievement among students nationally. Finally, compensatory effects of individual executive functions were found for both ELLs and economically disadvantaged students, even after accounting for classroom self-regulation skills. Results highlight the independent protective effects of classroom self-regulation, working memory, and attentional flexibility for longer-term academic achievement among economically disadvantaged students and ELLs nationally and suggest that working memory may be a particularly promising skill to target through interventions prior to kindergarten.

Identifying Compensatory Skills for School Readiness and Longer-Term Achievement Gaps in Statewide and National Contexts

How well children adjust to the heightened demands of the formal learning environment is a growing concern in the age of accountability (Pianta, Cox, & Snow, 2007). School readiness is a multidimensional concept that includes physical, socio-emotional, behavioral, language, and cognitive characteristics, all of which contribute to children's successful transition to formal school (Mashburn & Pianta, 2006; Rimm-Kaufman & Pianta, 2000). Children who enter kindergarten with higher vocabulary, reading, and mathematics, in particular, are more likely to attain greater academic success in elementary and beyond (Claessens, Duncan, & Engel, 2009; DiPerna, Lei, & Reid, 2007; Duncan et al., 2007; Rabiner, Godwin, & Dodge, 2016). Yet, major socioeconomic inequalities in school readiness place young children at risk of falling behind their peers throughout schooling (Aikens & Barbarin, 2008; Crosnoe, Leventhal, Worth, Pierce, & Pianta, 2010; Duncan & Magnuson, 2011; Reardon & Robinson, 2008). Recent estimates reveal that children in families with incomes in the bottom quintile enter kindergarten nearly a full standard deviation behind in math and literacy compared to children in the top income quintile (Reardon & Portilla, 2016). Economically disadvantaged children who are also English-language learners (ELLs) are at an even greater educational disadvantage when they start school (Genesee, Lindholm-Leary, Saunders & Christina, 2005; Lesaux, 2012). Furthermore, these early gaps tend to persist as children advance through school (Galindo, 2009; Sirin, 2005).

While early academic skills certainly forecast later success or failure, school readiness also encompasses malleable self-regulation skills that are important contributors to achievement trajectories (Casey et al., 2011; McClelland, Acock, & Morrison, 2006; McClelland, Acock, Piccinin, Rhea, & Stallings, 2013). Self-regulation is a broad term that refers to the integration of higher-order executive function processes and lower-order emotional responses that allow children to adapt to their environments (Blair & Ursache, 2011; McClelland & Cameron, 2012). Intervention studies have found that *boosting* self-regulation skills among economically disadvantaged students and ELLs prior to kindergarten can compensate for the negative effects of risk on academic achievement (Schmitt, McClelland, Tominey, & Acock, 2015; Zhai, Raver, & Jones, 2012). However, the evidence as to whether *possessing* strong self-regulation skills can serve as a protective factor for achievement is less clear (Li-Grining, Votruba-Drzal, Maldonado-Correno, & Haas, 2010; McClelland & Wanless, 2012; Morgan, Farkas, Hillemeir, Pun & Maczuga, 2018).

Researchers argue that measures of self-regulation within the classroom may not be sensitive enough to capture individual differences, and individual measures of executive function skills may be better indicators of children's ability to take advantage of learning opportunities (Duncan, McClelland, & Acock, 2017). While self-regulation and executive functions are overlapping and related constructs (e.g., Kim, Byers, Cameron, Brock, Cottone, & Grissmer, 2016), measures of classroom self-regulation are distinct from measures of executive function skills in that it they contextualize children's ability to meet environmental demands (Fuhs, Farran, & Turner Nesbitt, 2015; Lipsey, Turner Nesbitt, Farran, Dong, Fuhs, & Wilson, 2017; McClelland & Cameron, 2012).

The present study establishes whether relations between economic disadvantage and/or ELL status and academic achievement vary as a function of classroom-based self-regulation skills or individual executive functions. To increase the generalizability of findings, this study investigates whether these associations are robust to different contexts and measures by using Oregon's statewide kindergarten assessment data (OKA) and nationally representative data from the most recent cohort of the Early Childhood Longitudinal Study – Kindergarten (ECLS-K: 2010).

Individual Executive Function Skills

Executive functions are a set of higher order cognitive processes that promote goal driven behaviors and self-regulation (Bernier, Carlson, & Whipple, 2010). Executive function skills include three distinct processes that are critically tied to brain development within the prefrontal cortex during the years prior to kindergarten (Kane & Engle, 2002). *Working memory* refers to the extent to which children can store, recall, and update important information as they track their progress on a given task; Gathercole, Pickering, Ambridge, & Wearing, 2004), *attentional flexibility* can be defined as the ability to focus attention and shift back and forth between multiple tasks, operations, or mental sets; Rueda, Posner, & Rothbart, 2005), and i*nhibitory control* refers to the ability to stop an automatic response in favor of a more adaptive behavior; Dowsett & Livesey, 2000). Executive functions play a key role in facilitating achievement and classroom self-regulation (e.g., Brock, Rimm-Kaufman, Nathansan, & Grimm, 2009).

Executive function processes are both conceptually distinct and overlapping in early childhood (Friedman & Miyake, 2017; Garon, Bryson, & Smith, 2008; Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000). However, measurement impurity causes challenges when assessing individual executive functions because many executive function tasks require a combination of executive function processes (Zelazo, Blair & Willoughby, 2017). When assessed individually, measures of executive function skills tend to be moderately correlated around r = 0.30, indicating only partial shared variance and some degree of measurement discrepancy (Willoughby, Blair, & the Family Life Project Investigators, 2016). In the present study, executive function skills are treated as individual processes rather than a latent construct because it was important to make the distinction between individual cognitive processes and broader executive function abilities, which may have more overlap with contextually-based classroom self-regulation, in order to answer the research questions.

Of the individual executive function skills, working memory and attentional flexibility appear to be particularly important for learning during the elementary years (Best & Miller, 2010; Gathercole & Pickering, 2000). In previous research, these executive function skills have been found to uniquely contribute to performance on academic tasks (Bull, Espy, & Wiebe, 2008; Bull & Scerif, 2001; Duncan et al., 2007; Fuhs, Turner Nesbitt, Farran, & Dong, 2014; Welsh, Nix, Blair, Bierman, & Nelson, 2010), with the strongest links being those between working memory and subsequent mathematics (Bull et al., 2008). Notably, attention skills at school entry are independently predictive of later school success after accounting for other indices of readiness, including cognitive ability (McClelland, Morrison, & Holmes, 2000; McClelland et al., 2013; Rabiner et al., 2016). Therefore, it should come as no surprise that kindergarten children with deficits in working memory and attentional capacities are more likely to experience reading and mathematics difficulties in first grade than similar kindergarten children without such deficits (Morgan, Li, Farkas, Cook, Pun, & Hillemeier, 2017).

Classroom Self-Regulation Skills

Self-regulation in early childhood can be defined as the control of thoughts, feelings, and behaviors, which requires the coordination of all three executive function processes (McClelland & Cameron, 2012). In school, children must achieve a balance between activating executive function processes and managing their emotional and stress response systems. Researchers therefore argue that self-regulation is a broader construct that demonstrates the feedback between the child’s executive function processes and emotion regulation skills within classroom environment (Ursache, Blair, & Raver, 2012).

Teacher ratings of self-regulation are especially popular in early childhood because they are practical, cost-effective, and require little training (Cameron, McClelland, Matthews, & Morrison, 2009). Teacher ratings of classroom self-regulation and direct assessments of executive functions are similarly related to academic outcomes (Allan, Hume, Allan, Farrington, & Lonigan, 2014). However, studies have shown that teacher ratings of classroom self-regulation also independently contribute to academic achievement (Fuhs et al., 2015; Lipsey et al., 2017; McClelland & Cameron, 2012). Furthermore, there is some evidence that teacher ratings of self-regulation are better indicators of literacy skills than direct assessments, which are more strongly related to math skills (Schmitt, Pratt, & McClelland, 2014; von Suchodoletz et al., 2013).

Although direct assessments of executive functions have the advantage of providing a more objective assessment of children's regulatory capacities, teacher ratings of classroom self-regulation have the advantage of providing a window on the fit between the child and their learning environment. Thus, there is utility in using both direct assessments of executive function skills and teacher ratings of classroom self-regulation as measurement tools for foundational school readiness skills at the start of kindergarten (Fuhs et al., 2015).

School Readiness and Longer-Term Achievement Gaps

Children's academic trajectories are established early in life and set the stage for later academic success or failure (Entwisle, Alexander, & Olson, 2005). A large body of research has linked performance on kindergarten assessments of math and reading to elementary achievement and later educational attainment (e.g., Claessens et al., 2009; Duncan et al., 2007; Geary, Hoard, Nugent, & Bailey, 2013; Nguyen et al., 2016; Watts, Duncan, Siegler, & Davis-Kean, 2014). Similarly, there is evidence that achievement gaps originate prior to entry into the formal school system and persist as children progress in school (Alexander, Entwisle, & Horsey, 1997; Carneiro & Heckman, 2003; Duncan & Magnuson, 2011). For example, low-income children and ELLs tend to start kindergarten behind their middle-income peers in math and literacy skills, and these initial achievement levels are associated with persistent and sometimes widening achievement gaps through third grade (Aikens & Barbarin, 2008; Jordan, Kaplan, Nabors Oláh, & Locuniak, 2006; Jordan, Kaplan, Ramineni, & Locuniak, 2009; Roberts & Bryant, 2011).

Third grade benchmarks are recognized as being critical indicators of children's long-term academic achievement, based on evidence that later schooling and variations in schooling quality have little effect on reducing or widening the gaps that appear at this point (Heckman, 2006). One study demonstrated that children who did not read proficiently by third grade were four times more likely to leave school without a high school diploma, and for the worst readers, the rate of drop out was nearly six times greater (Hernandez, 2011). By elementary school, sociodemographic differences are robust and continue as children transition to high school. Thus, it is not surprising that gaps in children's early reading and mathematics achievement due to economic differences contribute to gaps in the rate of high school completion (Alexander et al., 1997; Brooks-Gunn & Duncan, 1997; Duncan & Magnuson, 2011; Entwisle et al., 2005). For instance, the graduation rates of children in the lowest income quintile are 31% lower than children in the top income quintile (Duncan & Magnuson, 2011; Heckman & LaFontaine, 2008).

While not as widely studied, achievement gaps for ELLs also appear to open early in schooling (Galindo, 2009). The high school dropout rate is much higher among students with limited English proficiency (Rumberger & Lim, 2008). In 2004, 31% of language minority youth aged 18 to 24 not enrolled in school had neither completed high school nor earned a GED compared to only 10% of native English speakers (Hoff, 2013; Klein, Bugarin, Beltranena, &

McArthur, 2004). To hold schools accountable, policies such as No Child Left Behind (NCLB) have been implemented that require children to reach academic proficiency by third grade. This pressure, in turn, has driven efforts to monitor children's progress even earlier in school and identify skills at kindergarten entry that matter for academic achievement (Pianta et al., 2007; Stipek, 2006).

Compensatory Skills for Achievement Gaps

A large focus of research has been to identify malleable factors that influence the educational trajectories of children at-risk for school failure (Burchinal, Roberts, Zeisel, Hennon, & Hooper, 2006; Chatterji, 2006; Kieffer, 2008; Kim-Cohen, Moffit, Caspi, & Taylor, 2004; Sirin, 2005). Consistent with this line of inquiry, scholars have hypothesized that self-regulation may serve as a protective factor for children facing risk. Indeed, relations between family risk and adjustment or behavior problems have been shown to vary as a function of executive function skills and self-regulation (Corapci, 2008; Flouri, Midouhas, & Joshi, 2014; Lengua, Bush, Long, Trancik, & Kovacs, 2008). To illustrate, Flouri and colleagues (2014) discovered that the gap in behavior problems due to socioeconomic disadvantage over the elementary years narrows when children have high self-regulation. Yet, when examining the compensatory effects of classroom self-regulation on academic outcomes, these results have not consistently been repeated (Duncan et al., 2017; Li-Grining et al., 2010; McClelland & Wanless, 2012; Morgan et al., 2018). In other words, classroom self-regulation skills may be just as important for children with risk factors and for children without risk factors when it comes to academic achievement in the early years (Sektnan, McClelland, Acock, & Morrison, 2010).

To explain these conflicting findings, Li-Grining and colleagues (2010) argue that specific dimensions of executive functioning, rather than broad measures of classroom self-regulation skills, may provide children with the appropriate set of tools to overcome the multiple stressors associated with poverty and its correlates within classroom environments. To illustrate, researchers have demonstrated that associations between income deficiency and academic achievement vary as a function of inhibitory control but not assessments of classroom self-regulation (Duncan et al., 2017). Yet, a recent study found a weak but significant protective effect of classroom self-regulation for second grade math among children in the lowest SES quintile (Morgan et al., 2018). These mixed findings may have resulted from differences in assessment tools used to measure classroom self-regulation and individual executive functions. In addition, classroom self-regulation and individual executive function skills may work independently to protect children's development of academic achievement from risk factors. Both explanations justify further investigation of the joint compensatory mechanisms of these related skills in large longitudinal datasets.

Present Study

The goal of the present study was to identify whether having strong classroom self-regulation skills and/or individual executive functions at kindergarten entry could compensate for the negative effects of economic disadvantage and being of ELL status on school readiness and longer-term academic achievement. These associations were explored in a statewide dataset and a nationally representative data for two purposes. The first was to leverage the extensive measures that large datasets offer in comparison to local datasets. For example, Oregon's kindergarten assessment (OKA), which includes data on the skills and knowledge of all entering kindergarteners in the state of Oregon, only measures children's classroom self-regulation at the start of kindergarten, while the ECLS-K, which includes comparable information on a sample of kindergarteners around the country, assesses children's classroom self-regulation and individual executive function abilities. Analyzing both datasets renders it possible to investigate questions about the relative contribution of subjective ratings of self-regulation abilities and more objective measures of executive function capacities. Furthermore, the state of Oregon has the 3rd lowest high-school graduation rate in the nation (National Center for Education Statistics, 2016), accompanied by higher than average rates of childhood poverty and a growing Latino immigrant population (Oregon Community Foundation, 2016; U.S. Census Bureau, 2016). The second reason for attempting to replicate results across datasets is the opportunity to examine whether associations are robust to differences in measurement, sample characteristics, and contexts. Two research questions and corresponding hypotheses were explored:

1. **Do classroom self-regulation skills at kindergarten entry compensate for the effects of economic disadvantage and English-language learner status on school readiness and academic achievement in third grade in a statewide dataset and a national dataset?**

The research to date is mixed as to whether classroom self-regulation skills can compensate for the effects of risk on academic achievement over the long-run (e.g., Li-Grinning et al., 2010; McClelland & Wanless, 2012; Morgan et al., 2018). However, based on results from a recent study finding that classroom self-regulation had protective effects for low-SES children, classroom self-regulation was expected to compensate for the negative effects of economic disadvantage and being of ELL status on school readiness and third grade math and reading achievement nationally. In Oregon, classroom self-regulation was also expected to compensate for experiencing risk among economically disadvantaged students and ELLs in kindergarten and third grade. However, any discrepancies in results between datasets were expected to stem from differences in measures used to obtain teacher ratings of children's classroom self-regulation in

Oregon and nationally. This is because teacher ratings are more subjective than direct assessments and may vary in the degree to which they capture the fit between the child's self-regulatory capacities and the environmental demands, especially among specific subgroups of children.

2. **In a national dataset, after controlling for classroom self-regulation, do individual executive function skills at kindergarten entry compensate for the effects of economic disadvantage and English-language learner status on school readiness and academic achievement in third grade?**

There is some evidence that relations between income and academic achievement vary as a function of specific executive function processes rather than classroom-based self-regulation (Duncan et al., 2017; Razza, Martin, & Brooks-Gunn, 2010). However, this research has not considered the joint protective effects of classroom self-regulation alongside executive functions. Therefore, it was hypothesized that individual executive function skills at kindergarten entry would compensate for the effects of economic disadvantage and ELL status on school readiness and third grade math and reading achievement even after accounting for classroom self-regulation. Specifically, strong attentional flexibility and working memory skills at kindergarten entry were expected to buffer against the negative effects of economic disadvantage and being of ELL status on school readiness and third grade math and reading achievement among students nationally. This was predicated on the notion that classroom self-regulation and individual executive functions have independent effects on academic achievement (Fuhs et al., 2015; Lipsey et al., 2017; McClelland & Cameron, 2012).

Method

Participants

ECLS-K. The proposed study uses data from the ECLS-K: Class of 2010-2011 and the OKA. The ECLS-K is a nationally representative sample of 17,339 kindergarten children who participated during the 2010-2011 school year, and approximately 13,600 children who were followed into the spring of third grade during the 2013-2014 school year. Children who repeated kindergarten or did not pass the language screener and spoke another language other than Spanish were excluded from the ECLS-K sample (n = 892). Children identified by teachers has having an IEP for special education services in kindergarten were also excluded (n = 750) because of the links between ADHD, learning disabilities, and executive functions (e.g., Biederman, 2004; Brocki & Bohlin, 2006). At baseline, the sample was 51% male. Forty-seven percent of the sample had family incomes at or below 200% of the poverty threshold. This is slightly higher than the U.S. Census Bureau estimate of children under 18 who lived in families with incomes 200% or below the poverty threshold in 2010 (44%; National Kids Count, 2017). The sample was fairly diverse in terms of race/ethnicity. A little less than half of the sample was White, non-Hispanic (47%), a quarter of the sample identified as Hispanic (25%), followed by Black (13%), Asian (9%), Mixed Race (4%), Native American (1%), and Pacific Islander (1%). Only 2% of the sample did not pass the English-language screener in kindergarten, indicating Spanish-speaking and limited English proficiency. Ninety-four percent of Spanish-speaking ELLs were also economically disadvantaged.

OKA. The OKA is a statewide effort led by the Oregon Department of Education to gain a snapshot of the skills that Oregon's children have when they enter kindergarten. The OKA dataset includes 34,490 entering kindergarteners in the 2013-2014 school year who had data that could be linked with third grade academic test scores during the 2016-2017 school year. Additional selection criteria prohibited including children who utilized special education services in kindergarten (n = 2,706) for the same reasons as stated in the national dataset. Children who attended schools that provided free or reduced lunch to all students under Provision 2 were also not included (n = 274) because their participation in Provision 2 made it impossible to decipher whether they themselves were experiencing economic disadvantage or whether they simply attended a school with a large proportion of economically disadvantaged students that made them eligible for this benefit. The final sample included 30, 876 children (49% male). Approximately 53% of the sample were eligible to receive either free or reduced lunch during the 2013-2014 kindergarten year (family income at or below 185% of the poverty level). This percentage is similar to the state as a whole for that school year (52%), according to the Oregon Department of Education. In kindergarten, parents reported on children's race/ethnicity. The sample was mostly White, non-Hispanic (63%), followed by Hispanic (24%), Mixed Race (5%), Asian (4%), Black (2%), Native American (1%), and Pacific Islander (1%). Approximately 14% of the sample were Spanish-speaking and had limited English proficiency in kindergarten. Eighty-nine percent of Spanish-speaking ELLs were also economically disadvantaged.

Procedures

ECLS-K. In the fall of kindergarten and spring of third grade children were directly assessed on cognitive assessments of reading (language use and literacy), mathematics, and executive functions (working memory and attentional flexibility). The study employed a one- or two-stage assessment for kindergarten and third grade achievement measures in which children completed a set of items appropriate for their ability level rather than all items in the assessment. Patterns of right and wrong responses on common items were used to calculate IRT-based ability scores in reading and math that were on the same scale for all children. The IRT score therefore represents an estimate of the number of items a child would have answered correctly given that the child received all items. IRT scoring makes it possible to assess longitudinal gains in achievement even when items on assessments are not identical at both time points. Parent interviews were also conducted in the fall of kindergarten to obtain information about parent and child demographic characteristics. Teachers were asked to fill out a questionnaire in the fall of kindergarten that included questions about how often children exhibited certain social skills and behaviors within the classroom.

OKA. Most children entering a publicly funded kindergarten in the state of Oregon during the 2013-2014 academic school year were included in the de-identified OKA dataset provided by the Oregon Department of Education (ODE). Children were directly assessed on math and literacy measures within the first three weeks of kindergarten. Teachers rated children’s self-regulation in the classroom setting via questionnaire within the first six weeks of the kindergarten school year. In addition, ODE provided child-level demographic variables. The state of Oregon uses Smarter Balanced assessments to measure children’s mathematics and English language arts abilities in the spring of third grade after 66% of instruction has been completed. The Smarter Balanced Assessment Consortium has developed a comprehensive assessment system for mathematics and English language arts that is aligned to the Common Core State Standards. To do this, each testing item is based on overall content claims and assessment targets. Smarter Balanced assessments use computer-adaptive software.

Measures

School readiness.

Literacy and reading. The reading assessment developed for the ECLS-K includes questions measuring basic skills (print familiarity, letter recognition, beginning and ending sounds, rhyming words, word recognition), vocabulary knowledge, and reading comprehension

(Tourangeau, Nord, Le, Sorongon, Hagerdorn, Daly, & Najarian, 2013). Reading comprehension questions asked children to identify information specifically stated in text (e.g., definitions, facts, supporting details), make complex inferences within and across texts, and consider the text objectively and judge its appropriateness and quality. Possible weighted IRT-based reading scores ranged from 0-83. ELLs were administered the reading assessment in Spanish. The reliability coefficient was calculated based on the variance of repeated estimates of the overall ability estimate for each individual child compared with the total sample variance. For the kindergarten reading assessment, the reliability coefficient is reported in the technical manual as .95 (Tourangeau et al., 2013).

The OKA measures literacy skills with the easyCBM Letter Names and easyCBM Letter Sounds tasks. The Letter Names task assesses children's ability to name the letters of the English alphabet. In this assessment, children are shown a chart with upper- and lower- case letters and are instructed to name as many letters as they can in 60 seconds. At the end of 60 seconds, the testing administrator marks the last letter named and calculates the total number of letters identified correctly to arrive at the child's 'per minute' fluency-based score (Alonzo & Tindal, 2007). Possible scores ranged from 0-100. In previous research, the easyCBM Letter Names showed strong construct validity through its correlation with the DIBELS Letter Naming (r = .86) in a Kindergarten sample (Lai, Alonzo, & Tindal, 2013).

The easyCBM Letter Sounds assessment measures children's' ability to produce common sounds associated with letters of the English alphabet and common digraphs (Lai, Nese, Jamgochian, Alonzo, & Tindal, 2010). Children are shown a chart with letters and digraphs and are instructed to produce as many letter sounds as they can in 60 seconds. At the end of 60 seconds, the testing administrator marks the last letter responded to and calculates the total number of letters sounded correctly to arrive at the child's 'per minute' fluency-based score (Alonzo & Tindal, 2007). Possible scores ranged from 0-100. In previous research, the easyCBM Letter Sounds measure showed moderate construct validity through its correlation with the Initial Sound Fluency tasks (r =.55) in a Kindergarten sample (Lai et al., 2013).

ELLs were administered both EasyCBM literacy measures in English. Scores on Letter Names and Letter Sounds assessments were highly correlated in the OKA dataset (r = .76), consistent with prior work (Lipscomb, Miao, Finders, Hatfield, & Pears, 2018). Furthermore, in Oregon and beyond, floor effects have occurred on letter sounding tasks while ceiling effects have occurred on letter naming tasks (Catts, Petscher, Schatschneider, Sittner-Bridges, & Mendoza, 2009; Tindal, Irvin, Nese, & Slater, 2015; Wagner, Torgesen, & Rashotte, 1994). Therefore, in the current study, children's scores on Letter Names and Letter Sounds were averaged to create a literacy composite score in order to balance these distributions.

Mathematics. The math assessment developed for the ECLS-K was designed to measure skills in conceptual knowledge, procedural knowledge, and problem solving. The assessment consists of questions on number sense, properties, and operations; measurement; geometry and spatial sense; data analysis, statistics, and probability (measured with a set of simple questions assessing children's ability to read a graph); and pre-algebra skills such as identification of patterns (Tourangeau et al., 2013). Most of the items were read aloud to children by the assessor, and children were offered pencil and paper as part of the protocol. ELLs were administered the math assessment in Spanish. Possible weighted IRT-based math scores ranged from 0-75. The reliability coefficient was calculated based on the variance of repeated estimates of the overall ability estimate for each individual child compared with the total sample variance. For the kindergarten math assessment, the reliability coefficient is reported in the technical manual as .92 (Tourangeau et al., 2013).

The OKA measures math skills with the easyCMB math task. The easyCBM assesses children's ability to understand numbers, number systems, relationships among numbers, and meanings of operations (Anderson et al., 2010). Children are shown items that include counting, simple addition, simple subtraction, and recognizing number patterns. The assessment includes two sample items and 16 multiple-choice items. Children point to indicate their choice for a correct response from three possible answers. Children receive a score of 1 for each correct response, and possible scores ranged from 0-16. Unlike literacy, ELLs were administered the math assessment in Spanish. In an examination of construct validity, the correlation between the TerraNova and easyCBM math in the fall of kindergarten was strong ($r = 0.59$; Anderson et al., 2010).

Executive function skills. The ECLS-K includes two direct assessments that tap executive function skills.

Attentional flexibility (DCCS). The Dimensional Change Card Sort (DCCS) assesses children's attentional flexibility (Zelazo, 2006). In the DCCS, children were asked to sort a series of 12 picture cards into one of two trays according to color and then shape. If children correctly sort four of the six cards by shape, then they move on to a third sorting rule that instructed them to sort 6 additional cards by color if the card had a black border or sort by shape if the card did not have a black border. Children received a post-switch score representing the number of cards the child correctly sorted by shape (after switching from sorting by color to sorting by shape) and a border game score representing the number of cards the child correctly sorted when the sorting rule was determined by the presence or absence of a border around the card. Children received a point for each correct sort on 6 items in the post-switch section and 6 items in the border game section. These scores were summed for analyses, with possible scores ranging from 0-12. This version of the DCCS has been shown to be reliable in previous work (Hongwanishkul, Happaney, Lee, & Zelazo, 2005; Zelazo, 2006). The reliability coefficient for the post-switch and border items is Cronbach's $\alpha = 0.98$ in the current study.

Working memory (WJ Numbers Reversed). The Numbers Reversed subtest of the Woodcock-Johnson III Tests of Cognitive Abilities assesses children's working memory (Mather & Woodcock, 2001). In the Numbers Reversed task, children were asked to repeat increasingly long strings of orally presented numbers in reverse order. Children were given 5 two-number sequences, followed by 5 three-number sequences. The sequences became increasingly longer, up to a maximum of eight numbers, until the child floored by answering incorrectly to three consecutive number sequences. Standardized W-scores were used in the analyses, which are normed to account for the child's raw number-right score, age in months, and the language of administration. Possible weighted W-Scores on the Numbers Reversed task ranged from 393-581. The reliability coefficient for the items in the Numbers Reversed task is Cronbach's α = 0.99 in the current study.

Classroom self-regulation skills. The ELCS-K includes a teacher rating of children's self-regulation within the classroom that is derived from the Child Behavior Questionnaire (CBQ; Putnam & Rothbart, 2006). Teachers rated 12 items on a 7-point Likert-type scale to assess the frequency of behaviors exhibited in the classroom (e.g., works independently; easily adapts to changes in routine; persists in completing tasks; and follows classroom rules). The items were averaged for each child, and scores ranged from 0-7 in the current study. The reliability coefficient for the CBQ as reported in the technical manual is Cronbach's α = .87 (Tourangeau et al., 2013).

In the OKA, teachers reported on children's classroom self-regulation using the Child Behavior Rating Scale (CBRS; Bronson, Goodson, Layzer, & Love, 1990). The CBRS is based on the Bronson Social Task and Skill Profile (Bronson, 1991). Teachers rated 10 items using a 5-point Likert-type scale. Items included statements such as "Observes rules and follows directions without requiring repeated reminders" and "Completes tasks successfully." The 10 items for self-regulation were averaged for each individual child. Average self-regulation scores ranged from 1-5 in the current study. In previous work, the self-regulation subscale of the CBRS has been found to be significantly correlated with direct measures of executive function skills, including the DCCS (r = .44; R. Duncan et al., 2017). The reliability coefficient for the self-regulation items of the CBRS is Cronbach's α = 0.97.

Third grade academic achievement.

Mathematics. The same math assessment was administered in third grade by the ECLS-K as in kindergarten and measured skills in conceptual knowledge, procedural knowledge, and problem solving. The testing specifications for the third grade math assessment were based on the same NAEP frameworks developed for the kindergarten math assessment. The task consists of questions on number sense, properties, and operations, measurement, geometry and spatial sense, data analysis, probability, and patterns. Possible weighted IRT-based math scores ranged from 0-135. The reliability coefficient was calculated based on the variance of repeated estimates of the overall ability estimate for each individual child compared with the total sample variance. For the third grade math items, the reliability coefficient as reported in the technical manual is 0.92 (Tourangeau et al., 2018).

The Smarter Balanced math task administered in third grade in Oregon assessed concepts and procedures, problem solving, communicating and reasoning, and modeling/data. Questions were asked in many formats, requiring students to respond to multiple choice items, short answers, matching, and equations. For instance, a sample item in third grade that assesses problem solving abilities may ask: “There are 9 cherry trees. Kim picks 8 cherries from each tree. Kim eats 14 of the cherries she picked. Enter the number of cherries Kim has left”. In the current sample, Smarter Balanced math scores range from 1963-2937 in the spring of third grade. Information on the reliability and validity of the Smarter Balanced English language arts and mathematics assessments can be found in the technical report (Smarter Balanced Assessment Consortium, 2017).

Reading. The same reading assessment was administered in third grade by the ECLS-K as in kindergarten and measured basic skills, such as word recognition, vocabulary knowledge, and reading comprehension. The testing specifications for the third grade reading assessment were based on the same NAEP frameworks developed for the kindergarten reading assessment. Reading comprehension questions asked the child to identify information specifically stated in text (e.g., definitions, facts, supporting details); to make complex inferences within texts; and to consider the text objectively and judge its appropriateness and quality. Possible IRT-based readings scores ranged from 0-141. The reliability coefficient was calculated based on the variance of repeated estimates of the overall ability estimate for each individual child compared with the total sample variance. For the third grade reading items, the reliability coefficient as reported in the technical manual is 0.87 (Tourangeau et al., 2018).

The Smarter Balanced English language arts task administered in third grade in Oregon assessed reading, writing, listening, and research/inquiry skills. For example, a short answer question from the reading subtest requires children to read a passage and answer questions related to what they read. A sample item may ask: "What can the reader infer about the secret the father tells his sons? Include information from the passage in your answer". In the current study, Smarter Balanced English Language Arts scores range from 2042-2712 in the spring of third grade. Information on the reliability and validity of the Smarter Balanced English language arts and mathematics assessments can be found in the technical report (Smarter Balanced Assessment Consortium, 2017).

Risk factors.

Economic disadvantage. In the ECLS-K, economic disadvantage was measured with a composite variable representing at or below 200% of the federal poverty level. This variable was created from each individual's household income and household size, as reported by parents in the fall of kindergarten. In 2010, a family of 4 would be considered economically disadvantaged under these criteria if their pooled income fell below $44,100.

In the OKA dataset, children were flagged based on whether they were eligible to receive free lunch (family income at or below 130% of the poverty level) or reduced lunch (family income between 130% and 185% of the poverty level) during the kindergarten year (U.S. Department of Agriculture, 2012). In 2013, a family of 4 would be considered economically disadvantaged under these criteria if their pooled income fell below $43,568.

English-language learner. In the ECLS-K, a composite variable was created that applies to children who did not pass the English language screener and were identified by schools as speaking a non-English language at home (Kieffer, 2010). In the current study, children who were identified as ELLs and whose primary language was Spanish were considered ELLs.

In the OKA, children were officially identified as ELLs by each school district. If parents reported a primary language other than English was spoken in the home, children qualified for an initial language assessment. Children were flagged as ELLs if they did not pass the screener. In the current study, children who were identified as ELLs and whose primary language was Spanish were considered ELLs.

Control variables. Control variables available in the OKA are limited to gender and race/ethnicity in kindergarten. The same control variables were included from the ECLS-K so that the results could be replicated more reliably. Previous research has linked gender (Isaacs, 2012; Matthews, Ponitz, & Morrison, 2009; McCoy & Reynolds, 1999) and race/ethnic minority status (Lee & Burkam, 2002; Little, 2017) to skills at school entry.

Analytic Strategy

Ordinary least squares (OLS) regression models were run in the national and statewide datasets to answer the first research question of whether the effects of economic disadvantage or ELL status on school readiness and third grade academic achievement varied as a function of classroom self-regulation at kindergarten entry. Interactions between classroom self-regulation and economic disadvantage and classroom self-regulation and ELL status were modeled together in order to account for the fact that the majority of ELLs are also economically disadvantaged (Ruiz Soto, Hooker, & Batalova, 2015). In addition, significant compensatory effects of self-regulation for ELLs could be interpreted after adjusting for the protective effects of classroom self-regulation for economic disadvantage. Math and literacy in kindergarten and math and reading in third grade were predicted by these interaction terms and a set of covariates including gender, racial/ethnic minority status, and the same kindergarten autoregressive skill in third grade models.

A similar set of OLS regression models were run in the national dataset for the second research question to determine whether the effects of economic disadvantage or ELL status on school readiness and third grade academic achievement varied as a function of individual executive function skills at kindergarten entry. Interactions between ELL status and each executive function skill (i.e., attentional flexibility and working memory) were modeled separately but included with interactions between economic disadvantage and the same executive function skill. This permitted testing the compensatory effects of attentional flexibility and working memory separately for ELLs, after adjusting for the protective effects of the same individual executive function skill for economic disadvantage. The same set of covariates were included from the prior models, with the addition of classroom self-regulation.

Weighting. Data collection in large-scale surveys is typically organized using specialized sampling techniques that include stratification, clustering, and multiple stages of collection. In the ECLS-K, a multi-stage sampling design involved sampling primary sampling units (PSUs) and schools with probabilities proportional to the targeted number of children attending the school. In addition, a cluster design was used which restricted data collection to a limited number of geographic areas and to as few schools as possible in order to maximize costs while achieving precision of estimates. Such equal probability sampling may lead to biased estimates and standard errors in clustered data when samples include unequal probability of selection (Kolenikov, 2010). To account for sampling design, researchers recommend weighting in order to produce point estimates that are representative of the target population (Solon, Haider, & Wooldridge, 2013). Sampling weights are the inverse probabilities of selection. In the current study, the W7C17P_20 weight was applied in all regression analyses using the national dataset, which adjusts for non-response and sampling error associated with child direct assessments in kindergarten and third grade as well as parent questionnaire data collected in the fall or spring of kindergarten (Tourangeau et al., 2018).

Standard errors. Weighting adjustments make inferences about the population parameters more valid but tend to increase the variance of the estimates. Therefore, it is necessary to correct the standard errors for these adjustments when using weighted data. Specifically, for the W7C17P_20 weight, the variance increases by approximately 44% due to weight adjustments (Tourangeau et a., 2018). For complex survey designs, clustered, multistage sampling and the use of differential sampling rates can be accounted for with variance estimation methods such as Taylor Series linearization and Replication. In the current study, replicate weights with the jackknife variance estimator procedure were preferred over Taylor linearization because Taylor Series is unable to estimate standard errors accurately when the number of observations within PSUs is small (Kreuter & Valliant, 2001). In the jackknife method, each survey estimate of interest is calculated for the full sample as well as for each of the replicates. The variation of the replicate estimates around the full-sample estimate is used to estimate the variance for the full sample. Replicate weights for the jackknife method with two PSUs per stratum (JK2) were applied using `jkrweight(W7C17P_21-W7C17P_240) vce(jack) mse`. In the analyses with the ECLS-K, the `svyset` function in Stata was used with the `svy: regress` command to specify sampling design, including probability weights, replicate weights, and jackknife replication in linear regression models. In Oregon, the `regress` command with a sandwich estimator specified by `vce(cluster clusterid)` was used to account for non-independence of the child observations within classrooms at both time points.

Results

Descriptive statistics, including means and standard deviations, are presented separately by economic disadvantage and ELL status for both datasets in Tables 1-4. In addition, bivariate correlations by economic disadvantage and ELL status are presented in Tables 5-8. For the national dataset, descriptive statistics are included for the unweighted and weighted data, but correlations were run on the weighted data only. Correlations for the national dataset were obtained in Mplus 7 (Muthén & Muthén, 2012) and all remaining data analyses were conducted in Stata 14.0 (Stata Corp, 2015).

Importantly, teacher ratings of classroom self-regulation were significantly correlated with direct assessments of executive function skills, regardless of the measure of executive functions or the subgroup analyzed. The strongest association was between classroom self-regulation and working memory among non-ELLs nationally ($r = 0.36$) and the weakest association was between classroom self-regulation and attentional flexibility among non-economically disadvantaged students nationally ($r = 0.17$).

Each column in Tables 9-11 represents a separate regression model. Table 9 presents the results for the first research question examining the compensatory effects of classroom self-regulation for school readiness and third grade achievement among economically disadvantaged students and ELLs in Oregon and nationally. Tables 10-11 present the results for the second research question examining the compensatory effects of executive function skills for school readiness and third grade achievement among economically disadvantaged students and ELLs nationally. In all tables, unstandardized regression coefficients for covariates, main effects, and interaction effects for each outcome are reported and bolded when significant. Robust standard errors are presented in parentheses in all tables. Simple slopes for significant linear effects were subsequently explored (Aiken & West, 1991).

Do classroom self-regulation skills at kindergarten entry compensate for the effects of economic disadvantage and English-language learner status on school readiness and academic achievement in third grade in a statewide dataset and a national dataset?

Associations between economic disadvantage and outcomes in kindergarten and third grade often significantly varied as a function of classroom self-regulation, but the direction of the compensatory effect varied by dataset and time point (Table 9). In Oregon, there was a negative interaction between classroom self-regulation and economic disadvantage for concurrent math ($b = -0.114$, $p < 0.05$) and literacy ($b = -1.488$, $p < 0.001$), suggesting that classroom self-regulation was more strongly associated with school readiness among non-economically disadvantaged students than it was for economically disadvantaged students. Thus, having strong self-regulation at kindergarten entry did more to improve the school readiness of non-at-risk children than at-risk children in Oregon (Figure 1). The same trend was observed in the national dataset for kindergarten literacy ($b = -0.374$, $p < 0.001$), but kindergarten math was not significantly predicted by the interaction between classroom self-regulation and economic disadvantage nationally (Figure 2).

In third grade, associations between economic disadvantage and math and reading did not significantly vary as a function of classroom self-regulation in Oregon. In the national dataset, however, there was a positive interaction between classroom self-regulation and economic disadvantage for third grade math ($b = 1.225$, $p < 0.001$) and reading ($b = 0.909$, $p < 0.001$), suggesting that classroom self-regulation had stronger predictive relations with third grade achievement among economically disadvantaged students than non-economically disadvantaged students. Investigation of conditional point estimates revealed that at the highest level of classroom self-regulation reported by teachers, economically disadvantaged students had significantly stronger predicted math scores (M = 106.02) than their non-economically disadvantaged peers (M = 105.46) in third grade ($F(1, 39) = 5.52$, $p < .0.05$)). These findings suggest that, consistent with the hypotheses, having strong classroom self-regulation at kindergarten entry compensated for the negative effects of economic disadvantage on third grade achievement nationally (Figure 3).

Overall, the results suggest that having strong classroom self-regulation helped to offset some of the negative effects associated with being economically disadvantaged on third grade math and reading among students nationally, while in Oregon, having strong self-regulation appeared to benefit non-economically disadvantaged students more than economically disadvantaged students in kindergarten.

Associations between ELL status and outcomes in kindergarten and third grade sometimes significantly varied as a function of classroom self-regulation, with similar directional trends as were observed for economic disadvantage between datasets (Table 9). In Oregon, there was a negative interaction between classroom self-regulation and ELL status for concurrent math ($b = -0.208$, $p < 0.01$) and literacy ($b = -2.344$, $p < 0.001$), suggesting that classroom self-regulation was more strongly associated with school readiness among non-ELLs than it was for ELLs. Again, having strong classroom self-regulation did more to improve the school readiness of non-at-risk children than at-risk children in Oregon (Figure 4). The same trend was observed in the national dataset for kindergarten literacy ($b = -1.480$, $p < 0.001$), but math was not significantly predicted by the interaction between classroom self-regulation and ELL status nationally (Figure 5).

In third grade, however, classroom self-regulation had stronger predictive relations with reading among ELLs than for non-ELLs nationally ($b = 0.720$, $p < 0.01$), but self-regulation did not significantly compensate for the effects of ELL status on third grade math (Figure 5). Investigation of conditional point estimates revealed that at the highest level of classroom self-regulation reported by teachers, ELLs nearly caught up (M = 117.54) to non-ELLs (M = 121.32) in third grade reading nationally ($F(1, 39) = 18.50$, $p < .0.001$)). Two unique findings also emerged in Oregon; predictive relations between ELL status and third grade math ($b = -6.284$, $p < 0.001$) and reading ($b = -3.200$, $p < 0.05$) varied as a function of kindergarten classroom self-regulation. However, the negative interactions suggested that classroom self-regulation had stronger predicted relations with achievement among non-ELLs than for ELLs in Oregon (Figure 6).

Overall, the results suggest that having strong classroom self-regulation helped to offset some of the negative effects associated with being of ELL status on third grade reading among students nationally, while in Oregon, having strong classroom self-regulation appeared to benefit non-ELLs more than ELLs in kindergarten and third grade.

In a national dataset, after controlling for classroom self-regulation, do individual executive function skills at kindergarten entry compensate for the effects of economic disadvantage and English-language learner status on school readiness and academic achievement in third grade?

Associations between economic disadvantage and outcomes in kindergarten and third grade frequently varied as a function of individual executive function skills nationally, even after accounting for classroom self-regulation (Table 10 and Table 11). In kindergarten, there was a negative interaction between attentional flexibility and concurrent math ($b = -0.289$, $p < 0.001$) and literacy ($b = -0.163$, $p < 0.001$), suggesting that attentional flexibility was more strongly associated with school readiness among non-economically disadvantaged students than it was for economically disadvantaged students nationally (Figure 7). However, by third grade, there was a positive interaction between attentional flexibility and economic disadvantage for math (b = 0.328, p < 0.001), but not reading (Figure 8). Investigation of conditional point estimates revealed that at the highest level of attentional flexibility, economically disadvantaged children (M = 103.88) nearly caught up to non-economically disadvantaged children (M = 104.73) in third grade math (F(1, 39) = 19.91, p < .0.001)). These results suggest that attentional flexibility had stronger predictive relations with math performance among economically disadvantaged students nationally.

Similar trends were observed with respect to working memory. In kindergarten, there was a negative interaction between working memory and economic disadvantage for concurrent literacy (b = -0.024, p < 0.001), suggesting that working memory was more strongly associated with kindergarten literacy among non-economically disadvantaged students than it was for economically disadvantaged students nationally (Figure 9). However, by third grade, there was a positive interaction between working memory and math (b = 0.062, p < 0.001) and reading (b = 0.051, p < 0.001), suggesting that working memory had stronger predictive relations with academic achievement among economically disadvantaged students than non-economically disadvantaged students nationally (Figure 10). Investigation of conditional point estimates revealed that, in the top 10th percentile of working memory, economically disadvantaged students scored significantly higher in third grade math (M = 106.57) than non-economically disadvantaged students (M = 105.92) nationally (F(1, 39) = 23.99, p < 0.001), and those differences continued to widen as working memory increased. Furthermore, in the top percentile of working memory, there were no significant differences in third grade reading between economically disadvantaged students (M = 123.71) and non-economically disadvantaged students (M = 123.89) nationally ($F(1,39) = 0.61$, $p > 0.05$).

Together, these findings suggest that having strong attentional flexibility and working memory at kindergarten entry helped to offset the negative effects of economic disadvantage associated with third grade math, even after accounting for classroom self-regulation skills. Furthermore, having strong working memory served as a compensatory factor for third grade reading.

Associations between ELL status and outcomes in kindergarten and third grade sometimes significantly varied as a function of individual executive function skills nationally (Table 10 and Table 11). In kindergarten, there was a negative interaction between attentional flexibility and concurrent literacy ($b = -0.663$, $p < 0.001$), which continued into third grade ($b = -0.347$, $p < 0.05$; Figure 11), suggesting that attentional flexibility was more strongly associated with kindergarten literacy and third grade reading among non-ELLs than among ELLs nationally.

A slightly different pattern of results was observed with respect to working memory. In kindergarten, there was a positive interaction between working memory and concurrent math ($b = 0.062$, $p < 0.001$), but a negative interaction between working memory and concurrent literacy ($b = -0.113$, $p < 0.001$; Figure 12). These results suggest that working memory was more strongly associated with math among ELLs nationally, but not literacy. By third grade, there was a positive interaction between working memory and math ($b = 0.041$, $p < 0.05$) and reading ($b = 0.063$, $p < 0.05$), suggesting that working memory compensated for the effects of being an ELL on academic achievement. Notably, investigation of conditional point estimates revealed that ELLs outperformed non-ELLs in third grade math at every level of working memory above the

25th percentile (Figure 12). However, significant differences in third grade reading between ELLs and non-ELLs were only found at the lowest levels of working memory (Figure 12).

Together, these findings suggest that, while demonstrating strong attentional flexibility at kindergarten entry benefitted the math achievement of non-ELLs more so than ELLs in the long-run, having strong working memory at kindergarten entry served as a compensatory factor for math in kindergarten and third grade even after accounting for classroom self-regulation skills.

Discussion

The aim of the current study was to examine the independent compensatory effects of classroom self-regulation and individual executive function skills for the achievement gaps experienced by economically disadvantaged students and ELLs in a statewide Oregon dataset and nationally representative dataset. The results were somewhat replicated between contexts with regards to school readiness outcomes; classroom self-regulation skills at kindergarten entry appeared to be more strongly associated with kindergarten literacy among non-economically disadvantaged students and non-ELLs in Oregon and nationally. Furthermore, in Oregon, classroom self-regulation was more strongly associated with kindergarten math among children who were not at-risk. By third grade, classroom self-regulation skills at kindergarten entry protected children against the negative effects of risk on third grade math and reading nationally, but this was not replicated in Oregon. In Oregon, demonstrating strong classroom self-regulation skills at kindergarten entry continued to be more strongly predictive of third grade math and reading among children who were not ELLs. Finally, having strong working memory consistently compensated for the negative effects associated with being economically disadvantaged and of ELL status on third grade achievement nationally, but attentional flexibility was only a protective factor for third grade math among economically disadvantaged students.

Classroom Self-Regulation as a Compensatory Skill for Academic Achievement

In the current study, demonstrating strong classroom self-regulation at kindergarten entry was a more meaningful indicator of school readiness among non-at-risk children than it was for at-risk children nationally and in Oregon. Prior research has not often been successful in detecting differential associations between self-regulation and achievement as a function of income and ELL status (Duncan et al., 2017; McClelland & Wanless, 2012). It's certainly puzzling that early classroom self-regulation did not appear to compensate for the negative effects associated with risk when achievement was measured concurrently, especially given the reciprocal relations between these skills in early childhood among populations of children at-risk (Bohlmann, Maier, & Palacios, 2015) and evidence from interventions demonstrating the protective effect of self-regulation for academic achievement (Schmitt et al., 2015; Zhai et al., 2012). It's possible that teacher ratings of children's classroom self-regulation may not be capturing the skills that are most relevant for at-risk children's performance on assessments of math and literacy in kindergarten. Prior research suggests that teachers in Oregon tend to rate ELLs and non-ELLs similarly on classroom self-regulation, despite ELLs performing worse on direct assessments of achievement than non-ELLs (Diaz, 2016). Perhaps measures of achievement are less related to measures of classroom self-regulation among ELLs compared to non-ELLs because non-ELLs tend to be rated highly on classroom self-regulation *and* perform higher on direct assessments of math and literacy. Indeed, correlations between self-regulation and kindergarten math and literacy were stronger among non-ELLs in Oregon ($r = 0.27$, $r = 0.32$) than among ELLs ($r = 0.20$, $r = 0.18$). The same was true for kindergarten literacy in the national dataset ($r = 0.31$ non-ELL, $r = 0.24$ ELL). Although in recent studies, the validity of measures that assess classroom self-regulation via teacher ratings has been examined across income and racial/ethnic groups (Daneri, Sulik, Raver, & Morris, 2018; Fantuzzo, Perry, & McDermott, 2004; Sulik et al., 2010), the weaker associations between teacher ratings of classroom self-regulation and academic achievement among ELLs in kindergarten may reflect teacher bias in reporting of adaptive classroom skills and behaviors, or low validity of teacher ratings for this particular subgroup of children.

In third grade, classroom self-regulation skills compensated for the negative effects of economic disadvantage and being of ELL status among children nationally, but not in Oregon. The findings in the national dataset are supported by research suggesting that associations between self-regulation and achievement shift across children's age (Best, Miller, & Naglieri, 2011). Furthermore, it's likely that measures of classroom self-regulation were better indicators of third achievement for ELLs in the national dataset because these tests were administered in English, and therefore, past or current ELLs were required to call upon regulatory skills as they completed math and reading tasks in their non-native language. What's more, ELLs tend to catch up to their non-ELL peers in English assessments of achievement over schooling because of their acquisition of English-language skills (Choi, Jeon, & Lippard, 2018; Kieffer, 2008; Reardon & Galindo, 2009). Advances in language skills, in turn, may have facilitated growth in academic achievement, which has been shown to be strongly related to classroom self-regulation (McClelland, Cameron, Connor, Farris, Jewkes, & Morrison, 2007; Swanson, Lussier, & Orosco, 2015). For economically disadvantaged students, the benefits of having strong self-regulation skills in the classroom at kindergarten entry may show up by third grade as they are able to accrue greater returns from their self-regulation abilities over time (Heckman, 2008).

In Oregon, classroom self-regulation was more strongly predictive of achievement among non-ELLs in third grade than ELLs, but classroom self-regulation was equally important for third grade math and reading among economically disadvantaged students as it was for non-economically disadvantaged students. Unlike nationally, ELLs completed third grade academic assessments in Spanish, which may have contributed to the discrepancy in findings. Furthermore, the slopes for ELLs and non-ELLs, while both positive and overlapping at lower levels self-regulation, became more differentiated at higher levels of self-regulation because non-ELLs improved in their achievement at a faster rate. This divergence of trajectories occurred in the upper end of the distribution of reading and math for ELLs, suggesting that high achieving non-ELLs may be the driving force behind these significant differences in the trajectories. Had there been a larger proportion of ELLs with higher third grade math and reading scores in Oregon, the coupling of their academic performance with self-regulation may be more akin to that of non-ELLs. The same explanation is not relevant for economically disadvantaged students in Oregon, however. The finding that classroom self-regulation was equally beneficial for students by third grade is consistent with prior work assessing academic trajectories of economically disadvantaged students as a function of self-regulation (Duncan et al., 2007; Li-Grining et al., 2010), and highlights the importance of broad classroom behaviors at kindergarten entry for longer-term academic achievement across socioeconomic gradients.

Differences in the measurement of classroom self-regulation by teacher ratings may explain discrepancies in findings at third grade between datasets. For example, classroom self-regulation was more strongly associated with third grade math and reading among ELLs and economically disadvantaged students in the national dataset (r = 0.30-0.44) than among non-ELLs and non-economically disadvantaged students (r = 0.24-0.34). But in the Oregon dataset, the opposite was true. This suggests that teachers may be able to more precisely assess at-risk children's ability to focus attention, complete academic tasks, and resist distractions using the

CBQ. Whereas teachers completing the CBRS in Oregon may be less likely to pick up on these specific classroom skills and instead have the tendency to rate children's broader classroom behaviors. This rationale is supported by evidence from studies using the ECLS-K: 1998 and ECLS-K: 2010, which have demonstrated the protective effects of classroom self-regulation on longer-term academic achievement with the CBQ (Morgan et al., 2018) but not with a combined measure of social skills and self-control among economically disadvantaged students (Li Grining et al., 2010). In other words, there may be variability in the validity of teacher ratings for measuring the adaptive classroom behaviors that are important for success in school.

Individual Executive Functions as Compensatory Skills for Academic Achievement

The current study extends prior research by examining the independent roles of individual executive function skills for school readiness and third grade achievement among children experiencing risk. Consistent with the results for self-regulation, attentional flexibility and working memory were more strongly associated with school readiness skills among non-at-risk children than at-risk children, with the exception that working memory appeared to compensate for the negative effects associated with being of ELL status on kindergarten math. Working memory has been implicated in second language proficiency and production among ELLs (Linck, Osthus, Koeth, & Bunting, 2013, for a review). Furthermore, working memory appears to underlie early math skills in populations at-risk (Swanson & Beebe-Frankenberger, 2004). In a recent study, growth in working memory significantly related to growth in math computation and increased bilingual proficiency among ELLs (Swanson, Kong, & Petcu, 2018). Thus, the strong association between working memory and kindergarten math for ELLs may be partially attributed to the effect of working memory on English language production, particularly when assessments are more linguistically taxing.

In third grade, demonstrating strong individual executive function skills at kindergarten entry compensated for the negative effects of economic disadvantage and being of ELL status on academic achievement. Specifically, attentional flexibility predicted higher third grade math skills among economically disadvantaged students, while working memory predicted higher third grade math and reading among both economically disadvantaged students and ELLs. Given that these assessments were administered in English in the national dataset, the protective effects of working memory for ELLs may be reflective of an early detection of the cognitive advantage of bilingual children (Barac, Bialystok, Castro, & Sanchez, 2014).

The results from this study are consistent with recent research indicating that attentional flexibility and working memory at kindergarten entry may differentially relate to achievement in later schooling (Morgan et al., 2018). Specifically, Morgan and colleagues (2018) demonstrated protective effects of kindergarten working memory for second grade math and reading among children from households with low-socioeconomic status (SES), but these results were not repeated with respect to kindergarten attentional flexibility. Why attentional flexibility would compensate for economic disadvantage in the present study and not low-SES in prior work raises the question of whether combining a measure of occupational prestige with income-to-needs masks the strong influence of income alone and how income deprivation may influence the effects of risks and protective factors in early childhood (Duncan & Magnuson, 2003). Nevertheless, the distinct predictive abilities of working memory and attentional flexibility for third grade achievement constitutes evidence of specialization of executive function processes in early childhood (Bull et al., 2008; Tucker-Drob, 2009).

Limitations and Future Directions

The present study has a few limitations that are worth mentioning. While the analyses carefully examined variance in school readiness and longer-term achievement explained by between-group differences, the somewhat inconsistent findings by dataset and time point may have resulted from large within-group variability. Indeed, there is likely to be as much or more variance within any given sociodemographic group as between groups. For instance, previous research has demonstrated how deterministic views of classifying ELLs largely ignore differences in first languages, children's migration history, parent education, home environments, and exposure to formal instruction in first and second languages, all of which have implications for academic test scores and achievement growth (Chang et al., 2007; Farver, Xu, Eppe, & Lonigan, 2006; Solano-Flores, 2008; Winsler et al., 2014). Furthermore, there has been a growing interest in the roles of English and Spanish language proficiency on associations between ELL status and executive function skills, self-regulation, and academic achievement (Diaz, 2016; Kieffer, 2008; Winsler, Kim, & Richard, 2014). Specifically, research suggests that the use of home language in early childhood classrooms is a positive moderating factor for ELLs development (Halle et al., 2014). A promising direction for future work would be to examine associations between self-regulation and achievement trajectories as a function of within-group differences using methods that account for more nuances (e.g., LCA; Quirk, Nylund-Gibson, & Furlong, 2013). Such research is in accordance with developmental systems theory and may provide an empirical explanation of how principles of equifinality and multifinality are demonstrated through intra-individual processes.

One methodological challenge was deciding how to appropriately handle shared method variance, specifically as it related to including multiple interaction terms in the models in order to isolate the protective effects of self-regulation and executive function skills. Shared method variance refers to the degree to which parameter estimators converge to values that are not truly reflective of the population due to the fact that measured variables are assessed using a common method (Spector, 2006). When two variables are assessed the same way, such as in the case of a main effect and an interaction effect, the covariance among them can be inflated and lead to Type I error. The *Variance Inflation Factor* (VIF) can detect the degree of multicollinearity by measuring the impact of multicollinearity on the precision of the estimate (Robinson & Schumacker, 2009). In the present study, exploration of the VIF's did not provide convincing evidence that covariances were influencing parameter estimates. However, in future work, it may be compelling to use structural equation modeling (SEM) for regression models with several interactions because SEM has the ability to account for shared variance by removing the method variance that is common to observed variables (Williams, Edwards, & Vandenberg, 2003). Furthermore, SEM avoids the strenuous task of having to enter a large number of interaction terms, multiple times, as each dependent variable is regressed on a long list of predictors (Raver, Gershoff, & Aber, 2007).

Implications

Acknowledging the importance of replication for the robustness of scientific results and for promoting research integrity (Duncan, Engel, Claessens, & Dowsett, 2014), this study aimed to replicate compensatory effects in a statewide and national dataset. However, inconsistent findings in Oregon and nationally only yielded partial evidence for the protective effects of classroom self-regulation skills. Moreover, results that were replicated did not align with the hypothesis that classroom self-regulation skills could compensate for the negative effects of risk on school readiness. The inability to replicate findings suggests that associations are not generalizable and may be somewhat specific to context, measures, or sample characteristics. This lack of robustness provokes more questions than concrete answers for future research, policy, and practice (Miguel et al., 2014).

Overall, the findings suggest that classroom self-regulation skills as rated by teachers at kindergarten entry appear to have different implications for achievement among these at-risk subgroups in kindergarten than in third grade. For educators, these results do not lend themselves to obvious or straightforward conclusions about the best approach for closing achievement gaps. It may be necessary to collect information on children's self-regulation skills between kindergarten and third grade as they progress through school to examine whether changes in children's ability to pay attention, follow instructions, persist on tasks, and ignore distractions is a better indicator of strong performance on achievement tasks than a static measure of self-regulation at the start of kindergarten. For instance, prior research has found that growth in behavioral self-regulation and measures of individual executive function are predictive of growth in achievement over the preschool and kindergarten years (McClelland et al., 2014). Furthermore, changes in ratings of children's self-regulation from kindergarten to first grade have been linked to adolescent academic outcomes (Howard & Williams, 2018). Assessing the development of classroom self-regulation skills during these formative years may be key to understanding children's ability to adapt to the increasing demands of formal schooling.

Preliminary evidence from the present study supports the notion that individual executive function skills may serve as compensatory factors for third grade achievement among children from economically disadvantaged families. A critical next step is to replicate these findings in statewide and local datasets in order to increase confidence in where to prioritize investments. For instance, if having strong working memory and attentional flexibility skills at the start of kindergarten can help low-income children catch up to their more advantaged peers by the end of third grade, it may be beneficial to more explicitly target the development of these skills prior to the start of kindergarten. There is debate as to whether training specific executive function skills can produce positive transfer effects to academic domains (e.g., Diamond & Ling, 2016; Jacob & Parkinson, 2015). However, the majority of self-regulation interventions that have analyzed distal achievement outcomes have found significant improvements in literacy, math, reading, letter naming, and vocabulary (Pandey, Hale, Das, Goddings, Blakemore, & Viner, 2018). In particular, when support for aspects of executive functioning are embedded into broader classroom learning activities, such as during reading or math, low-income children are more likely to close the gap into first grade (Blair & Raver, 2014). Therefore, identifying the processes through which these individual skills, or their overlapping components, foster positive adjustment among children facing risk can help to clarify the necessary elements that programs and interventions should strive to incorporate.

Conclusion

The present study uniquely contributes to the literature by examining heterogeneity in compensatory abilities of classroom self-regulation and individual executive functions across diverse at-risk subgroups and datasets. Results suggest that teacher ratings of classroom self-regulation in kindergarten are more likely to accurately reflect the academic readiness of non-at-risk students than at-risk students in kindergarten. These findings were robust to differences in context and measurement as they were replicated in statewide and national datasets. Educators and policymakers in Oregon and elsewhere should therefore use caution when relying on a single measure of classroom self-regulation at kindergarten entry to make inferences about the school readiness of children from economically disadvantaged backgrounds and ELLs. Alternatively, results show the compensatory effects of classroom self-regulation, working memory, and attentional flexibility for third grade achievement among economically disadvantaged students and ELLs nationally. These findings suggest robustness of self-regulatory processes, broadly speaking, in supporting academic resiliency, and indicate validity of teacher ratings of self-regulation for forecasting longer-term achievement among at-risk students. Future work should establish whether the protective effects of individual executive functions for longer term achievement can be replicated in statewide contexts. Doing so will clarify the potential impact of targeting such skills through interventions in order to attenuate achievement gaps.

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Table 1

Descriptive statistics by economic disadvantage (OKA)

	Economically Disadvantaged			**Non-Economically Disadvantaged**		
	N	***M***	***SD***	***N***	***M***	***SD***
K Math	16,190	7.36	2.98	14,602	9.06	3.18
K Literacy	16,035	9.16	10.35	14,557	18.02	13.12
K Self-Regulation	16,069	3.49	0.82	14,397	3.77	0.79
3^{rd} Grade Math	16,132	2403.63	77.25	14,549	2460.52	77.86
3^{rd} Grade Reading	16,111	2393.63	82.29	14,558	2454.20	83.30
English-Language	16,239	0.23	0.42	14,637	0.03	0.18
Female	16,239	0.52	0.50	14,637	0.50	0.50
Racial/Ethnic Minority	16,239	0.50	0.50	14,637	0.24	0.42

Table 2

Descriptive statistics by economic disadvantage (ECLS-K)

	Economically Disadvantaged			Non-Economically Disadvantaged		
Weighted	***N***	***M***	***SD***	***N***	***M***	***SD***
K Math	3,506	31.59	8.19	4,556	38.97	9.52
K Literacy	3,500	49.94	7.45	4,558	56.35	9.97
K Self-Regulation	3,260	4.75	0.95	4,274	5.05	0.93
Attention	3,506	8.09	2.55	4,557	9.05	2.12
Working Memory	3,506	427.43	22.59	4,557	442.79	24.80
3rd Grade Math	3,515	98.06	12.17	4,561	107.24	11.02
3rd Grade Reading	3,514	112.29	11.34	4,560	121.24	10.33
English-Language	3,522	0.04	0.16	4,565	0.00	0.05
Female	3,522	0.50	0.39	4,565	0.49	0.42
Racial/Ethnic Minority	3,522	0.64	0.46	4,564	0.31	0.48
Unweighted	***N***	***M***	***SD***	***N***	***M***	***SD***
K Math	4,867	31.44	10.50	5,863	39.40	11.57
K Literacy	4,859	49.85	9.76	5,867	56.71	12.34
K Self-Regulation	4,570	4.70	1.23	5,510	5.08	1.13
Attention	4,867	8.08	3.27	5,864	9.06	2.58
Working Memory	4,865	427.05	28.78	5,864	443.44	29.78
3rd Grade Math	4,165	98.01	15.46	5,102	107.77	13.16
3rd Grade Reading	4,164	112.03	14.66	5,101	121.81	12.18
English-Language	4,894	0.04	0.20	5,878	0.00	0.05
Female	5,740	0.50	0.50	6,600	0.49	0.50
Racial/Ethnic Minority	5,739	0.66	0.47	6,599	0.35	0.48

Note. ECLS-K estimates weighted by W7C17P_20 using jackknife replicate weights W7C17P_21- W7C17P_240 to adjust standard errors; some subpopulation observations were dropped in weighted estimates due to missing values

Table 3

Descriptive statistics by English-language learner status (OKA)

	English-Language Learner			Non-English Language Learner		
	N	***M***	***SD***	***N***	***M***	***SD***
K Math	4,213	6.37	2.77	26,579	8.45	3.17
K Literacy	4,107	3.55	6.00	26,485	14.90	12.61
K Self-Regulation	4,206	3.48	0.81	26,260	3.65	0.82
3rd Grade Math	4,204	2382.96	72.64	26,477	2438.17	81.53
3rd Grade Reading	4,199	2364.86	74.84	26,470	2431.51	86.60
English-Language	4,228	0.89	0.32	26,648	0.47	0.50
Female	4,228	0.53	0.50	26,648	0.51	0.50
Racial/Ethnic Minority	4,228	0.98	0.14	26,648	0.28	0.45

Table 4

Descriptive statistics by English-language learner status (ECLS-K)

	English-Language Learner			**Non-English-Language Learner**		
Weighted	***N***	***M***	***SD***	***N***	***M***	***SD***
K Math	225	21.68	7.65	9,072	35.32	10.11
K Literacy	212	40.53	4.85	9,080	53.19	9.98
K Self-Regulation	220	4.53	1.02	8,440	4.90	1.04
Attention	226	5.51	3.48	9,072	8.60	2.59
Working Memory	226	402.58	17.51	9,071	435.39	26.85
3rd Grade Math	238	88.38	12.83	9,077	102.71	13.31
3rd Grade Reading	237	100.41	11.90	9,078	116.94	12.39
Economic Disadvantage	196	0.92	0.22	7,891	0.46	0.44
Female	238	0.50	0.41	9,092	0.50	0.45
Racial/Ethnic Minority	238	1.0	0.0	9,090	0.47	0.45
Unweighted	***N***	***M***	***SD***	***N***	***M***	***SD***
K Math	290	21.16	8.58	13,941	35.06	11.50
K Literacy	275	40.46	5.79	13,958	52.95	11.39
K Self-Regulation	284	4,56	1.20	12,939	4.88	1.21
Attention	291	5.27	4.23	13,938	8.54	2.99
Working Memory	291	401.00	19.29	13,934	434.66	30.10
3rd Grade Math	278	87.67	15.77	9,934	102.91	14.91
3rd Grade Reading	277	99.56	14.83	9,935	117.14	13.92
Economic Disadvantage	220	0.94	0.24	10,552	0.44	0.50
Female	315	0.49	0.50	13,957	0.50	0.50
Racial/Ethnic Minority	316	1.0	0.06	13,954	0.50	0.50

Note. ECLS-K estimates weighted by W7C17P_20 using jackknife replicate weights W7C17P_21- W7C17P_240 to adjust standard errors; some subpopulation observations were dropped in weighted estimates due to missing values

Table 5

Correlations for all major study variables by economic disadvantage (OKA)

Variables	1	2	3	4	5	6	7	8
1. K Math	-	0.49***	0.23***	0.44***	0.40***	-0.19***	-0.00	-0.16***
2. K Literacy	0.55***	-	0.24***	0.42***	0.45***	-0.30***	0.04***	-0.21***
3. K Self-Regulation	0.25***	0.31***	-	0.30***	0.30***	-0.01	0.22***	0.01
4. 3rd Grade Math	0.51***	0.49***	0.33***	-	0.76***	-0.16***	-0.03***	-0.15***
5. 3rd Reading	0.45***	0.50***	0.33***	0.79***	-	-0.21***	0.09***	-0.18***
6. English-Language Learner	-0.15***	-0.19***	-0.07***	-0.14***	-0.15***	-	0.01	0.53***
7. Female	-0.04***	0.04***	0.22***	-0.05***	0.10***	-0.00	-	0.02**
8. Racial/Ethnic Minority	-0.06***	-0.04***	-0.03***	-0.05***	-0.06***	0.31***	0.01	-

*Note. * p<.05, ** p<.01, *** p<.001;* not economically disadvantaged in bottom diagonal and economically disadvantaged in top diagonal

Table 6

Correlations for all major study variables by economic disadvantage (ECLS-K)

Variables	1	2	3	4	5	6	7	8	9	10
1. K Math	-	0.75***	0.33***	0.34***	0.62***	0.66***	0.60***	-0.19***	-0.02*	-0.25***
2. K Literacy	0.72***	-	0.31***	0.29***	0.52***	0.51***	0.57***	-0.19***	0.06***	-0.18***
3. K Self-Regulation	0.30***	0.27***	-	0.18***	0.25***	0.30***	0.33***	-0.04***	0.24***	-0.04***
4. K Attention	0.29***	0.22***	0.17***	-	0.29***	0.32***	0.29***	-0.16***	0.05***	-0.18***
5. K Working Memory	0.57***	0.49***	0.25***	0.25***	-	0.51***	0.48***	-0.18***	0.02***	-0.26***
6. 3rd Grade Math	0.63***	0.45***	0.24***	0.25***	0.46***	-	0.70***	-0.12***	-0.10***	-0.28***
7. 3rd Grade Reading	0.57***	0.50***	0.30***	0.26***	0.44***	0.65***	-	-0.17***	0.09***	-0.22***
8. English-Language Learner	-0.10***	-0.07***	-0.01	-0.09**	-0.08***	-0.08**	-0.08**	-	-0.01	0.16***
9. Female	-0.04***	0.03***	0.22***	0.04***	0.03***	-0.13***	0.11***	0.01	-	-0.01
10. Racial/Ethnic Minority	-0.11***	-0.01	-0.07***	-0.12***	-0.12***	-0.16***	-0.12***	0.09***	0.00	-

Note. ECLS-K estimates weighted by W7C17P_20 using jackknife replicate weights W7C17P_21- W7C17P_240 to adjust standard errors; * *p<.05*, ** *p<.01*, *** *p<.001;* not economically disadvantaged in bottom diagonal and economically disadvantaged in top diagonal

Table 7

Correlations for all major study variables by English-language learner status (OKA)

Variables	1	2	3	4	5	6	7	8
1. K Math	-	0.33***	0.20***	0.35***	0.28***	-0.02	-0.02	-0.01
2. K Literacy	0.55***	-	0.18***	0.29***	0.30***	-0.05***	0.02	0.01
3. K Self-Regulation	0.27***	0.32***	-	0.24***	0.24***	0.01	0.19***	0.00
4. 3rd Grade Math	0.51***	0.51***	0.35***	-	0.71***	-0.09***	-0.05**	-0.00
5. 3rd Grade Reading	0.47***	0.51***	0.35***	0.79***	-	-0.10***	0.06***	-0.02
6. Economic Disadvantage	-0.23***	-0.30***	-0.17***	-0.32***	-0.31***	-	0.03*	0.07***
7. Female	-0.03***	0.04***	0.21***	-0.04***	0.09***	0.02***	-	-0.00
8. Racial/Ethnic Minority	-0.08***	-0.06***	-0.02**	-0.09***	-0.09***	0.16***	0.02**	-

Note. * $p<.05$, ** $p<.01$, *** $p<.001$; not ELL in bottom diagonal and ELL in top diagonal

Table 8

Correlations for all major study variables by English-language learner status (ECLS-K)

Variables	1	2	3	4	5	6	7	8	9	10
1. K Math	-	0.55***	0.40***	0.37***	0.11***	0.39***	0.39***	0.13***	0.39***	-
2. K Literacy	0.75***	-	0.24***	0.13***	0.20***	0.40***	0.45***	-0.05	0.23***	-
3. K Self-Regulation	0.34***	0.31***	-	0.29***	0.20**	0.44***	0.44***	-0.11	-0.36***	-
4. K Attention	0.33***	0.27***	0.18***	-	0.19***	0.42***	0.27***	0.01	-0.22***	-
5. K Working Memory	0.85***	0.68***	0.36***	0.35***	-	0.05***	0.07***	0.11***	0.21***	-
6. 3rd Grade Math	0.66***	0.51***	0.29***	0.31***	0.67***	-	0.31***	-0.03***	0.12***	-
7. 3rd Grade Reading	0.63***	0.55***	0.34***	0.29***	0.67***	0.73***	-	-0.21***	0.44***	-
8. Economic Disadvantage	-0.39***	-0.36***	-0.15***	-0.19***	-0.39***	-0.37***	-0.38***	-	-0.12	-
9. Female	-0.05***	0.05***	0.27***	0.05***	0.03***	-0.15***	0.12***	0.02***	-	-
10. Racial/Ethnic Minority	-	-	-	-	-	-	-	-	-	-

Note. ECLS-K estimates weighted by W7C17P_20 using jackknife replicate weights W7C17P_21- W7C17P_240 to adjust standard errors; * *p<.05, ** p<.01, *** p<.001*; not ELL in bottom diagonal and ELL in top diagonal; correlations by subgroup for racial/ethnic minority status are omitted because 99% of ELLs are also racial/ethnic minorities

Table 9

Compensatory effects of self-regulation on school readiness and third grade academic achievement (OKA and ECLS-K)

	OKA				ECLS-K			
	Kindergarten		Third Grade		Kindergarten		Third Grade	
	Math	**Literacy**	**Math**	**Reading**	**Math**	**Literacy**	**Math**	**Reading**
Main Effects								
Gender	-0.469***	-0.429**	-12.370***	6.929***	-2.273***	-0.500***	-3.664***	1.099***
	(0.039)	(0.137)	(0.795)	(0.850)	(0.115)	(0.101)	(0.074)	(0.116)
Racial/Ethnic Minority	-0.330***	-0.475	-4.619**	-8.946***	-3.489***	-1.336***	-3.474***	-3.229***
	(0.063)	(0.257)	(1.570)	(1.421)	(0.141)	(0.132)	(0.104)	(0.155)
Economic Disadvantage	-0.662**	-0.630	-24.382***	-30.708***	-4.298***	-2.895***	-8.006***	-8.118***
	(0.190)	(0.732)	(4.453)	(4.419)	(0.419)	(0.474)	(0.554)	(0.493)
ELL Status	-0.479	0.435	7.176	-3.299	-6.745***	-2.486*	-4.560*	-8.826***
	(0.291)	(0.657)	(6.564)	(5.953)	(1.414)	(1.167)	(1.728)	(1.219)
Self-Regulation	1.041***	5.083***	23.833***	19.050***	3.160***	2.840***	0.645***	1.466***
	(0.043)	(0.182)	(0.994)	(0.962)	(0.065)	(0.083)	(0.051)	(0.062)
Kindergarten Math	–	–	10.103***	–	–	–	0.769***	–
			(0.180)				(0.005)	
Kindergarten Literacy	–	–	–	2.804***	–	–	–	0.551***
				(0.048)				(0.006)
Interaction Effects								
Self-Regulation X Economic Disadvantage	**-0.114***	**-1.488*****	-1.237	1.560	-0.135	**-0.374*****	**1.225*****	**0.909*****
	(0.050)	**(0.201)**	(1.132)	(1.125)	(0.090)	**(0.094)**	**(0.108)**	**(0.090)**
Self-Regulation X ELL Status	**-0.208****	**-2.344*****	**-6.284*****	**-3.200***	-0.405	**-1.480*****	0.957	**0.720****
	(0.074)	**(0.192)**	**(1.737)**	**(1.617)**	(0.317)	**(0.289)**	(0.356)	**(0.261)**

Note: coefficients unstandardized and standard errors in parenthesis; ECLS-K estimates weighted by W7C17P_20 using jackknife replicate weights W7C17P_21- W7C17P_240 to adjust standard errors; OKA robust standard errors clustered by classroom; * *p<.05*, ** *p<.01*, *** *p<.001*

Table 10

Compensatory effects of attentional flexibility on school readiness and third grade academic achievement (ECLS-K)

	ECLS-K			
	Kindergarten		Third Grade	
	Math	**Literacy**	**Math**	**Reading**
Main Effects				
Gender	-2.333***	-0.534***	-3.741***	1.046***
	(0.100)	(0.093)	(0.071)	(0.114)
Racial/Ethnic Minority	-2.756***	-0.745***	-3.209***	-2.802***
	(0.126)	(0.119)	(0.102)	(0.154)
Economic Disadvantage	-2.004***	-2.968***	-4.790***	-3.431***
	(0.467)	(0.442)	(0.403)	(0.519)
ELL Status	-6.161***	-3.936***	0.768	-2.613*
	(0.703)	(0.571)	(1.053)	(1.044)
Self-Regulation	2.715***	2.341***	1.207***	1.803***
	(0.458)	(0.055)	(0.044)	(0.154)
Attention	1.086***	0.831***	0.205***	0.555***
	(0.039)	(0.036)	(0.034)	(0.048)
Kindergarten Math	–	–	0.743***	–
			(0.005)	
Kindergarten Literacy	–	–	–	0.522***
				(0.006)
Interaction Effects				
Attention X Economic Disadvantage	**-0.289*** **	**-0.163*** **	**0.328*** **	-0.012
	(0.045)	**(0.042)**	**(0.045)**	(0.053)
Attention X ELL Status	-0.100	**-0.663*** **	-0.030	**-0.347* **
	(0.100)	**(0.076)**	(0.136)	**(0.131)**

Note: coefficients unstandardized and standard errors in parenthesis; ECLS-K estimates weighted by W7C17P_20 using jackknife replicate weights W7C17P_21- W7C17P_240 to adjust standard errors; * *p<.05*, ** *p<.01*, *** *p<.001*

Table 11

Compensatory effects of working memory on school readiness and third grade academic achievement (ECLS-K)

	ECLS-K			
	Kindergarten		Third Grade	
	Math	**Literacy**	**Math**	**Reading**
Main Effects				
Gender	-1.848***	-0.118	-3.751***	1.257***
	(0.090)	(0.084)	(0.073)	(0.110)
Racial/Ethnic Minority	-1.514***	0.300*	-2.980***	-2.230***
	(0.115)	(0.120)	(0.104)	(0.139)
Economic Disadvantage	-1.574	7.063***	-29.079***	-25.680***
	(1.555)	(1.382)	(1.599)	(1.662)
ELL Status	-29.399***	39.737***	-15.452*	-28.832*
	(5.712)	(6.089)	(7.585)	(11.381)
Self-Regulation	1.857***	1.590***	1.159***	1.611***
	(0.042)	(0.045)	(0.043)	(0.046)
Working Memory	0.217***	0.178***	0.043***	0.080***
	(0.002)	(0.003)	(0.002)	(0.003)
Kindergarten Math	–	–	0.663***	–
			(0.005)	
Kindergarten Literacy	–	–	–	0.429***
				(0.005)
Interaction Effects				
Working Memory X Economic Disadvantage	-0.004	**-0.024*** **	**0.062*** **	**0.051*** **
	(0.003)	**(0.003)**	**(0.004)**	**(0.004)**
Working Memory X ELL Status	**0.062*** **	**-0.113*** **	**0.041* **	**0.063* **
	(0.014)	**(0.015)**	**(0.019)**	**(0.028)**

Note: coefficients unstandardized and standard errors in parenthesis; ECLS-K estimates weighted by W7C17P_20 using jackknife replicate weights W7C17P_21- W7C17P_240 to adjust standard errors; * *p<.05, *** *p<.01, **** *p<.001*

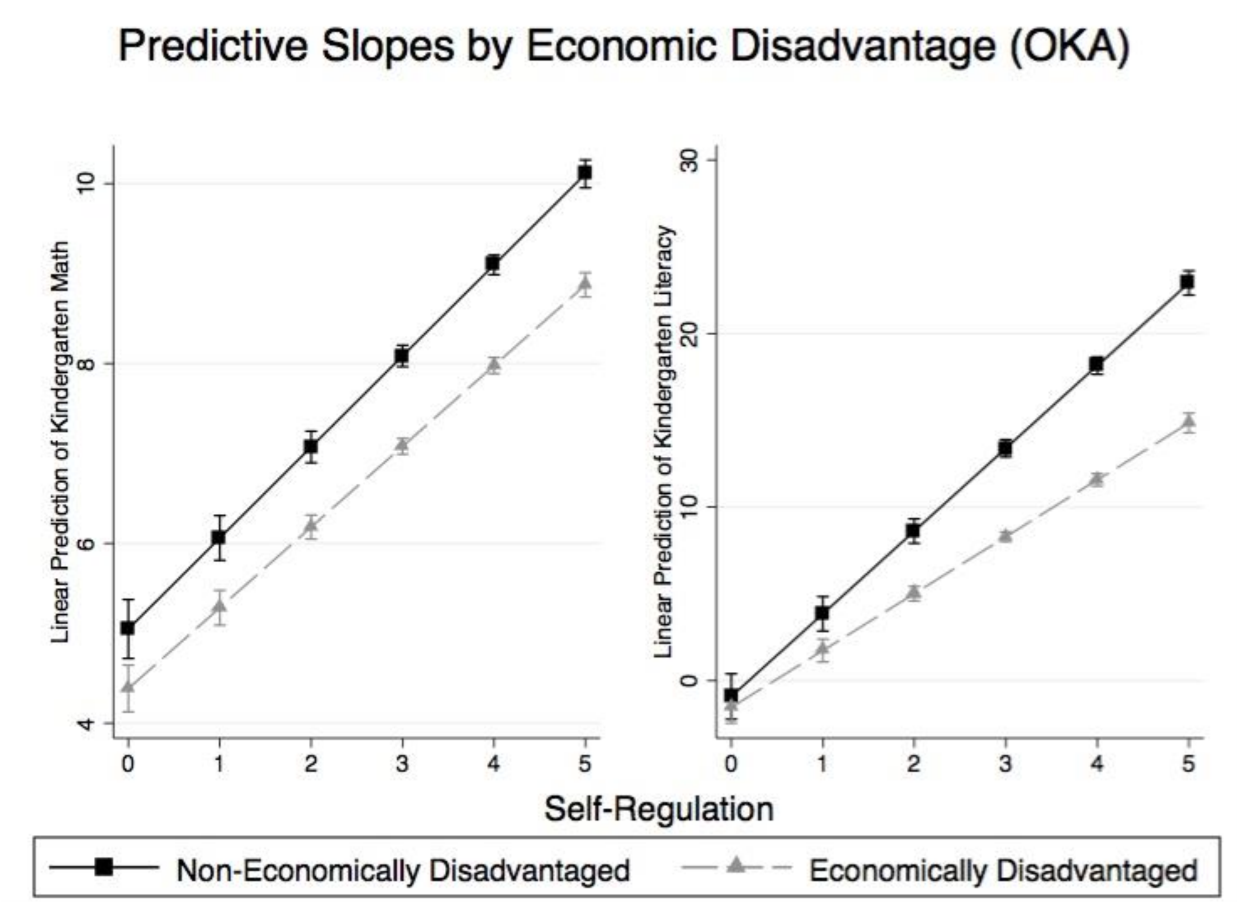

Figure 1. Effects of self-regulation on predicted kindergarten math (left panel) and kindergarten literacy (right panel) by economic disadvantage in Oregon

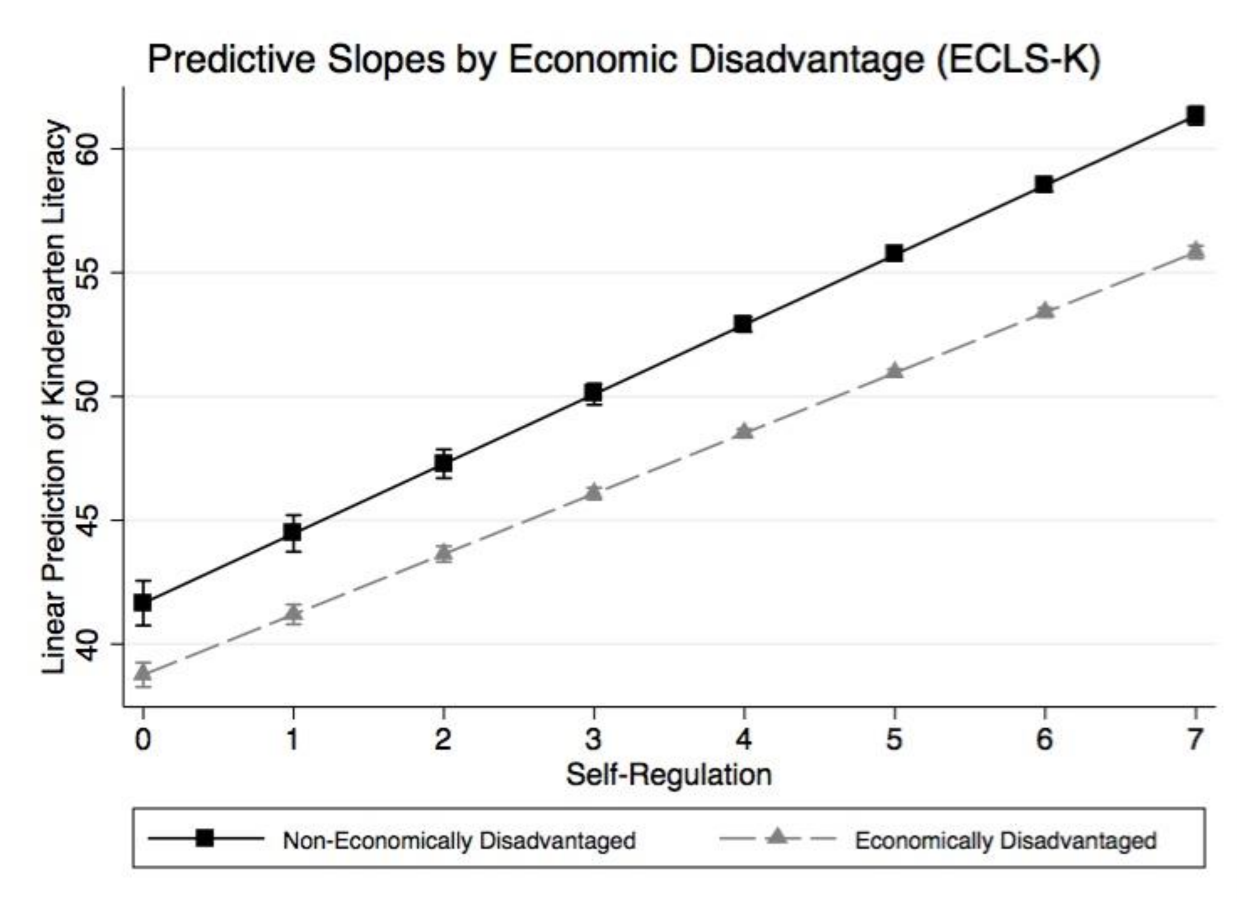

Figure 2. Effects of self-regulation on predicted kindergarten literacy by economic disadvantage nationally

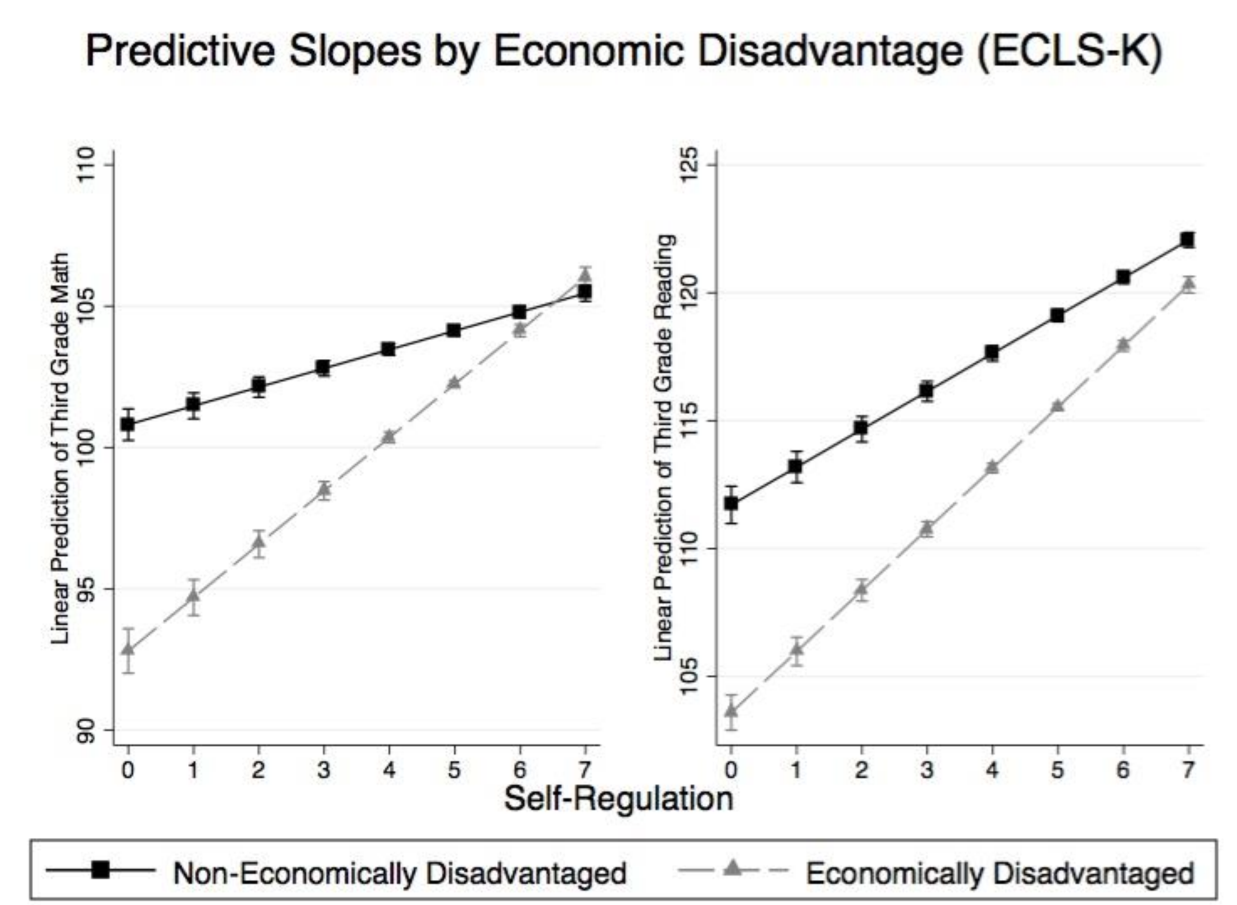

Figure 3. Effects of self-regulation on predicted third grade math (left panel) and third grade reading (right panel) by economic disadvantage nationally

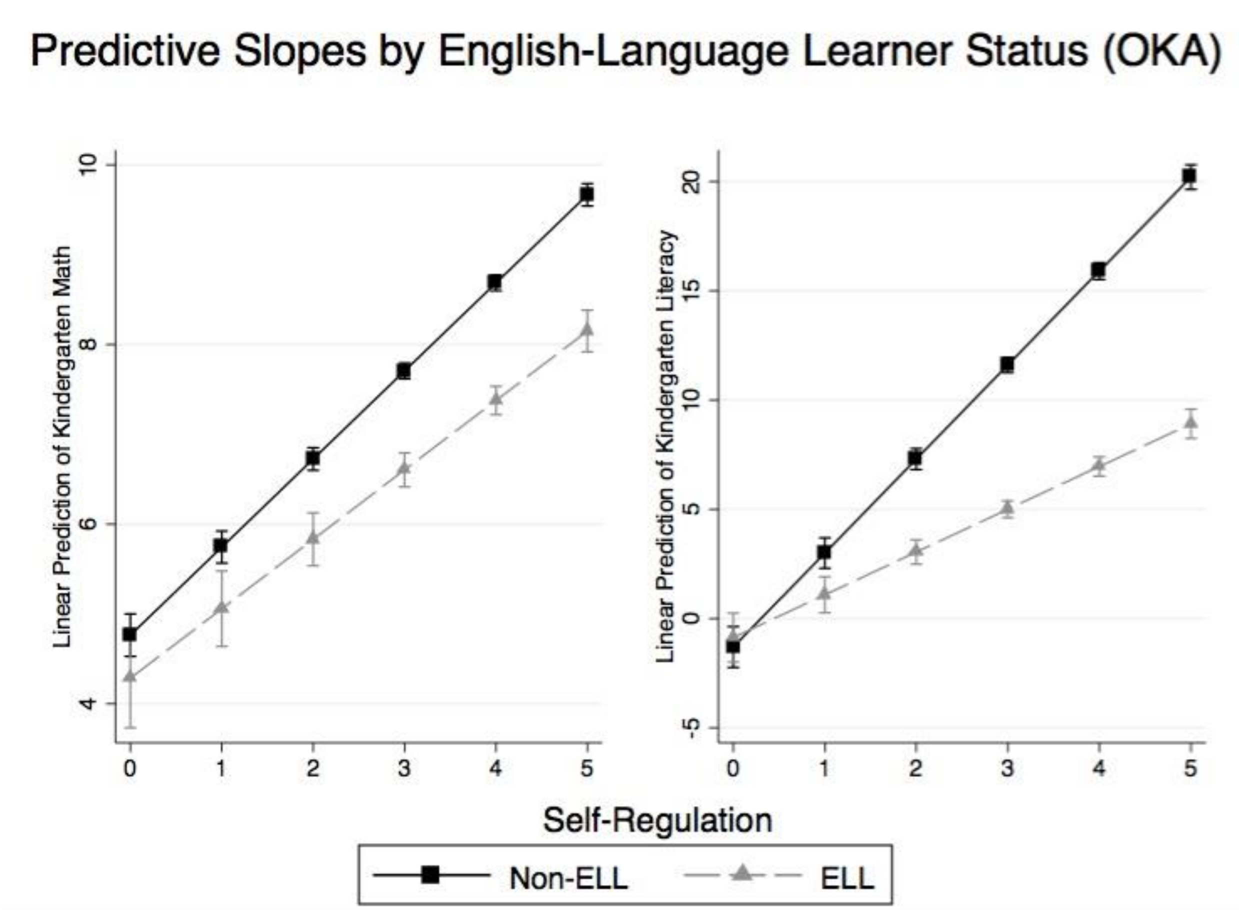

Figure 4. Effects of self-regulation on predicted kindergarten literacy (left panel) and kindergarten math (right panel) by ELL status in Oregon

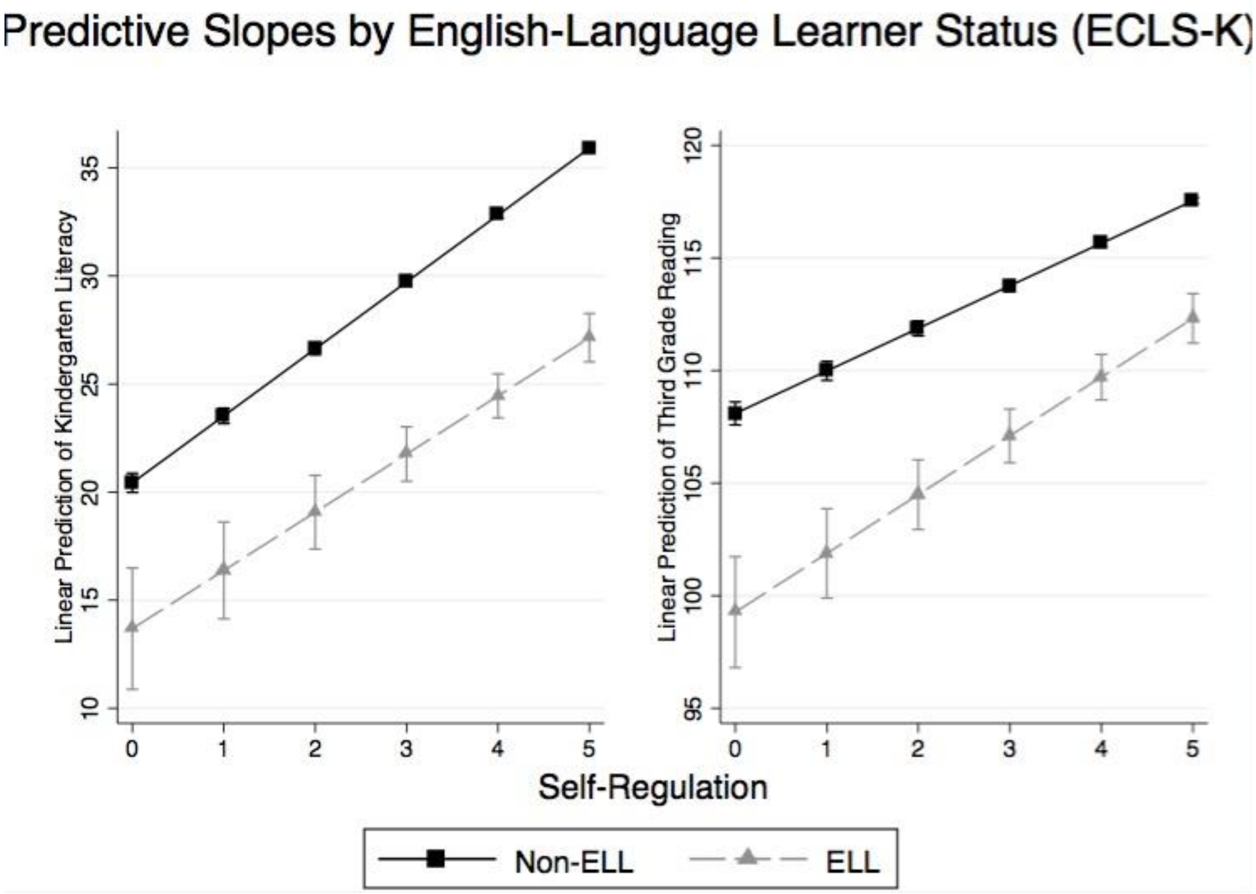

Figure 5. Effects of self-regulation on predicted kindergarten literacy (left panel) and third grade reading (right panel) by ELL status nationally

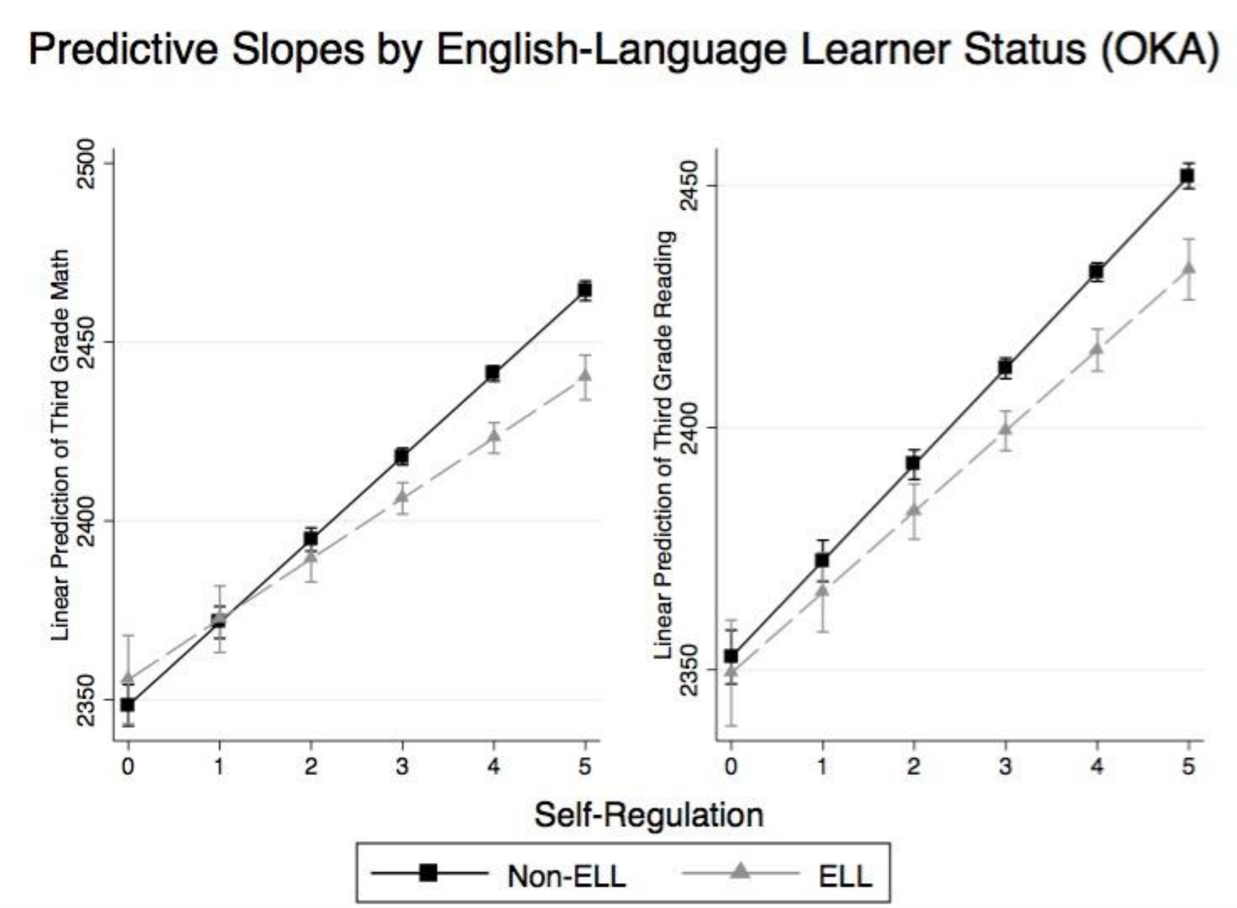

Figure 6. Effects of self-regulation on predicted third grade math (left panel) and third grade reading (right panel) by ELL status in Oregon

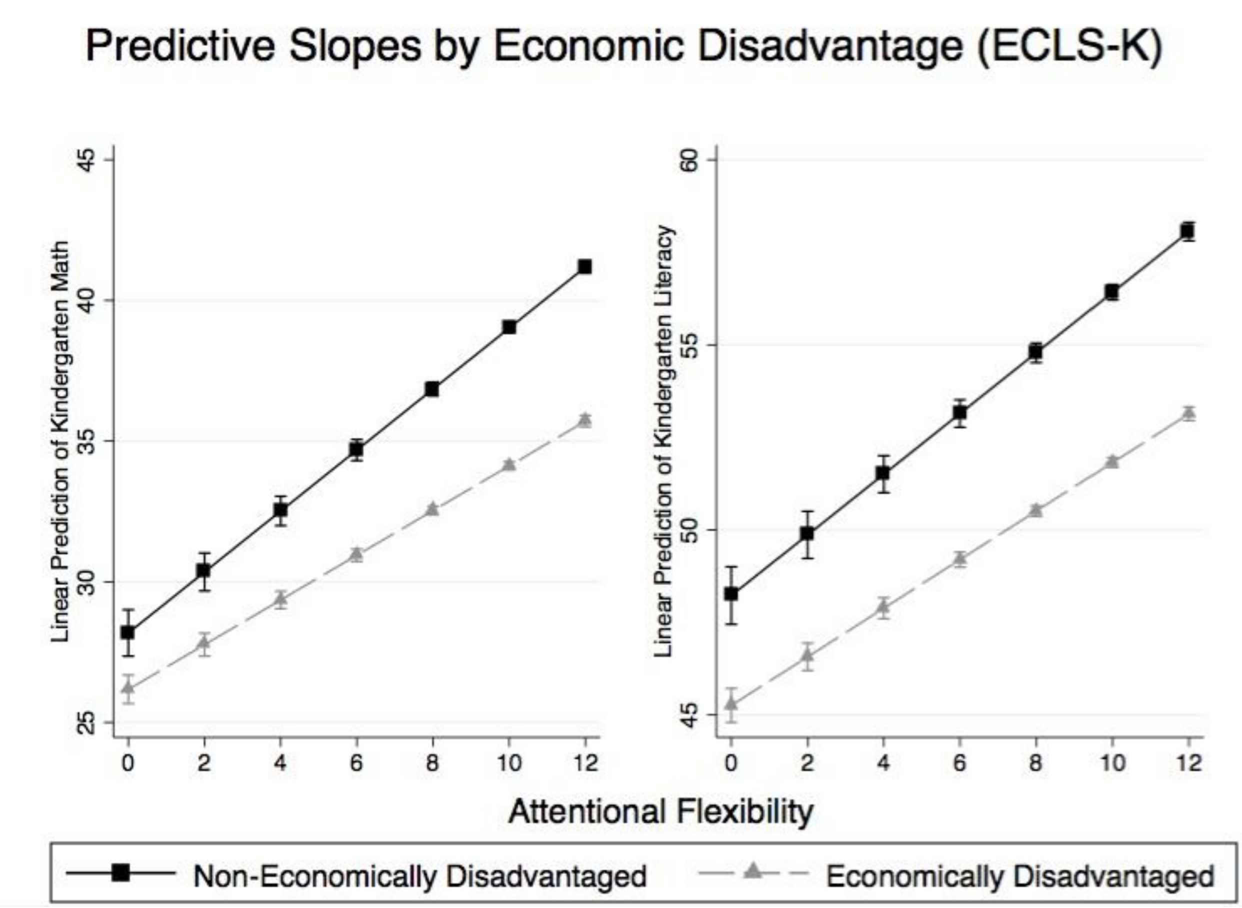

Figure 7. Effects of attentional flexibility on predicted kindergarten math (left panel) and kindergarten literacy (right panel) by economic disadvantage nationally

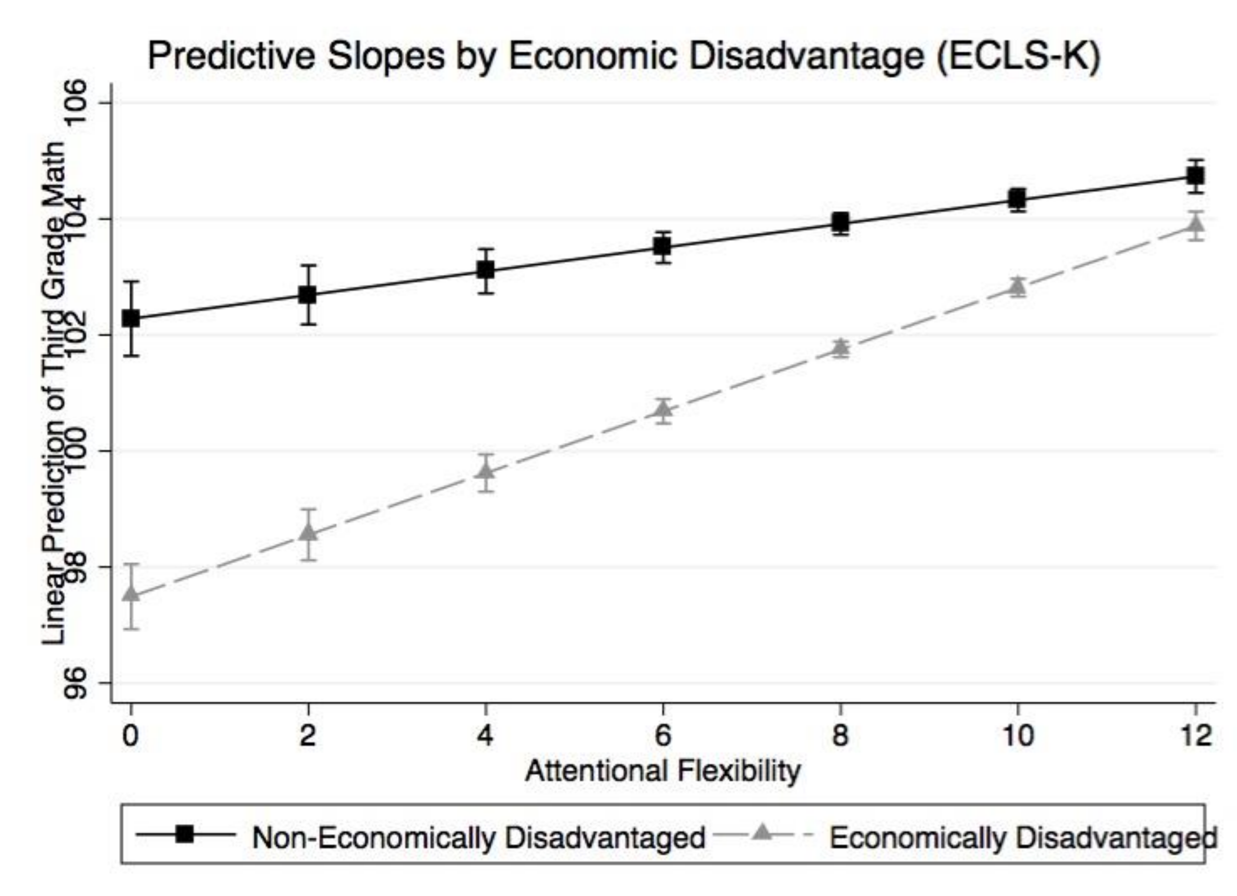

Figure 8. Effects of attentional flexibility on predicted third grade math by economic disadvantage nationally

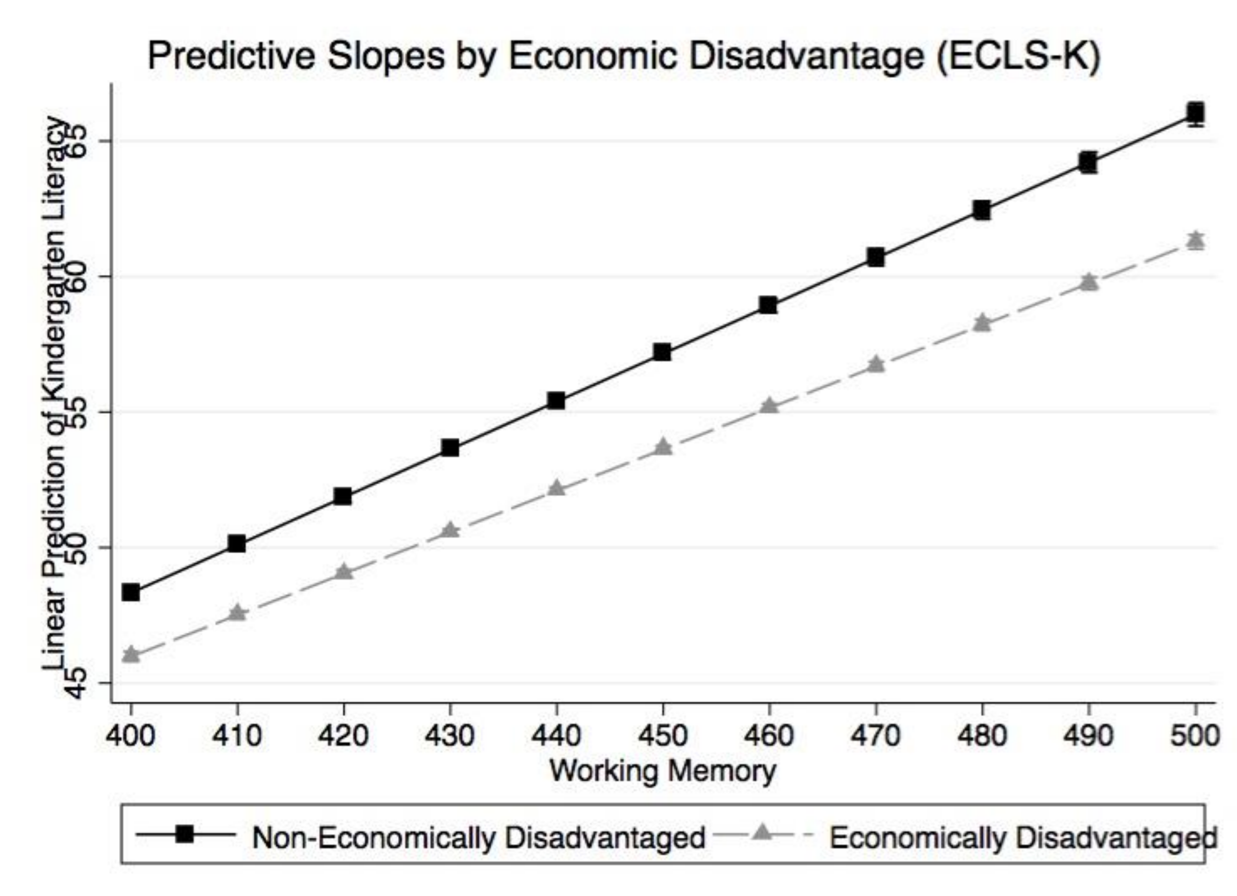

Figure 9. Effects of working memory on predicted kindergarten literacy by economic disadvantage nationally

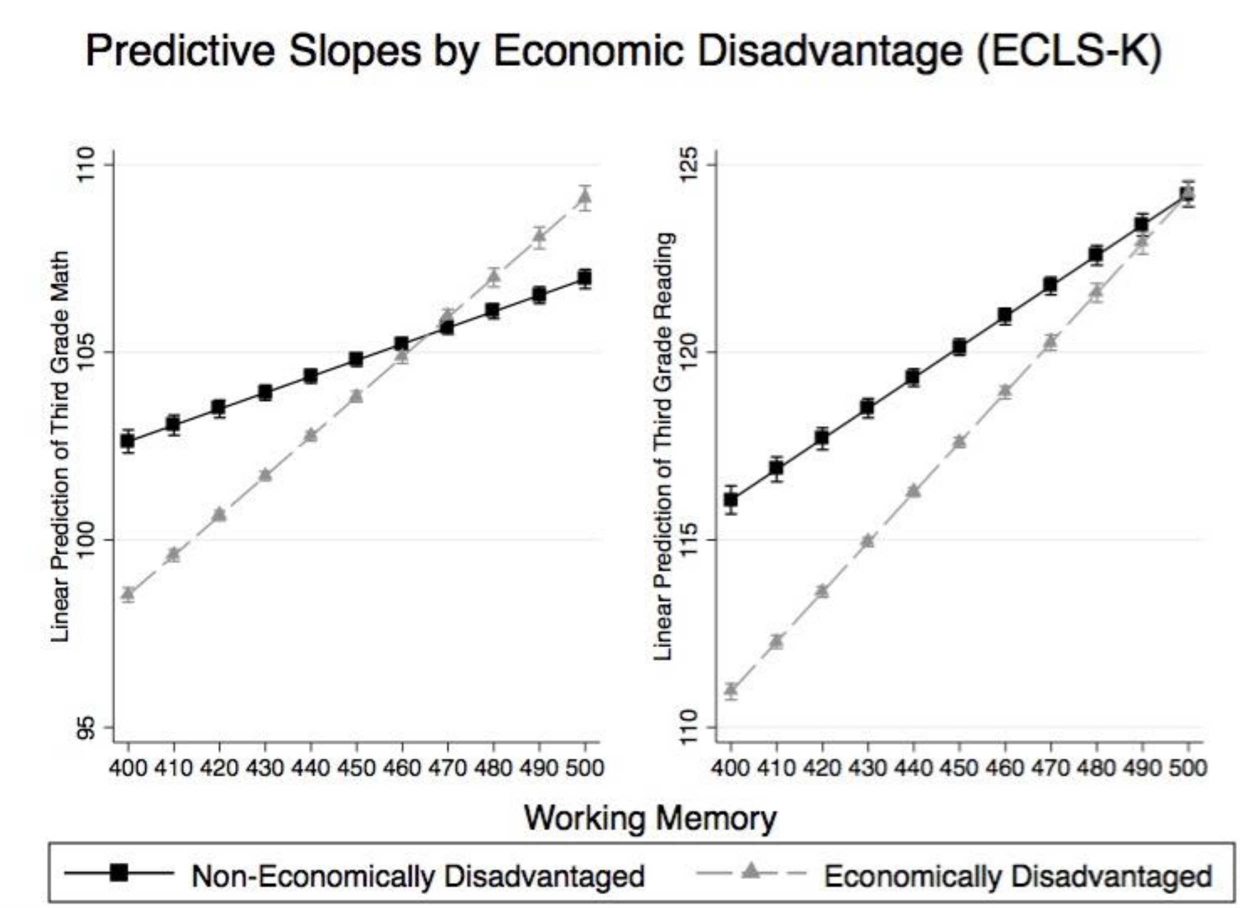

Figure 10. Effects of working memory on predicted third grade math (left panel) and third grade reading (ight panel) by economic disadvantage nationally

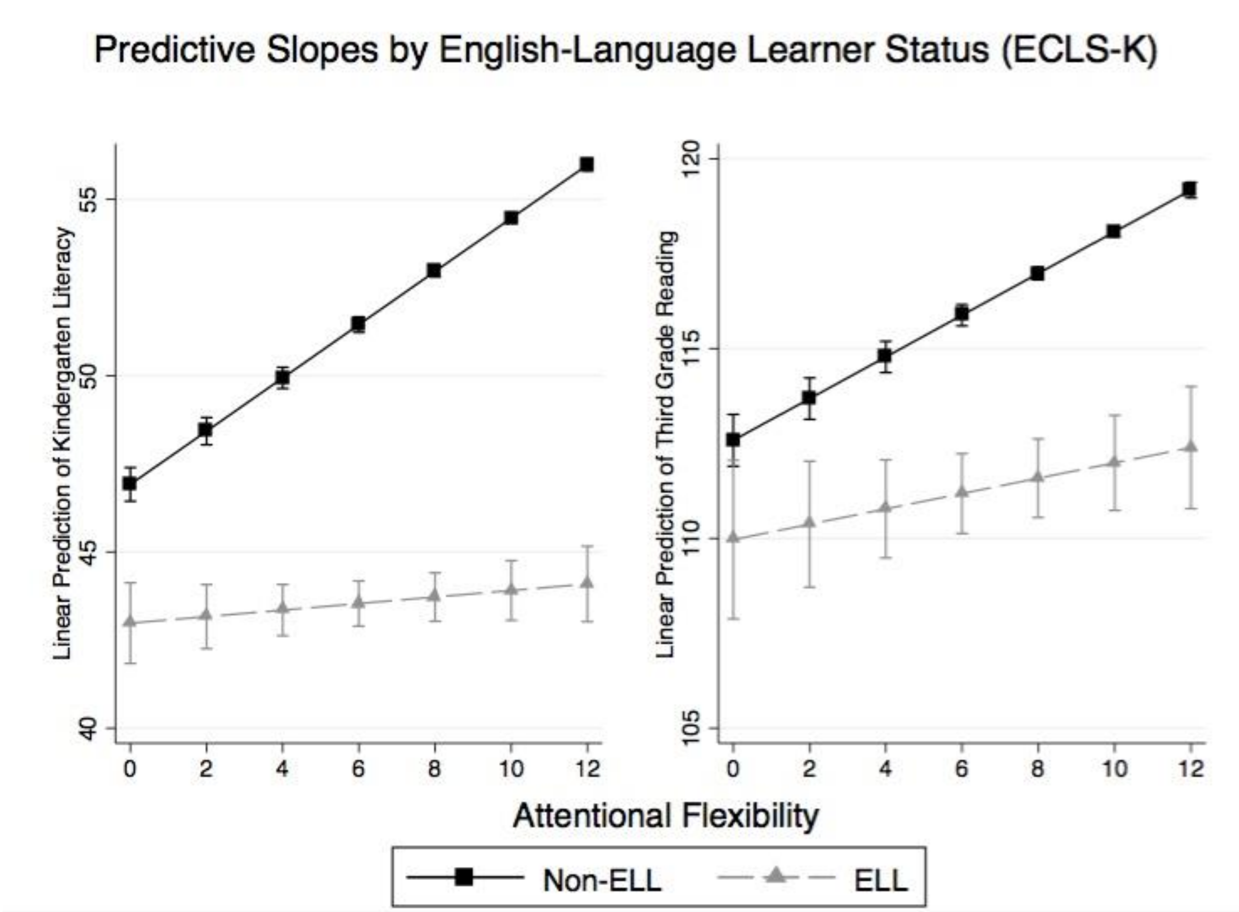

Figure 11. Effects of attentional flexibility on predicted kindergarten literacy (left panel) and third grade reading (right panel) by ELL status nationally

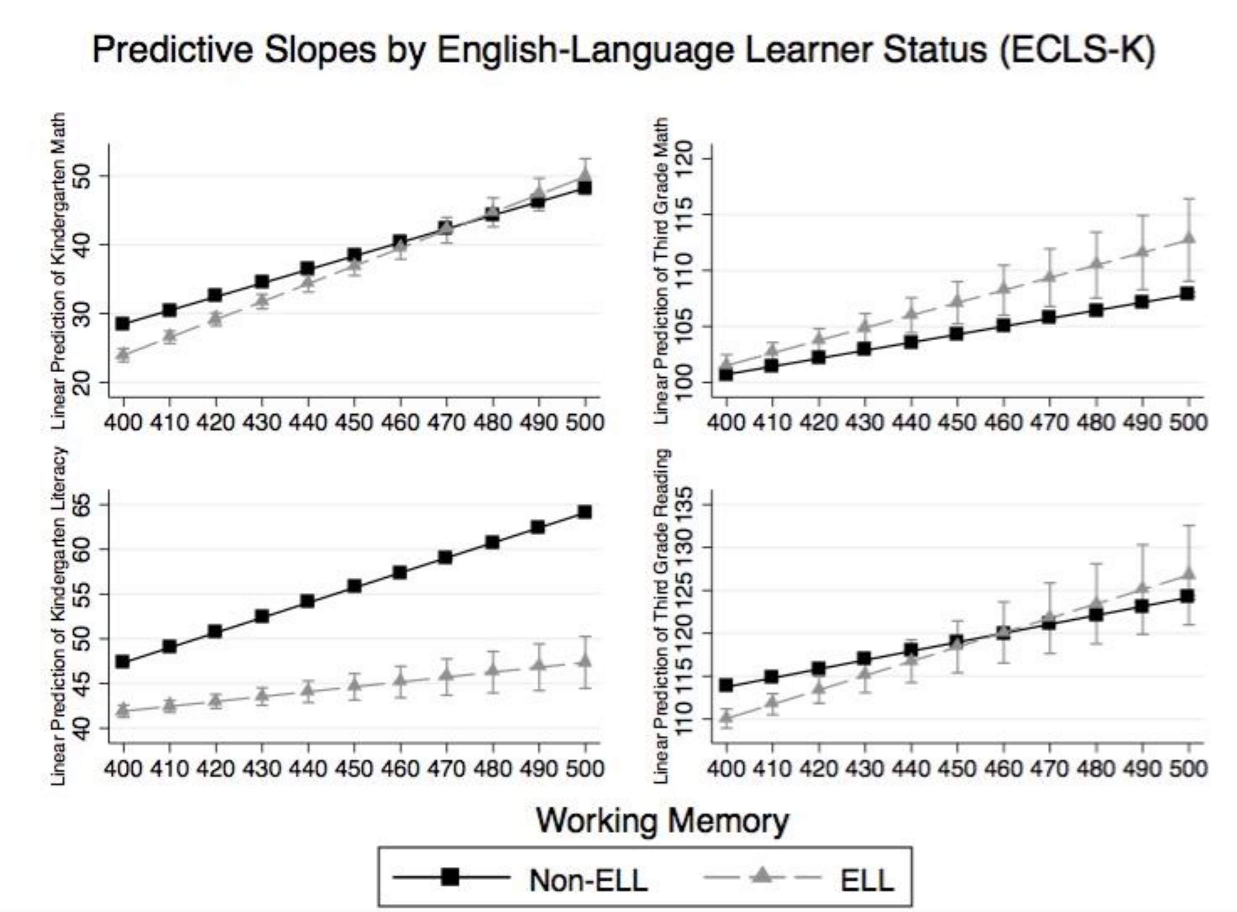

Figure 12. Effects of working memory on predicted kindergarten math (top left panel); third grade math (top right panel); kindergarten literacy (bottom left panel); and third grade reading (bottom right panel) by ELL status nationally

CONCLUSION

The early education landscape has changed dramatically over the past two decades. Prior to the start of formal schooling, children in the 21st century need to attain a level of mastery across skills and knowledge that was previously unnecessary for future success (National Research Council, 2012). This shift in expectations has motivated a large body of research focused on understanding, measuring, and promoting school readiness (Sabol & Pianta, 2017). In addition, significant educational policy initiatives since the early 2000s, such as the No Child Left Behind Act (NCLB) and Race to the Top – Early Learning Challenge (RttT), have placed greater emphasis on test scores as a means for states to be held accountable for reducing achievement gaps. In 2015, the Every Student Succeeds Act (ESSA) was signed into law and granted states flexibility in meeting the rigorous requirements of NCLB in exchange for comprehensive state-developed plans designated to close achievement gaps, increase equity, improve the quality of instruction, and increase outcomes for all children. ESSA opened the door for other important skills, such as self-regulation and executive functions, to be included in accountability systems because it requires states to include at least one non-academic measure (Little, 2017). Yet, until now, the extent to which kindergarten assessments of classroom self-regulation and individual executive functions could forecast and combat longer-term achievement gaps was largely unknown. Specifically, the propensity for these malleable skills to demonstrate independent explanatory and protective effects among economically disadvantaged students and ELLs that could be replicated across contexts had not been investigated. This dissertation attempted to address these gaps in the literature with two studies.

Utilizing data from the OKA and from the most recent cohort of the ECLS-K, study 1 estimated the achievement gaps between economically disadvantaged students and non-economically disadvantaged students and between ELLs and non-ELLs in kindergarten and third grade in Oregon and nationally. In addition, study 1 investigated whether the achievement gaps experienced by economically disadvantaged students and ELLs in kindergarten and third grade could be explained by classroom self-regulation skills in Oregon and nationally, and if individual executive functions provided additional explanatory power nationally. Study 2 complemented study 1 by investigating whether having strong classroom self-regulation compensated for the negative effects of economic disadvantage being of ELL status on kindergarten and third grade academic achievement in Oregon and nationally, and examining the added protective effects of individual executive functions nationally. Together, the findings from these studies inform the broader literature by providing evidence of the specificity and generalizability of developmental processes across contexts and have implications for efforts aimed at reducing achievement gaps as well as how states measure school readiness.

Overview of Study Findings

Results from the first study, *Explaining School Readiness and Longer-Term Achievement Gaps in Statewide and National Contexts*, uncovered slight differences in the magnitude of the achievement gaps experienced by children in Oregon when compared to children nationally. In kindergarten, the math gap due to economic disadvantage was larger nationally than in Oregon, but the reading gap was larger in Oregon than nationally. By third grade, the achievement gaps mostly converged such that the economically disadvantaged students experienced similar consequences in Oregon and nationally. Findings demonstrated consistently larger achievement gaps between ELLs and non-ELLs in Oregon than nationally both in kindergarten and third grade. Subsequent analyses revealed that classroom self-regulation consistently explained a moderate portion of the kindergarten math and literacy gaps experienced by economically disadvantaged students and ELLs in Oregon and nationally. In third grade, classroom self-regulation continued to explain the effect of economic disadvantage on third grade math and reading in Oregon, but only a small portion of the reading gap experienced by ELLs in Oregon. Final analyses demonstrated the strong explanatory power of individual executive functions for kindergarten and third grade achievement gaps nationally, even after accounting for classroom self-regulation skills. Attentional flexibility and working memory explained a large portion of the kindergarten math and literacy gaps experienced by ELLs and economically disadvantaged students nationally, and these effects persisted but weakened in third grade.

Results from the second study, *Identifying Compensatory Skills for School Readiness and Longer-Term Achievement Gaps in Statewide and National Contexts*, indicated that having strong classroom self-regulation benefitted the kindergarten math and literacy skills of non-economically disadvantaged students and non-ELLs in Oregon and nationally more than children who were experiencing risk. However, demonstrating strong classroom self-regulation in kindergarten helped to offset some of the negative effects associated with being economically disadvantaged and of ELL status on third grade achievement among students nationally. Compensatory effects of individual executive functions were also found for ELLs and economically disadvantaged students in the national dataset at third grade. In particular, having strong attention and working memory at kindergarten entry helped to offset the negative effects of economic disadvantage associated with third grade math. Furthermore, having strong working memory served as a compensatory factor for third grade math and reading among ELLs and economically disadvantaged students.

Commonalities Between Studies

Independent roles of classroom self-regulation and individual executive functions. A common thread linking both studies in this dissertation are findings that classroom self-regulation skills and individual executive functions operated independently in their ability to explain and compensate for achievement gaps. Results from study 1 showed that classroom self-regulation skills contributed to school readiness and longer-term achievement gaps experienced by economically disadvantaged students. These findings align with prior research examining associations between teacher ratings of self-regulation, academic achievement, and sociodemographic risk factors (e.g., Sektnan et al., 2010). Expanding on previous studies implicating executive functions as mechanisms explaining achievement gaps (Fitzpatrick et al., 2014; Morgan et al., 2017), individual executive functions also significantly reduced achievement gaps nationally even after controlling for classroom self-regulation. In addition, although classroom self-regulation did not explain achievement gaps experienced by ELLs in third grade, individual executive functions largely reduced these same achievement gaps nationally (Choi et al., 2018).

Further emphasizing the independent roles of self-regulation and executive functions, results from study 2 revealed that classroom self-regulation skills compensated for achievement gaps in third grade but not in kindergarten. Meanwhile, working memory emerged as an integral protective factor for kindergarten math among ELLs after accounting for the classroom self-regulation (Morgan et al., 2018). Together, these results are compatible with conclusions in the broader literature suggesting that subjective ratings of children's classroom self-regulation and objective assessments of individual executive functions may be capturing related but distinct skills in context. Specifically, unique associations between classroom self-regulation and individual executive functions have been found with respect to different academic domains (Fuhs et al., 2015; Schmitt et al., 2014; von Suchodoletz et al., 2013). However, these are the first studies to document independent effects of classroom self-regulation and individual executive functions based their power to explain and buffer the achievement gaps among particular subgroups of children at-risk.

Homogeneity and Heterogeneity in developmental processes. The results from both dissertation studies affirm key principles of Developmental Systems Theories. Conclusions from study 1 reflect the dynamic nature of development and demonstrate the interplay between contextual resources and child capacities for helping or hindering cognitive competencies (Mashburn & Pianta, 2006). Specifically, socioeconomic gaps in academic abilities at school entry and beyond can be partially attributed to the effects of economic disadvantaged and limited English proficiency on children's development of self-regulation and executive function skills (Raver et al., 2013). In other words, study 1 uncovered homogenous pathways to achievement gaps in kindergarten between economically disadvantaged students and ELLs via individual executive functions and classroom self-regulation. This was further illustrated by results from study 2 that confirm the universal protective effects of working memory for longer-term achievement among economically disadvantaged students and ELLs. These findings additionally highlight the importance of intervening during sensitive periods of development when changes to the developing system can have longer-term implications for education trajectories (Heckman, 2006; McClelland et al., 2015).

Conclusions from study also 2 support the equifinality and multifinality principles of developmental systems theory, which underscore the probabilistic nature of development (G. Duncan et al., 2017). Adaptive development appeared to be reached from a diverse array of interactions between children and their contexts (Cichetti & Rogosch, 1996). For instance, early attention skills served as compensatory factors for later math among economically disadvantaged students but not ELLs, and working memory skills were protective against the effect of being an ELL on kindergarten math but not against the effect of economic disadvantage. Furthermore, classroom self-regulation in Oregon and attentional flexibility nationally served to benefit the third grade reading achievement of non-ELLs more so than ELLs. In other words, developmental processes of individual executive functions exhibited heterogeneity in their relations to achievement gaps.

Replication and extension in local and national contexts. The final shared theme across these studies is the replication of findings in statewide and national datasets and also the extension of research questions to offer promising directions for future research (Duncan et al., 2014). Results that were robust to contexts and measures in study 1 suggested that, when direct assessments of executive function skills were not available, classroom self-regulation reliably explained school readiness gaps among economically disadvantaged students and ELLs. Results that were robust to contexts and measures in study 2 indicated that classroom self-regulation skills in kindergarten were more likely to accurately reflect the academic readiness of non-economically disadvantaged students and non-ELLs. However, one key difference between datasets was the finding that classroom self-regulation served as a compensatory factor for third grade achievement among economically disadvantaged students and ELLs nationally but not in Oregon. Measurement discrepancies may be one explanation as to why classroom self-regulation skills did not contribute to academic achievement the same way among ELLs and economically disadvantaged students in Oregon as across the nation, especially given that Oregon has larger populations of both subgroups.

Some unique results emerged in the extensions of both studies within the national dataset that warrant further investigation in local or statewide contexts. In study 1, individual executive functions consistently reduced kindergarten and third grade achievement gaps nationally after controlling for classroom self-regulation. Furthermore, the proportion of the achievement gaps explained by individual executive functions was much greater than the proportion of the achievement gaps explained by classroom self-regulation. These findings are consistent with prior research demonstrating stronger associations between individual executive functions and achievement than between measures of classroom self-regulation and achievement among low-income children (R. Duncan et al., 2017; Razza et al., 2010). An extension of study 2 in the national dataset that did not parallel findings on classroom self-regulation was that working memory emerged as the only protective factor for kindergarten achievement among ELLs. Together, these findings suggest that individual executive functions may be more effective leverage points for interventions than classroom self-regulation skills, particularly with respect to attenuating math achievement gaps among ELLs.

Practical Implications

The findings from these studies have several practical implications, including consequences for enhancing curricula and professional development opportunities to support children at-risk. The results suggest that poorly developed individual executive functions and classroom self-regulation skills at school entry can undermine basic academic skill acquisition and shift longer-term educational trajectories. However, it is not clear how much teachers are explicitly focusing on developing these skills in the years prior to kindergarten. For example, Head Start is intended to narrow the achievement gaps, and although it does produce short term gains in self-regulation and academic achievement, the long-term impacts are difficult to detect

(Puma et al., 2012). Recent evidence suggests that targeted teacher supports mitigate fadeout in early elementary grades (Jenkins et al., 2018). With regards to ELLs, general education teachers who do not hold bilingual or English as a Second Language (ESL) certifications may not be well prepared to meet the needs of ELL students. This is concerning given that recent estimates suggest over 30 states do not require professional development for teaching ELLs beyond federal requirements (Education Commission of the States, 2014). Furthermore, Head Start teachers and teachers of ELLs often report feeling overwhelmed by their competing demands (Gándara, Maxwell-Jolly, & Driscoll, 2005; Yoshikawa & Knitzer, 1997). Policy recommendations may involve establishing evidence-based curricula and classroom practices derived from early learning standards that target ELLs, such as instituting licensing criteria for teachers and offering resources that support systematic efforts to foster language development (Castro et al., 2011). Interventions for teachers of children from economically disadvantaged backgrounds may include caregiver co-regulation strategies for improving student and teacher self-regulation (Murray & Rosanbalm, 2017).

The results from these studies also have important implications for how states select their Kindergarten Entry Assessments (KEAs). Sometimes called Kindergarten Readiness Assessments, KEAs refer to a range of assessment activities designed to measure multiple domains that are important for learning (Saluja, Scott-Little, & Clifford, 2000). KEAs provide a snapshot of what children know and can do at the start of kindergarten (Connors-Tadros, 2014; Saluja et al., 2000; Shields, Cook, & Greller, 2016). From 2010 to 2014, the number of states that were implementing KEAs rose from just 7 to 29 (Conors-Tadros, 2014). The purpose of KEAs are generally to inform efforts to close the school readiness gaps, guide instructional practices, and identify children who need additional testing (Connors-Tadros, 2014; Shields et al., 2016). However, few appropriate and valid measures of school readiness exist for children transitioning to school (Janus & Offord, 2007; Snow, 2006). Furthermore, the lack of consensus around defining school readiness means that states are left on their own to select measures to include in their KEAs. The findings from this dissertation suggest that kindergarten assessments of classroom self-regulation in Oregon may not be as strongly related to longer-term achievement within these particularly vulnerable subgroups of children as direct assessments of individual executive function skills may be. However, when ELLs or economically disadvantaged students score high on measures of classroom self-regulation, these assessments may offer insight into how likely at-risk children will be to catch up to their non-at-risk peers in the future. Therefore, state leaders should consider a wide variety of kindergarten assessments for multiple purposes, including predicting the progress of at-risk populations over the early years of schooling.

Limitations and Future Directions

A few common limitations should be noted. First, it is necessary to acknowledge that the measures of economic disadvantage utilized from both datasets were far from perfect. The official US poverty thresholds ensure consistency in measuring poverty rates over time, adjusting for inflation and family size, and determine eligibility for many means-tested programs. However, these precise dollar thresholds may not qualitatively differentiate family experiences. For example, researchers have found that children in poor families (100% or below the poverty threshold) versus near poor families (100-200% of the poverty threshold) have stark differences in kindergarten and overall life outcomes (G. Duncan et al., 2017). The measure of economic disadvantage in the current study likely underestimates the true gap between children in poverty and children not in poverty, given that it includes a wider income distribution. Therefore, lumping children in these categories together may ignore these important nuances and may bias results. Still, some research supports the use of free and reduced lunch as a proxy for SES and has found that relations between SES and academic achievement are stronger for measures of free and reduced lunch than parental occupation, education, and income (Sirin, 2005). Given that eligibility for free or reduced lunch is often the only measure available through administrative datasets to estimate gaps in student achievement, future work should focus on ways to obtain more detailed measures of economic disadvantaged between kindergarten and third grade. For example, Michelmore & Dyrnaski (2015) created a measure that accounts for distinctions between current disadvantage, persistent disadvantage, or never disadvantaged. They argue that by taking these differences into account, practitioners and policymakers can better target resources intended to support the most disadvantaged children and their schools.

Similarly, the measure of ELL status in both datasets was also fairly limited, and the concerns of this are compounded by the fact ELLs were inconsistency assessed using Spanish or English measures across samples. Unlike in the national dataset, Oregon kindergarteners identified as ELLs were administered direct assessments of math in Spanish and early literacy in English. This could potentially bias their actual literacy abilities in Oregon, as research suggests that when Spanish-speaking ELL children are assessed in their native language, associations between learning-related skills and achievement are stronger (Lonigan, Lerner, Goodrich, Farrington, & Allan, 2016). This was not an issue in the national dataset because ELLs were administered all direct assessments in Spanish, however, the inconsistency across datasets creates an additional complication when attempting to replicate results. In addition, in the Oregon dataset, there was no way to know whether children remained limited English proficient from kindergarten to third grade, whereas in the national dataset, all children were assumed to be

English proficient in third grade and therefore received all direct assessments in English. In the future, researchers should utilize more nuanced measures of ELL status that take into account patterns of English-language proficiency when examining longitudinal achievement gaps.

In terms of the replication and extension of findings, it would have been ideal if the datasets matched in their scope, measurements, and timeline. For example, the Oregon kindergarten data was collected in fall of 2013 and the national kindergarten data was collected in fall of 2010. In addition, the ability to reliably and validly capture growth over time in the Oregon data was limited by the fact that school readiness assessments of math and literacy in kindergarten were different from standardized assessments of math and reading in third grade. This was not an issue in the national data because the assessments were purposefully aligned (Tourangeau et al., 2018). Indeed, different test metrics may lead to dramatically different conclusions regarding how achievement gaps change with age (e.g., Fryer & Levitt, 2004). The Oregon data was also somewhat scarce in what variables it could offer. Depending on the state, the comprehensiveness of administrative data may vary (Levesque, Fitzgerald, & Pfeiffer, 2015). However, what the Oregon dataset lacked in measurement precision it made up for by its size of observations. Furthermore, a unique strength of this study was the ability to capitalize on these weaknesses by using a complementary dataset in order to improve generalizability. When researchers are faced with similar limitations of using administrative data, it may be beneficial to perform robustness checks in national datasets as a means to increase confidence in results.

A final limitation to acknowledge is the fact that there is a host of other known factors that contribute to achievement gaps which were largely unaccounted for in these studies. For example, the effects of economic disadvantage on child development have been demonstrated through indirect pathways, with the quality of the home environment, access to stimulating learning materials and opportunities, and parent-child interactions accounting for as much as 50% of the variance between income-to-needs and child outcomes (Bradley & Corwyn, 2002; Duncan & Brooks-Gunn, 2000). Furthermore, families with limited economic resources are less likely to invest in high-quality child care and education, afford housing in good neighborhoods, and provide rich learning experiences enhance children's development, all of which may undermine early academic achievement (Hart & Risley, 1995; Lee & Burkam, 2002; Whitehurst & Lonigan, 1998). Similarly, parent participation in adult-orchestrated learning activities, investments in educational materials, and involvement with school mediate a large proportion of the Hispanic-white gap in math and reading at kindergarten entry (Cheadle, 2008). In addition, home language usage appears to have a strong influence on early language, literacy, and math among ELLs (Halle et al., 2012; Mancilla-Martinez & Lesaux, 2011). Likewise, English oral language skills have a large effect on English reading comprehension and math achievement among elementary school children from Spanish-speaking homes (Choi et al., 2018; Gottardo & Mueller, 2009; Lesaux, Crosson, Kieffer, & Pierce, 2010). The narrowing of achievement gaps in early elementary school ELLs and economically disadvantage students may therefore result from other important individual and contextual factors, or the interplay between these factors and the development of executive functions and self-regulation. These pathways are essential to establish in future work.

Conclusion

The two studies in this dissertation clarify the roles of individual executive function skills and classroom self-regulation at kindergarten entry for school readiness and longer-term achievement gaps. Findings provide evidence that classroom self-regulation both explains the achievement gaps experienced by economically disadvantaged students and ELLs at the start of kindergarten and may compensate for these gaps in third grade. In addition, results highlight the independent and unique contributions of individually assessed executive functions, including attentional flexibility and working memory, for school readiness and longer-term achievement among economically disadvantaged students and ELLs. In particular, working memory materialized as a promising intervention point for ELLs. Together, the results from these studies expand our knowledge on the specificity and generalizability of developmental processes across subgroups and contexts. Future work should attempt to replicate these associations in statewide datasets that offer a wider variety of kindergarten assessments in order make firmer conclusions about the relative importance of individual executive functions and classroom self-regulation for short- and long- term achievement as measured by standardized tests.

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