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DO GAINS IN EXECUTIVE FUNCTIONS SUPPORT SUSTAINED INTERVENTION EFFECTS IN A HOME AND PRESCHOOL-BASED SCHOOL READINESS INTERVENTION?

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Abstract

School readiness at Kindergarten entry is crucial to children's subsequent academic performance and is predictive of lifelong success across multiple domains of functioning. Children growing up in a context of poverty show reduced school readiness, including deficits in both emergent academic skills and self-regulatory capacity. The REDI (Research-based Developmentally Informed) Parent school readiness intervention (REDI-P) sought to enhance growth in both these areas and consisted of school- and home-based components. REDI-P has previously demonstrated social-emotional and academic gains which were sustained through 3rd grade. This study examined the processes underlying these sustained gains by testing whether the REDI-P led to growth in children's self-regulatory capacities between kindergarten and 3rd grade and whether these gains mediated academic and social-emotional effects. Participants were 200 pre-kindergarten children attending Head Start and their caregivers, randomized to either REDI-P, a 16-session home-visiting intervention that promoted parent-child interactions designed to foster language, literacy, and social-emotional development, or "usual practice" Head Start home visits. Results of latent growth curve analyses showed that the REDI-P intervention demonstrated significant intervention effects on growth in children's Working Memory and Inhibitory Control between kindergarten and 3rd grade. The intervention also resulted in gains in the domain of Set Shifting. Tests of indirect effects found significant mediation between REDI-P and children's Academic Skills via Working Memory and between REDI-P and children's Social Skills via Inhibitory Control. Results are discussed with respect to their implications for intervention development and ongoing research.

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Introduction

The academic achievement gap between children from middle versus low income families has grown steadily over the last 50 years and is now almost twice as large as the racial achievement gap (Reardon, 2011). At Kindergarten entry, early indicators of the gap are evident in income-linked discrepancies on measures of children's pre-academic skills, such as emergent literacy and numeracy (e.g., Aikens & Barbarin, 2008; Denton & West, 2002; Durham & Smith, 2006), as well as measures of social-emotional development (Raver, 2004). Together, these pre-academic and social-emotional skills, as well as related self-regulatory capacities (e.g., Eisenberg, Spinrad, & Eggum, 2010; Liew, 2012), are often termed "school readiness" (Snow, 2006) and they are foundational to subsequent school success (Duncan et al., 2007). Deficits in these capacities at kindergarten entry set children on a trajectory of relatively low achievement, from which they often never recover (Ryan, Fauth, & Brooks-Gunn, 2006). Moreover, for children growing up in the context of poverty, the long-term interplay of academic and self-regulatory struggles may be perpetuated across the lifespan (Blair & Diamond, 2008; Nota, Soresi, & Zimmerman, 2004), leading to reduced educational attainment, employment potential, income, and overall well-being (Hershbein, 2016; Ryan et al., 2006)

The mounting evidence supporting the importance of school readiness at kindergarten entry has fueled the creation, implementation, and evaluation of pre-kindergarten intervention programs that specifically target aspects of school readiness, with the larger goal of narrowing the income-linked achievement gap (Anderson et al., 2003; Duncan, Ludwig, & Magnuson, 2007; Ramey & Ramey, 2004). These classroom-based interventions aim to enhance academic skills that are crucial to future academic success, such as emergent literacy and numeracy skills (Arnold, Fisher, Doctoroff, & Dobbs, 2002; Justice & Pullen, 2003; Ramani & Siegler, 2008) as

well as children's self-regulatory capabilities, such as problem solving and emotion regulation strategies (Blair & Razza, 2007; Verdine, Irwin, Golinkoff, & Hirsh-Pasek, 2014), which are believed to comprise the neurobiological underpinnings that support learning (Blair & Diamond, 2008; Ursache, Blair, & Raver, 2012). Many of these intervention programs have shown promising effects for both academic and self-regulatory outcomes (Camilli, Vargas, Ryan, & Barnett, 2010; Tucker-Drop, 2012; Wong, Cook, Barnett, & Jung, 2008); however, evidence is mixed with respect to longer-term benefits, with many studies showing fade out of effects as children progress into elementary school (Bailey, Duncan, Odgers, & Yu, 2017; Puma, et al., 2010).

Aiming to promote sustained effects, the REDI (Research-based Developmentally Informed) Parent school readiness intervention (REDI-P) was designed to provide support across the transition into kindergarten. REDI-P was built upon the success of an exisiting classroom-based program (Head Start REDI; Bierman et al., 2008). It extended the classroom program by reaching out to parents with home visits that provided them with similar activities and strategies for use at home. Like the classroom program, REDI-P was designed to increase children's language and literacy development and bolster their emotional understanding and problem solving competence via enhancement of self-regulatory skills. Home visitors also worked directly with parents to help them engage with their children and use the learning materials in ways that would optimally promote children's academic and social-emotional development over time.

In a randomized controlled trial, REDI-P demonstrated intervention gains for children in both academic and social-emotional domains following their transition from preschool into kindergarten (Bierman, Welsh, Heinrichs, Nix, & Mathis, 2015) and a recent follow-up study

showed that these gains were maintained into the 3rd grade year (Bierman et al., in press). The goal of the present study is to examine the purported processes underlying the long-term maintenance of these gains. Specifically, this study aims to test whether the REDI-P intervention led to growth in children's self-regulatory capacities and, if so, whether enhanced self-regulation at 3rd grade accounted for the sustained academic and social-emotional effects.

Children's Self-Regulatory Development

Self-regulation refers to the ability to receive information, evaluate potential consequences of actions, and enact behaviors that optimally achieve intended goals (McClelland, Geldhof, Cameron, & Wanless, 2015). It encompasses a broad array of both voluntary (e.g., inhibiting a behavioral response) and involuntary (e.g., physiologic reactivity to a stressor) processes. Self-regulatory development has been of particular interest to early childhood education researchers as it is believed to represent an interface between the core domains of school readiness (i.e., social-emotional and academic competence; Blair, Calkins, & Kopp, 2010) and is closely linked with children's school success (Morrison, Ponitz, & McClelland, 2010).

Representing the cognitive, volitional component of self-regulation (Clarke, Martinez, Nelson, Wiebe, & Espy, 2014), children's executive functioning (EF) has been a key focus of inquiry within the field of school readiness research (Blair, 2002; Carlson, 2005; McClelland, Acock, & Morrison, 2006). EF is a broad term referring to three related, but distinct self-regulatory processes: working memory, inhibitory control, and set shifting (Best & Miller, 2010; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). Working memory allows for input and processing of novel information as well as retrieval and manipulation of knowledge stored in long-term memory (Swanson, Jerman, & Zheng, 2008). Inhibitory control refers to the ability to inhibit a strong or well-developed behavioral and/or cognitive impulse in favor of a more

adaptive response to a given task (Diamond, 2012). Set shifting describes a child's ability to focus and flexibly shift attention as needed, as well as to ignore irrelevant stimuli (Blair and Diamond, 2008). Together, these three core components of EF in children enable them to regulate behavior and thinking, facilitating increasingly complex planning and problem solving abilities as they mature (Diamond, 2013).

EF development is both biologically and environmentally influenced (Best & Miller, 2010). At a neurological level, EF is supported by the development of prefrontal cortical (PFC) regions of the brain (Barrasso-Catanzaro, & Eslinger, 2016; Zelazo, Carlson, & Kesek, 2008), as well as areas with PFC projections, such as the anterior cingulate cortex (Gilbert & Burgess, 2008). The preschool years represent a crucial period of growth for children's EF and the underlying PFC regions due to their rapid development during this time (Toga et al., 2006). Between the ages of 3 and 5, children exhibit a dramatic increase in EF capabilities, resulting in a greater capacity to engage in tasks requiring self-regulation as well as increasingly efficient neurological processing while performing these types of tasks (Best, Miller, Naglieri, 2012; Carlson, 2005; Clark et al., 2013; Luciana & Nelson, 1998).

EF includes processes that are both affected by and that have an influence upon social-emotional functioning, resulting in a strong association and reciprocal longitudinal influence between these two competency domains (Stenseng, Belsky, Skalicka, & Wichstrøm, 2015). Many of the same environmental factors that shape children's social-emotional development also predict their EF capabilities, including qualities within the parent-child relationship and peer interactions (Bagdi & Vacca, 2005; Elias & Berk, 2002; Volet, Vauras, & Salonen, 2009). Moreover, due to its sensitivity to the environment, EF represents a valuable target for early childhood intervention and there is increasing evidence of intervention-driven growth in

children's EF (Diamond & Lee, 2011). Thus, in addition to providing children with cognitive stimulation (e.g., exposure to rich language, learning, and problem-solving opportunities; Baroody & Diamond, 2014; Cartwright, 2012), it has been proposed that universal preschool-based preventative intervention programs may effectively increase children's EF skills by specifically targeting aspects of social-emotional competence that are linked to self-regulatory development (Domitrovich, Durlak, Staley, & Weissberg, 2017).

Executive Functions and School Success

Given the self-regulatory demands that are necessary to actively engage in the process of learning (McClelland & Cameron, 2011), it follows that children's pre-kindergarten EF is a robust predictor of both concurrent and future school performance in a variety of domains. For example, Willoughby and colleagues (2017) found that lower EF trajectories between the ages of 3 and 5 were associated with impaired academic readiness at Kindergarten. Conversely, multiple studies have found that greater EF skills at the beginning of children's pre-kindergarten year predict gains in both early math and literacy skills by the end of the year, controlling for prior performance (Fuhs, Farran, & Nesbitt, 2015; Weiland, Barata, & Yoshikawa, 2014). Prospectively, pre-kindergarten EF has been found to predict children's math ability at 1st grade (Clark, Pritchard, & Woodward, 2010), as well as math and overall teacher-rated academic functioning into 3rd grade (Sasser, Bierman, & Heinrichs, 2015).

Perhaps reflecting the overlapping processes in their development, children's pre-kindergarten EF and their social-emotional functioning are also highly related. Observing children's behavioral regulation in the context of peer play interactions, Hughes, White, Sharpen, and Dunn (2000), for example, found that children with lower EF tended to display more antisocial and less prosocial behaviors, as well as higher levels of negative emotion. The

association between pre-K EF and behavioral regulatory struggles has been found within both the classroom and home contexts, with lower EF predicting greater parent and teacher-rated behavior problems (Hughes & Ensor, 2008). Longitudinally, greater EF skills in early childhood predict children's social competence at 3rd grade (Sasser et al., 2015) as well as reduced peer problems into adolescence (Holmes, Kim-Spoon, & Deater-Deckard, 2016).

Studies of EF development and academic success show increasing differentiation among the core components of EF (i.e., working memory, inhibitory control, and set shifting) as children progress through elementary school (e.g., Brocki & Bohlin, 2004; Huizinga, Dolan, & van der Molen, 2006; Isquith, Gioia, & Espy, 2004). Thus, in the later elementary years, these components are often examined separately as they gain increasing predictive validity for outcomes in unique domains as children age (Best, Miller, & Jones, 2009).

Two components of EF that appear to be crucial to success in math and reading during elementary school are working memory and set shifting (e.g., Morgan et al., 2016). Working memory has been found to specifically predict language and math ability and achievement in children throughout both early (e.g., Bull, Espy, & Wiebe, 2008) and later (e.g., St Clair-Thompson & Gathercole, 2006) elementary school. Similarly, set shifting is associated with functions crucial to problem-solving, such as reading comprehension and information processing. Passolunghi and Cornoldi (2000) found that children who struggle in this area of EF tend to remember less relevant and more irrelevant information when solving math word problems. A meta-analysis by Yeniad and colleagues (2013) confirmed that set shifting is a robust predictor of both math and reading performance throughout elementary school.

Empirical evidence strongly links the inhibitory control component of EF with the development of children's social-emotional functioning. Based on both parent and teacher-

report, children's inhibitory control has been found to predict emotional regulatory difficulties as well as behavioral problems throughout elementary school (Riggs, Blair, & Greenberg, 2004; Vuontela et al., 2013). Within a peer context, inhibitory control is also predictive of more cooperative behavior (Ciairano, Visu-Petra, & Settanni, 2007) as well as lower levels of peer aggression (Ellis, Weiss, & Lochman, 2009).

In sum, there is a substantial body of research linking children's EF with concurrent and future school success. Developmental theory and emerging empirical evidence support a neurobiological link in which EF represents the underlying support structure upon which both academic and social-emotional capacities are built and reinforced (Blair & Diamond, 2008). To date, however, few studies have conducted a direct test of this proposed framework by intervening in ways designed to promote EF and following children with a longitudinal design that would enable stronger causal inference. This type of test is particularly relevant to school readiness research, given mixed evidence with regard to whether or not pre-kindergarten interventions targeting EF are effective at boosting children's academic skills (e.g., Clements, Sarama, & Germeroth, 2016; Diamond & Lee, 2011; Hughes & Ensor, 2011; Jacob & Parkinson, 2015; Welsh, Nix, Blair, Bierman, & Nelson, 2010). Further, while previous research has examined growth in EF—measured as a unitary construct—across the elementary years, given the evidence of increasing differentiation of EF components as children progress through school, it may be beneficial to examine the degree to which intervention might differentially affect these components. Understanding the sustained effects of preschool interventions on the development of EF is particularly important for children growing up in poverty, given evidence of the delays in EF development associated with poverty.

The Effects of Poverty on Children's Executive Functions and School Success

Socioeconomic status (SES) is strongly associated with children's EF development (Hackman, Gallop, Evans, Farah, 2015; Lawson, Hook, & Farah, 2017) and there is evidence that EF mediates the link between SES and academic achievement (Dilworth-Bart, 2012; Fitzpatrick, McKinnon, Blair, & Willoughby, 2014; Lawson & Farah, 2017). Multiple theoretical explanations have been proposed to explain how poverty may impede EF development, postulating negative effects for chronic exposure to high levels of toxic stress (Evans & Kim, 2013), disrupted parent-child relational processes and reduced opportunities for positive socialization of social-emotional regulatory skills (Becker & Luthar, 2002; Milteer, Ginsburg, & Mulligan, 2012), and reduced levels of cognitive stimulation (Votruba-Drzal, 2003).

An increasing number of studies support the link between EF deficits and the elevated toxic stress associated with living in poverty, which may undermine self-regulatory development at a neurobiological level (Obradović, 2016). For example, a magnetic resonance imaging study showed that reduced parent income was associated with less cortical tissue in areas of children's brains associated with EF (Noble et al., 2015). Additional research has shown poverty to be associated with patterns of less well-developed specialization of processing within the brain (Hackman & Farah, 2013), which, coupled with dysregulated stress responses (Blair, Granger, & Razza, 2005), may reflect a "trade-off" in which children's self-regulatory development is de-emphasized in order to attend to immediate threats within the environment (e.g., Blair & Raver, 2012; Del Guidice, Ellis, & Shirtcliff, 2011). These threats may occur across multiple contexts, over a prolonged period of time as children from low-SES backgrounds experience greater levels of neighborhood disadvantage, such as violence and other crime (Child Trends, 2013), and are more likely to be exposed to harsh, inconsistent discipline (Dodge, Pettit, & Bates, 1994; Pinderhughes, Dodge, Bates, Pettit, & Zelli, 2000). In essence, the chronic, toxic stress and

associated unpredictability experienced by children growing up in poverty reinforces reactive, self-protective responding, a pattern which emerges and is supported by structural and functional adaptations within the brain.

The neurobiological effects of exposure to poverty-associated chronic stress on children's capacity to succeed in school may be compounded by reduced exposure to opportunities for social-emotional development, both at school and within the home (e.g., Crosnoe, Purtell, Davis-Kean, Ansari, & Benner, 2016; McCoy, Connors, Morris, Yoshikawa, & Friedman-Krauss, 2015). For example, whereas high quality preschool programs provide an opportunity for children to develop and practice social-emotional skills via both teacher-led classroom activities and opportunities for supervised peer interactions (Coolahan, Fantuzzo, Mendez, & McDermott, 2000; McCabe & Altamura, 2011), children from low-SES backgrounds are more likely to attend low-quality preschools that do not provide these opportunities (Crosnoe, Purtell, Davis-Kean, Ansari, & Benner, 2016; Fuller, Kagan, Loeb, Chang, 2004; Hillemeier, Morgan, Farkas, & Maczuga, 2013). These low-quality preschool programs may, in fact, promote child behavior problems via factors such as less adult supervision and negative teacher-child interactions (McCartney et al., 2010; McCoy, Connors, Morris, Yoshikawa, & Friedman-Krauss, 2015).

Within the home, poverty-related stressors disrupt family wellbeing through multiple factors, including increased likelihood of parental depression and inter-parental conflict (e.g.Conger, Rueter, & Conger, 2000; Conger, Wallace, Sun, Simons, McLoyd, & Brody, 2002; Lorant, Deliège, Eaton, Robert, Philippot, & Ansseau, 2003). This disruption, in turn, may result in children being exposed to more intrusive, negative, and harsh parenting (Ispa et al., 2004), coupled with less availability of emotional support from parents, which has been found to partially mediate the association between SES and children's EF (Sarsour, Sheridan, Jutte, Nuru-

Jeter, Hinshaw, & Boyce, 2011). Thus, the conditions of poverty may interfere with and reduce opportunities for children to experience positive, supportive interactions with parents and appropriately supervised peer play at preschool or daycare. In essence, children growing up in poverty have far fewer resources to guide healthy social-emotional development and related self-regulatory capacity.

In addition to the increased likelihood of chronic toxic stress and decreased likelihood of supports for social-emotional development, the constraints of poverty often interfere with the availability of both material and psychological resources to provide cognitive stimulation that promotes growth in EF. Not only is there tremendous variability in quality of preschool and other childcare facilities in low-income areas, but also the availability of material resources, such as curriculum materials, computers, and games is directly associated with neighborhood SES, with greater neighborhood poverty predicting fewer resources (Fuller et al., 2004; McCoy et al., 2015). Preschools serving low-income families are also less likely to adopt or effectively utilize an empirically-supported curriculum that could boost children's emergent academic and self-regulatory skills (Justice, Mashburn, Hamre, & Pianta, 2008; Mashburn et al., 2008).

Furthermore, within the home, there are documented disparities in the availability of income to spend on child resources for high versus low-income families (Coley, Sims, & Votruba-Drzal, 2016). Lower levels of access to cognitively stimulating materials and preschool curricula, coupled with fewer opportunities for stimulating engagement with adults, such as rich language interaction, is, in turn, linked to reduced academic and self-regulatory outcomes at school for children growing up in poverty (National Institute of Child Health and Human Development Early Child Care Research Network, 2005; Guo & Harris, 2000; Thompson, Foster, & Kapinos, 2016).

The pathway linking poverty to struggles at school is complex and multi-faceted; however, it is clear that the conditions of poverty exert a powerful, deleterious influence on children's EF development through unpredictability and negative stress overload, reduced support for healthy social-emotional development, and lower levels of cognitive stimulation. These factors are each associated with children's school performance and, taken together, they paint a striking portrait of how poverty impacts children's school performance by hindering EF development.

Interventions to Enhance Executive Function Development in Children

Aiming to address the factors linking poverty with school struggles, over the last 15 years there has been a focus on interventions that enrich preschool classrooms in ways that promote EF and might thereby reduce the negative effects of poverty. Drawing on the most prominent hypotheses about EF and poverty, these interventions aim to disrupt this link by creating preschool environments and classroom routines that feel safe and predictable, providing opportunities for social-emotional learning and scaffolded peer play, and by incorporating cognitively stimulating games, activities, and interactions into the curriculum.

For example, the Chicago School Readiness Project (CSRP) and its successor, the Foundations of Learning program, aimed to foster development of self-regulation in preschool children by creating safety and predictability via classroom routines and positive, supportive teacher-child relationships (Morris, Lloyd, Millenky, Leacock, Raver, & Bangser, 2013; Raver, Jones, Li-Grining, Metzger, Champion, & Sardin, 2008). For the CSRP, RCT results showed that, from fall to spring of the Head Start year, children in the intervention group made gains in both EF and pre-academic skills relative to those in the control group, with some evidence that EF gains mediated intervention effects on pre-academic skills (Raver, Jones, Li-Grining, Zhai,

Bub, & Pressler, 2011). In a study that followed these children into kindergarten and 1st grade, however, both academic and EF effects (measured via children's approaches to learning, an indicator of underlying EF development; Blair, 2002) were no longer present (Li-Grining & Haas, 2010). Similarly, an RCT of the Foundations of Learning program found that it promoted gains in both EF and social-emotional skills in preschool; however, subsequent follow-up revealed no evidence that effects persisted beyond the preschool year (Morris et al., 2013).

Given its strong association with overall self-regulation, another intervention approach to foster EF skills has been to focus upon children's social-emotional learning, using strategies such as explicit instruction in emotion identification and regulation strategies. For example, through use of lessons and activities designed to build emotion regulation skills via cognitive and behavioral techniques, the Promoting Alternative THinking Strategies curriculum (PATHS; Greenberg & Kusché, 1993) promoted inhibitory control capacity in elementary school students, which was found to mediate effects of the PATHS curriculum on teacher-reported behavior problems one year after the intervention (Riggs, Greenberg, Kusché, & Pentz, 2006). Utilizing an approach similar to PATHS, the I Can Problem Solve program (ICPS) provided preschool teachers with a series of lessons designed to help children develop strategies to approach interpersonal problem solving, including use of emotion identification, empathy, and creative solution generation (Feis & Simons, 1985). Although EF was not directly tested, children's interpersonal problem solving abilities, which serve as a proxy for flexible thinking and inhibition of automatic responses (Aberson, 2014), were promoted by the ICPS program across the preschool year and these gains mediated a reduction in levels of children's behavior problems during both preschool and kindergarten (Shure, 2001; Shure & Spivack, 1980). To date,

however, the ICPS program has not been examined with respect to EF gains beyond its initial trial.

A third approach to preschool-based EF intervention is the use of games and activities that directly utilize EF in order to build and enhance these skills through ongoing practice. This approach was used in Tominey & McClelland's (2011) Red Light, Purple Light intervention. Using playgroup sessions led by one of the researchers, the intervention incorporated music and movement into a series of games with increasingly complex instructions for children to follow. Although no main effects emerged for EF in an RCT of the intervention, children with lower self-regulatory skills at baseline made significant gains in these skills relative to children in the control group. Based upon Vygotskian learning principles, the Tools of the Mind curriculum (Bodrova & Leong, 2007) also consisted of EF practice, focusing on training teachers to scaffold children in their development and use of cognitive "tools" (i.e., EF and related self-regulatory skills) to support their ongoing learning. This was accomplished through group and individual activities that encouraged children to plan and enact sociodramatic play and participate in games designed to foster self-regulation, such as "Simon Says." Despite some early evidence supporting the program's effectiveness (Barnett et al., 2008; Diamond, Barnett, Thomas, & Munro, 2007), rigorous RCTs have failed to find any effects (Lonigan & Phillips, 2012) and, in fact, one study reported iatrogenic effects as children progressed through kindergarten and first grade (Farran & Wilson, 2014).

Moving beyond a single focus, a number of intervention programs have targeted multiple components of the link between poverty and EF. One such program, the Second Step Early Learning (SSEL) curriculum, was designed to increase children's EF and social-emotional skills via classroom activities that promote paying attention and following directions and that foster

empathy and perspective taking skills (Committee for Children, 2011). For example, the curriculum included a series of "Brain Builder Games" with complex sets of behavioral instructions to follow (e.g., "When I say 'patty,' clap your hands; When I way 'cake,' clap your partner's hands up high"), as well as class discussions about emotions and strategies for regulating them. Preliminary results from a recent RCT showed that, relative to those in control classrooms, children in SSEL intervention classrooms demonstrated better EF skills at the end of the prekindergarten year, controlling for prior EF skills (Upshur, Heyman, & Wenz-Gross, 2017).

Also taking a dual-pronged approach by targeting both social-emotional learning and cognitive stimulation, the REDI Classroom (REDI-C) program was designed to enrich existing Head Start curricula. The social-emotional component of REDI-C consisted of the Preschool version of the PATHS program (Preschool PATHS; Domitrovich, Greenberg, Cortes, & Kusche, 1999), which includes activities that target children's emotion recognition, prosocial skills, self-regulatory functioning, and social problem solving. Preschool PATHS has previously demonstrated success in increasing children's social competence (Domitrovich, Cortes, & Greenberg, 2007). REDI-C also included language and learning activities linked to EF development in children (e.g.,Welsh, Nix, Blair, Bierman, & Nelson, 2010). Results of an RCT of the REDI-C program demonstrated that, from fall to spring of the pre-kindergarten year, intervention effects emerged in both academic and social-emotional domains of school readiness (Bierman et al., 2008). A follow-up study showed that these effects were sustained through the kindergarten year (Bierman et al., 2014). With respect to EF, children in the intervention group made gains across the preschool year, relative to those in intervention group (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008). Main effects on EF were no longer evident as children

progressed through elementary school, although the effects were sustained for those who began preschool with either particularly high or particularly low EF (Sasser, Bierman, Heinrichs, & Nix, 2017).

Taken together, these intervention programs demonstrate that, by targeting one or more of the hypothesized factors linking poverty and EF, preschool-based efforts to boost children's EF development in the context of poverty have demonstrated remarkable success. However, studies of the interventions also reveal the challenges associated with this preschool-based approach. In particular, it is notable that all programs demonstrated initial intervention effects on children's EF. However, these effects faded as children progressed through elementary school, indicating a need to consider additional program elements that might help sustain EF effects over time.

Including Parents in Interventions Targeting Executive Functions

One reason that intervention effects on children's EF might fade quickly following preschool-based programs is that poverty exerts its influence across many of the contexts in which children develop. Parents represent a far more lasting influence on children's development than a preschool classroom. Conceptually, poverty constrains and interferes with family processes that promote parents' capacity to provide children with the kinds of social-emotional support and cognitive stimulation that promote self-regulatory growth. An intervention that removes or reduces those constraints could have a lasting influence on EF growth, by empowering parents to more effectively support their children's development. It is important to note that constraints on parenting often represent a response to the conditions of poverty, rather than a deficit in parenting skills. For example, one study demonstrated that experimentally-induced increases in income for low-income parents led to increases in parents

engaging in cognitively stimulating activities with their children (Portnow & Hussain, 2016). Another study revealed that increases in parent appropriate limit setting and scaffolding over a six month time period were protective against EF deficits in children from low-SES families (Lengua, Honorado, & Bush, 2007). The results of these studies are promising and support the proposition—which has received little attention to date—that interventions can attenuate poverty-related constraints and, thereby, promote supportive, cognitively stimulating parent-child interactions, creating conditions that reduce the negative effects of poverty and promote child self-regulatory growth in ways that sustain through elementary school.

To assist with intervention design, a sizeable developmental literature suggests that a focus on cognitively stimulating parent-child activities, coupled with support for positive interactions, may promote child EF growth. For example, developmental research documents associations between child EF development and frequent verbal interactions between parents and children, including book reading, toy play, and extended conversations (Bradley, McKelvey, & Whiteside-Mansell, 2011; Clark et al., 2013; Hackman, 2012). Additional research suggests that warm and sensitive parent-child interactions support the development of EF during and well beyond the preschool years, possibly because they provide social-emotional support and buffer children from exposure to chronic stress (Matte-Gagné, Bernier, Sirois, Lalonde, & Hertz, 2017). Parents who use problem-solving dialogue with their children and help children navigate challenging situations and problems may also promote EF, by helping children persist toward a goal with a flexible problem solving orientation (e.g., Hammond, Müller, Carpendale, Bibok, & Liebermann-Finestone, 2012; Lengua et al., 2014; Obradović, Yousafzai, Finch, & Rasheed, 2016). Child EF is also associated with positive parent behavior management strategies, including clear and predictable expectations and limits (e.g., Sosic-Vasic et al., 2017) as well as

offering choices to children, rather than relying primarily on commands (Bindman, Hindman, Bowles, & Morrison, 2013; Merz et al., 2016).

Thus, there is substantial evidence supporting developmental links between these parenting factors and child EF development; however, experimental studies that document the impact of parent interventions on child EF growth are scarce. One study that validates the approach examined the impact of the Attachment and Biobehavioral Catch-Up (ABC) program, which promoted warm-sensitive responding in foster mothers caring for infants (Dozier, Lindheim, & Ackerman, 2005) and produced gains in children's EF two to three years later as children reached preschool age (Lewis-Morrarty, Dozier, Bernard, Terracciano, & Moore, 2012). Building upon this success, an upward extension of the ABC intervention was designed for foster parents of toddler-age children and similar EF gains emerged in a recent randomized-controlled study of this new program (Lind, Raby, Caron, Roben, & Dozier, 2017).

Thus, in considering ways to optimally support the development of children's EF as they transition into elementary school, developmental theory and research as well as a handful of recent intervention studies point to the potential utility of a parent-focused intervention that aims to support and enhance parenting factors that are linked developmentally with EF growth in preschool children, such as cognitive stimulation and conversation, warm-sensitive social-emotional support, scaffolding and problem-solving dialogue, and predictable, non-punitive behavior management. It is possible that parent-focused interventions of this kind may have longer-term effects than interventions located solely in preschool classrooms, because parents represent a permanent source of support in children's lives with the capacity to extend intervention support even after the intervention program, itself, has concluded. If poised at the point of transition into kindergarten, a parent-focused program might also extend the benefits of

a preschool program, preventing fade out of preschool benefits in elementary school. The REDI Parent program was designed with these goals in mind.

The REDI Parent Program

Building on the success of the classroom-only REDI-C intervention, REDI-P aimed to extend intervention effects by supplementing the classroom program with a parenting component designed to support parents in providing their children with predictable social-emotional support and cognitive stimulation. During the pre-kindergarten year, home visitors provided parents of children in the REDI-P intervention with games, activities, and books designed to facilitate parent-child interactions that would support and enhance sensitivity and responsiveness in parents and increase children's emergent literacy as well as their social-emotional skills. Home visitors also worked with parents to explore optimal ways of using the provided learning materials with their children. For example, parents were provided with books that had embedded questions to help them discuss emotions with their children and home visitors coached parents in ways to ask questions and talk about characters with their children during shared book-reading sessions.

In addition to helping parents find optimal ways in which to use the learning materials, REDI-P also aimed to bolster intervention effects by capitalizing on the high level of desire of parents to support their children in the transition from preschool to kindergarten (e.g., McIntyre, Eckert, Fiese, DiGennaro, & Wildenger, 2007). Thus, following the pre-kindergarten year home visits, an additional six visits were provided to parents leading up to and during the first part of children's kindergarten year. During these sessions, home visitors worked with parents to help them plan and establish new routines with their children (e.g., bedtime, homework, etc.) and

troubleshoot any difficulties that they were encountering as their children transitioned to kindergarten.

By supporting warm, sensitive interactions between parents and children, centered on cognitively stimulating games, books, and activities, REDI-P intended to lay the groundwork for parents to promote long-term EF growth in their children, thereby sustaining academic and social-emotional gains made during the intervention. This strategy was further enhanced by extending the intervention across the transition to kindergarten, providing an opportunity to further cement new, adaptive patterns and routines as children began elementary school. A key goal was to foster engaged, self-regulated learning as children started kindergarten, thereby enhancing their capacity to benefit from elementary school instruction.

The Present Study

The purpose of this study was to examine the longitudinal effects of the REDI-P intervention on children's EF. Drawing on a framework informed by both developmental and early childhood intervention literatures, one primary research question was whether the REDI-P intervention promoted sustained growth in child EF that extended through the early elementary grades to third grade. Additional research questions focused on the degree to which and ways in which intervention effects on children's academic and social-emotional competencies in elementary school (3rd grade) were mediated by intervention effects on EF – essentially sustained longitudinally by the intervention effects on the underlying neurobiological self-regulatory processes that support adaptive learning and social interaction. Based on prior intervention studies documenting the effectiveness of preschool classroom-based programs in enhancing children's EF, as well as developmental studies relating parenting and children's EF, it was hypothesized that REDI-P would promote growth in children's EF across the early

elementary years (kindergarten to 3rd grade), promoting significantly higher EF scores by 3rd grade for children who received the REDI-P intervention relative to the control group. In addition, given the increasing self-regulatory demands as children progress through elementary school (e.g., McClelland & Wanless, 2012), coupled with the assertion that EF serves as marker of self-regulatory neurobiological functioning that may scaffold learning processes (Blair & Raver, 2015), it was further hypothesized that intervention-driven gains in EF at 3rd grade would contribute to enhanced 3rd grade academic and social-emotional outcomes, controlling for baseline, and emerge as a mediator of these effects. Finally, based upon research supporting differentiation among EF components as children progress through elementary school, as well as differential predictive validity of these components for children's academic and social-emotional outcomes, it was hypothesized that children's working memory, set shifting, and inhibitory control would differentially mediate school readiness outcomes; specifically, it was hypothesized that working memory and set shifting would mediate academic outcomes, while inhibitory control would mediate social-emotional outcomes.

Method

Participants

Pre-kindergarten children and their parents were recruited from 24 Head Start classrooms across three Pennsylvania counties. Approximately half of the classrooms were located in an urban area, while the others were located in more rural regions of the state. Initially, letters were sent to parents of all preschool children in participating classrooms who were eligible to attend kindergarten the following fall (N = 509). Participation in the study required parents to agree to be randomized to receive learning materials either via home visits (intervention condition) or postal mail (control condition). Of those invited, 299 agreed, 210 declined, and 35 were deemed

ineligible (either because the child was not attending kindergarten in the fall, was identified with special needs, or did not speak English). Pre-intervention assessments were completed until cells were filled and no more families could be accommodated, resulting in the final sample of 200 children, who were then randomized to intervention versus control condition. Families were followed longitudinally as children transitioned into elementary school.

The resulting sample consisted of 200 children (baseline M_{age} = 4.45 years, SD = .29) and their parents (89% mothers). Families were low-income, with a median annual household income of $18,000. Children were primarily European-American (55%), African American (26%), and Latino (19%). The majority of parents in the sample were either married (36%) or living with a committed partner (25%); approximately one third of parents were single. All parents reported that English was spoken at home, with an additional 16% of parents reporting that Spanish was also spoken. Across the five waves of data in the present study, attrition ranged from 5.2% to 8.5% between successive waves. No baseline demographic variables were systematically associated with attrition. Full Information Maximum Likelihood procedures were used to estimate missing data in all analyses.

Intervention

Participants in both the REDI-P intervention and control groups received the classroom-based REDI intervention (for additional details of the REDI classroom intervention protocol, see Bierman et al., 2008). Supplementing the classroom program, REDI-P participants also received 16 home visits - 10 during the spring of the child's Head Start pre-kindergarten year and an additional 6 "booster" sessions after the transition into kindergarten. Following a manualized protocol, home visitors provided parents with materials that paralleled the REDI classroom program. Parents were given a "menu" of options for parent-child activities, which included

books with embedded questions designed to engage dyads in conversation around social-emotional learning themes (e.g., feelings, self-control, etc.). Additional activities focused on pretend play, such as "restaurant" or "post office," which enabled ongoing practice of both academic skills (e.g., alphabet soup letter identification game) and EF (e.g., role playing, sorting mail).

On three occasions during the pre-kindergarten year, parents were videotaped engaging in parent-child interaction tasks using the REDI-P learning materials. Home visitors subsequently reviewed these videotapes with parents, which served as a basis for highlighting and celebrating successes and identifying ongoing areas for growth. Home visitors also provided guidance and support as parents discussed challenges they encountered while engaging with their children using intervention materials as well as in parenting, in general. In order to enhance feelings of self-efficacy, parents were encouraged to monitor and recognize their successes throughout the program and to set ongoing goals for future growth. Thus, through provision of learning materials, ongoing coaching, and feedback, including video review, parents were supported in development of warm, sensitive engagement with their children around activities designed to enhance children's social-emotional and academic school readiness.

Data Collection Procedures

Baseline assessments took place during the fall of children's pre-kindergarten year. Subsequent assessments occurred during the spring of children's kindergarten, 1st, 2nd, and 3rd grade years. Parent interviews were conducted in the home by a trained research assistant. Parents were compensated financially for each interview. Child data was collected during 30-45 minute "pull-out" sessions held at school. Classroom teachers filled out assessment scales for each child in the study. Research assistants delivered and explained these teacher rating forms.

Teachers were also compensated financially for completing rating scales. All procedures were approved by the Penn State Institutional Review Board.

Measures

Executive Function. Children's EF was assessed at each time point, using a series of tasks to capture the three core EF domains of working memory, inhibitory control, and set-shifting.

From preschool through 2nd grade, children's working memory was assessed using the Backward Word Span task (BWS; Davis & Pratt, 1996). On this task, children listened to a list of words and were then asked to repeat them back in reverse order. Word lists began with two words and increased to a maximum of five words. Scores on the task represented the longest span of words which children were able to repeat correctly in reverse. At 3rd grade, a modified version of this task was used, in which numerical digits replaced words.

Inhibitory control was assessed using the Walk-A-Line slowly task (WAL; Kochanska, Murray, Jacques, Koenig, & Vandegeest, 1996). In this task, children walked along a line of string taped to the floor. After a baseline trial, children were asked to walk more slowly for a second trial, and then as slowly as possible for a third trial. Scores for the task were computed by subtracting children's baseline trial time from their average time for the two subsequent trials. Larger scores indicated greater inhibitory control.

Children's set-shifting was measured using the Dimensional Change Card Sort task (DCCS; Frye, Zelazo, & Palfai, 1995). In this task, children were shown two target pictures that varied according to two dimensions (e.g., color and shape). Children were asked to sort a series of cards with the target pictures according to one dimension (e.g., play the color game) and then, after a specified number of trials, to sort based on the other dimension (e.g., play the shape

game). At preschool, children's DCCS scores represented the percentage of cards correctly sorted following the rule switch. In kindergarten and 1st grade, the border version of DCCS was administered. This involved an additional series of trials in which children had to follow one sorting rule (color game, shape game) when the card presented contained a border around it and the other sorting rule when the card had no border. Scores consisted of percentage of correctly sorted cards during border game trials. By 2nd and 3rd grade, a majority of children could correctly sort 100% of cards in the border game; therefore, a computerized version of the DCCS was used, which measured latency to respond during mixed-rule trials. In these trials, the computer prompted children to sort based on different dimensions throughout mixed-rule trials. As these time scores were positively skewed, a natural log transformation was used to achieve normality.

Academic Skills. Children's academic skills were measured at 3rd grade. Reading fluency was assessed using the Test of Word Reading Efficiency (TOWRE; Torgesen, Wagner, &; Rashotte, 1999), which measured phonemic decoding (the number of phonetic non-words children could read correctly in 45 seconds) and sight word fluency (the number of sight words children could read correctly in 45 seconds). Teachers also rated children's academic performance using the Academic Competence Evaluation Scales (DiPerna & Elliott, 1999), which have demonstrated high correlations with children's academic achievement test scores. Items were rated on a 5-point scale (1 = far below to 5 = far above expectations) and asked teachers to rate how well a student's performance compared to grade level expectations. Scales assessed children's performance in reading and language arts (11 items, $\alpha = .97$), math (8 items, $\alpha = .98$), critical thinking (9 items, $\alpha = .97$), and academic motivation (11 items, $\alpha = .97$). The academic skills measures were combined to form a composite.

Social-Emotional Skills. Children's social-emotional skills were measured using the 5-item Peer Problems scale from the Strengths and Difficulties Questionnaire (Goodman, 1997). This scale asked parents to rate items (e.g., "my child is rather solitary, tends to play alone") on a 3-point scale (0 = Not True; 1 = Somewhat True; 2 = Certainly True). In addition, children completed an abbreviated version of the Pragmatic Judgment scale of the Comprehensive Assessment of Spoken Language (Carrow-Woolfolk, 1999). This scale included 12 scenarios depicting common social challenges (e.g., "A friend invites Bonnie to a small party. Bonnie wants to go but she has already made plans for that night. What can Bonnie say to turn down her friend without hurting her friend's feelings?") which were read aloud to children. Children's responses were scored either 0 or 1 based on their situational appropriateness. Children's scores on the Peer Problems and Pragmatic Judgment scales were standardized and averaged to create a composite representing social-emotional skills ($\alpha = .75$).

Additional covariates. All analytic models controlled for child age, sex, race, family SES, financial struggles, and single-parent status. In addition, models which examined intervention effects at 3rd grade (i.e., child academic and social-emotional skills) controlled for the pre-intervention levels of these variables.

Analytic Plan

Latent growth curve modeling (Preacher, 2008) was used to examine the effect of the REDI-P intervention on the longitudinal development of children's EF skills in the domains of working memory and inhibitory control, where the same measure was administered during each assessment wave. In this approach a latent EF intercept and slope were estimated using children's EF scores at each time point, beginning at post-intervention (i.e., kindergarten). EF values at pre-intervention (i.e., preschool) were included in these models as covariates. Pre-

intervention scores were used as covariates rather than included in the growth curves to ensure that the potential discontinuity in growth created by the intervention was accurately modeled (Chou, Chi, Weisner, Pentz, & Hser, 2010). A conceptual diagram of these latent growth curve models is presented in figure 1. First, to obtain the shape of growth, each of these models began with an intercept, with sequential addition of polynomial growth terms (i.e., linear, quadratic) until model fit no longer improved or a term was non-significant. Next, covariates and a treatment indicator variable were included in the models to assess the effect of treatment on longitudinal growth in EF, captured via the latent EF slope. In addition, each model's intercept was set to the final time point (i.e., 3rd grade), thereby allowing for an assessment of intervention effects on EF skill level at the final assessment wave. The difference between the control and intervention group's EF at 3rd grade was evaluated by examining the effect of treatment on the latent EF intercept.

The measurement of DCCS underwent changes over time to account for the ceiling effects that emerged on the initial card sort task used in preschool. Likely for this reason, DCCS demonstrated low correlations across time. As a result, latent growth curves could not be estimated for this measure. Instead, to examine the effect of the REDI-P intervention on the set-shifting domain of children's EF, a path analysis was conducted in which children's 3rd grade DCCS latency to respond scores were regressed upon a treatment indicator and control variables, as well as prekindergarten DCCS scores. To control for increased response speed due to random guessing, children's accuracy (percent of correct responses) was also included as a covariate in these models.

Additional analyses were then conducted to determine whether treatment-driven differences in EF at 3rd grade accounted for 3rd grade treatment effects on children's academic

and social-emotional outcomes (see figure 2). Using the growth curve models constructed for working memory and inhibitory control, 3rd grade outcomes (controlling for pre-kindergarten performance) were regressed upon the latent EF intercepts. For the set-shifting EF domain, the outcomes were entered into a two-wave longitudinal mediation path model (MacKinnon, 2008), with intervention-driven gains in attention set-shifting serving as the mediator. All three models (i.e., working memory, inhibitory control, and set shifting) estimated the indirect effects of the intervention on children's 3rd grade academic performance and social-emotional skills via intervention effects on EF. For models in which significant indirect regression paths emerged, follow-up tests of formal mediation were conducted using asymmetric confidence intervals (MacKinnon, Fritz, Williams, & Lockwood, 2007).

A variety of fit indices were used to assess adequacy of fit. These included the overall chi-square test (χ^2) which should ideally be non-significant; however, due to its sensitivity to sample size, it is rarely used as a stand-alone indicator of model fit (Brown, 2015). In addition, the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR) were also considered, using cutoff values recommended by Hu and Bentler (1998) of CFI $\geq$ .95, RMSEA $\leq$ .06, and SRMR $\leq$ .08. No single index was used to rule a model acceptable or unacceptable due to the complex influences upon model fit as well as the ongoing debate regarding fit index cutoff thresholds (e.g., Chen, Curran, Bollen, Kirby, & Paxton, 2008).

Results

Preliminary Analyses

Means and standard deviations for all study variables are presented in Table 1. In general, children's EF in all three core domains improved between pre-kindergarten and 3rd

grade. Zero-order correlations are presented in Table 2. Both working memory and inhibitory control demonstrated moderate year-to-year stability across time (r = .23 - .36 for working memory, r = .37 - .47 for inhibitory control, all ps < .05), whereas (as noted above) correlations within the set-shifting domain showed substantial variability from year to year, with r values ranging from -.04 (ns) to .35 (p < .01).

Testing the Effect of REDI-P on Children's Executive Functions

Analyses first examined whether REDI-P had an effect on growth in children's EF in the domains of working memory, inhibitory control, and set-shifting.

Working Memory. The growth curve model for working memory revealed a significant estimate for a linear slope (p < .01), indicating that children's working memory increased over time. The quadratic slope term was not significant and, therefore, was not included. The final model estimating REDI-P's intervention effect on children's working memory fit the data well, with χ^2 (14) = 15.76, p = .32, RMSEA = .03, 90% CI [.00, .08], CFI = .99, and SRMR= .02. This model revealed that REDI-P had a significant positive effect on growth in children's working memory (β_{slope} = .10, p < .05) and on the level of working memory attained by third grade ($\beta_{intercept}$ = .32, p < .01).

Inhibitory Control. The initial model of inhibitory control showed a significant linear growth term (p < .01). A quadratic growth term, which was not significant and did not improve model fit, was trimmed from the model. The final model, with all covariates, fit the data well, with χ^2 (13) = 14.71, p = .33, RMSEA = .03, 90% CI [.00, .08], CFI = .99, and SRMR = .02. Treatment showed a significant effect on both the latent slope (β = 2.71, p < .01) and intercept (β = 7.73, p < .05), indicating that the REDI-P intervention had a positive effect on growth in

children's inhibitory control from pre-kindergarten to 3rd grade, resulting in a significant difference in this EF domain between the intervention and control groups at 3rd grade.

Set Shifting. By conducting an ordinary least squares regression in a path analytic context, the regression represents a saturated model. Thus, fit indices were not evaluated for the set shifting model. REDI-P showed a treatment effect at third grade on children's set shifting ability ($\beta = -.07$ $p < .05$). Children in the treatment group took less time to respond accurately to the set-shifting demands of the DCCS task than those in the control group, indicating that the REDI-P intervention had a positive effect on children's set shifting abilities.

Testing Children's Executive Functions as Mediators of REDI-P 3rd Grade Outcomes

The next set of analyses examined whether treatment effects on children's executive functions mediated treatment effects on children's academic and social emotional adjustment at 3rd grade.

Working Memory. The model of working memory as a mediator of 3rd grade outcomes showed a good fit, with χ^2 (23) = 30.46, $p = .14$, RMSEA = .04, 90% CI [.00, .08], CFI = .97, and SRMR = .02. Standardized results are presented in figure 3. As depicted, intervention-driven growth in children's working memory was significantly associated with greater academic skills at 3rd grade, but not with children's social-emotional skills. Follow-up tests of asymmetric confidence intervals demonstrated that intervention-related gains in working memory significantly mediated intervention effects on children's academic skills, $\mu = .24$, $p < .05$, 95% CI for the mediated effect [.08, .44], confirming that 3rd grade intervention effects on academic skills were mediated by gains in working memory.

Inhibitory Control. The model testing inhibitory control as a mediator of 3rd grade outcomes demonstrated a good fit, with χ^2 (50) = 89.24, $p = .00$, RMSEA = .06, 90% CI [.04,

.08], CFI = .93, and SRMR = .04. Standardized effect estimates, depicted in figure 4, showed that the effect of REDI-P on children's inhibitory control was significantly associated with social-emotional skills at 3rd grade, but not their academic skills. A follow-up test of formal mediation confirmed that this indirect effect was significant $\mu = .08$, $p < .05$, 95% CI [.01, .19]. Thus, the gains in inhibitory control promoted by the REDI-P intervention mediated improvements in children's social-emotional skills.

Set Shifting. This model, in which set-shifting served as a mediator of 3rd grade outcomes showed an excellent fit, with χ^2 (6) = 6.49, $p = .37$, RMSEA = .02, 90% CI [.00, .11], CFI = .99, and SRMR = .01. Estimates of standardized effects are presented in figure 5. The intervention-driven reduction in response time on this measure of EF was negatively associated with children's academic skills, indicating that faster (i.e., smaller) response times predicted greater academic skills. A follow up test of this indirect effect, however, showed that it was not significant $\mu = .02$, $p > .05$, 95% CI [-.01, .07]. In other words, intervention-promoted gains in set-shifting were associated with, but did not mediate, intervention effects on 3rd grade academic skills.

Discussion

Developmental theorists have speculated that preschool interventions may have sustained effects when they build skills that are malleable and fundamental, as well as unlikely to develop without intervention, and when those skills prepare a child to take advantage of developmental opportunities in their natural environments (Bailey, Duncan, Odgers, & Yu, 2017). Based upon developmental neuroscience research that has accumulated over the past two decades, early interventions for socio-economically disadvantaged children have increasingly focused on executive function skills as intervention targets that have these characteristics. The hope is that

by boosting growth in executive function skills, which are malleable and fundamental for efficient self-regulation and learning, early interventions will position children to take advantage of new social and academic learning opportunities when they enter school.

This study examined the effects of the REDI-P intervention on the development of children's EF skills, tracking EF growth through the early elementary school years. It also investigated the degree to which intervention effects on EF at 3rd grade mediated intervention effects on children's school functioning. Consistent with hypotheses, the REDI-P intervention led to greater growth in children's EF between kindergarten and 3rd grade, relative to a control group. At third grade, differences in EF were found to mediate intervention effects on children's academic and social-emotional functioning in a specific, hypothesized pattern: gains in working memory mediated effects on children's academic skills, while gains in inhibitory control mediated effects on their social-emotional skills.

REDI-P Intervention Effects on Growth in Children's EF

Prior research has demonstrated that children growing up in poverty often experience delays in EF skill development (Hackman, Gallop, Evans, Farah, 2015; Lawson, Hook, & Farah, 2017). Conceptually, these delays occur as a function of heightened exposure to adversity and chronic stressors that impede EF development (e.g., Noble et al., 2015; Obradović, 2016), along with reduced access to high-quality early care and educational opportunities (e.g., Crosnoe, Purtell, Davis-Kean, Ansari, & Benner, 2016; McCoy, Connors, Morris, Yoshikawa, & Friedman-Krauss, 2015). The REDI-P intervention was designed to build upon and extend the REDI-C intervention that enriched Head Start preschool classrooms with programming to support social-emotional and language-literacy skill development. This study compared the progress of children who received the combination of REDI-P and REDI-C with children who

received REDI-C alone. It was hypothesized that REDI-P would strengthen program impact on child self-regulation skills, by extending social-emotional and academic skill-building opportunities and supportive parent practices into the home and also by extending these developmental supports across the transition from preschool into kindergarten.

The present findings demonstrate that adding REDI-P to the classroom intervention promoted accelerated growth in children's EF between kindergarten and 3rd grade, controlling for preschool baseline levels, and resulted in the intervention group showing a significantly greater EF capacity than the control group by 3rd grade. These findings build upon a growing literature that demonstrates the malleability of early EF development, and the positive impact that preschool intervention programs can have on children's EF during the preschool years (e.g., Raver, Jones, Li-Grining, Zhai, Bub, & Pressler, 2011; Upshur, Heyman, & Wenz-Gross, 2017). They also extend upon a prior study examining growth in EF skills experienced by children who received the REDI-C program relative to usual practice Head Start. That study demonstrated that REDI-C alone (without the accompanying parent program) accelerated growth in EF through third grade only for the subset of children in the bottom 20% of the sample in baseline EF skills (Sasser et al., 2017). The present study documents the power of the REDI-P intervention to amplify the benefits of the REDI-C intervention alone, producing main effects on EF growth that were sustained into middle childhood.

As EF growth in childhood is supported by PFC development (Barrasso-Catanzaro, & Eslinger, 2016; Zelazo, Carlson, & Kesek, 2008), this intervention effect on children's EF may reflect positive growth in the underlying neurobiological architecture that is crucial to children's school performance. To experience success at learning within a classroom environment requires persistent application of self-regulation (e.g., McCelland, Acock, & Morrison, 2006). Initial

skills acquired during the course of the REDI-P intervention may have positioned children to take more advantage of the learning opportunities available to them as they entered elementary school, sustaining the benefits of their preschool intervention. That is, children in the intervention group arrived in kindergarten with an increased likelihood of having both the knowledge to experience early academic success, as well as the underlying EF capabilities to support ongoing learning in the classroom. The intervention set their EF growth on a trajectory that enabled them to continue to adapt to an increasingly complex learning environment and accommodate new domain specific academic skills.

Why might the REDI-P have led to growth in children's EF?

Several aspects of the REDI-P intervention may have contributed to ongoing growth in EF across the elementary years. The REDI-P targeted skill domains with strong links to EF development. The social-emotional skill enrichment components of the intervention included activities that helped children to navigate social settings effectively (e.g., problem solving with peers, taking turns, etc.), and to recognize, express, and—if necessary—actively regulate emotions and associated behavioral reactions. Development of this type of social-emotional competency is linked with neurocognitive growth that supports overall self-regulatory functioning (Riggs, Greenberg, Kusche, & Pentz, 2006). Thus, the REDI-P's targeted social-emotional learning focus may have supported broad self-regulatory development.

The REDI-P also included activities designed to promote language and literacy. The task of reading and associated activities (e.g., recall, comprehension, etc.) requires substantial self-regulation. To read effectively, children must stay sufficiently focused in order to pay attention to information and encode, process, and recall narrative details. It is, therefore, unsurprising that language and literacy, throughout the pre-kindergarten and elementary years, are strongly linked

with EF development (Gooch, Thompson, Nash, Snowling, & Hulme, 2016; Kuhn, Willoughby, Wilbourn, Vernon-Feagans, & Blair, 2014; McClelland et al., 2007).

In addition to directly fostering reading skills, themselves, embedded within the REDI-P language and literacy activities were components that helped to bolster children's EF. For example, questions within REDI-P storybooks prompted children to recall an event that had previously happened in the story or to speculate about what might happen next. This strategy of simultaneously practicing reading and EF skills may have had a mutually reinforcing effect, promoting gains in both domains. This speculation is supported by a recent study finding that combined EF and reading practice promoted greater gains in early literacy skills relative to reading practice, alone (van de Sande, Segers, & Verhoeven, 2018). Further, by enhancing children's language and literacy in pre-K, the REDI-P may have increased their overall success in learning to read which, in turn, gave a powerful vehicle for the ongoing integration of new knowledge and skills, thereby fostering growth in areas of the brain that support EF. By extending learning activities from the school to the home setting, REDI-P may have expanded the power of REDI-C alone to provide children with sustained and sequenced skill learning opportunities.

It is also possible that the power of REDI-P to promote growth in children's EF occurred via the inclusion of parents in ways other than, or in addition to, their use of the home learning materials. Parenting is associated with children's EF development through a variety of mechanisms, including warmth and sensitivity, provision of a cognitively stimulating environment, and effective scaffolding of learning activities (Fay-Stammbach, Hawes, & Meredith, 2014). Because poverty may increase intra-familial stress and constrain the time and resources that parents have to engage with their children, the home visitation component of the

REDI-P worked to remove some of these barriers. REDI-P provided parents with learning materials that paralleled the classroom program. In addition, home visitors supported parents in finding optimal ways to use the learning materials with their children. In essence, parents received training in using the home materials that paralleled the training that pre-kindergarten teachers received in using the classroom materials. Thus, not only were parents contributing to their children's EF development during the intervention period, but also they represented an ongoing intervention facilitator, even after the formal intervention ended.

The REDI-P home visits also included activities designed to bolster the parent-child relationship, a component of parenting that is strongly associated with development of children's self-regulatory functioning (e.g., Bernier, Carlson, & Whipple, 2010; Parker, Boak, Griffin, Ripple, & Peay, 1999; Schroeder & Kelley, 2010). Home visitors encouraged parents to reflect on their experiences as caregivers. They helped to normalize the challenges associated with parenting and highlighted ways to increase the likelihood of having positive, rewarding interactions with their children. They also provided coaching in parenting strategies that are linked to development of children's EF and self-regulation, such as emotion coaching (e.g., Ramsden & Hubbard, 2002; Wilson et al., 2014), engagement in conversations with rich language interactions (Zauche, Mahoney, Thul, Zauche, Weldon, & Stapel-Wax, 2017), and provision of support for self-control (Fox & Calkins, 2003). To highlight progress and promote ongoing self-reflection, parents were videotaped on three occasions interacting with their children. These tapes were then reviewed with home visitors, who encouraged parents to reflect on their own strengths and challenges within the parent-child relationship and to set goals for ongoing growth, a strategy that has been successfully utilized to promote self-reflection and enhance the parent-child relationship in several interventions (e.g., Juffer, Struis, Werner, &

Bakermans-Kranenburg, 2017). As the parent-child relationship may serve as a crucial buffer in the face of chronic stressors associated with poverty (Johnson, Mliner, Depasquale, Troy, & Gunnar, 2018), the promotion of a strong, supportive parent-child relationship by REDI-P may have attenuated some deleterious effects of poverty-related stressors, thereby removing a barrier to optimal EF development. Further, the home visitation component of the REDI-P led to increases in parents' expectations for their children's academic success (Loughlin-Presnal & Bierman, 2017), indicating that these visits may have helped to increase parents' beliefs that they could be effective in supporting their children's learning. Parents' feelings of self-efficacy have a profound effect on parenting behaviors that support children's growth and learning processes (Jones & Prinz, 2005). Thus, by providing parents with learning materials and supporting them in feeling efficacious to help their children learn, the REDI-P may have helped parents effectively promote long-term growth in their children's EF.

Finally, the REDI-P may have led to EF growth by bridging the gap between pre-kindergarten and kindergarten, with home visits extending into fall of children's kindergarten year. Although pre-kindergarten represents a crucial time for intervention with respect to fostering important school readiness skills, it is not until the transition to kindergarten that these skills are put into action. By maintaining intervention support for parents and their children into the kindergarten year, the REDI-P may have helped to cement processes, both at school and at home, that afforded children maximal opportunities to develop self-regulatory skills.

Intervention Gains Occurred in All Three Domains of EF

This study was unique in that it not only took a developmental approach by examining intervention-driven growth in EF from early to middle childhood, but also it examined this growth across the three related, but distinct domains of EF (i.e., working memory, inhibitory

control, and set shifting). This approach was conceptually important because there is increasing differentiation among the three domains as children progress through elementary school (Brocki & Bohlin, 2004; Huizinga, Dolan, & van der Molen, 2006; Isquith, Gioia, & Espy, 2004). Whereas previous studies of EF in early childhood have examined intervention effects on a single domain or a composite (e.g., Willoughby, Magnus, Vernon-Feagans, Blair, & Family Life Project Investigators, 2017), this is the first study to examine intervention effects in each domain of EF. It is, therefore, intriguing that the REDI-P intervention led to growth in all three domains. This finding may be a result of the multi-faceted nature of the REDI-P in that different aspects of the intervention led to growth in the unique components of EF. Alternatively, it is possible that, because the intervention occurred during a time period of less EF differentiation, the boost in growth of EF across elementary school reflects an initial effect on EF, more broadly, that was sustained, even as differentiation occurred.

EF Gains at 3rd Grade Mediated REDI-P's Sustained Intervention Effects

As hypothesized, gains in children's EF by 3rd grade were found to mediate the REDI-P's sustained intervention effects at 3rd grade. This is consistent with a large body of theoretical and empirical work showing that EF underlies children's abilities to succeed, both academically (e.g., Clark, Pritchard, & Woodward, 2010; Fuhs, Farran, & Nesbitt, 2015; Weiland, Barata, & Yoshikawa, 2014) and socially (e.g., Hughes, White, Sharpen, & Dunn, 2000; Hughes & Ensor, 2008). Several other intervention studies have also shown that gains in EF mediate academic and social-emotional outcomes (e.g., Raver, Jones, Li-Grining, Zhai, Bub, & Pressler, 2011; Welsh, Nix, Blair, Bierman, & Nelson, 2010); however, this is the first study to examine these processes across a longer-term developmental timeframe and to find mediation for outcomes that occurred

several years after the intervention. This finding underscores the crucial role of EF in supporting children's capacities to acquire new knowledge and skills in a classroom environment.

An additional finding from this study is that the three domains of EF differentially mediated intervention effects. Whereas gains in working memory mediated effects on children's academic skills, inhibitory control gains mediated effects on their social-emotional functioning. Gains in set shifting ability were associated with intervention effects on children's academic skills; however, this indirect effect was not significant in a formal test of mediation. Taken together, these findings lend support to the idea that each component of EF contributes to unique aspects of children's functioning. This is an intuitively appealing finding that is well-supported in the literature, in that reading success requires a capacity to effectively attend to new information (i.e., set-shifting), and to encode, process, and recall that information (i.e., working memory; Bull, Espy, & Wiebe, 2008; Morgan et al., 2016; Yeniad et al., 2013). Similarly, effective navigation of social interactions requires adaptive regulation of associated emotional reactions and behavioral impulses (i.e., inhibitory control), which may explain why this component of EF demonstrates a unique link to social-emotional functioning both in the present study and in the larger empirical literature (e.g., Ciairano, Visu-Petra, & Settanni, 2007; Ellis, Weiss, & Lochman, 2009; Riggs, Blair, & Greenberg, 2004; Vuontela et al., 2013).

Strengths and Limitations

This study tested whether a pre-kindergarten intervention facilitated growth in children's EF through 3rd grade, and whether EF gains at 3rd grade mediated the intervention's sustained academic and social-emotional effects. Although there are strong theoretical reasons to suspect that growth in EF supports children's school success, this is one of a very limited number of studies to empirically test this theoretical framework. The strength of the present findings is

supported by the rigorous experimental design, which consisted of an RCT with a low-income sample. Further, children's EF was assessed at each wave of data collection, enabling a developmental modeling approach to be used. This also allowed for examination of growth in the separate components of EF as children progressed through elementary school, resulting in the first evidence that intervention-driven growth in individual components of EF differentially mediated gains in school-related outcomes.

The present findings must be considered within the context of several limitations. While this study specifically sought to test a theoretical model in which EF represents the neurobiological foundation that supports learning, evidence also shows that EF develops from learning, itself; in other words, there is a bi-directional relationship between domain specific and domain general learning processes (e.g., Daneri & Blair, 2017) . Although this study was not intended to disentangle this directionality, the present findings may not represent an entirely straightforward mediational relationship; however, it is clear that EF supports the development of academic skills throughout elementary school (Ribner, Willoughby, Blair, & The Family Life Project Key Investigators, 2017). An additional limitation of the present study is that, due to developmental shifts in children's abilities, growth in the set-shifting domain of EF could not be modeled in a way that paralleled models of working memory and inhibitory control. Finally, intervention effects on children's EF were relatively small. While the mediational models clearly indicate that these small effects resulted in important differences in school performance at 3rd grade, they also indicate the challenges associated with creating a sizable impact on processes related to children's learning and achievement.

In addition, because this study compared the effects of REDI-P and REDI-C combined relative to REDI-C alone, it is not possible to determine the effects of REDI-P in isolation or

compared to a no-intervention group. It remains unclear whether REDI-P would have the same effects if implemented as a "stand-alone" intervention without the foundation of the classroom program. Furthermore, since REDI-P included multiple components, it is not possible to determine whether or which specific components accounted for the effects.

Implications and Future Research

The results of this study have important implications for the development and implementation of interventions targeting school readiness. Given that the effects of pre-kindergarten intervention on children's school performance typically tend to diminish or disappear entirely as they progress through elementary school (Bailey et al., 2017; Puma et al., 2010), the present study's finding of an effect on EF development may represent a key to sustaining intervention effects on school performance. Thus, in developing future intervention programs, it may be highly beneficial to focus both on specific academic and social-emotional skills, as well as the underlying general processes which support ongoing acquisition of knowledge.

Drawing on decades of research showing the important contributions of parents to their children's school readiness (e.g., Chazan-Cohen et al., 2009), a growing literature suggests that the implementation of parent-focused interventions that align with school interventions may be a powerful strategy for closing the SES-linked achievement gap. For example, when the Getting Ready for School Intervention (Noble, Duch, Darvique, Grundleger, Rodriguez, & Landers, 2012; Marti, Merz, Repka, Landers, Noble, & Duch, 2018) expanded preschool programming to include classroom-based and parent-focused activities designed to boost child academic and self-regulation skills, they found that parent attendance at program training events (e.g., workshops, parties, etc.) and use of the intervention materials was associated with greater gains in school

readiness. In a large RCT, the ParentCorps program (Brotman et al., 2013) provided an intervention for children attending preschools serving primarily socioeconomically disadvantaged students that included coordinated components for teachers and parents. Training focused on strategies for behavior management, positive behavior support, and promotion of child self-regulatory capacity. Intervention boosted academic skills that were sustained through 2nd grade, along with emerging mental health benefits (Brotman et al., 2016).

As with REDI-P, results from these additional examples of parallel school-based and parent-focused programs are promising; however, given the complex, multi-faceted nature of these interventions, it is difficult to determine the active mechanisms of change. Given the large financial investment required for effective early childhood interventions (Reynolds & Temple, 2008), understanding these mechanisms and finding alternative cost-effective modes of delivery will be crucial in order to bring them to scale. One way in which this challenge is being addressed is through use of technology. For example, the Chicago Parent Program, an early childhood intervention aimed at promoting positive reinforcement of desired behaviors and reducing instances of harsh, inconsistent discipline, was recently adapted to be self-administered via tablet-based software. Effect sizes for this modified program were comparable to the in-person version of the program (Breitenstein, Fogg, Ocampo, Acosta, & Gross, 2016). Due to the particularly high cost associated with home visitation interventions (e.g., Dalziel & Segal 2012), another strategy to reduce program cost and, thereby, to increase reach, is to embed the interventions within naturally occurring settings, such as pediatric visits (e.g., Cates et al., 2018).

In examining the effects of interventions that include a parent-focused component, an additional consideration is the type of intervention content. Whereas the core focus of the home visitation component of REDI-P was a highly specified language-literacy and social-emotional

learning curriculum, other programs provide a greater focus on parenting strategies (e.g., Brotman et al., 2013; Gross, Garvey, Julion, Fogg, Tucker, & Mokros, 2009). It is unclear whether these differing foci result in equivalent effects with respect to children's self-regulation and academic performance, or whether they function in different ways, depending upon the unique characteristics of the intervention participant. More research would help to illuminate variability in response to intervention content, thereby informing the optimization of parenting programs. This, in turn, would help to create scalable versions that may play a key role in closing the SES-linked school readiness gap and promoting lasting improvements in child school performance and educational attainment.

Additional areas for ongoing investigation include working to better understand the nature of the intervention effects that emerge for school and home-based programs such as REDI-P. It is possible that initial effects result from children arriving at kindergarten "ready to learn," with an academic skillset that enables them to maximally benefit from classroom-based instruction. Alternatively, these interventions may promote children's capacities for behavioral self-regulation, increasing opportunities for positive bonding with adults (e.g., parents, teachers, etc.) and, thereby, facilitating connection that serves to enhance learning processes (e.g., Faith, Boak, Griffin, Ripple, & Peay, 1999; Rucinski, Brown, & Downer, 2017). As the overarching goal for these interventions is to bring about change that places children on a positive, long-term trajectory, it will also be important to examine how different approaches to parent-focused intervention work to sustain effects, with follow-up studies across the elementary years and beyond.

Conclusions

Children growing up in a context of poverty show deficits in school readiness relative to their economically-advantaged peers. Struggles are apparent in both emergent academic skills and self-regulation as children transition to kindergarten. As a result, a key focus of early childhood intervention programs has been to help narrow the income-linked school readiness gap. Despite initial success of several programs, intervention effects have been difficult to sustain. In contrast, the REDI-P program has shown sustained intervention effects on children's academic and social-emotional functioning through 3rd grade. The present study found that the intervention also led to gains in children's EF, which mediated intervention effects, lending support to the idea that a dual-focus on enhancing both specific skills and general processes that support learning may help to sustain intervention effects.

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APPENDIX A

TABLES

Table 1

Means and Standard Deviations of Study Variables at Each Time Point

Variable	Entire Sample M (SD)	REDI-P Intervention M (SD)	Control M (SD)
Working Memory			
Pre-K	1.30 (.60)	1.25 (.53)	1.35 (.65)
Kindergarten	1.96 (.71)	1.99 (.70)	1.93 (.72)
1st Grade	2.38 (.68)	2.38 (.66)	2.38 (.70)
2nd Grade	2.76 (.72)	2.80 (.75)	2.71 (.69)
3rd Grade	3.19 (.87)	3.27 (.88)	3.10 (.89)
Inhibitory Control			
Pre-K	11.99 (10.16)	11.87 (11.14)	12.11 (9.23)
Kindergarten	16.39 (10.58)	15.57 (9.8)	17.12 (11.22)
1st Grade	26.60 (17.73)	27.86 (19.79)	25.36 (15.44)
2nd Grade	28.44 (18.39)	29.56 (20.59)	27.40 (16.14)
3rd Grade	31.19 (26.02)	36.09 (31.73)	26.71 (18.50)
Set Shifting			
Pre-K	.58 (.43)	.66 (.43)	.69 (.42)
Kindergarten	.52 (.27)	.53 (.27)	.52 (.26)
1st Grade	.69 (.25)	.71 (.24)	.66 (.25)
2nd Grade	1.67 (.43)	1.66 (.44)	1.67 (.43)
3rd Grade	1.50 (.41)	1.47 (.36)	1.53 (.45)
3rd Grade Outcomes			
Academic Skills	27.40 (9.30)	28.22 (8.52)	26.63 (9.96)
Social-Emotional Skills	3.02 (.93)	3.14 (1.05)	2.91 (.80)

Note: to account for skill development over time, the set shifting variable changed from a measure of percentage of correct answers (higher values are more proficient) from pre-K through 1st grade to reaction time (lower values are more proficient) during 2nd and 3rd grade.

Table 2

Correlations Among Study Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
Working Memory																
1. Pre-K																
2. Kindergarten	.31**															
3. 1st Grade	.23**	.23**														
4. 2nd Grade	.27**	.36**	.36**													
5. 3rd Grade	.16*	.19*	.26**	.36**												
Inhibitory Control																
6. Pre-K	.33**	.15*	.22**	.15*	.23**											
7. Kindergarten	.23**	.35**	.17*	.25**	.17*	.37**										
8. 1st Grade	.27**	.16*	.26**	.20*	.16*	.24**	.45**									
9. 2nd Grade	.22**	.27**	.21**	.29**	.26**	.20*	.43**	.45**								
10. 3rd Grade	.15	.24**	.22**	.17*	.10	.22**	.51**	.40**	.47**							
Set Shifting																
11. Pre-K	.11	.11	.25**	.00	.12	.14	.21**	.21**	.20*	.13						
12. Kindergarten	.05	.17*	.10	.11	.18*	.05	.02	.11	.00	.02	.16*					
13. 1st Grade	.17*	.25**	.20**	.21**	.27**	.19*	.18*	.11	.25**	.12	.21**	.26**				
14. 2nd Grade	-.10	-.13	-.11	-.20*	-.13	.04	-.02	.08	.05	.10	-.03	-.07	-.04			
15. 3rd Grade	-.17*	-.19*	-.05	-.19*	-.14	-.03	-.01	-.06	-.05	.06	-.01	-.17*	-.06	.35**		
3rd Grade Outcomes																
16. Academic Skills	.33**	.17*	.34**	.32**	.37**	.25**	.23**	.14	.09	.13	.07	.20*	.28**	-.32	-.15	
17. Social-Emotional Skills	.06	.14	.19*	.16*	.08	.16*	.09	.16*	.12	.00	.14	.11	.16*	.09	-.01	-.03

Note: * $p < .05$; ** $p < .01$

APPENDIX B

FIGURES

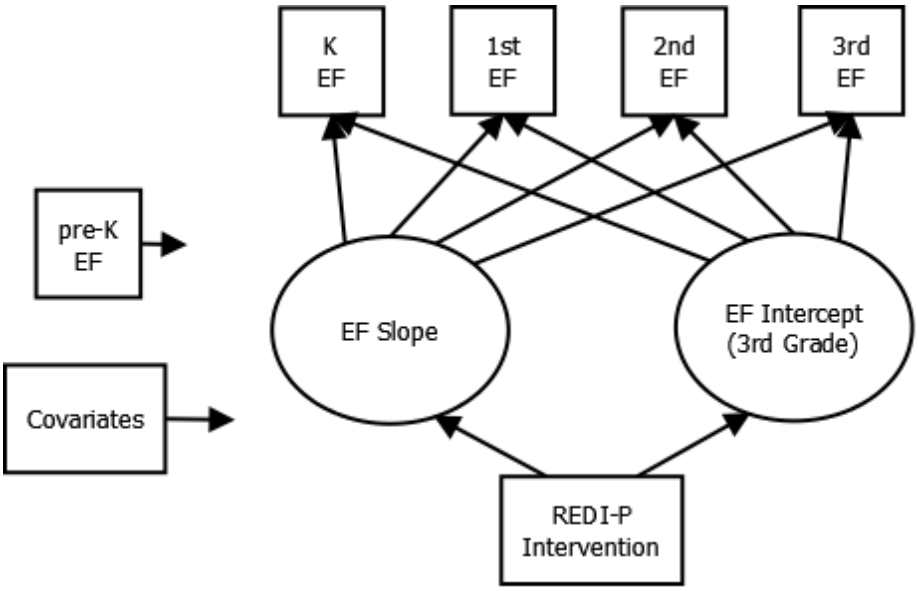

Figure 1. Conceptual diagram of EF latent growth curve models.

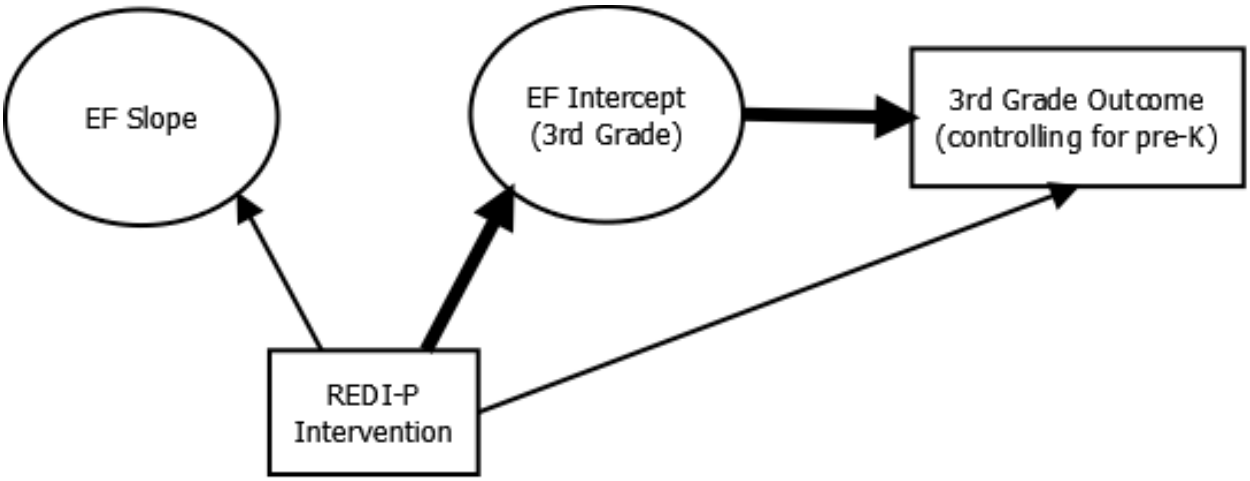

Figure 2. Conceptual diagram of models testing indirect effects of REDI-P on 3rd grade academic and social-emotional outcomes via gains in EF. Note: indirect path bolded.

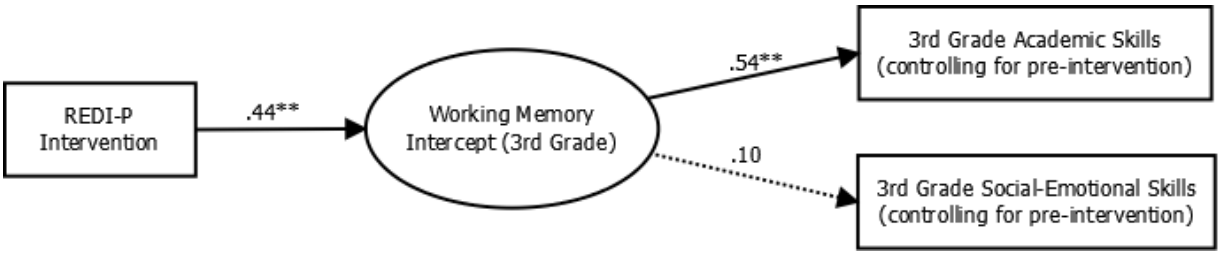

Figure 3. Mediation model predicting 3rd grade outcomes via working memory. Note: dotted lines indicate non-significant paths; control variables include child age, sex, race, family SES, financial struggles, and single-parent status. *$p < .05$. **$p < .01$.

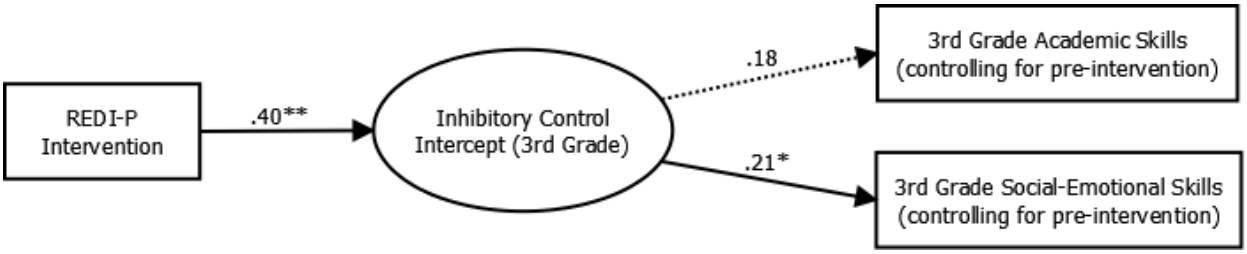

Figure 4. Mediation model predicting 3rd grade outcomes via inhibitory control. Note: dotted lines indicate non-significant paths; control variables include child age, sex, race, family SES, financial struggles, and single-parent status. *$p < .05$. **$p < .01$.

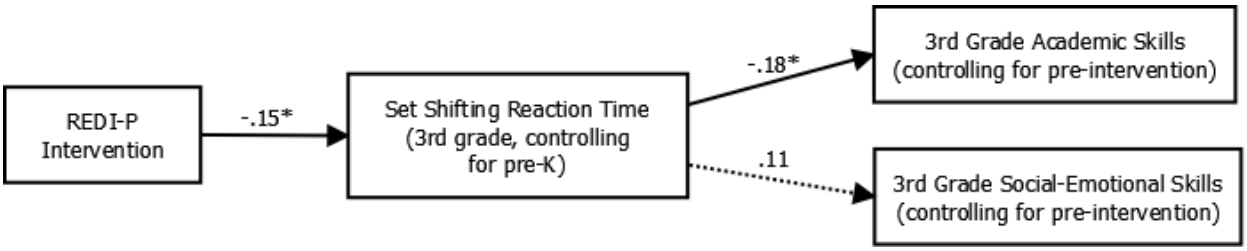

Figure 5. Mediation model predicting 3rd grade outcomes via set shifting reaction time. Note: as smaller reaction times indicate a faster response, a negative sign indicates a desired treatment effect; dotted lines indicate non-significant paths; control variables include child age, sex, race, family SES, financial struggles, and single-parent status. *$p < .05$.

Vita

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Education

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Publications

Bendezu, J.J., **Loughlin-Presnal, J. E.**, & Wadsworth, M. E. (in press). Attachment security moderates effects of uncontrollable stress on preadolescent HPA responses: evidence of regulatory fit. *Clinical Psychological Science.*

Wadsworth, M.E., Broderick, A.V., **Loughlin-Presnal, J. E.**, Bendezu, J.J., McDonald, A., Perzow, S., Joos, C., Ahlkvist, J.A. (in press). Co-activation of SAM and HPA responses to acute stress: a review of the literature and test of differential associations with preadolescents' internalizing and externalizing. *Developmental Psychobiology*.

Loughlin-Presnal, J. E., & Bierman, K. L. (2017). How do parent expectations promote child academic achievement in early elementary school? A test of three mediators. *Developmental Psychology, 53*(9), 1694-1708.

Loughlin-Presnal, J. E., & Bierman, K. L. (2017). Promoting parent academic expectations predicts improved school outcomes for low-income children entering kindergarten. *Journal of School Psychology*, 62, 67-80.

Wadsworth, M. E., Bendezú, J. J., **Loughlin-Presnal, J. E.**, Ahlkvist, J. A., Tilghman-Osborne, E., Bianco, H., ... & Hurwich-Reiss, E. (2016). Unlocking the black box: a multilevel analysis of preadolescent children's coping. *Journal of Clinical Child & Adolescent Psychology,* 1-15.