Abstract Title Page
Not included in page count.

Title: Executive function as a mediator of effects on kindergarten learning behaviors one year after the pre-K Head Start REDI intervention

Author(s): Ursache, A., Blair, C., Bierman, K., & Nix, R.

Abstract Body

Limit 5 pages single spaced.

Background / Context:

Description of prior research and its intellectual context.

Executive functioning has been shown in many studies to be an important mechanism of academic performance in literacy and math as well as in school competence (Blair & Razza, 2007; Bull & Scerif, 2001; Espy, McDiarmid, Cwik, Stalets, Hamby, & Senn, 2004; McClelland, Cameron, Connor, Farris, Jewkes, & Morrison, 2007; Welsh, Nix, Blair, Bierman, & Nelson, 2010). Executive functioning, defined as separable but related abilities of working memory, inhibitory control, and attention set-shifting likely also promotes school engagement and self-directed learning. In the context of school, EF can be thought of as children's abilities to resist distractions, to control their thinking, and to engage in goal-directed activities that promote learning. Thus EF can be characterized and measured in terms of cognitive capabilities as well as in terms of the behaviors that manifest these cognitive capabilities. Furthermore, executive functioning is also bi-directionally linked to processes of emotion regulation, attention, and stress reactivity (Blair, 2002; Blair & Dennis, 2010). When these bottom up processes of regulation and reactivity promote an optimal level of arousal they support the use of EF. On the other hand, when children are in a context where they experience stress and emotional reactivity, they are less likely to be able to use and thus further develop EF.

In this study we investigate the role that executive functioning plays in explaining the impacts of the prekindergarten REDI intervention on follow up long-term effects on kindergarten learning behaviors, one year after the end of the intervention. While the REDI intervention did not provide direct instruction in EF skills, the curriculum may have fostered the development of EF by using language and classroom structure to create a classroom climate that was less stressful for children. This less stressful climate may then have aided them in regulating their emotions and attention to maintain a more optimal level of arousal which in turn set the stage for them to be able to use EF skills to direct their learning.

Initial analyses revealed positive effects of the REDI intervention on emergent literacy skills and social-emotional functioning at the end of the pre-kindergarten year (Bierman, Domitrovich, Nix, Gest, Welsh, Greenberg, Blair, Nelson & Gill, 2008). Further analyses demonstrated that improvements in executive functioning (EF) partially mediated the intervention effects on achievement measures (Bierman, Nix, Greenberg, Blair & Domitrovich, 2008). One problem with using standardized achievement scores as an outcome measure, however, is that they capture relatively little variance in student performance. Another factor is that these tests do not give us any insight into the ways in which students are engaging in learning. Students who engage in more effective or self-directed learning may be better prepared to persevere as the pace of learning increases in later grades. Moreover, teacher's views of student learning behaviors are likely related to their expectations of student success and in turn to students' perceptions of their own efficacy at school.

Purpose / Objective / Research Question / Focus of Study:

Description of the focus of the research.

In the current study we examine follow-up effects of the pre-K REDI intervention on executive functioning and adaptive learning behaviors, one year post intervention, when the children are in kindergarten. We find that although there are intervention effects on EF at the end of pre-K, these effects are not sustained through kindergarten. The REDI intervention did, however, continue to have an effect on student's teacher-rated learning behaviors in kindergarten. In order to more fully examine this relationship, we examine how REDI effects on EF at the end of preschool may have in turn affected children's learning behaviors in kindergarten. Although no impacts of the intervention were found on kindergarten EF, we hypothesize that EF at the end of the preschool year may mediate intervention effects on adaptive learning behaviors in kindergarten. By creating a classroom climate that supported an optimal level of arousal for children, intervention classrooms likely set the stage for EF which in turn supports learning abilities such as staying on task and school engagement. As mediating EF measures we will look at the Dimensional Change Card Sort Task (DCCS) and task-orientation (an assessor rating of global self-regulation skills) since these two measures showed intervention effects at the end of pre-K year.

Setting:
Description of the research location.

The experimental evaluation of the intervention was conducted with forty-four Head Start classrooms in 3 Pennsylvania counties. Follow up assessments in took place in 204 kindergarten classrooms.

Population / Participants / Subjects:
Description of the participants in the study: who, how many, key features or characteristics.

While the classrooms contained both 3 and 4 year olds, only 4 year olds participated in the evaluation of the program. 356 children (58% European American; 17% Latino; 25% African American; 54% girls) were recruited from these classrooms and completed pre-intervention and post-intervention assessments. These children transitioned into 204 kindergarten classrooms, and 94% completed follow-up assessments.

Intervention / Program / Practice:
Description of the intervention, program or practice, including details of administration and duration.

Developed in partnership with Head Start programs, the REDI (Research-based, Developmentally-Informed) enrichment intervention was designed to complement and strengthen the impact of existing Head Start experiences on children's school readiness. REDI included research-based curriculum components and teaching practices designed to promote child competencies in the dual domains of language/emergent literacy skills and social-emotional functioning. The intervention was implemented by classroom teachers as an integrated part of their usual classroom program. REDI curriculum components included: (1) a dialogic reading program with vocabulary props, (2) sound games to build phonological awareness, (3) print center activities to support letter identification skills, and (4) a social-emotional learning program, *Preschool PATHS* (Domitrovich, Cortes & Greenberg, 1999). In addition, the program targeted classroom teaching practices, including positive classroom management, rich and complex language use, emotion coaching, and support for social problem-solving skills.

Teachers received 4 days of workshop training and on-going professional development provided by REDI mentors. The program was implemented during one pre-kindergarten school year.

Research Design:
Description of research design (e.g., qualitative case study, quasi-experimental design, secondary analysis, analytic essay, randomized field trial).

An experimental design was used in which forty-four Head Start classrooms in 3 Pennsylvania counties were stratified on demographic characteristics and randomly assigned to intervention or "usual practice."

Data Collection and Analysis:
Description of the methods for collecting and analyzing data.

Initial child assessments began 3 weeks into the pre-kindergarten school year and lasted until the end of October. End of the year assessments took place in March and April. Executive functions were assessed near the beginning and end of the school year using measures of working memory (backward word span task), inhibitory control (the peg tapping task), and attention shifting (the dimensional change card sort task). The walk-a-line slowly task was also used to assess motor inhibition. As well, a global rating of self-regulation, task orientation, was made by the assessor based on how well the child regulated behavior throughout the administration of the executive function tasks. Emergent literacy skills including vocabulary, phonological sensitivity, and letter knowledge were assessed using the Expressive One-Word Picture Vocabulary Test (Brownell, 2000) and relevant subtests of the Test of Language Development (Hammill & Newcomer, 1997) and Test of Preschool Early Literacy (Lonigan, Wagner, Torgesen, & Rashotte, 2007).

Follow up assessments in kindergarten consisted of literacy measures including Letter-Word Identification (Woodcock Johnson III, 2001) and Word Attack Skills (TOWRE; Torgesen et al., 1999), and the EF tasks described above. In kindergarten, classroom quality was measured by CLASS observations (La Paro & Pianta, 2003) as well as an index of school risk which included the percentage of students receiving free/reduced price lunch and the percentage of under-achieving students. Learning behaviors were measured using a subset of items from the School Readiness Questionnaire (Bierman et al., 2008) in which teachers were asked to rate a series of statements about adaptive learning behaviors on a scale of 1 (strongly disagree) to 6 (strongly agree). Ratings were averaged to yield an average level of agreement across a variety of behaviors such that a higher score indicates a higher level of school readiness in terms of learning behaviors.

We used STATA to estimate a series of hierarchical linear models in order to account for nesting of children within pre-K classrooms. All of our models control for gender, race, and age as Level 1 variables and program location, cohort as Level 2 Variables.

Findings / Results:
Description of the main findings with specific details.

We first estimated the impact of the REDI on scores on each individual EF tasks at the end of pre-K, controlling for pre-intervention score on the relevant EF task as well as the other covariates listed above. Consistent with prior analyses (Bierman et al, 2008), we find that the intervention has significant impact on scores on the DCCS and task orientation (see Table 1).

In Model A (see Table 2) we then estimate the impact of the REDI intervention on kindergarten learning behaviors. We find that on average, children who received the REDI intervention are rated .265 points higher than control children on their learning behaviors in kindergarten.

In Model B (see Table 2) we estimate the impact of EF at the end of pre-K on learning behaviors in kindergarten. We restrict our analyses to the DCCS and task orientation because performance on these tasks was shown to be impacted by the REDI intervention. We find that both the DCCS and task orientation at the end of pre-K significantly and positively predict learning behaviors in kindergarten.

In Model C (see Table 2) we again estimated Model A, this time including performance on the DCCS and task orientation. Thus the difference between the estimate of the intervention effect in Model A and Model C provides a preliminary look at EF as a mediator of intervention effects on kindergarten learning behaviors. We find that in adding DCCS and task orientation to our model reduced the treatment impact such that it was no longer significant. The two EF measures, however, remained significant positive predictors of kindergarten learning behaviors. While we recognize that these analyses are not a formal test of mediation in a multi-level framework, they do offer preliminary analyses to suggest that mediation of intervention effects on kindergarten learning behaviors may be occurring through EF. We plan to follow up these preliminary analyses by testing mediation using a multilevel SEM approach to test the specific indirect effects of interest.

Conclusions:

Description of conclusions, recommendations, and limitations based on findings.

Overall, while we plan to formally test our hypothesis in further analyses, we do find preliminary support for our hypothesis that EF scores at the end of pre-K mediate effects of the REDI intervention on learning behaviors in kindergarten. The REDI intervention impacted children's executive functioning and executive functioning was positively related to children's learning behaviors in kindergarten. Although the intervention did not specifically target development of EF, it is likely that REDI classrooms provided supports that made it easier for children to be less emotionally reactive, less stressed, and thus in a more optimal level of arousal to use EF. In turn, EF, seems to be a likely mediator of effects on learning behaviors one year post intervention. Moreover, these learning behaviors are skills that should be important for children to use throughout their time in school in order to engage more effectively with academic material. Thus, EF is likely one mechanism by which early childhood interventions such as REDI can have an impact on future school success.

Appendices

Not included in page count.

Appendix A. References

References are to be in APA version 6 format.

Bierman, K.L., Domitrovich, C.E., Nix, R.L., Gest, S.D., Welsh, J.A., Greenberg, M.T., Blair, C., Nelson, K. & Gill, S. (2008). Promoting academic and social-emotional school readiness: The Head Start REDI Program. *Child Development, 79,* 1802-1817.

Bierman, K. L., Nix, R. L., Greenberg, M. T., Blair, C., & Domitrovich, C. E. (2008). Executive functions and school readiness intervention: Impact, moderation, and mediation in the head start REDI program. *Development and Psychopathology, 20*(3), 821-843.

Blair, C. (2002). School readiness: Integrating cognition and emotion in a neurobiological conceptualization of children's functioning at school entry. *American Psychologist, 57(2),* 111-127.

Blair, C. & Dennis, T. (2010). An optimal balance: Emotion-cognition integration in context. In S. Calkins and M. Bell (Eds.) *Child development at the intersection of cognition and emotion* (pp. 17-36). Washington DC: American Psychological Association.

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development, 78*(2), 647-663.

Brownell, R. (2000). *Expressive One-Word Picture Vocabulary Test Manual*. Novato, CA: Academic Therapy Publications

Bull, R., & Scerif, G. (2001). Executive functioning as a predictor of children's mathematics ability: Inhibition, switching, and working memory. *Developmental Neuropsychology, 19*(3), 273-293.

Domitrovich, C. E., Cortes, R. C., & Greenberg, M. T. (2007). Improving young children's social and emotional competence: A randomized trial of the preschool "PATHS" curriculum. *The Journal of Primary Prevention, 28*(2), 67-91.

Espy, K. A., McDiarmid, M. M., Cwik, M. F., Stalets, M. M., Hamby, A., & Senn, T. E. (2004). The contribution of executive functions to emergent mathematic skills in preschool children. *Developmental Neuropsychology, 26*(1), 465-486.

Hammill, D. & Newcomer, P. L. (1997). *Test of Language Development.* Austin, TX: Pro-Ed.

LaParo, K.M. & Pianta, R.C. *CLASS: Classroom assessment scoring system.* Charlotesville: University of Virginia.

Lonigan, C. J., Wagner, R. K., Togesen, J. K., & Rashotte, C. A. (2007). *TOPEL: Test of Preschool Early Literacy*. Austin, TX: Pro-Ed.

McClelland, M. M., Cameron, C. E., Connor, C. M., Farris, C. L., Jewkes, A. M., & Morrison, F. J. (2007). Links between behavioral regulation and preschoolers' literacy, vocabulary, and math skills. *Developmental Psychology, 43*(4), 947-959.

Torgeson, J. K., Wagner, R. K., & Rashotte, C. A. (1999). *Test of word reading efficiency.* Austin, TX: Pro-Ed.

Welsh, J., Nix, R., Blair, C., Bierman, K., & Nelson, K. (in press). The development of cognitive skills and gains in academic school readiness for children from low-income families. *Journal of Educational Psychology,*

Appendix B. Tables and Figures

Not included in page count.

Table 1: Effects on EF measures at the end of pre-K		
	DCCS	Task Orientation
Level 1 Controls		
Black	-.046	-.071
Latino	-.127	-.061
Female	.044	-.003
Age	-.017	-.076
Level 2 Controls		
Site	.076	.019
Cohort	-.033	-.084
REDI intervention	.097* .364***	.144*
Beginning of Pre-K DCCS		
Beginning of Pre-K Task Orientation		.535***
* p < .05 ** p < .01 *** p<.001		

Table 2: Effects on kindergarten learning behaviors			
	Model A	Model B	Model C
Level 1 Controls			
Black	.229	.192	.253
Latino	.597***	.593***	.654***
Female	.589	.433***	.485***
Age	.639***	.303	.574***
Level 2 Controls			
Site	-.228	-.219	-.281*
Cohort	-.030	-.132	-.0166
REDI intervention	.265*		.201
End of Pre-K DCCS		.399**	.320*
End of Pre-K Task Orientation		.552***	.752***
* p < .05 ** p < .01 *** p<.001			