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An after-school intervention targeting executive function and visuospatial skills also improves classroom behavior

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Abstract

Executive function (EF) describes a complex set of skills, including flexible attention, inhibitory control, and working memory, that coordinate to achieve behavioral regulation. Visuospatial skills (VS) describe the capacity to visually perceive and understand spatial relationships among objects. Emerging research suggests VS skills are associated with classroom functioning, including behavioral adjustment. Children from socioeconomically disadvantaged backgrounds are more likely to enter school with EF and VS deficits, with consequences for classroom adjustment. In response, we developed and experimentally tested an after-school intervention that incorporates fine and gross motor activities targeting EF and VS skills in a sample of 87 kindergarten and first-grade students from low-income communities. The aim of the present study was to preliminarily explore whether EF and VS skills were bolstered by the intervention and subsequently whether EF and VS skills mediate or moderate intervention impacts on learning-related and problem behaviors in the classroom. Intent-to-treat analyses confirm intervention effects for EF and VS skills. Using full information maximum likelihood and bias-corrected bootstrapping, results indicate that improvements in EF mediated the impact of assignment to the treatment condition on improvements in learning-related behaviors and reductions in problem behavior. Taken together, findings suggest out-of-school contexts are a reasonable point of intervention for improving daytime classroom behavior.

Keywords

Executive function, visuospatial skills, learning-related behavior, problem behavior, after school, intervention

Children from socioeconomically disadvantaged backgrounds enter formal schooling with gaps in foundational skills that impede school readiness and classroom behavioral adjustment (Grissmer & Eiseman, 2008; Isaacs, 2012). Despite decades of research, policy, and practice dedicated to improving classroom quality, teacher training, and curricular innovation within the classroom setting, skill gaps have remained fairly constant (Reardon, 2011). Expanding learning opportunities to after-school contexts has garnered attention as an avenue for closing persistent skill gaps between children from low-income communities and affluent counterparts (Afterschool Alliance, 2015).

In response, we developed an after-school intervention which includes a combination of structured and creative play with games, activities, manipulatives, and arts and crafts that children find both challenging and engaging. We implemented a randomized controlled trial with kindergarten and first-grade students attending an established after-school program in three elementary schools where over 90% of students received free or reduced price lunch. After-school activities were designed to bolster foundational skills (i.e., executive function [EF] and visuospatial [VS] skills) known to contribute to classroom behavioral adjustment. The aim of the present study was to preliminarily test the efficacy of the intervention in improving EF and VS skills and then to determine whether participation in the after-school intervention led to improvements in daytime classroom behavior. Specifically, we explore whether foundational skills mediate or moderate improvements in learning-related or problem behaviors.

The importance of classroom behavior

Success in later life is heavily dependent on early school adjustment and subsequent behavioral trajectories. Children learn from teachers and peers in a social context, with the classroom carrying a heavy demand for social skills and self-control (Durlak & Weissberg, 2011). Children's behavior can either enhance or hinder learning affordances both for individual children and the entire class (Rimm-Kaufman & Pianta, 2000). Preschool and kindergarten teachers regard children's classroom behavior as more valuable than academic skills in facilitating a smooth adjustment to formal schooling (Curby et al., 2017; Rimm-Kaufman, Pianta, & Cox, 2000). Moreover, teacher ratings of children's classroom behavior

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in first grade predict achievement through twelfth grade (Darney, Reinke, Herman, Stormont, & Ialongo, 2013). Despite demands placed on teachers to boost academic achievement, most teachers report managing classroom behavior is the most stressful aspect of their profession (Ozdemir, 2007).

Classroom behavior can be articulated across two domains: learning-related behaviors promote positive, goal-directed interactions with peers and learning materials and include self-control of emotions and behavior as well as self-regulated learning behavior. For example, a child demonstrating learning-related behaviors may successfully share, take turns, attend to learning tasks, and remain focused on a goal despite opportunity for distraction. Problem behaviors describe off-task, disruptive, impulsive, or challenging behaviors that distract from learning and can signal future adjustment difficulties. A child exhibiting problem behaviors may require repeated redirection, exhibit a low frustration threshold, or have difficulty focusing attention on learning goals. Evidence suggests learning-related behaviors are associated with better school performance and overall well-being (Durlak & Weissberg, 2011; McClelland, Acock, & Morrison, 2006; Moffitt et al., 2011) whereas problem behaviors are associated with academic and interpersonal difficulties (Guerra & Bradshaw, 2008; Stormont, Beckner, Mitchell, & Richter, 2005). In brief, children's classroom behavior plays a role in the amount of individual and group learning that can occur. Yet, when faced with competing priorities, explicit efforts to promote positive behavior generally take a back seat to academic learning. One approach to create more time for behavioral development may be to expand learning opportunities beyond the classroom to other settings, including after-school programming.

Skills foundational to classroom behavior

The goal of the intervention was to build foundational or domain-general skills known to facilitate classroom adjustment. A broad range of skills and behaviors are required for children to be successful in school (Diamond, 2010). Beyond basic academic skills, researchers have identified a number of domain-general skills that support learning and learning-related behaviors across content areas, but are developed largely outside of direct academic instruction. One of the most studied of these foundational skills is EF. Considered a complex skill set that underlies learning and behavioral regulation, EF includes sustaining attention, flexibility in shifting attention, inhibition of distracting impulses, and the capacity for maintaining, manipulating, and accessing information in working memory (Best & Miller, 2010; Diamond & Lee, 2011). Applied to the classroom context, children rely on EF when they deploy attention to the task at hand while inhibiting distracting or impulsive behaviors; EF is also engaged when children listen to and follow directions or plan the execution of a task with multiple steps. Past research indicates direct assessment of EF predicts teacher ratings of children's classroom behavior (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Kim et al., 2016).

Visuospatial skills describe the capacity to visually perceive and understand spatial relationships among objects (Carlson, Rowe, & Curby, 2013). We employ VS skills when we interpret, mentally represent, and replicate visual information, including working with symbols (e.g., letters and numbers) or manipulating learning materials. VS skills are embedded in nearly all aspects of classroom instruction and activities (Marr, Cermak, Cohn, & Henderson, 2003). An emerging line of research suggests VS skills are an additional foundational predictor of academic achievement (Carlson et al., 2013; Verdine, Irwin, Golinkoff, & Hirsh-Pasek, 2014), even when EF is considered (Becker, Miao, Duncan, & McClelland, 2014; Cameron et al., 2012). More recently, research indicates VS skills also predict children's behavioral regulation and classroom adjustment (Cameron et al., 2015; Cameron, Cottone, Murrah, & Grissmer, 2016). Moreover, VS skills predict teacher ratings of behavioral regulation beyond the contribution of EF (Kim et al., 2016). Although the mechanisms that support the association between VS skills and children's classroom behavior aren't well understood, one hypothesis is that children in early elementary classrooms must employ VS skills in tandem with other complex cognitive tasks (e.g., representing and manipulating letter sounds while spelling or appreciating number magnitude while writing out math problems). Children with low VS skills may experience a cognitive overload when attempting to keep up with the pace of the learning environment, whereas children who have reached a level of automaticity with VS tasks may be less prone to cognitive overload and subsequent problem behaviors (Artino, 2008; Cameron et al., 2012).

Diamond and Lee (2011) note that EF can be improved by intervention, intervention is more effective with disadvantaged populations where skill gaps are common, and EF interventions that promote complementary skill development (e.g., VS skills) are more effective than targeting skills in isolation. Evidence suggests EF and VS skill deficits are pervasive for children growing up in poverty (Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010; Raver, Blair, & Willoughby, 2013). Black students enter kindergarten with an 8 month lag in VS skill level and a 10 month lag in EF skill level compared with white peers (Grissmer & Eiseman, 2008). Advantaged children may have higher levels of foundational skills because of increased parental awareness and capacity to teach such skills, and greater opportunity provided by the home environment to engage in manipulative-based activities and arts and craft projects that support skill development (Ramani & Siegler, 2011). Consequently, the intervention was designed and tested with a sample of predominantly Black kindergarteners and first graders living below the poverty level and likely to enter formal schooling lagging in EF and VS skills.

Intervention targeting EF and VS skills

The curriculum was designed to be an engaging and non-academic alternative to conventional classroom instruction that aimed to improve classroom functioning through a focus on foundational skill development. Specifically, the curriculum targeted EF and VS skills, and was developed using the collective expertise of professionals with varied knowledge of foundational skills, including occupational therapists, teachers trained in the Waldorf and Montessori traditions, and teachers experienced in curriculum development and implementation.

Curriculum activities consisted of increasingly complex constructional tasks that required children to visually perceive a predetermined design or model, and then recreate it. A large number of age-appropriate, commercially available arts and crafts activities and games were screened using four criteria; (1) adaptability: flexible enough to be appropriately challenging for K-1 children with different initial skills, (2) complexity: versatile enough to be continually and increasingly stimulating as children's skills improve, (3) trainability: easy enough to train paraprofessional instructors and deliver to play groups ranging from 4 to 7 children, and (4) variety of materials: diverse enough to maintain high levels of engagement. Templates were built for constructional activities that used a variety of arts and craft materials such as paper, waxed yarn, heat-fused beads, clay, pattern blocks, and other commercially available building toys. Subsequent to a structured constructional phase, children were able to innovate or create their own models individually and in small groups.

In addition to building three-dimensional objects, we employed a small number of tracing and motor precision tasks, which utilized a combination of arts and crafts materials, a commercially available handwriting program set to music (Callirobics©; Laufer & Schleifer, 1990), as well as selected worksheets from a commercially available Visual Motor Integration (VMI) workbook (Beery & Beery, 2006), collectively referred to as Paper and Pencil Activities. VMI worksheets presented increasingly complex mazes and coloring sheets to reinforce fine motor skills and specific developmentally appropriate VS skills including crossing the midline.

Finally, instructors were prepared to implement gross motor activities as needed when students completed tasks ahead of schedule or appeared to need to expend energy before concentrating on the constructional task. Activities were purposefully selected to build and reinforce EF components including impulse control, sustained attention, and working memory. For example, “Red Light, Green Light” requires children to start and stop gross motor movements, “Duck, Duck, Goose” asks children to sustain attention by listening for the action word, and “Simon Says” requires children to listen for and remember a rule and then inhibit the impulse to perform an action when the rule is broken.

Activities were designed around materials that were highly interesting to children, relatively low in cost or reusable, and easily manageable in a small group setting. Lessons were written in a prescriptive, yet flexible manner that allowed for heterogeneity in children’s skill levels, and for fairly inexperienced adults (i.e., after-school counselors, college students) to be successfully trained implementers of the intervention. The games provided were largely commercially available products that, through the course of play, naturally instilled practice of some combination of EF and VS skill. Skill demands were present throughout the curriculum, as the successful completion of many of these activities in a small group setting inherently required the exercise of sustained attention, working memory, response inhibition, fine and gross motor control, and cognitive flexibility along with visual perception, mental representation, and recreation of spatial designs. See Appendix A for additional supplementary curriculum details.

EF and VS skills as mediators and moderators of intervention impacts

Given that EF and VS skills would be trained in an after-school setting, it was important to ask whether skills could transfer across contexts and be demonstrated in meaningful ways. Specifically, could improvements in EF or VS skills lead to observable differences in children’s daytime classroom behavior? Past work on skill transfer to other contexts and to other untrained skills yields mixed findings (Barnett & Ceci, 2002). In terms of skill transfer to untrained skills, a meta-analysis of VS skill-boosting interventions concluded that training was often effective and enduring, with some studies nonetheless reporting null findings (Uttal & Cohen, 2012). Moreover, VS training demonstrated skill transfer into science, math, engineering, and technology (STEM) domains (Uttal & Cohen, 2012). Although examples of successful EF interventions (Diamond & Lee, 2011) and successful skill transfer to academic outcomes (Barnett et al., 2008) are readily available, other work suggests training on components of EF is effective only in the short term (e.g., working memory; Melby-Lervåg & Hulme, 2012) and does not reliably demonstrate transfer to untrained skills (Thorell, Lindqvist, Nutley, Bohlin, & Klingberg, 2009).

Finally, skill transfer to other contexts (i.e., from an after-school setting to the classroom) also yields mixed findings. Some studies demonstrate improved classroom behavior as a result of participation in after-school programming (Durlak, Mahoney, Bohnert, & Parente, 2010; Riggs & Greenberg, 2004). Yet, a meta-analysis of 27 studies examining the efficacy of after-school programming on school outcome improvement was inconclusive (McComb & Scott-Little, 2003). After-school programming can be variable in the quality of implementation (Bodilly et al., 2010), but tightly controlled experiments involving structured interventions outside of classroom contexts can lead to observable changes in children’s classroom behavior (Bratton et al., 2013). Taken together, we anticipate our after-school intervention has the potential to improve daytime classroom behavior and that the underlying mediating mechanism will be improvement in EF and VS skills.

Alongside examining improvement in EF and VS skills as mediators of intervention impacts, it may also be important to consider initial EF and VS skills as moderators of impacts. Even when family, school, and community factors are considered, the best predictor of classroom behavior at the end of first grade is classroom behavior at the beginning of first grade (Hoglund & Leadbeater, 2004). In order to intervene on relatively stable behavioral trajectories, it is important to identify and promote skills foundational to positive classroom behavior. Past work suggests children with initial EF deficits benefit incrementally from intervention (Diamond & Lee, 2011) and children from disadvantaged backgrounds with skill gaps benefit more from attending after-school programming compared with affluent peers (McComb & Scott-Little, 2003).

The present study

Three research questions are examined. First, does intervention condition assignment have a direct effect on EF, VS skills, and classroom behavior? The curriculum was explicitly designed to provide opportunity to hone and practice EF and VS skills in an under-resourced population that was expected to have low initial skill levels. Reviews of prior research suggest that both EF and VS skills can be improved via direct intervention (Diamond & Lee, 2011; Uttal & Cohen, 2012). The intervention does not explicitly teach behavior management strategies to children. Rather, we anticipate that behavior will be supported by EF and VS skill development. Nonetheless, the after-school setting does implicitly provide further opportunity for children to develop positive behaviors by working in groups and following directions. As such, we test whether the intervention directly impacts classroom behavior prior to conducting mediator and moderator analyses.

Second, does EF or VS skill improvement mediate the impact of assignment to the treatment condition on children’s learning-related and problem behaviors? Past research describes a link between direct assessment of EF and VS with teacher ratings of children’s behavior (Cameron et al., 2015; Kim et al., 2016). We hypothesize that assignment to the treatment condition will impact children's classroom behavior indirectly through improvement in EF and VS skills. If assignment to the intervention condition leads to improvements in children's behavior above and beyond typical after-school programming, then EF or VS improvements may help explain the underlying mechanisms that link intervention participation with behavioral gains. If evidence for mediation exists, either through EF or VS, then we could further conclude that behavioral gains are attributable to the EF/VS intervention components rather than increased opportunity for social skill development as a by-product of participation in an after-school program.

Third, do initial levels of EF or VS moderate the impact of the intervention on children's learning-related and problem behaviors? Children who enter the school year with low initial levels of EF or VS skills are anticipated to also receive poor ratings for classroom behavior in the fall. Diamond and Lee (2011) summarize research suggesting initial EF skill level moderates intervention impacts. The same may be true for VS skills, which have received relatively less intervention attention compared with EF. We anticipate that children who enter the treatment condition with low initial levels of EF or VS skills will make greater improvements in classroom behavior over the course of the school year relative to children in the control condition and children in the treatment condition who had higher initial levels of either EF or VS skills.

Method

Participants

The intervention was distributed across three underperforming Title 1 elementary schools situated in an industrial belt surrounding an urban center in the Southeast. Schools were selected based on (a) neighborhood risk status (majority of residents live 200% below the federally designated poverty rate, majority of births to single mothers, and high incidence of violent crime; U.S. Census Bureau, 2008), (b) school performance (less than half of elementary students performed on grade level across all subject areas and less than half of students in the neighborhood graduate high school in 4 years (McGinley, Rose, & Donnelly, 2009; South Carolina Department of Education, 2011), and (c) the existence of an established free after-school program with high attendance.

Kindergarten and first-grade children enrolled in an after-school program were invited to participate in the study at a parent open-house event attended by approximately 60% of parents. All parents who attended the open-house event consented to participate in the study with the exception of one family who had a child with autism and one family that did not speak English and could not provide informed consent. The remaining families received invitations to participate in the study through book bags from school. In total, 97 families consented to participate in the study, representing approximately 70% of the total number of students enrolled in the after-school program. Between securing consent and randomization, seven children relocated or dropped out of the after-school program, two children were removed from the program, and one child did not meet inclusion criteria (i.e., kindergarten or first-grade student). Eighty-seven children were randomized into treatment and control conditions. The final sample (see Table 1) comprised 42 (48%) kindergarten and 46 (52%) first-grade children who were, on average, 6.07 years old (SD = 0.62 years) and included 46 males (53%) and 41 females (47%). Over 90% of child participants were Black and eligible for free/reduced price lunch, which is consistent with the demographic characteristics of both the after-school program and the three participating elementary schools. Missing teacher questionnaire data in the fall (n = 13) was the result of failing to receive questionnaire packets from one classroom teacher. Missing child direct assessment data in the spring (n = 4) was due to student relocations during the school year.

All eight kindergarten and 10 first-grade teachers across three participating schools were invited to participate in the study and all consented. Eighteen teachers, one male and 17 female, six Black and 12 White, held at least a Bachelor's degree in education and had at least 1 year of teaching experience. After-school implementers also participated in the study. All seven instructors were female, four instructors were Black and three were White. All instructors were enrolled in either a liberal arts or technical college with majors in education, nursing, psychology, and undecided.

Procedure

The intervention was incorporated into an established after-school program across three schools. Randomization occurred at the school level. Within each after-school program, participants were assigned to a treatment group that received the intervention 4 days a week during a 45 minute block of time. To account for any treatment effects that could be attributed simply to participation in an after-school activity, the control group also attended the same after-school program but participated in different activities (e.g., girl scouts, basketball, cooking class). Children received 24 weeks of after-school programming between pre- and post-assessment. Pretest direct assessments occurred during the after-school program but prior to Day 1 of intervention implementation. Post-testing began after week 18 and continued through week 24. The range of sessions attended (intervention dosage) prior to post-testing was 51–96, with an average of 73 sessions. Prior to both direct assessment windows, research assistants obtained child assent.

All after-school staff members received a week-long training workshop on behavior management and group leadership regardless of study condition. Seven after-school staff members assigned to implement the intervention received 11 hours of additional training in curriculum implementation. Lesson plans were written for each 45 minute period with opportunities embedded to individualize instruction by increasing or decreasing the level of difficulty. Each instructor worked with four to seven children in mixed gender and age (K-1) groups.

Teachers rated children's behavior and research assistants conducted direct assessments of children's VS and EF skills at school entry prior to curriculum implementation in order to obtain baseline scores. The intervention was implemented after the first 9 weeks of school and continued through the end of the school year. Near the end of the school year, teachers rated children's behavior and research assistants conducted individual child assessment of VS and EF skills. Because participants in both treatment and control groups attended the same after-school program, teachers were blind to study condition when they rated children's behavior.

Measures

Classroom behavior. Learning-related and problem behaviors represent composites derived from two measures. The Social Skills Improvement System (SSIS; Gresham & Elliott, 2008) is a widely used teacher-reported measure of an individual child's relationships

Table 1. Descriptive statistics by condition.

		Full Sample (*N*=87)					Control (*n*=43)					Treatment (*n*=44)				
		n	%	M (SD)	Min	Max	*n*	%	M (SD)	Min	Max	*n*	%	M (SD)	Min	Max
Age in years at Time 1		87		6.07 (.62)	5	7.6	43		6.04 (.63)	5	7.5	44		6.10 (.63)	5	7.6
Sex:	Female = 0	41	47				23	26				18	21			
	Male = 1	46	53				20	23				26	30			
Grade:	Kindergarten	46					22	25				19	22			
	First Grade	41					21	24				25	29			
Ethnicity:	African–American/Black	79	90				40	46				39	45			
	Caucasian/White	4	5				1	1				4	5			
	Hispanic/Latino	3	4				3	3				1	1			
	Other Ethnicity	1	1				0	0				1	1			
Pre-test[1]:	Executive function	87		84.27 (14.39)	53	121	43		87.40 (14.94)	53	121	44		81.14 (13.44)	56	113
	Visuospatial skills	87		92.87 (11.69)	68	121	43		94.23 (10.24)	68	112	44		91.55 (13.05)	70	121
	Learning-related behaviors	75		2.81 (.63)	1.3	4	37		2.78 (.54)	1.5	4	38		2.84 (.72)	1.3	4
	Problem behaviors	74		1.90 (.61)	1	3.4	37		1.88 (.53)	1	3.3	37		1.92 (.70)	1	3.4
Post-test:	Executive function	83		98.28 (16.20)	63	137	41		96.22 (15.67)	63	126	42		100.29 (16.84)	67	137
	Visuospatial skills	83		97.13 (12.45)	70	136	41		95.07 (11.20)	70	112	42		99.14 (13.53)	76	136
	Learning-related behaviors	87		3.02 (.64)	1.6	4	43		3.00 (.69)	1.6	4	44		3.04 (.60)	1.6	4
	Problem behaviors	87		1.86 (.59)	1	3.5	43		1.93 (.58)	1	3.2	44		1.78 (.60)	1	3.5
Change:	Executive function	82		14.23 (13.14)	–14	50	41		.24 (3.41)	–14	26	41		2.45 (3.20)	–11	50
(T2-T1)	Visuospatial skills	83		4.16 (10.45)	–24	33	41		3.63 (4.12)	–24	27	42		7.61 (5.27)	–18	33
	Learning-related behaviors	75		.22 (.44)	–.91	1.1	37		.19 (.49)	–.91	1.1	38		.26 (.39)	–.51	.99
	Problem behaviors	74		–.03 (.48)	–.95	1.8	37		.06 (.50)	–.95	1.8	37		–.12 (.44)	–.95	.88

Note. [1] At baseline, the treatment group displayed lower executive function compared with the control group ($t = 2.06$; $p < .05$, $d = 0.44$); T: Time; Min: minimum, Max: maximum.

and social behaviors in the classroom. The Child Behavior Rating Scale (CBRS; Bronson, Goodson, Layzer, & Love, 1990) assesses children's behavioral regulation across 17 items (e.g., "Cooperative with playmates when participating in a group play activity; willing to give and take in the group, to listen to or help others"). For both measures, teachers rated the frequency of children's observed behaviors on a scale of 1 to 4 (where 1 indicated "never" and 4 indicated "almost always"). The problem behavior composite ($\alpha = .93$) was created by calculating the mean of two SSIS constructs: externalizing ($\alpha = .92$) and hyperactive /inattention ($\alpha = .91$). The learning-related behaviors composite ($\alpha = .96$) was created by calculating the mean of the self-regulation ($\alpha = .95$) from the CBRS along with the SSIS self-control ($\alpha = .94$).

EF and VS skills. The neuropsychological assessment (NEPSY; Korkman, Kirk, & Kemp, 1998) includes three subtests used to assess EF that targeted selective attention, inhibitory control, and cognitive flexibility. The selective attention subtest requires children to quickly and accurately identify specific stimuli from an array of pictures that are similar in nature ($\alpha = .68$ per instrument developers for age 6; Korkman et al., 1998). For inhibitory control, children must listen to an audiotape and give a specified response or inhibit responses as rules shift across sets. For example, a child may need to perform an action when hearing the word *blue* in part A, and then inhibit a response to the word *blue* in part B and instead take action when hearing the word *green* ($\alpha = .84$; Korkman et al., 1998). Finally, the cognitive flexibility task asks children to move colored balls along a series of towers to arrive at a specified finish point and requires thinking through multi-step or planned sequential moves ($\alpha = .90$; Korkman et al., 1998). Two subtests were used to assess VS skills: spatial orientation and design copying. For spatial orientation, children must identify which of several arrows are directed at a central target ($\alpha = .88$; Korkman et al., 1998). The design copying measure was assessed through drawing of 18 increasingly complex figures ($\alpha = .81$; Korkman et al., 1998). EF and VS domain scores were creating by averaging subtest scaled scores. The NEPSY technical manual reports the following split half reliabilities for ages 5–8: VS = .86, S = .81, EF = .85 (Korkman et al., 1998).

Analytic approach

All analyses were conducted in Mplus version 7.31 using full information maximum likelihood (FIML) estimation to address missing data in the sample (Muthén & Muthén, 2012). Direct effects were assessed using an intent-to-treat (ITT) approach (Gupta, 2011). ITT analyses include all participants randomized into the treatment and control conditions regardless of compliance (dosage) and adherence (fidelity). ITT analyses are considered a conservative approach to detecting treatment effects that are more readily generalizable to real-world settings versus strict laboratory conditions (e.g., perfect attendance or flawless intervention implementation). We elected to employ ITT analyses because after-school program attendance can be variable compared with the conventional school day and staff training is typically minimal within after-school settings.

Due to the small sample size and the inclusion of indirect effects, which typically violate multivariate normality assumptions (Preacher & Hayes, 2008), we used bias-corrected bootstrapping to generate confidence intervals (CI) for determining statistical significance of all parameters. All CIs were generated using 10,000 iterations and reported at the 95% confidence level. All models included age and gender as covariates. To account for differences

Table 2. Correlations among variables using full information maximum likelihood.

	1	2	3	4	5	6	7	8	9	10	11
1. Intervention (treatment = 1)	–										
2. Sex (male = 1)	.13	–									
3. Age	.05	.03	–								
4. Learning-Related Behaviors T1	.00	–.27**	.19 t	–							
5. Problem Behaviors T1	.02	.25*	.23*	–.80***	–						
6. Executive Function T1	–.23*	.00	–.01	.31**	–.25*	–					
7. Visuospatial Skills T1	–.16	–.01	–.27**	.06	.00	.34***	–				
8. Learning-Related Behaviors T2	.03	–.23*	–.07	.76***	–.58***	.18 t	.17 t	–			
9. Problem Behaviors T2	–.12	.20 t	–.03	–.75***	.69***	–.12	–.12	–.88***	–		
10. Executive Function T2	.11	–.10	–.18 t	.26 t	–.23*	.65***	.39***	.34***	–.27**	–	
11. Visuospatial Skills T2	.16	.04	–.28**	.18 t	–.14	.29**	.63***	.27**	–.22*	.42***	–

Note. $N = 87$; $t < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. T1: Time 1; T2: Time 2.

Table 3. Intent-to-treat analyses of learning-related and problem behaviors.

	Learning-Related Behaviors			Problem Behaviors		
		95% CI			95% CI	
Predictor	*b*	Low	High	*b*	Low	High
Intervention (treatment = 1)	0.053	0.210	0.354	–0.139	0.186	0.342t
School B	0.158	0.016	0.166*	–0.181	–0.077	0.133*
School C	–0.244	0.065	0.243**	0.136	–0.028	0.124
Grade (K = 0, 1st = 1)	–0.009	0.300	0.554	–0.039	–0.084	0.238
Sex (Male = 1)	–0.066	–0.174	–0.030	0.017	–0.046	0.116
Age	–0.119	–0.655	–0.407	0.101	–0.392	–0.042
Learning-related (Time 1)	0.698	0.572	0.718***	–0.502	0.039	0.221***
Problem behaviors (Time 1)	–0.071	0.026	0.160	0.348	0.460	0.672**

Note. $N = 87$; $t = p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. CI: Confidence interval.

in initial levels of EF, VS, and classroom behavior, baseline measures were included in all models.

Results

Table 1 reports descriptive statistics by condition. Means and standard deviations contain values from the FIML models and account for missing data. Condition assignment was determined by simple randomization procedures. By chance, more boys were assigned to the treatment condition and more girls to the control condition. As well, the treatment group displayed lower EF at baseline compared to the control group ($t = 2.06$; $p < .05$). Although EF and VS baseline scores were well below national averages, there was nonetheless variability in both initial EF and VS skills and floor effects were not a concern. Learning-related behaviors were more normally distributed than problem behaviors, which were positively skewed, indicating that most participants had low scores on problem behaviors. Table 2 contains correlations for all variables in the analyses. Learning-related and problem behaviors are strongly negatively correlated at time 1 ($r = –.80$, $p < .001$) and time 2 ($r = –.88$, $p < .001$).

Tables 3 and 4 display ITT analyses testing the direct association between condition assignment and EF, VS, learning-related behaviors, and problem behaviors. Regression analyses control for school, age, sex, grade, and pre-test scores. As hypothesized, the intervention improves directly assessed EF ($b = .28$, $p < .001$) and VS ($b = .26$, $p < .001$) skills. We do not find support for direct effects for learning-related and problem behavior composites, although a trend is noted for problem behaviors ($b = –.14$, $p = .06$). Age, grade level, and sex did not contribute variance to outcomes with the exception of EF, where both age and grade were significant. School (three locations) contributed variance to teacher-rated outcomes and pre-test scores predicted all outcomes.

Mediation analyses were conducted to test the hypothesis that the intervention might have indirect effects on classroom behaviors through improvements in EF and VS. Congruent with current methodological approaches, we explore mediating pathways even though we do not detect direct association between intervention assignment and classroom behavior composites because we have no hypothesis that the treatment group would improve behavior in isolation but rather through bolstering EF and VS skills (Hayes, 2009; Shrout & Bolger, 2002). Models were built by controlling for school, age, grade, sex, classroom behaviors and EF/VS at time 1 (fall).

The multiple mediation analysis is consistent with the conclusion that assignment to the treatment condition increased learning-related behavior and reduced problem behaviors, through its effect on EF, compared with the control condition. Formal tests of the indirect effects and the bias-corrected boostrapped CIs are given in Table 5. The CIs around the indirect effects of EF on learning-related ($b = 0.13$, CI [0.05, 0.26]) and problem behaviors ($b = –0.07$, CI [–0.17, –0.01]) were found to exclude zero, supporting the rejection of the null hypothesis of no indirect effect between

Table 4. Intent-to-treat analyses of executive function and visuospatial skills.

	Executive Function			Visuospatial Skills		
		95% CI			95% CI	
predictor	*b*	Low	High	*b*	Low	High
Intervention (treatment = 1)	0.282	0.210	0.354***	0.264	0.186	0.342***
School B	0.091	0.016	0.166	0.028	–0.077	0.133
School C	0.154	0.065	0.243 t	0.048	–0.028	0.124
Grade (K = 0, 1st = 1)	0.427	0.300	0.554***	0.077	–0.084	0.238
Sex (Male = 1)	–0.102	–0.174	–0.030	0.035	–0.046	0.116
Age	–0.531	–0.655	–0.407***	–0.217	–0.392	–0.042
Executive function (Time 1)	0.645	0.572	0.718***	0.130	0.039	0.221
Visuospatial skills (Time 1)	0.093	0.026	0.160	0.566	0.460	0.672***

Note. $N = 87$; $t = p < .10$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$. CI: Confidence interval.

Table 5. Bootstrap mediation for learning-related and problem behaviors[a].

		BC 95% CI[a]	
Model Effects	Coef.[b]	Lower	Higher
Learning-related behavior			
Condition (total effect)	0.05	–0.12	0.22
Condition (direct effect)	–0.09	–0.27	0.07
Total indirect effect	0.14*	0.04	0.28
Specific indirect effects			
Executive function	0.13*	0.05	0.26
Visuospatial skills	0.01	–0.04	0.08
Problem Behavior			
Condition (Total Effect)	– 0.13	–0.31	0.05
Condition (Direct Effect)	–0.07	–0.25	0.11
Total Indirect Effect	–0.06	– 0.17	0.02
Specific Indirect Effects			
Executive Function	–0.07*	– 0.17	–0.01
Visuospatial Skills	0.01	–0.05	0.07

Note. $N = 87$.
[a]Covariates include school, grade, age, sex, executive function, visuospatial skills, learning-related, and problem behaviors at Time 1.
[b]BC 95% CI: 95% confidence interval using bias-corrected bootstrapping.
[c]Coef.: unstandardized coefficient.
[d]Treatment = 1, Control = 0.
$^{*}p < .05$ as determined by the BC 95% CI.

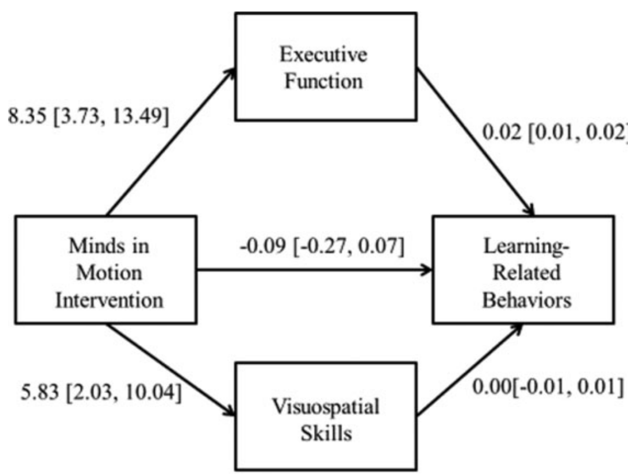

Figure 1. Executive function improvement mediates learning-related behavior improvement for the treatment group.
Note. $N = 87$; Analyses control for school, age, grade, sex, baseline executive function, visuospatial skills, learning-related and problem behaviors.

intervention assignment and behavior outcomes through EF. However, CIs for the indirect effect of VS for learning-related ($b = 0.01$, CI [–0.04, 0.08]) and problem behavior ($b = 0.01$, CI [–0.05, 0.07]) both included zero, and therefore provide no support for rejecting the null hypothesis of no indirect effect on outcomes through VS. Figures 1 and 2 contain the path models (unstandardized coefficients; Hayes, 2013) for EF and VS skills, and show that assignment to the treatment condition had a positive impact on EF ($b = 8.35$, $p < .001$) and VS skill improvement ($b = 5.83$, $p < .001$). We found evidence that improvements in EF were related to differences in both learning-related ($b = 0.02$, $p < .001$) and problem behaviors ($b = –0.01$, $p < .05$), but no evidence that gains in VS were related to differences between conditions for both learning-related and problem behaviors.

Moderation analyses were conducted to determine if intervention impacts on classroom behaviors were dependent upon the initial level of EF and VS. Both EF and VS skills and their interaction terms were entered into the same model to reduce the risk for false positives that occur with multiple models. Our results do not provide evidence for moderation of initial skill levels on intervention effect. A trend is noted where VS skills at school entry nearly moderate intervention impacts on learning-related behaviors ($b = –0.02$, $p = .08$).

Discussion

Teachers view children's classroom behavior as the key ingredient to a successful transition into formal schooling (Curby et al., 2017; Rimm-Kaufman et al., 2000). Classroom misbehavior detracts from learning time both for the individual and for the entire classroom (Stormont et al., 2005). Moreover, behavior management is cited as a primary reason for teacher burnout and leaving the profession (Ozdemir, 2007). Given the importance teachers place on children's classroom behavior, the amount of classroom time teachers are able to devote to building foundational skills and developing learning-related behaviors is relatively scarce. Findings from the present study demonstrate intervention impacts on EF and VS skills as well

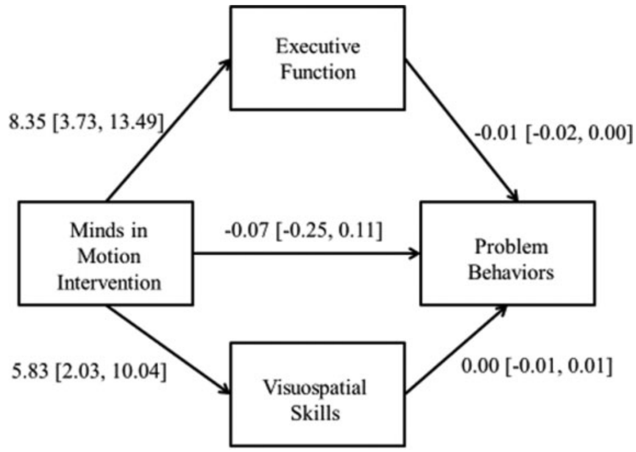

Figure 2. Executive function improvement mediates problem behavior improvement for the treatment group.
Note. $N = 87$; Analyses control for school, age, grade, sex, baseline executive function, visuospatial skills, learning-related and problem behaviors.

as a trend for ameliorating problem behavior, all within an after-school context.

Daytime classroom intervention research endorses the redirection of some academic instructional time towards the promotion of behavioral skills. For example, Responsive Classroom© promotes positive classroom behavior in elementary settings (Rimm-Kaufman, Fan, Chiu, & You, 2007) and Foundations of Learning emphasizes social and emotional learning in preschool settings (Morris, Millenky, Raver, & Jones, 2013); both interventions also report improved academic achievement. Intervening to improve foundational skills, notably EF, that support positive classroom behavior is another approach that has been applied more often in preschool settings (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008; Jones, Bub, & Raver, 2013; Tominey & McClelland, 2013). Despite the success of these and other interventions designed to promote positive classroom behaviors or bolster related foundational skills, widespread implementation of classroom-based behavioral interventions is limited in elementary settings. Administrators may perceive classroom resources dedicated to non-academic skill development as detracting from traditional instructional time. Schools and districts are judged exclusively by the academic content knowledge of their students and so the prioritization of basic academic skill instruction over foundational skill development is understandable. Findings from the present study address both the critical skill gaps that exist for children living below the poverty level (EF and VS direct effects) and the scarce resource of time during the elementary school day.

Mediation analyses provide evidence for EF as a mediator of impacts leading to improvements in learning-related behavior and reductions in problem behavior. Findings are consistent with prior intervention research. For example, the Head Start REDI project found EF mediated improvements in observed social competence and aggression (Bierman et al., 2008) and the Chicago School Readiness Project noted improvement in EF mediated reductions in problem behaviors; yet both studies intervened to improve EF within the classroom context. Unique to the present study, EF was able to explain variance in improvements in daytime classroom behavior despite the fact that the intervention did not occur during the school day, did not explicitly target children's behavior and was facilitated by non-school personnel (i.e., college students) with different behavioral expectations, socialization norms, and lower levels of training and experience than daytime classroom teachers.

Mediation findings suggest that the intervention boosts EF skills which in turn explain variance in improvements in learning-related behavior. However, the structured nature of the intervention may also have some unmeasured negative impacts on children's outcomes. In correlational work with more affluent samples, children who spent more time engaged in unstructured activities performed better on EF tasks compared with children with more structured activities scheduled (Barker et al., 2014). The control group participated in "business as usual" after-school activities which involved more free play, more peer interaction, and fewer proscribed activities relative to the treatment group which experienced a mix of semi-structured and structured activities. Yet, free play and peer socialization are also important developmental tasks that promote social skills through opportunity for practice (Coolahan, Fantuzzo, Mendez, & McDermott, 2000). Perhaps the intervention boosts EF through structured activities which in turn foster learning-related behaviors, but time spent in free play or informal socialization may have a unique positive direct effect on classroom behavior for the control group. Thus, without EF included as a mediator, the intervention impact on learning-related behavior goes undetected, highlighting the notion that multiple pathways exist for skill development dependent upon context (Ayoub & Fischer, 2006).

Mediation analyses did not provide evidence for VS skill improvement mediating improvements in classroom behavior. The hypothesized mechanism for VS skills promoting positive classroom behavior assumes that VS skills make learning less challenging, thereby reducing a propensity for distraction and frustration. Contrary to other studies (e.g., Cameron et al., 2012), VS were not correlated with behavioral ratings at school entry. VS skills in the fall fell around the 33rd percentile on average. Given the preponderance of students who demonstrated delays in VS skills, teachers may have chosen activities that did not place significant burden on VS skills (or allowed adequate time to complete VS tasks for their skill level) and consequently avoided behavior problems that may emerge from an overtaxed child. VS skills were correlated with spring behavior ratings, suggesting teachers may have had more opportunity to observe VS-laden instructional contexts as classroom demands increased.

We did not find statistically significant evidence for moderation, suggesting that all participants, regardless of initial skill level, benefited similarly from condition assignment. However, because of the small sample size we cannot rule out the possibility that the study was simply underpowered to detect moderation effects. The trend noted hints that children with lower initial VS skills may see greater improvements in learning-related behaviors when assigned to the treatment group.

Limitations and future directions

Our results derive from a small-scale intervention; a study with a larger sample size would be better powered to detect effects. Findings are nonetheless intriguing and hint at the potential for future behavioral intervention work in after-school contexts. Several limitations require mention. First, missing data were not at random. One classroom teacher did not submit fall ratings of children's classroom behavior.

Second, our small sample size limited our options analytically. Although children were nested in classrooms and after-school groups, the study was underpowered to conduct hierarchical analyses. We controlled for school-level effects and note significant differences across settings, suggesting either differences in implementation across sites or differences in teacher expectations for student behavior.

Third, by chance the treatment group had lower initial EF scores. It is not possible to know how this non-equivalence between groups influenced treatment effects and mediation and moderation analyses. It is important to note, however, that the treatment group had higher EF scores than the control group at post-test despite initial disparities.

In terms of next steps, the present study does not account for dosage or treatment fidelity. Analyses employ the ITT model, which represents the gold standard for intervention research. Work with under-resourced schools and high-risk populations during after-school contexts should acknowledge that transient attendance issues often occur and staff training is typically less robust. Careful attention to training and implementation were possible in the context of this small-scale effort. Other work suggests VS skill gains are bolstered by high-quality instruction and highly trained teachers (Byers, Cameron, Ko, LoCasale-Crouch, & Grissmer, 2016). Any large-scale intervention replication would likely experience greater variation in training and implementation quality, and thus measurement of treatment fidelity would be critical to understanding impact differences within the treatment group. In addition future work should unpack how much exposure to the intervention (dosage) is necessary to promote improvements in EF, VS skills, and classroom behavior.

Finally, within the context of the present study, it is not possible to determine the intervention components that map onto specific outcomes (e.g., perhaps paper and pencil activities promote VS and gross motor activities promote EF) or whether the collective components work synergistically to boost foundational skills (e.g., constructional tasks only promote foundational skills when paper and pencil and gross motor activities are offered in tandem). If the intervention can be replicated on a larger scale, perhaps subgroups could purposefully alter implementation to test which component combinations are essential.

Practical implications

Acknowledging that schools have multiple priorities and finite time, expanding learning opportunities into after-school contexts is increasingly popular, especially for children that enter school with skill gaps. Despite the potential that exists for closing skill gaps, after-school programs for under-served students have traditionally been poorly organized and lacked clear goals (Bodilly et al., 2010). In terms of scalability, the cost of operating a free high-quality after-school program is high and varies widely once food and transportation are also considered. If the infrastructure for programming exists, this curriculum can easily be implemented with after-school staff members (e.g., paraprofessionals, college students) providing both organizational structure and tangible goals. Materials involve common school supplies and commercially available (durable and reusable) games and manipulatives. After a moderate upfront investment, material replacement expenses would be negligible.

In terms of benefits, children can bolster EF and VS skills by engaging with increasingly complex and structured activities as an alternative to rote instruction or free play (two common contexts in after-school settings). EF and VS skills are foundational to a broad range of behavioral and academic outcomes and have the potential to narrow achievement skill gaps (Cameron et al., 2012; Kim et al., 2016). Indeed, EF and VS skills were raised to national averages for the treatment group in the present study (Korkman et al., 1998). Next steps can include determining whether treatment effects persist over time and whether intervention impacts translate to achievement trajectories. Following, a cost benefit analysis may assist policy makers in determining the value of investing in high-quality after-school programming to augment a broad range of skills that promote school performance and narrow skill gaps.

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Supplemental material

Supplemental material for this article is available online.

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