Learning and Individual Differences 55 (2017) 183–192

Contents lists available at ScienceDirect

Learning and Individual Differences

journal homepage: www.elsevier.com/locate/lindif

Independent and compensatory contributions of executive functions and challenge preference for students' adaptive classroom behaviors

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ARTICLE INFO

Article history:
Received 7 May 2016
Received in revised form 27 January 2017
Accepted 3 March 2017

Keywords:
Executive functions
Adaptive classroom behaviors
Challenge preference

ABSTRACT

This study examined the unique contributions and interplay of children's executive function (EF) skills and challenge preference for adaptive classroom behaviors. The sample included socioeconomically and ethnically diverse third, fourth, and fifth grade students ($N = 334$, $M = 9.30$ years). EFs were directly assessed using tablet tasks in the classroom setting, challenge preference was measured with self-report questionnaires, and teachers reported on students' classroom behaviors. Both EFs and challenge preference independently predicted students' task orientation, assertiveness, peer social skills, and frustration tolerance, whereas only EFs were linked to students' conduct problems. Further, challenge preference emerged as a significant moderator of the association between EFs and students' assertiveness. Specifically, EFs were more strongly associated with students' assertiveness among students with low challenge preference. Implications include structuring classrooms to promote challenge preference by focusing on effort and learning.

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1. Introduction

There is increasing interest in understanding how non-academic or so-called "soft" skills, such as persistence, motivation, and self-regulation, promote school success. Students' behavioral adaptation to the classroom is critical for their academic achievement. Skills such as staying focused and completing tasks independently, interacting well with peers, and participating in classroom discussions provide a foundation for positive learning experiences. A rich body of research has established the importance self-regulatory skills, known as executive function (EF) skills, for various academic outcomes and classroom behaviors (Best, Miller, & Jones, 2009; Blair & Diamond, 2008). Separately, researchers have examined how different aspects of children's intrinsic motivation contribute to academic attainment (Broussard, 2004; Lepper, Corpus, & Iyengar, 2005). For example, students who believe that intellectual abilities can be grown and improved are more likely to seek cognitive challenges and demonstrate academic resilience (Yeager & Dweck, 2012). Both EFs and motivational processes contribute to children's ability and desire to engage in the classroom context. While the effective execution of EFs in the real world is modulated by motivational processes (Somerville & Casey, 2010), the two constructs have not been studied together. Given that the greater levels of EFs and motivation have both been linked to adaptive behaviors in the classroom, it is important to know if these effects are overlapping, independent, or interactive. Bridging disparate lines of research, the present study examines the unique and interactive effects of EFs and challenge preference, an aspect of intrinsic motivation, on children's adaptive classroom behaviors implicated in school success. Using an ethnically and socio-economically diverse sample, we extend prior research on these constructs to middle childhood.

1.1. The importance of adaptive classroom behaviors for school success

Adaptive classroom behaviors, which encompass students' abilities to attend to learning goals and complete tasks, positively interact with peers, and engage in classroom activities, enable students to gain the most from their time in the classroom. Most researchers employ teacher reports of adaptive classroom behaviors using questionnaires such as the Teacher-Child Rating Scale (Hightower et al., 1986), that are designed to assess students' adjustment to and positive engagement in the classroom setting. Adaptive classroom behaviors have been associated with longitudinal growth in math and reading skills over the elementary and middle school years (DiPerna, Lei, & Reid, 2007; Li-Grining, Votruba-Drzal, Maldonado-Carreño, & Haas, 2010; Oberle, Schonert-Reichl, Hertzman, & Zumbo, 2014), even after controlling for socio-demographic measures and the home learning environment (McClelland, Morrison, & Holmes, 2000; Stipek, Newton, & Chudgar, 2010). Given their importance for school success, many researchers over the past two decades have explored family-level and school-level correlates of students' adaptive classroom behaviors (de Bruyn, Deković, & Meijnen, 2003; Ladd, Birch, & Buhs, 1999; Mashburn et al., 2008). Less is known about how malleable *individual-level* factors predict adaptive behaviors in the classroom context. It is important to

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http://dx.doi.org/10.1016/j.lindif.2017.03.002
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understand how competencies which can be improved by family-level and school-level factors are linked to positive adaptation in the classroom.

1.2. Executive functions and adaptive classroom behaviors

EFs are higher-order cognitive processes, under the broad umbrella of self-regulatory skills, that allow children to regulate their behavior, attention, and emotions (Diamond, 2013). Children's EFs have been linked to their school success via two distinct pathways (Allan, Hume, Allan, Farrington, & Lonigan, 2014; Fuhs, Nesbitt, Farran, & Dong, 2014; St Clair-Thompson & Gathercole, 2006). First, EFs are implicated in the direct acquisition of reading, mathematics, and problem-solving skills (Cartwright, 2012; Foy & Mann, 2013; Kolkman, Hoijtink, Kroesbergen, & Leseman, 2013; Kroesbergen, Van Luit, Van Lieshout, Van Loosbroek, & Van de Rijt, 2009). Second, EFs promote adaptive classroom behaviors, such as abilities to stay on task, follow rules, organize materials, control emotions, and participate in group activities (Fantuzzo, Perry, & McDermott, 2004; McClelland, Acock, & Morrison, 2006). Indeed, studies of kindergarteners revealed that higher EFs, as indexed by both teacher-ratings and direct assessments, were linked with better work habits, higher rates of self-directed learning, and decreased inattention and hyperactivity (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Neuenschwander, Röthlisberger, Cimeli, & Roebers, 2012; Ponitz, McClelland, Matthews, & Morrison, 2009; Rimm-Kaufman, Curby, Grimm, Nathanson, & Brock, 2009). Further, recent studies showed that the effect of EFs on prekindergarten children's academic achievement, social competence, and aggression have been mediated by adaptive classroom behaviors (Nesbitt, Farran, & Fuhs, 2015; Sasser, Bierman, & Heinrichs, 2015).

Children's EFs have also been linked to social skills and appropriate conduct in the classroom. At school entry, performance on EF tasks was associated with social competence and decreased behavior problems, even after controlling for children's preschool EFs (Hughes & Ensor, 2008, 2011). Early EFs are shown to predict decreased behavior problems and increased social skills in the classroom setting years later (Ciairano, Visu-Petra, & Settanni, 2007; Eisenberg et al., 1997; Riggs, Blair, & Greenberg, 2004). Recent longitudinal research from early childhood through adolescence, suggests that there are reciprocal relations between social skills and EFs (Holmes, Kim-Spoon, & Deater-Deckard, 2015). Children's EFs support positive peer interactions, and play activities with peers provide children with opportunities to practice and grow their regulatory skills (Meldrum & Hay, 2012; Stenseng, Belsky, Skalicka, & Wichstrøm, 2015).

During middle childhood, children face increased attentional and cognitive demands and are asked to manage their behaviors in the classroom and on the playground without adult scaffolding. Children are expected to be self-directed as they listen and keep track of directions, collaborate on group activities, complete work independently, and play well with other children. Thus, EFs provide a foundation for successful adaptation in the classroom setting of upper-elementary school grades. Yet, links between EFs and adaptive classroom behaviors have been largely unexamined during this developmental period. Given that EFs are malleable to environmental influences, particularly the quality of early home and school environments (Lengua et al., 2014; Weiland & Yoshikawa, 2013) and also continue to develop into early adulthood (Casey, Giedd, & Thomas, 2000; Weintraub et al., 2013), it is important to understand how EFs contribute to successful adaptation to school. Finally, while EFs support students' adaptive classroom behaviors via self-regulation, students' adaptation in the classroom also depends on their motivation to engage and persist with challenges.

1.3. Motivation, challenge preference, and adaptive classroom behaviors

A recent shift in education research has focused on the importance of non-academic "soft" skills or character traits, such as motivation, mindset, and perseverance, in predicting grades, test scores, educational attainment, and job retention (Duckworth & Gross, 2014; Duckworth, Peterson, Matthews, & Kelly, 2007; Eskreis-Winkler, Shulman, Beal, & Duckworth, 2014; Heckman & Kautz, 2012; Lepper et al., 2005). In contrast to many broad measures of non-academic skills, challenge preference captures children's inclination to choose more difficult learning opportunities over easier ones and persevere when activities become challenging. It is considered a component of intrinsic motivation in that it reflects the extent to which children are driven by curiosity, interest, and desire to master learning independently, rather than by external rewards and validation (Gillet, Vallerand, & Lafrenière, 2012; Harter, 1981; Lepper et al., 2005; Ryan & Deci, 2000).

Challenge preference has been measured directly using puzzle and persistence tasks (Day & Burns, 2011; Smiley & Dweck, 1994; D. J. Stipek & Ryan, 1997) and via self, parent, and teacher reports (Broussard, 2004; Turner & Johnson, 2003). Empirical research shows that children who are more likely to choose challenging puzzles over easier ones they had already solved, display "learning goals" rather than "performance goals" (Cain & Dweck, 1995; Smiley & Dweck, 1994). Children who hold "learning goals" are mastery-oriented and focus on the process of learning and improving, rather than achievement and social comparison. They also use better learning strategies by connecting and integrating new information with existing knowledge, that benefit academic achievement (Greene, Miller, Crowson, Duke, & Akey, 2004). In contrast, children who hold "performance goals" are concerned how they will be judged and often display patterns of helplessness in response to setbacks (Elliott & Dweck, 1988; Heyman & Dweck, 1992).

Extant research has linked a higher preference for challenge to better academic achievement (Broussard, 2004), even after controlling for prior achievement and IQ (Turner & Johnson, 2003). Although the association between challenge preference and adaptive classroom behaviors has not been studied, per se, studies employing a composite measure of intrinsic motivation, as indexed by multiple skills including persistence, curiosity, preference for challenge, and mastery-orientation, provide initial evidence that challenge preference may be linked to adaptive classroom behaviors. For example, students who are intrinsically motivated demonstrate more adaptive behaviors in the classroom, including increased engagement in schoolwork, use of learning strategies, and effort management (Appleton, Christenson, & Furlong, 2008; Pintrich & de Groot, 1990; Walker, Greene, & Mansell, 2006).

While this work gives us a broad understanding that intrinsic motivation is related to children's performance and behaviors in schools, it lacks specificity. Despite a growing interest in how non-academic skills contribute to children's school success, empirical evidence is lacking on how these distinct constructs *independently* contribute to learning and social behaviors in the classroom context. This line of research is particularly important because challenge preference is malleable to contextual factors, especially adult feedback. The framing of learning activities and the feedback children receive from teachers influences their willingness to pursue challenging options and persevere when tasks become challenging (Harter, 1978; Kamins & Dweck, 1999).

1.4. Executive functions and challenge preference: independent or interactive model?

Given the importance of both EFs and challenge preference for children's school success, we need to understand how these skills uniquely contribute to adaptive classroom behaviors. Although EFs and challenge preference are conceptually related constructs, their effects on classroom behaviors may be independent. EFs support children's ability to regulate their own attention and behavior, whereas challenge preference provides them with the motivation to engage in the classroom setting. Higher EFs may help children stay focused, wait turns, and not perseverate on a failed problem-solving strategy or a negative experience with peers. On the other hand, challenge preference may encourage children to seek out novel learning opportunities and persist when they get difficult. Therefore, both EFs and challenge preference may independently contribute to children's school success. This model is consistent with the notion that self-regulation requires an understanding of what is adaptive and expected in a situation, sufficient motivation to engage in the behavior, and the ability to accomplish the behavior in light of barriers (Baumeister & Heatherton, 1996; Hofmann, Schmeichel, & Baddeley, 2012). Theoretically, EFs and challenge preference are both necessary components of self-regulated learning as children plan, monitor, and care to execute achievement-directed behaviors (Garner, 2009; Knouse, Feldman, & Blevins, 2014; McCombs & Marzano, 1990; Zimmerman, 1990). A study by Howse, Lange, Farran, and Boyles (2003) provided initial evidence that children's motivation (including challenge preference) and attentional skills, more broadly, may uniquely contribute to achievement. They found that teacher ratings of children's motivation and ability to resist distractions independently contributed to the reading achievement of kindergarteners (Howse et al., 2003).

Alternatively, EFs and challenge preference may interact to influence children's adaptive classroom behaviors in a mutual enhancing or compensating manner. The relation between EFs and adaptive classroom behaviors may be *stronger* for children with *high* challenge preference. In this case, high levels of challenge preference would provide an additional boost to children with high EFs as they would have both ability and inclination to follow directions, stay on task, engage with peers, and cope with stressors (see panel a in Fig. 1). Alternatively, the relation between EFs and adaptive classroom behaviors may be *weaker* for children with *high* challenge preference (see panel b in Fig. 1). In this case, high challenge preference would serve as a protective factor, supporting adaptive classroom behaviors in students who have low EFs (Luthar, Cicchetti, & Becker, 2000). No empirical research has examined how the interplay of EFs and challenge preference contribute to classroom behaviors. Understanding whether their effects are independent or interactive can have implications for interventions aiming to increase challenge preference and EFs in students as way to improve school success.

1.5. Current study

This study investigates how EFs and challenge preference contribute to students' adaptive classroom behaviors. Based on previous empirical and theoretical evidence (Hofmann et al., 2012; Howse et al., 2003; Zimmerman, 1990), we hypothesize that there will be independent benefits of both EFs and challenge preference. Further, we explore whether there are interactive effects between challenge preference and EFs, such that EFs differentially affect adaptive classroom behaviors for students with high or low challenge preference. Given that the link between EFs and adaptive classroom behaviors has stronger empirical support than the link between challenge preference and adaptive classroom behaviors, we conceptualize challenge preference as a moderator of the association between EFs and adaptive classroom behaviors. However, we elaborate on this in the Discussion section.

To minimize the shared variance across these related constructs, we used a multi-method and multi-informant design. EFs were directly assessed using standard tasks and challenge preference was assessed with self-report questionnaires. Teachers reported on students' acting out, task orientation, assertiveness, peer social skills, and frustration tolerance with a survey.

2. Method

2.1. Sample and setting

Teachers were recruited from two public school districts in the San Francisco Bay Area in the academic year before data collection took place. All students in target classrooms were invited to participate through home mailings and back-to-school night presentations. The full sample included 813 students from third through fifth grade classrooms. All students participated in the EF classroom protocol and completed information on challenge preference, such that we were able to gain a representative sample of all students in participating classrooms. Our subsample of students for whom teachers reported on their adaptive classroom behaviors included 334 children (134 third-graders, 126 fourth-graders, 74 fifth-graders, 53% female). We used purposive sampling based on teachers' ratings of student EFs to ensure we had students with both low and high EFs. There were significantly more girls in our subsample of students with teacher ratings ($t(807) = -2.314$, $p = 0.021$). The samples did not differ significantly on any other study variables. The mean age of children in this subsample was 9.30 years ($SD = 0.82$, range = 7.40–11.78). Our subsample was socioeconomically and ethnically diverse; children were identified as 6% African American, 21% Caucasian or White, 34% Asian or Pacific Islander, 32% Hispanic/Latino, and 6% as multiracial or other. Thirty-seven percent of parents had a high school education or less.

2.2. Procedure

Data for this study were collected in the fall and spring of a single academic year. All procedures and materials had prior approval from the University Institutional Review Board and the procedures and subsequent data analyses were done in accordance with APA ethical standards in the treatment of human subjects. Teachers gave active consent for their involvement in the study. Parents gave passive consent for their child's participation in the classroom protocols and provided active consent for the use of demographic and school records data. All students completed EF tasks on tablet computers in the fall, at the beginning of the school year, to avoid capturing the effects of classroom experiences on EFs. Students were measured simultaneously in the classroom setting, to provide an ecologically-valid assessment of their EFs within the school context. Challenge preference was assessed in

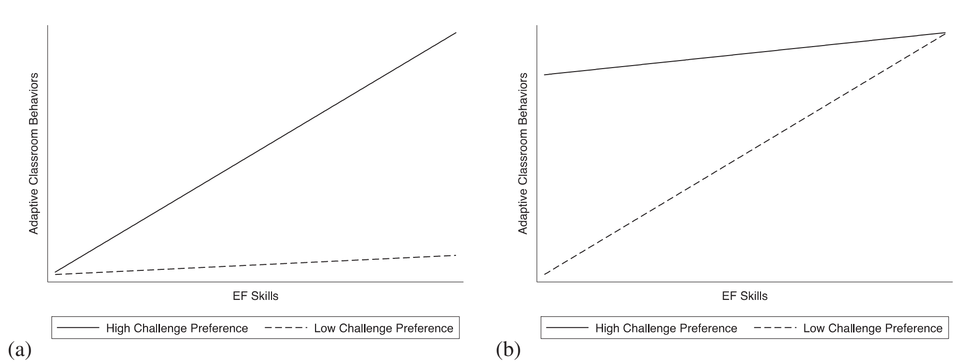

Fig. 1. Interactions between challenge preference and EF skills such that (a) the association between EF skills and adaptive classroom behaviors is stronger for children with high challenge preference and (b) the association between EF skills and adaptive classroom behaviors is weaker for children with high challenge preference.

the spring due to time constraints during the fall classroom assessment, using an in-class survey. Teachers reported on students' classroom behaviors using an online questionnaire in the spring, when teacher report is most reliable, and were compensated $95 for their participation.

2.3. Measures

Descriptive statistics for all measures and their components are provided in Table 1.

2.3.1. Executive functions

The *Digit Span Backward* (DSB) drawn from the Wechsler Intelligence Scale for Children-IV (Flanagan & Kaufman, 2009), is a common measure of working memory in middle childhood (Blankenship & Bell, 2015; Brocki & Bohlin, 2004; St Clair-Thompson & Gathercole, 2006). A series of digits were presented sequentially on the tablet screen. The student was instructed to enter those numbers backwards onto a numeric keypad after the last digit was presented. There were four practice trials, each using strings that were two digits long. These practice trials were followed by eight test trials of increasing difficulty (two trials each of length two, three, four, and five digits).

The *Multi-Source Interference Test* (MSIT) is a measure of children's inhibitory control skills in middle childhood and adolescence (Bush & Shin, 2006; Liu, Angstadt, Taylor, & Fitzgerald, 2016; Ursache, Noble, & Blair, 2015). There were two blocks: (1) 24 congruent trials and (2) 24 incongruent trials. On both blocks, students were presented with a sequence of three digits. For each trial, two of these digits (the distractors) were the same and one (the target) differed from the distractors (e.g., "2 2 1"). Students were instructed to press a button whose numeric value corresponded to the numeric value of the target. For example, the correct response to the sequence "2 2 1" would be "1." For the congruent trials, the distractors were always zeroes and the position of the target always corresponded to the numeric value of the correct button press (i.e., "1 0 0", "0 2 0", "0 0 3"). For the incongruent trials, the distractors were non-zero and the numeric value of correct button press was always *different* from the position of the correct response (e.g., "2 3 3", "2 2 1", "1 3 1").

The *Flanker* task is a widely-used measure of students' inhibitory control and cognitive flexibility skills (Diamond, Barnett, Thomas, & Munro, 2007; Karbach & Unger, 2014; Zelazo et al., 2013). There were three blocks: (1) 17 blue fish trials, (2) 17 pink fish trials, and (3) 45 mixed blue and pink fish trials. Students were asked to focus on a given stimulus while inhibiting attention to stimuli flanking it. They were shown a row of fish on a screen and told to press the right or left arrow, depending on the direction the target fish is facing. In the first blue fish block, the target is in the middle fish, whereas in the second pink fish block the target fish are the flanking outside fish. In the third block, pink and blue fish were mixed. During congruent trials, all fish face the same direction, whereas during incongruent trials the middle and outside fish do not face the same direction.

The *Hearts and Flowers* (HF) is a common measure of inhibitory control and cognitive flexibility skills used in elementary school students (Davidson, Amso, Anderson, & Diamond, 2006; Oberle & Schonert-Reichl, 2013; Roy, McCoy, & Raver, 2014; Yeniad, Malda, van IJzendoorn, Emmen, & Prevoo, 2014). There were three blocks: (1) 12 congruent heart trials, (2) 12 incongruent flower trials, and (3) 33 mixed heart and flower trials. Students were presented with an image of a red heart or red flower on one side of the screen. During congruent heart trials, students press the button on the same side as the presented stimuli (i.e., heart). During incongruent flower trials, students were instructed to press the button on the opposite side of the stimuli (i.e., flower).

We used confirmatory factor analysis (CFA) to inform our data reduction approach for the EF accuracy scores. Mplus 7.3 (Muthén & Muthén, 2014) was used to estimate these models. We started with six indicator variables: (1) DSB (working memory, $\alpha = 0.79$); (2) MSIT incongruent block (inhibitory control, $\alpha = 0.94$); (3) HF incongruent block (inhibitory control, $\alpha = 0.87$); (4) HF mixed block (cognitive flexibility, $\alpha = 0.91$); (5) Flanker blue and pink incongruent blocks (inhibitory control, $\alpha = 0.88$); and (6) Flanker mixed block (cognitive flexibility, $\alpha = 0.88$). Above, we report a version of alpha based on tetrachoric correlations, because prior research indicates that Cronbach's alpha systematically underestimates the reliability when estimated on scales with binary response variables (Raykov, Dimitrov, & Asparouhov, 2010). To account for similarity between different blocks for each task, we estimated a one-factor model in which we correlated the residual variances for the two HF blocks and for the two Flanker blocks. Model fit was acceptable for the fall assessment, $\chi^2(\text{df} = 7) = 26.529$, $p < 0.001$, RMSEA $= 0.062$, CFI $= 0.964$, SRMR $= 0.033$. We also estimated a two-factor model with an inhibitory control factor (observed variables: HF incongruent block, MSIT incongruent block, and Flanker blue and pink incongruent blocks) and a working memory/cognitive flexibility factor (observed variables: DSB, HF mixed block, and Flanker mixed block). The fit of this model was acceptable, $\chi^2(\text{df} = 7) = 26.951$, $p < 0.001$, RMSEA $= 0.063$, CFI $= 0.963$, SRMR $= 0.033$. However, this two-factor model did not fit significantly better than the more parsimonious one-factor model, $\chi^2(\text{df} = 1) = 0.104$, $p = 0.747$. Furthermore, the inhibitory control and working memory/cognitive flexibility factors were highly correlated ($r = 0.98$), indicating that the two latent factors were not distinctive. A single factor structure is consistent with other research demonstrating that children's EFs are undifferentiated into the independent components of inhibitory control, working memory, and cognitive flexibility between the ages of 8 and 10 (Brydges, Reid, Fox, & Anderson, 2012; Shing, Lindenberger, Diamond, Li, & Davidson, 2010; Xu et al., 2013).

Based on these CFA results, we standardized and averaged the HF incongruent and mixed blocks and we standardized and averaged the Flanker incongruent and mixed blocks to create a single score for each of these tasks. We then standardized the scores from each of the four tasks to create a single composite score ($\alpha = 0.62$). This composite measure is weighted most heavily toward inhibitory control skills, though it represents all three EF components. We have chosen to use accuracy scores, instead of reaction time scores, predominantly because our working memory measure is untimed, and thus, does not include a measure of reaction time. We wanted the EF composite to reflect all three EF components.

2.3.2. Challenge preference

Students reported on their challenge preference using a 5-question survey (Developmental Studies Center, 2013). Each question asked

Table 1
Descriptive statistics for analytic variables and composite components.

Variable	Valid *N*	Mean	(*SD*)/%	Range
Challenge preference	288	3.67	(1.48)	0–5
EF Composite	311	0.03	(0.67)	−2.33–1.50
DSB accuracy	294	0.45	(0.19)	0–1
MSIT incongruent accuracy	309	0.84	(0.18)	0.08–1
Flanker incongruent accuracy	308	0.83	(0.18)	0.08–1
Flanker mixed accuracy	305	0.72	(0.12)	0.24–0.96
HF incongruent accuracy	302	0.86	(0.15)	0.33–1
HF mixed accuracy	282	0.48	(0.19)	0.06–0.97
Classroom Behaviors				
Acting out	334	1.88	(0.94)	1–4.83
Task orientation	334	3.63	(1.12)	1–5
Assertiveness	334	3.29	(0.93)	1.20–5
Peer social skills	334	3.88	(0.94)	1–5
Frustration tolerance	334	3.54	(0.96)	1–5
Covariates				
Age	336	9.30	(0.82)	7.40–11.78
Female	335		52.54%	0–1
Ethnic minority	317		78.55%	0–1

Note. EF = executive function, DSB = Digit Span Backwards, MSIT = Multi-Source Interference Test, HF = Hearts and Flowers.

students to choose between an easy or more challenging scenario (e.g. "I like a puzzle… that takes hard work to solve or that is easy to solve") and was coded as a binary variable (0 = easy, 1 = challenging). The final score is the sum across the 5 items ($\alpha = 0.71$), and scores were set to missing for the three students who were unable to complete the survey to get a more reliable measure of their challenge preference.

2.3.3. Children's adaptive classroom behaviors

Teachers reported on students' classroom behaviors using the Teacher-Child Rating Scale (TCRS; Hightower et al., 1986). Each item is rated on a five-point scale, ranging from 1 = "not at all" to 5 = "very well". Five behavior subscales were created by averaging the ratings on individual items: *acting out* (defiant, disruptive, fidgety, $\alpha = 0.89$, 6 items), *task orientation* (well-organized, completes work, works well without adult support, $\alpha = 0.91$, 5 items), *assertiveness* (leader, participates in class discussions, defends own view, $\alpha = 0.80$, 5 items), *peer social skills* (makes friends easily, friendly toward peers, $\alpha = 0.91$, 5 items), and *frustration tolerance* (accepts things not going his/her way, copes well with failure, $\alpha = 0.88$, 5 items).

2.3.4. Covariates

Child age in years, child sex (1 = female), and child ethnic minority status (1 = ethnic minority) were included as covariates.

2.4. Analytic plan

Hierarchical linear modeling (HLM) in Stata version 13 (StataCorp, 2013) was used to assess the main and interactive effects of EFs and challenge preference on five classroom behavior domains. To adjust the parameter estimates and standard errors for the clustering of children within schools and classrooms, all models included random intercepts for classrooms and fixed effects for schools (Rabe-Hesketh & Skrondal, 2012). For each domain, a stepwise HLM model was conducted to explore the unique contributions and interplay of EFs and challenge preference on students' classroom behaviors. After each step, we tested whether the additional parameter added to the model contributed significantly to the variance explained (using *mi test*); *F*-statistics are reported. Model 0 included only associations between covariates and students' classroom behaviors. Models 1 and 2 added EFs and challenge preference, respectively. Model 3 added an interaction term between challenge preference and EFs to examine whether challenge preference moderated the effects of EFs on students' classroom behaviors. Significant interactions between EFs and challenge preference were probed by calculating and plotting simple slopes at ±1 *SD* from the mean of children's EFs. We controlled for children's age, gender, and ethnic minority status. The percentage of missing data was small, ranging from 0.00% to 7.19%, except for the challenge preference measure (13.73%) where most cases were due to students' absence on the day of the spring classroom protocol. Other reasons for missing data included students leaving the classroom or school and students incompletion of the full classroom protocol. Missing data (see Table 1 for valid *N*) was addressed by estimating 20 datasets using multiple imputation with chained equations (MI).

3. Results

3.1. Bivariate correlations

Bivariate correlations among all variables are presented in Table 2. Students' challenge preference and EFs were modestly correlated. This association was primarily driven by the significant association between the blue and pink incongruent block on the Flanker task and challenge preference, as the other blocks in the EF composite were not significantly correlated with challenge preference. EFs were negatively correlated with acting out and both EFs and challenge preference were positively correlated with task orientation, assertiveness, peer social skills, and frustration tolerance. Most measures of children's adaptive classroom behaviors were correlated in the expected directions. Acting out and assertiveness were not significantly correlated. Girls had significantly lower rates of acting out, and higher levels of task-orientation, assertiveness, and frustration tolerance, compared to boys. Older children demonstrated higher levels of EFs and lower levels of peer social skills. Ethnic minority students had lower levels of challenge preference, EFs, and assertiveness, compared to white students.

3.2. Multilevel stepwise regression analyses

Results of regression analyses are reported in Table 3. As shown in Model 1, students' EFs significantly predicted all five domains of adaptive classroom behaviors. Higher levels of EFs were associated with lower levels of acting out ($\beta = -0.29$, $p < 0.001$) and higher levels of task orientation ($\beta = 0.51$, $p < 0.001$), assertiveness ($\beta = 0.44$, $p < 0.001$), peer social skills ($\beta = 0.41$, $p < 0.001$), and frustration tolerance ($\beta = 0.34$, $p < 0.001$). Model 2 shows that students' challenge preference independently predicted four domains of classroom behaviors, controlling for EFs. Higher levels of challenge preference were associated with higher levels of task orientation ($\beta = 0.18$, $p < 0.001$), assertiveness ($\beta = 0.16$, $p = 0.003$), peer social skills ($\beta = 0.21$, $p < 0.001$), and

Table 2
Zero-order correlations between predictor variables, outcome variables, and covariates.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Chal pref	–														
2. EFs	.14*	–													
3. DSB	.08	.74***	–												
4. MSIT inc	−.01	.66***	.33***	–											
5. FL inc	.27***	.58***	.31***	.28***	–										
6. FL mixed	.08	.58***	.30***	.22***	.29***	–									
7. HF inc	.12+	.58***	.28***	.19***	.22***	.23***	–								
8. HF mixed	.01	.60***	.30***	.20***	.23***	.27***	.48***	–							
9. Acting out	−.06	−.22***	−.22***	−.15**	−.17**	−.07	−.08	−.07	–						
10. Task or	.20***	.40***	.32***	.29***	.35***	.15**	.22***	.15*	−.66***	–					
11. Assert	.16**	.34***	.19***	.26***	.32***	.21***	.19***	.07	−.03	.41***	–				
12. Peer SS	.17**	.28***	.17**	.18**	.26***	.17**	.16**	.11	−.52***	.59***	.39***	–			
13. Frust tol	.12*	.29***	.27***	.20****	.22***	.12*	.13*	.12*	−.73***	.65***	.13*	.67***	–		
14. Age	.09	.38***	.35***	.20***	.27***	.16**	.23***	.22***	−.06	.05	−.01	−.12*	.05	–	
15. Female	−.11+	−.13*	−.02	.05	−.05	−.16**	−.16**	−.28***	−.26***	.30***	.13*	.10	.21***	−.09	–
16. Minority	−.15*	−.18**	−.12*	−.12*	−.12*	−.19***	−.06	−.05	−.10	.05	−.13*	.01	.08	−.13*	.04

Note. EF = executive function, DSB = Digit Span Backwards, MSIT = Multi-Source Interference Test, HF = Hearts and Flowers.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 3
Stepwise multi-level regression analyses predicting children's classroom behaviors from challenge preference and EFs.

	Acting Out	Task Orientation	Assertiveness	Peer Social Skills	Frustration Tolerance
Model 0					
Child age	−0.04 (0.07)	0.06 (0.06)	0.02 (0.06)	−0.07 (0.07)	0.08 (0.07)
Female child	−0.50 (0.09)***	0.60 (0.10)***	0.27 (0.11)*	0.17 (0.11)	0.41 (0.10)***
Minority child	−0.30 (0.15)*	0.24 (0.15)	−0.36 (0.16)*	−0.12 (0.16)	0.18 (0.15)
Model 1					
Child age	0.04 (0.07)	−0.12 (0.06)*	−0.17 (0.06)**	−0.21 (0.07)**	−0.04 (0.07)
Female child	−0.48 (0.09)***	0.63 (0.09)***	0.31 (0.10)**	0.18 (0.10)	0.43 (0.10)***
Minority child	−0.42 (0.15)**	0.31 (0.14)*	−0.28 (0.15)	−0.03 (0.16)	0.30 (0.16)
EFs	−0.29 (0.05)***	0.51 (0.05)***	0.44 (0.06)***	0.41 (0.06)***	0.34 (0.06)***
	F=28.62***	F=93.88***	F=59.00***	F=49.24***	F=36.42***
Model 2					
Child age	0.04 (0.07)	−0.11 (0.06)*	−0.17 (0.06)**	−0.21 (0.07)**	−0.04 (0.07)
Female child	−0.50 (0.10)***	0.67 (0.09)***	0.34 (0.10)***	0.22 (0.10)*	0.46 (0.10)***
Minority child	−0.43 (0.15)**	0.33 (0.14)*	−0.26 (0.15)	−0.00 (0.16)	0.32 (0.16)*
EFs	−0.28 (0.05)***	0.50 (0.05)***	0.43 (0.06)***	0.39 (0.06)***	0.33 (0.06)***
Chal pref	−0.06 (0.05)	0.18 (0.05)***	0.16 (0.06)**	0.2 (0.06)***	0.15 (0.06)**
	F=1.30	F=13.29***	F=8.79**	F=14.91***	F=7.62**
Model 3					
Child age	0.04 (0.07)	−0.12 (0.06)*	−0.18 (0.06)**	−0.21 (0.07)**	−0.03 (0.07)
Female child	−0.50 (0.10)***	0.67 (0.09)***	0.35 (0.10)***	0.23 (0.10)*	0.46 (0.10)***
Minority child	−0.43 (0.15)**	0.33 (0.14)*	−0.26 (0.15)	−0.00 (0.16)	0.32 (0.16)*
EFs	−0.28 (0.05)***	0.49 (0.05)***	0.41 (0.06)***	0.38 (0.06)***	0.33 (0.06)***
Chal pref	−0.06 (0.05)	0.18 (0.05)***	0.15 (0.06)**	0.21 (0.06)***	0.16 (0.06)**
CP x EFs	−0.01 (0.05)	−0.07 (0.05)	−0.11 (0.05)*	−0.07 (0.05)	0.03 (0.05)
	F=0.02	F=1.99	F=4.80*	F=1.80	F=0.38

Note. EFs = executive functions, Chal pref = challenge preference.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

frustration tolerance ($\beta = 0.15$, $p = 0.006$). Associations between EFs and students' classroom behaviors remained significant. In Model 3, a significant interaction between students' EFs and challenge preference emerged for assertiveness ($\beta = -0.111$, $p = 0.029$). EFs were more strongly associated with assertiveness for students with low challenge preference ($\beta = 0.55$, $p < 0.001$), compared to their peers with high challenge preference ($\beta = 0.27$, $p = 0.001$). Challenge preference served as a protective factor for students with low EFs, in that it buffered against the negative effects of low EFs on classroom behaviors (see Fig. 2). While significant interactive effects qualify the interpretation of the main effects for assertiveness, significant additive effects of challenge preference and EFs remained for three domains: task orientation, peer social skills, and frustration tolerance.

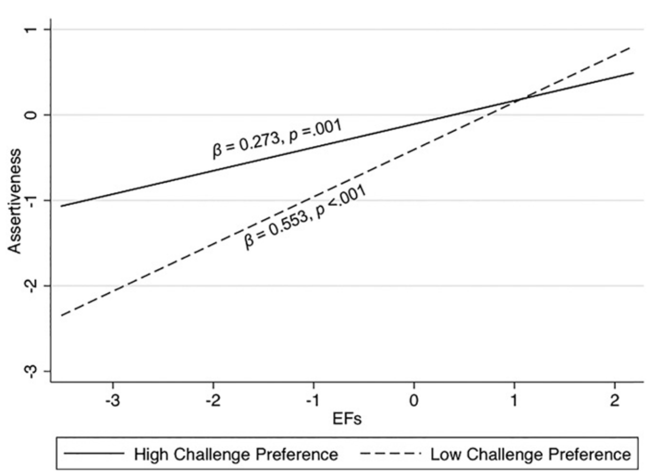

Fig. 2. Interactions between challenge preference and executive functions in association with assertiveness. Simple slopes represent +1 *SD* (high) and −1 *SD* (low) fall challenge preference.

4. Discussion

This study elucidates how two specific non-academic skills relate to children's school success in middle childhood (Dweck, 2008; Tough, 2013). Since combining measures of various non-academic skills obscures our understanding of how specific skills promote adaptive classroom behaviors (Cerasoli, Nicklin, & Ford, 2014; Duckworth et al., 2007; Eskreis-Winkler et al., 2014), the current study was designed to identify the independent effects of students' EFs and challenge preference. The findings revealed that both EFs and challenge preference uniquely contribute to positive classroom behaviors. Further, high challenge preference protected against the effect of low EFs on assertiveness in the classroom.

Our findings highlight the continued importance of EFs for children's adaptive classroom behaviors in middle childhood. First, children's EFs were associated with less aggressive, defiant, and disruptive classroom behaviors, a finding which is supported by a large body of literature demonstrating a negative association between EFs and externalizing behavior problems throughout elementary and middle school (Eisenberg et al., 2005; Hughes & Ensor, 2011; Riggs et al., 2004). Second, our results show the importance of EFs for staying on task and tolerating frustration in middle childhood. These findings extend work that links higher EFs with persistence and engagement in kindergarteners (Brock et al., 2009; Neuenschwander et al., 2012; Rimm-Kaufman et al., 2009). Third, higher EFs were also associated with positive peer relationships, leadership skills, and willingness to participate in classroom discussions. This is consistent with previous work which shows that growth in EFs across the transition to elementary school is linked to decreased behavior problems and that EFs predict higher levels of cooperative behaviors and lower levels of non-cooperative behaviors with peers in elementary school students (Ciairano et al., 2007; Hughes & Ensor, 2011). Future studies should continue to explore how EFs may promote adaptive behaviors within the classroom setting, particularly as schools begin to test students' non-academic skills, such as EFs and more general measures of self-regulation, as part of new accountability systems (Darling-Hammond et al., 2016).

Further, our study extends the current literature by demonstrating the unique contribution of challenge preference for adaptive classroom behavior, over and above the effect of EFs. Significant links between challenge preference and task orientation, peer social skills, and frustration tolerance extend research linking broader measures of intrinsic motivation, which include challenge preference, to positive academic behaviors such as study habits, goal setting, and engagement in adolescents (Greene et al., 2004; Pintrich & de Groot, 1990; Walker et al., 2006). These independent effects are notable, providing support for the hypothesis that both EFs and intrinsic motivation are needed for students to regulate the behaviors and emotions needed to focus during class and complete work independently, work well with peers and make friends, and cope well with failures. In addition, significant interactive effects revealed that high challenge preference may buffer against the effect of low EFs on students' assertiveness and leadership skills in the classroom context. Among students with low EFs, those who reported a higher likelihood for choosing more challenging scenarios were more likely to defend their opinions and take on leadership roles than their peers with low challenge preference. Students with high EFs demonstrated high levels of assertiveness, regardless of their level of challenge preference.

Given the importance of EFs and challenge preference for academic and social success, finding levers that can promote these skills is critical. Although children's tendencies to avoid or seek challenges are influenced by track record of failures and successes, contextual factors also matter (Hokoda & Fincham, 1995; Wigfield, Eccles, & Rodriguez, 1998). For example, an emphasis on grades and evaluation decreases children's willingness to pursue challenging options (Boggiano, Main, & Katz, 1988; Harter, 1978). Harter (1978) found that sixth-graders who were told they would receive a grade for their performance on a puzzle task, chose significantly less challenging puzzles than those who were told that puzzles were just a game. Similarly, fifth-graders were more likely to choose a difficult puzzle if they were told the goal of the task was "to learn" compared to a group of students who were told the task would "demonstrate their skills" (Elliott & Dweck, 1988).

Further, teachers who praise or criticize students, rather than students' effort or outcomes, may inadvertently encourage students to "play it safe" in order to preserve their sense of self-esteem (Mueller & Dweck, 1998). Kamins and Dweck (1999) conducted an experiment to examine how feedback influences children's persistence in a building task. They found that kindergarteners in the person-criticism group ("I ′m very disappointed in you") exhibited significantly lower persistence than both outcome-criticism group ("That's not the right way to do it") and process-criticism group ("The blocks are crooked, maybe you could think of another way to do it"). In a follow-up experiment, they found that children in the process-praise group ("You must have tried really hard") exhibited significantly more persistence than did children in the person-praise group ("I′m very proud of you"). Thus, praising students' effort, rather than their ability, promoted higher levels of challenge preference. Theoretical work also suggests that the use of encouragement, instead of praise, may convey teacher respect and belief in students' abilities while fostering students' responsibility for their behavior (Larrivee, 2002). Separately, students' inclination to choose challenges and persist through tasks may be increased through short interventions. An educational computer game enhanced with "brain points," a system which incentivizes effort and the use of strategy and incremental progress, have been shown to improve students' persistence (O'Rourke, Haimovitz, Ballweber, Dweck, & Popović, 2014). Although the intervention was very short (3 min on average), students in the experimental condition continued with the game for more levels, even after struggling with a challenging level.

While both EFs and challenge preference are shaped by environmental influences, we chose challenge preference as a moderator in this study because the association between EFs and adaptive classroom behaviors is more established than the association between challenge preference and adaptive classroom behaviors. However, EFs are also malleable to environmental contexts and could have been chosen as the moderator. Mindfulness interventions in elementary school classrooms have shown significant effects on EFs (Schonert-Reichl et al., 2015) and teacher-rated self-control and attention in the classroom (Black & Fernando, 2014). This work provides evidence that mindfulness training can be effectively built into normal elementary school curricula to produce meaningful effects on children's EFs. Further, research from early childhood suggests that the quality of classroom contexts contribute to EF development. In particular, classroom management and routines have been linked to positive EF development for preschoolers (Hamre, Hatfield, Pianta, & Jamil, 2014; Rimm-Kaufman et al., 2009). More work is needed to understand how the school context can promote positive EF development in middle childhood, but work with younger students suggests that teachers may play a critical role in the development of EFs.

4.1. Limitations

This study has several limitations. First, our study could be strengthened by directly assessing children's persistence and challenge preference. While student-report of challenge preference allowed us to assess all students across many classrooms in a way that minimizes the amount of instructional time missed, direct assessment of persistence and challenge preference via puzzle tasks may be preferable in smaller-scale studies. We hope that researchers will design new direct assessments of challenge preference that can be scaled-up to larger, school-based studies, possibly using a similar tablet-based platform as our EF tasks. Second, future studies should also examine other aspects of intrinsic motivation, such as independent mastery (i.e. child prefers to work and figure out problems on her own) and curiosity and interest (i.e. child completes work to satisfy own interest and curiosity instead of to satisfy teacher) as described in Harter's (1981) seminal paper defining the different components of intrinsic motivation. Third, our measure of EFs is composed mostly of measures of inhibitory control skills. As more researchers focus on the middle childhood period, we hope that they will explore domain specificity between specific EF components and children's adaptive classroom behaviors.

Fourth, repeated measurements would enable examination of bidirectional influences between EFs, motivation, and children's behaviors over time. While EFs and intrinsic motivation are important for students' adaptive classroom behaviors and subsequent achievement, their experiences within the classroom and perceptions of their academic competence likely influence students' growth in EFs and motivation in subsequent years. Fifth, the analyses are correlational and do not provide causal evidence. Despite the use of several important control variables, the possibility of selection bias and omitted variable bias cannot be eliminated. Sixth, our measure of challenge preference was collected in the spring, and could have been influenced by students' classroom experiences during the school year. In future studies, we advise that researchers collect measures of challenge preference at the beginning of the year to minimize the effects of classroom experience on students' reported challenge preference. Finally, we hope that researchers will expand this work to include measures of academic achievement. It will be important to both explore whether challenge preference and EFs are directly linked to academic achievement in an additive manner, and whether these associations are mediated by adaptive classroom behaviors.

4.2. Conclusion

In conclusion, this study provides initial evidence that challenge preference and EFs have independent effects on students' adaptive classroom behaviors in middle childhood. Further, challenge preference emerged as a significant moderator of the association between EFs and children's assertiveness. The relation between EFs and these classroom behaviors was stronger for students with low challenge preference, suggesting that high challenge preference may buffer students against the negative effects of low EFs. Our findings suggest that educators should focus on creating contexts which promote challenge preference, particularly for children with poor EFs. Experimental work shows that teachers could promote greater preference for challenge by reframing classroom activities as opportunities to learn and grow rather than emphasizing grades and performance goals (Elliott & Dweck, 1988; Kamins & Dweck, 1999; O'Rourke et al., 2014).

Acknowledgements

This research was supported by a Scholar's award from the William T. Grant Foundation (180826) to Jelena Obradović. The preparation of this manuscript is also supported by a William R. and Sara Hart Kimball Stanford Graduate Fellowship and the Institute of Education Sciences (IES), U.S. Department of Education, Grant R305B090016 to the Board of Trustees of the Leland Stanford Junior University, to Jenna Finch. The authors thank the children, teachers, and schools who participated and made this research possible, and many graduate and undergraduate students who helped collect and process the data. The findings, conclusions, and opinions here are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

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