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Teacher Stress Predicts Child Executive Function: Moderation by School Poverty

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ABSTRACT

Research Findings: Recent research has explored relations between classroom quality and child executive function (EF), but little is known about how teachers' well-being, including stress, relates to child EF—a crucial component of self-regulation. We hypothesized that teacher stress is negatively or curvilinearly related to child EF and classroom quality may be one mechanism explaining this relation. Furthermore, as working with young, low-income children may be particularly stressful, we tested the extent to which the relation between teacher stress and child EF varies by school-level poverty. Two-level hierarchical linear models using a sample of 171 kindergarten children and 33 teachers revealed a marginally significant linear relation between teacher stress and child EF (spring) controlling for baseline child EF (fall); there was no evidence for mediation by classroom quality. School-level poverty moderated the relation between teacher stress and child EF: Children attending low-poverty schools demonstrated smaller gains in EF when their teachers reported higher stress levels. However, in high-poverty schools high levels of teacher stress were not a risk factor for child EF. *Practice or Policy*: These novel findings are a first step to understanding how teachers' well-being relates to child EF across schools and have implications for supporting teachers.

Surprisingly little is known about how teacher stress relates to young children's developmental outcomes, including self-regulatory abilities. Although it is well known that the transition to school is a significant event that is associated with new challenges for children's self-regulatory abilities (Blair, 2002; Rimm-Kaufman, Pianta, & Cox, 2000), there is an additional need to identify classroom and school experiences that challenge children's self-regulation and ultimately may play a crucial role in shaping children's self-regulation. In particular, executive function (EF)—a set of cognitive processes integral to emerging self-regulatory behavior and the development of social, cognitive, and academic competence in young children (Blair, 2002; Bridgett, Burt, Edwards, & Deater-Deckard, 2015)—has been shown to be malleable based on specific experiences both at home and at school (for reviews, see Diamond & Lee, 2011; Hughes, 2011). Recently research has shed some light on the role that classroom quality plays in shaping children's EF (e.g., Rimm-Kaufman, Curby, Grimm, Nathanson, & Brock, 2009). Little is known, however, about how teachers' social and emotional competence and well-being, which may include stress (Jennings & Greenberg, 2009), relates to child EF. Teachers who experience high levels of job-related stress may be at risk for problems regulating their own emotions, attention, and rising stress reactivity, all of which may interfere with building supportive and effective relationships and interactions with children, leading in turn to poorer classroom quality (Raver, Blair, & Li-Grining, 2012). Stress at moderate levels, however, is also known to enhance performance and might have beneficial effects on teachers'

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abilities (Yerkes & Dodson, 1908). Given the high prevalence of teacher stress, especially among early childhood educators serving low-income children (Li-Grining et al., 2010; Whitaker, Becker, Herman, & Gooze, 2013), the present study aims to examine how teacher stress relates to kindergarten children's EF abilities. We ask the question of whether the relation between teacher stress and child EF (assessed with traditional behavioral tasks) varies by school-level poverty and whether classroom quality (measured with the Classroom Assessment Scoring System [CLASS]; Pianta, La Paro, & Hamre, 2007) serves as a mechanism of this relation. We test our hypotheses using a sample of 5-year-old children attending kindergarten in suburban regions in the northeastern United States.

EF and Self-Regulation

EF represents a complex and interrelated set of higher order cognitive processes, including the maintenance and manipulation of relevant information (updating), inhibition of predominant responses (inhibition), and mental set shifting (shifting; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). It is one key component of self-regulation (i.e., flexible regulation of cognition, emotion, and behavior; Blair, 2002; Bridgett et al., 2015). The development of self-regulation and EF is central to a child's emerging ability to adaptively respond to the academic and social demands of his or her preschool and early elementary classrooms (Calkins & Howse, 2004; Calkins & Williford, 2009).

Bridgett and colleagues (2015) have recently described a taxonomy for understanding self-regulation that includes both top-down and bottom-up regulatory processes. In their framework two distinct but related top-down self-regulatory processes (i.e., behavioral [including EF] and emotional self-regulation) are modulated by neural structures within the frontal lobes and the anterior cingulate cortex. In addition, two bottom-up or reactive self-regulatory processes (i.e., behavioral inhibition/fear as overcontrolled and impulsivity as undercontrolled type of self-regulation) are served by subcortical structures.

Both bottom-up and top-down self-regulatory processes emerge as early as in the first year of life. Relative to the more rapidly maturing bottom-up processes, top-down self-regulatory processes undergo a protracted period of development, with EF following a particularly protracted timetable to maturation. Rapid development of EF occurs between birth and 5–8 years of age, but EF does not fully develop until adulthood (Diamond, 2002). Across development, there is a complex, shifting interplay between bottom-up and top-down self-regulatory processes (Bridgett et al., 2015), suggesting multiple pathways in which self-regulation in general and EF in particular may be influenced by environmental factors such as teacher stress.

Although EF can play a top-down role in behavior regulation, EF is also dependent on reactivity and regulation in lower order, more automatic emotion, attention, and stress response systems (Blair & Dennis, 2010; Blair & Ursache, 2011). That is, in contexts that lead to particularly high levels of emotion and/or stress arousal, EF is impaired, but moderate levels of stress can facilitate EF (e.g., Arnsten, 2009; Lupien, Maheu, Tu, Fiocco, & Schramek, 2007). This specific association reflects to some extent the fact that stress hormone levels (e.g., cortisol) modulate synaptic activity in the neural circuitry of the prefrontal cortex. In the present study, we therefore test a curvilinear relationship between children's EF and teacher stress.

Prosocial Classroom Model

The prosocial classroom model proposed by Jennings and Greenberg (2009) offers theoretical and empirical insights into ways in which teachers' own social and emotional competence and well-being, which may include stress, matter for classroom quality and students' socioemotional and academic outcomes. Teachers who lack strong socioemotional skills may be less competent at managing emotions in challenging situations. They may also be less effective at managing their classrooms, which in turn creates a lower quality classroom climate, which can precipitate additional challenging situations for teachers. This cycle can lead teachers to experience emotional exhaustion, provoking a burnout cascade (Montgomery & Rupp, 2005). It is important to note that in the prosocial classroom model, teachers' characteristics and students' outcomes are bidirectionally related through their influence on classroom quality. Although recent studies have linked teacher stress with classroom quality (Friedman-Krauss, Raver, Morris, & Jones, 2014; Li-Grining et al., 2010) and with teacher–student relationships (Whitaker, Dearth-Wesley, & Gooze, 2015; Yoon, 2002), to date only very few studies have looked at the relations between teacher well-being and students' outcomes (for exceptions, see Mashburn, Hamre, Downer, & Pianta, 2006; McLean & Connor, 2015), and none have focused on children's EF. Therefore, Jennings and Greenberg argued that increased attention should be paid to the examination of how teachers' own social and emotional competence and well-being relate to child outcomes, preferably with longitudinal data. In the present study, we heed their call and examine the associations of teachers' perceptions of their own job-related stress and children's EF between the fall and spring of the kindergarten year while also considering the role of teachers' abilities to provide emotionally supporting and effective classroom management.

Teacher Stress

Stress can be defined as the sense that environmental events tax or exceed a person's resources (Lazarus, 1991). The most widely studied model of workplace stress is the demand–control–support model, which describes how high workplace demands, low control, and/or low support raises the risk of negative psychological and physical outcomes that may lead to poor work functioning (Karasek et al., 1998). Teaching has been ranked among the most stressful of occupations, and the emotional involvement of teachers with their students is considered the primary cause of teachers' high levels of stress (Johnson et al., 2005). In their meta-analysis Montgomery and Rupp (2005) showed that characteristics of the environment such as teachers' grade level, their average class size, or the type of school in which they are teaching show a small but consistent association with intraindividual processes of dealing with stressful events (i.e., coping, emotional response, burnout). Working with young, low-income children may be particularly stressful, as these children are at risk for behavioral and academic difficulties and have less access to mental health supports and services (Curbow, Spratt, Ungaretti, McDonnell, & Breckler, 2000; Guin, 2004; Li-Grining et al., 2010; MetLife, 2012). According to a 2012 MetLife survey, elementary school teachers were found to be more likely than middle or high school teachers to report high stress (59% vs. 44% vs. 42%, respectively). Moreover, teachers at schools where the budget had decreased within the past year were more likely to experience higher levels of stress on the job. A recent study (Whitaker et al., 2013) compared the prevalence of health indicators in a sample of Head Start and Early Head Start staff (i.e., teachers of low-income, at-risk children) to the prevalence of health indicators in two national samples of adults with similar sociodemographic characteristics. They found poorer physical and mental health (especially high levels of depression) among the Head Start teachers compared to the other adults. Building on this evidence and the fact that schools serving low-income children may often be in disadvantaged neighborhoods with fewer resources available to teachers (Evans, 2004; Yoshikawa & Knitzer, 1997), the present study examines whether school-level poverty moderates the relation between teacher stress and child EF.

Raver et al. (2012) provided a theoretical framework for why teachers experiencing job-related stress are at risk for problems with their own self-regulation that may interfere with maintaining high-quality classrooms. Specifically, teachers who are experiencing high levels of negative emotional arousal may have a more difficult time focusing their attention on multiple details of their classroom, including the activity and behavior of the children. Classrooms may become more chaotic as teachers who are caught in cycles of negative interaction with one or two children may be less able to effectively scan, monitor, and support the behavior and learning of the larger group of less disruptive children.

However, the Yerkes–Dodson principle, a key axiom in cognitive neuroscience, states that stress affects performance on cognitively demanding tasks in ways that represent an inverted U-shaped curve. Therefore, teacher cognition, attention, and motivation to teach might be most easily recruited during periods of moderate stress but may be depleted under conditions of high stress (Blair & Ursache, 2011; Yerkes & Dodson, 1908). That is, teachers may be most engaged when under moderately challenging conditions because experiencing moderate stress acts as a motivating force (Hebb, 1955). In contrast, when classrooms become too chaotic and work environments are too stressful, teachers may be less able to engage in positive teacher–child relationships and maintain a positive classroom climate. A recent study indeed found that teacher stress was curvilinearly related to classroom emotional climate, with moderate levels of teacher stress being associated with the most positive climate (Friedman-Krauss, Raver, Morris, et al., 2014). The question remains, however, whether this curvilinear relationship with teacher stress is also found for child outcomes, a question that is examined in the present study.

Teacher Stress and Child Outcomes

Although previous research on teacher stress has focused on predictors of teacher stress (Kyriacou, 2001; Spilt, Koomen, & Thijs, 2011), interventions to reduce teacher stress (Roeser et al., 2013), and recently relations between teacher stress and teacher–child relationships and classroom quality (Brown, Jones, LaRusso, & Aber, 2010; Friedman-Krauss, Raver, Morris, et al., 2014; Li-Grining et al., 2010; Whitaker et al., 2015), very little research has examined how teacher stress affects students' well-being and learning outcomes. To the best of our knowledge only three studies have examined the effects of teacher stress on students' socioemotional and motivational outcomes—and none have examined child EF.

Two of these studies used a large sample of Finnish kindergarten children and their teachers. One study (Siekkinen et al., 2013) found that higher observed instructional support in the classroom and lower levels of reported teacher stress predicted more child empathy and less child disruptiveness (based on teacher ratings) in that particular classroom. Furthermore, high teacher stress was exclusively associated with higher children's impulsivity and lower cooperation skills. The other study (Pakarinen et al., 2010) showed that low teacher stress and higher classroom organization predicted higher learning motivation in children (measured using a direct assessment), which in turn contributed to higher phonological awareness. That is, children's learning motivation mediated the association between teacher stress and children's phonological awareness. Finally, Zinsser, Bailey, Curby, Denham, and Bassett (2013) examined associations between mean levels of and variability in classroom emotional support, teacher stress, and children's social and emotional behaviors in Head Start and private preschool classroom in the United States. They found that teacher stress, variability in emotional support, and an interaction of mean level and variability in emotional support all predicted emotion regulation and prosocial behaviors in 3- and 4-year-olds, although only in private and not Head Start classrooms. In private classrooms, children showed poorer emotion regulation and more aggression when teachers were inconsistent in their emotional supportiveness, even when those teachers were on average very supportive. These findings indicate that teacher stress may play a distinct role in high- versus low-poverty schools. Together, these studies are important pieces of empirical evidence that support the notion that teachers' well-being, specifically teacher stress, matters for young children's socioemotional and motivational outcomes, which leaves open the question of how teacher stress affects child EF.

Classroom Quality and Child EF

Potential mechanisms of the relation between teacher stress and child outcomes may be found in classroom quality. Several potential pathways have been suggested to explain how high-quality classrooms can promote children's EF. Some scholars have proposed that higher quality classrooms may build children's EF by supporting child activity choice and reflection (Bodrova & Leong, 2007). Others have suggested that better classroom management may promote children's EF skills, as children in better managed classrooms may internalize modeled regulatory behaviors and thus show internal management of their own behavior (Rimm-Kaufman et al., 2009). Likewise, well-organized classrooms may improve instructional time in the classroom by minimizing distractions and time spent on transitions. Furthermore, if teachers are warm and responsive, they may be better able to motivate children to learn (LaParo et al., 2009), and by offering higher levels of emotional support teachers may help students to experience moderate levels of arousal that are optimal for the development of EF (Blair & Ursache, 2011). Poorly managed classrooms, in contrast, can be stressful places for children that may lead to higher levels of arousal that can undermine the development of EF.

Although interventions targeting classroom quality have reliably been shown to improve EF (e.g., Blair & Raver, 2014; Raver et al., 2011), empirical evidence of how typical variation in classroom quality matters for children's EF development is only beginning to emerge. A number of very recent studies (Degol & Bachman, 2015; Hamre, Hatfield, Pianta, & Jamil, 2014; Merritt, Wanless, Rimm-Kaufman, Cameron, & Peugh, 2012; Ponitz, Rimm-Kaufman, Grimm, & Curby, 2009; Rimm-Kaufman et al., 2009; Weiland & Yoshikawa, 2013; Williford, Whittaker, Vitiello, & Downer, 2013) have shown promising and interesting findings regarding the role that classroom quality plays in shaping children's EF. All but one (Merritt et al., 2012) of these rigorous studies controlled for baseline EF and other self-regulatory behaviors—thus predicting change in EF and other self-regulatory behaviors. Furthermore, most of the studies measured quality using the CLASS (Pianta et al., 2007), a structured observational rating scale assessing classroom organization, emotional support, and instructional support, thus facilitating comparison across studies.

Although the findings from this set of studies appear to be somewhat inconsistent, an emerging pattern is discernable whereby classroom organization is consistently, positively associated with child EF and other self-regulatory behaviors (Hamre et al., 2014; Rimm-Kaufman et al., 2009). However, emotional support has been found to be both positively (Merritt et al., 2012) and negatively (Hamre et al., 2014) associated with child EF and other self-regulatory behaviors, thus showing inconsistent findings. Finally, instructional support has been found to be negatively related to child EF and other self-regulatory behaviors (Degol & Bachman, 2015; Rimm-Kaufman et al., 2009). In sum, emerging research in early childhood education suggests that typical variation in classroom quality matters for child EF and other self-regulatory behaviors but that the direction of that association varies by CLASS domain. Building on this evidence, we test classroom quality as a potential mediator of the relation between teacher stress and child EF.

The Present Study

Based on prior research and theory, we hypothesize that teacher stress is negatively (Pakarinen et al., 2010; Siekkinen et al., 2013; Zinsser et al., 2013) or curvilinearly (Blair & Ursache, 2011; Friedman-Krauss, Raver, Morris, et al., 2014; Raver et al., 2012) related to child EF and that potential mechanisms of this relation can be found in classroom quality (Friedman-Krauss, Raver, Morris, et al., 2014; Li-Grining et al., 2010). Furthermore, as previous research has shown that working with young, low-income children can be particularly stressful (Curbow et al., 2000; Whitaker et al., 2013), we ask whether the relation between teacher stress and child EF varies by school-level poverty. We hypothesize that the relation between teacher stress and child EF is exacerbated (i.e., stronger and more negative) in high-poverty schools. We test these hypotheses using rigorous methods that include controlling for baseline EF and thus in effect predicting change in child EF from fall to spring of the kindergarten year. Furthermore, we control for several teacher characteristics—most important, for teacher depression. Although depressive symptoms could be the result of stress and thereby contribute to poor teacher–child relationships and poor child outcomes, these symptoms could also confound the relationship between teacher stress and child outcomes (McLean & Connor, 2015).

Method

Participants

Participants included 171 children enrolled in 33 kindergarten classrooms in 14 schools in the northeastern United States. An average of five children per classroom (*SD* = 1.2) were randomly selected to be included in the study, with classroom sizes averaging 22 children (*SD* = 4.9). Children were assessed during kindergarten in Fall 2011 and Spring 2012, henceforth referred to as "Time 1" and "Time 2," respectively. At Time 1, children were on average 5 years, 7 months of age (*M* = 68.9 months, *SD* = 4.2 months). About half (51%) of the children were girls. The sample was primarily non-Hispanic White (65%), with other children reported as Hispanic (15%), multiracial (11%), African American (4%), or other ethnicities (5%). Parents' educational attainment was relatively high, with 79% of children having at least one parent reporting at least some college.

All of the 33 teachers were women with an average age of 45 years (*SD* = 10.7 years). All but one of the teachers were non-Hispanic White (one was Hispanic). The level of education of the teachers was high, with 66.7% reporting having a master's degree and the remaining having a bachelor's degree (see Table 1). Teachers had an average of 15.8 years of experience teaching, ranging from 0 to 30 years.

This sample was recruited as a part of a larger randomized controlled trial (Blair & Raver, 2014) to assess the effectiveness of the Tools of the Mind curriculum in kindergarten, which aims to foster the development of children's EF skills (Bodrova & Leong, 2007). Only control group classrooms from this intervention study were included in the current study in order to avoid the confounding effect of the intervention on the current study's research questions.

Procedure

Participants were tested individually by trained research assistants over two different days per semester at Time 1 and Time 2 in a quiet area in their schools. The measures used in this study were administered as part of a larger battery of tasks, all of which totaled 1 hr of administration per day. The EF tasks were completed in a fixed order. Trained classroom observers administered the CLASS to measure classroom quality in early Spring 2012 (thus for most children between Time 1 and Time 2).

Table 1. Descriptive statistics for study variables.

Variable	*n*	M (SD)	%	*Min*	*Max*
Child characteristics (*n* = 171)					
EF composite score T1	163	.68 (.15)		.24	.93
z-stand EF composite score T1		0 (1)		−3.00	1.67
EF composite score T2	161	.66 (.13)		.32	.94
z-stand EF composite score T2		0 (1)		−2.60	2.10
Teacher characteristics (*n* = 33)					
Teacher stress T1	26	2.33 (0.43)		1.44	2.94
Depression T1	25	1.54 (0.56)		1	2.67
Teacher education (percent bachelor's/master's degree)	30		24.20/66.70		
Teacher experience (years)	30	15.80 (8.52)		0	30
Classroom characteristics (*n* = 33)					
Percent free/reduced lunches in classrooms	33	.33 (.30)		.05	.92
CLASS Emotional Support	33	5.59 (0.65)		3.75	6.94
CLASS Classroom Organization	33	5.18 (0.77)		3.00	6.25
CLASS Instructional Support	33	2.95 (0.99)		1.42	5.17

Note. Teacher stress and teacher depression were rated on a 5-point Likert scale. CLASS variables were observed on a 7-point Likert scale. EF = executive function; CLASS = Classroom Assessment Scoring System; *z*-stand = *z*-standardized; EF composite score T1 = standard Flanker; T1 = Fall 2011; EF composite score T2 = reverse Flanker; T2 = Spring 2012.

Measures

EF

Children completed a battery of three widely used computerized EF tasks—the Dimensional Change Card Sort (DCCS; Zelazo, 2006), Hearts & Flowers (Davidson, Amso, Anderson, & Diamond, 2006; Diamond, Barnett, Thomas, & Munro, 2007), and Fish Flanker (Diamond et al., 2007)—at both time points. These tasks were chosen to represent common EF measures for children in this age range that capture performance of all three components of EF (inhibition, updating, and shifting; Miyake et al., 2000). Acknowledging that an EF task often does not measure only one EF component in isolation (cf. Garon, Bryson, & Smith, 2008), and the chosen tasks each capture all three EF components, although to various degrees: DCCS and Hearts & Flowers measure mainly inhibition and shifting while Fish Flanker captures mainly inhibition and working memory. Taken together, these three tasks provide a comprehensive measure of the construct of EF.

Hearts & Flowers. In this task, children have to react to a stimulus (heart or flower) that is presented for 2,500 ms by pressing one of two fuzzy buttons located on opposite sides of the keyboard. There are three blocks of trials in this task. During the first block, which consists of 12 trials, hearts appear on either the left or the right side of the screen, and children are instructed to press the fuzzy button on the same side as the heart. In the second block, which also consists of 12 trials, flowers appear on either the left or the right side of the screen, and children are instructed to press the fuzzy button on the opposite side of the flower. Both blocks include a short set of instructions with eight practice trials. The last block (i.e., a mixed block) consists of 33 trials in which hearts and flowers appear on either side of the screen. Children are instructed to press the fuzzy button according to the previously learned rules. That is, they have to remember the two rules and shift between them depending on the stimuli presented (heart or flower). The dependent variable used in the current analyses was the proportion of correct responses in the mixed block.

DCCS. In this task, children are required to sort cards according to two different features of the cards: shape and color. Two cards are presented at the bottom of the screen, and a target card is presented at the top of the screen. A word (either *color* or *shape*) is both presented on the screen and spoken by a prerecorded voice to cue children to match the target card with the correct corresponding card on the bottom of the screen. To match the pictures, the child is asked to press one of two fuzzy buttons on opposite sides of the keyboard corresponding with the location of their selection. In the first block, children sort cards either by shape or by color. In the second block, they sort cards by the other dimension. Children must successfully sort three out of four cards by color and three out of four cards by shape in order to advance to the third block. In the third block, trials are mixed, and children sort 50 cards according to a cue they hear and see at the beginning of each trial that identifies the dimension by which they should sort. The dependent variable used in the current analyses was the proportion of correct responses in the mixed block.

Fish Flanker. Fish Flanker has a standard version, which children in the current study completed at Time 1, and a reverse version, which children completed at Time 2. In the standard version, children see a row of fish or arrows and have to select the side to which the middle stimulus is facing by pressing the fuzzy button on the same side as the fish is facing. In congruent trials, all of the stimuli are facing the same way. In incongruent trials, the middle stimulus faces the opposite direction as the stimuli to either side of it. In the reverse version, an extra rule is added to increase working memory demands. Stimuli are either blue or pink, and children follow the standard rules when stimuli are blue but respond according to the direction the stimuli on the side are facing when the stimuli are pink. Thus, the goal of the task is the same in both versions, but the added rule in the reverse version increases the difficulty of the task. In both versions, children must correctly complete three out of four practice trials before advancing to test trials, which consist of 25 fish trials (10 of which are incongruent) and 25 arrow trials (10 of which are also incongruent). The dependent variable used in the current analyses was the proportion of correct responses in the incongruent trials.

To create a composite score of EF, we calculated the mean percent correct from the mixed trials of DCCS and Hearts & Flowers and the mean percent correct from the incongruent trials of Fish Flanker. Consistent with prior literature, individual EF tasks were moderately to weakly correlated within each time point (Time 1: *r*s = .29–.52, Time 2: *r*s = .27–.50, all *p*s < .01).

Teacher Stress

Teachers' self-reported job stress was measured at Time 1 using a slightly modified version of the Child Care Worker Job Stress Inventory (CCW-JSI; Curbow et al., 2000). The CCW-JSI is designed to capture the job stress experienced by child care providers in family day care homes and child care centers and demonstrates high validity and internal consistency. We used 15 items from this inventory measuring job control, job demands, and job resources. Items from the CCW-JSI are reported on a 5-point Likert scale with response choices ranging from *rarely* (1) to *most of the time* (5). Sample items are "Children with behavior problems are hard to deal with," "There are major sources of stress in the children's lives that I can't do anything about," "All the children need attention at the same time," "I feel I have control over getting the parents to be consistent with me in how to deal with a child," and "I know the children are happy with me" (reverse coded). Furthermore, we included three items rewritten by Raver for the Chicago School Readiness Project (Raver et al., 2011) based on research regarding teachers' attributions about the causes of children's behavior (Scott-Little & Holloway, 1992). These items aim to capture the extent to which teachers have to cover other classrooms and have enough help in the classroom. A sample item is "I have enough help from childhood consultants." In total our teacher stress scale included 18 items with sufficient reliability (Cronbach's α = .76).

Classroom Quality

The CLASS (Pianta et al., 2007) was used to measure classroom quality in early Spring 2012. It provides a global measure of all teachers' interactions within their classrooms with children, interactions between children, the emotional climate of the classroom, and behavior management. We used all three subscales: (a) Emotional Support, which was an average of four indicators: Positive Climate, Negative Climate, Teacher Sensitivity, and Regard for Student Perspectives (Cronbach's α = .83); (b) Classroom Organization, which was an average of three indicators: Behavior Management, Productivity, and Instructional Learning Formats (Cronbach's α = .81); and (c) Instructional Support, which was an average of three indicators: Concept Development, Quality of Feedback, Language Modeling (Cronbach's α = .90). CLASS indicators are scored on a 7-point Likert scale, with higher scores reflecting higher quality. Data collectors observed each class for 20 min, taking notes, and then scored the indicators for 10 min, repeating this cycle four times throughout the day. To establish reliability, raters watched and scored five 20-min video segments with no feedback or discussion. Raters had to score within 1 point of the master code on 80% of all codes across segments and score within 1 point of the master code on each dimension on at least two of the five segments to be considered reliable.

School-Level Poverty

The percentage of children receiving free or reduced lunch at each school was obtained from state and federal databases. On average 33% of children per school were eligible for free or reduced-price lunch, but this varied from 5% to 92% of children per school.

Teacher Covariates

Teacher covariates included highest degree earned, years of experience teaching, and teacher depression. For the latter, teachers completed the Kessler Psychological Distress Scale (K6) (Kessler et al., 2002), a 6-item assessment of mental health representing in particular domains of depression and anxiety (Cronbach's α = .87).

Missing Data

In order to handle missing data, we ran all analyses using restricted maximum likelihood. For multi-level models restricted maximum likelihood is preferred over full information maximum likelihood because the estimation of variance components is unbiased (Rabe-Hesketh & Skrondal, 2012).

Statistical Analyses

To test our hypotheses, we estimated two-level hierarchical linear models in STATA 12 with children nested in kindergarten classrooms (with one teacher per classroom). Children's EF skills at Time 2 when children were in kindergarten (Spring 2012) were predicted from teacher stress at Time 1 (Fall 2011) as well as teacher and child covariates, including child EF at Time 1. We included these covariates in our models in order to make them more rigorous and conservatively specified, which allowed for greater precision in the estimates. Using this residualized change approach also helped to mitigate concern about the role of unobserved characteristics (such as unobserved stable child characteristics) in the relationship between child EF and teacher stress. Results from an unconditional two-level hierarchical linear model indicated that 13% of the variance in children's EF skills was attributable to between-classroom differences (intraclass correlation coefficient = 0.13).

Multilevel modeling allows for the simultaneous estimation of variances associated with the individual and the classroom based on the specification of fixed- and random-effects variables in the model. Accounting for the nested structure of the data minimizes bias in parameter estimates due to the nonindependence of observations (Raudenbush & Bryk, 2002). The associations between child EF, teacher stress, school-level poverty, and classroom quality were modeled using the following equations.

The child-level (Level 1) equation used was

$$EFT2_{ij} = \beta_{0j} + \beta_1 \ EFT1_{ij} + \Sigma_n \beta_2 Child\ Characteristics_{ij} + e_{ij}, \tag{1}$$

where $EFT2_{ij}$ is the Spring 2012 measure of EF for child i in classroom j; $\beta_{1j}EFT1_{ij}$ is the Fall 2011 measure of EF for child i in classroom j; and $\Sigma_n\beta_2 Child\ Characteristics_{ij}$ represents the sum n of child characteristics, including child age and child sex. β_{0j} is the classroom-specific intercept, and e_{ij} is the random error term.

The teacher-level (Level 2) equation used was

$$\begin{array}{l}\beta_{0j} = \gamma_0 + \gamma_1 Teacher\ StressT1_j + \gamma_2 Teacher\ StressT1_j{}^2 + \\ \Sigma_m \gamma_3 Teacher\ Characteristics_j + r_j\end{array}, \tag{2}$$

where $\gamma_1 Teacher\ StressT1_j$ represents the Fall 2011 teacher stress of teacher j; $\gamma_2 Teacher\ StressT1_j^2$ represents the quadratic term of teacher stress in Fall 2011 of teacher j; and $\Sigma_m\gamma_3 Teacher\ Characteristics_j$ represents the sum of m teacher characteristics, including teacher depression in Fall 2011, teacher education, and teacher experience. r_j is a random error term.

To test the moderation by school-level poverty hypothesis we added the following terms to the teacher-level (Level 2) equation[1]:

$$\begin{aligned}\beta_{0j} = \gamma_0 &+ \gamma_1 Teacher\ Stress\ T1_j + \gamma_2 Teacher\ StressT1_j{}^2 \\ &+ \Sigma_m \gamma_3 Teacher\ Characteristics_j + \gamma_4 Free/reduced\ lunches_j \\ &+ \gamma_{14} Teacher\ StressT1_j \times Free/reduced\ lunches_j + r_j\end{aligned} \tag{3}$$

where $\gamma_4 Free/reduced\ lunches_j$ represents the percentage of children receiving free or reduced lunches and $\gamma_{14} Teacher\ StressT1_j \times Free/reduced\ lunches_j$ represents the interaction between teacher stress and school-level poverty.

Finally, to test the hypothesis that classroom quality mediates the relation between teacher stress and child EF we added the following terms to the teacher-level equation (Equation 2):

$$\begin{aligned}\beta_{0j} = {} & \gamma_0 + \gamma_1 Teacher\ StressT1_j + \gamma_2 Teacher\ StressT1_j^{\,2} \\ & + \Sigma_m \gamma_3 Teacher\ Characteristics_j + \gamma_4 Free/reduced\ lunches_j \\ & + \Sigma_p \gamma_5 Classroom\ quality_j + \gamma_{14} Teacher\ StressT1_j \\ & \times Free/reduced\ lunches_j + r_j\end{aligned} \tag{4}$$

where $\Sigma_p \gamma_5$ *Classroom quality*$_j$ represents each one of the CLASS measures: Emotional Support, Classroom Organization, and Instructional Support. That is, three separate regression models were run for each of the CLASS measures to test each of the measures independently. Following the Baron and Kenny (1986) method, if the effect of teacher stress on child EF is smaller when classroom quality is added to the model, then classroom quality can be seen as a mediator or partial mediator of the relation between teacher stress and child EF.

All variables were centered at the grand mean. We centered teacher stress and school-level poverty at the grand mean prior to creating the interaction term, and these centered variables were used in the analyses. We unpacked significant interactions by testing the statistical significance of the simple slopes. Given the limited statistical power to detect classroom-level effects due to the small number of classrooms and teachers, we reduced the risk of Type II error by describing trend-level ($p < .10$) effects. We also report effect sizes using Cohen's (1988) d so that readers can judge the meaningfulness of the findings.

Results

Table 1 presents descriptive data for all measures included in the present study. Note that the mean of the EF composite was lower at Time 2 than at Time 1 because of the different Flanker versions used at each time point (i.e., the more difficult task was used at Time 2). Therefore, we used the z-standardized EF composite score (standardized within each time point) in all analyses. Doing so allowed us to compare where each child was at each time point relative to the other children. Also note that CLASS Instructional Support was relatively low in the current study, which is consistent with prior studies, whereas Emotional Support and Classroom Organization were relatively high.

Table 2 shows zero-order correlations between the included variables. EF showed high stability over half a year of kindergarten (i.e., from Time 1 to Time 2; $r = .70$, $p < .001$). Furthermore, EF showed significant small to modest correlations in the expected directions with teacher stress, CLASS Emotional Support, and CLASS Classroom Organization but was not significantly correlated with teacher depression, teacher education, or CLASS Instructional Support. Teacher stress was moderately and positively correlated with teacher depression but not with teacher education or teacher experience. Furthermore, teacher stress was moderately correlated with CLASS Emotional Support and CLASS Classroom Organization but not with CLASS Instructional Support. The three CLASS measures were moderately to highly correlated with one another, but consistent with prior literature CLASS Emotional Support and CLASS Classroom Organization showed the strongest association. Finally, school-level poverty was correlated with all variables of interest in the expected directions (i.e., negatively with child EF and all CLASS measures and positively with teacher stress). Moreover, school-level poverty was negatively correlated with teacher education but was not correlated with teacher depression or teacher experience.

[1]Note that in our models, for the sake of parsimony, we treated school-level poverty as a classroom-level variable. However, results did not change if we treated it as a school-level variable.

Table 2. Intercorrelations between child EF, teacher stress, classroom-level variables, and covariates.

Variable	1	2	3	4	5	6	7	8	9	10
1. Child EF T1	—	.70***	−.22*	.13	.14	.03	.30***	.29***	.03	−.40***
2. Child EF T2		—	−.21*	−.04	.15†	.00	.36***	.31***	.08	−.43***
3. Teacher stress			—	.39***	−.04	.07	−.36***	−.49***	.06	.54***
4. Teacher depression				—	−.25**	−.28**	−.01	−.10	.04	−.11
5. Teacher education					—	.10	.19*	.14†	.17*	−.21**
6. Teacher experience						—	−.04	−.12	−.33***	.12
7. CLASS Emotional Support							—	.85***	.53***	−.71***
8. CLASS Classroom Organization								—	.57***	−.72***
9. CLASS Instructional Support									—	−.17*
10. Percent free/reduced lunches										—

Note. EF = executive function; CLASS = Classroom Assessment Scoring System; T1 = Fall 2011; T2 = Spring 2012.
†$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Teacher Stress Predicting Child EF

In order to test the first hypothesis, we ran a two-level hierarchical linear model in which child EF at Time 2 was predicted from teacher stress at Time 1 while controlling for child EF at Time 1 as well as teacher and child characteristics (Equations 1 and 2). As can be seen in Table 3, Model 1, EF at Time 1 was, as expected, a strong predictor of EF at Time 2 (β = 0.66, $p < .001$), such that for each additional standard deviation of EF at Time 1, EF at Time 2 increased by two thirds of a standard deviation, yielding a medium effect size. Teacher stress predicted EF at Time 2 at the trend level (β = −0.33, $p = .084$) above and beyond EF at Time 1 and all of the teacher covariates. Thus, for each additional standard deviation of teacher stress, EF at Time 2 decreased by one third of a standard deviation, yielding a small effect size. The quadratic term for teacher stress was not significantly related to child EF at Time 2.

Moderation by School-Level Poverty

In order to test the second hypothesis, we added school-level poverty as well as the interaction between school-level poverty and teacher stress to the teacher level (Equation 3; with Equation 1 as the child-level equation). Note that for reasons of parsimony and because of limited power, the

Table 3. Parameter coefficients and standard errors from multilevel modeling examining teacher stress predicting child EF at Time 2.

	Model 1		Model 2	
Variable	*β*	*SE*	*β*	*SE*
Child characteristics (individual level)				
z-stand EF composite score T1	0.66***	0.07	0.63***	0.08
Gender	0.01	0.13	−0.01	0.13
Age	0.00	0.02	0.00	0.01
Teacher characteristics (group level)				
Teacher stress T1	−0.33††	0.19	−0.05	0.23
Teacher stress T1^2	0.21	0.39		
Depression T1	0.11	0.14	0.12	0.16
Teacher education	0.13	0.15	0.07	0.15
Teacher experience	0.01	0.01	0.01	0.01
Classroom characteristics (group level)				
Percent free/reduced lunches			−0.89*	0.36
Interaction				
Teacher Stress T1 × Percent Free/Reduced Lunches			1.87*	0.84
Constant	−0.15	1.22	−0.24	1.19
Variance components				
Classroom random effects	0.00	0.00	0.00	0.00
Residual variance	0.53	0.07	0.50	0.07

Note. EF = executive function; *z*-stand = *z*-standardized; T1 = Fall 2011.
††$p \leq .084$. *$p < .05$. ***$p < .001$.

quadratic term of teacher stress was dropped from the teacher-level equation, as it was not a significant predictor of child EF. Results shown in Table 3, Model 2, indicate that teacher stress interacted with school-level poverty to predict child EF at Time 2 ($\beta = 1.87$, $p < .05$). As shown in Figure 1, when teachers reported high levels of stress, child EF did not differ between high- and low-poverty schools. However, when teachers reported low levels of stress, school-level poverty seemed to matter for children's EF: Low teacher stress was beneficial to child EF in low-poverty schools, but the opposite was true in high-poverty schools—low teacher stress was not beneficial to child EF. Inspection of the simple slopes revealed that in low-poverty schools (1 *SD* below the mean), children in classrooms where teachers reported low levels of stress demonstrated higher EF at Time 2 than children in classrooms where teachers reported high levels of stress (simple slope for low-poverty schools: $B = -0.61$, $p = .057$), such that for each additional standard deviation of teacher stress, child EF decreased by .18 units, or one fifth of a standard deviation. This resulted in a difference in child EF (between classrooms with low and high teacher stress) of .36 units, yielding a medium effect of Cohen's $d = .52$. In high-poverty schools, however, child EF at Time 2 did not differ significantly between children in classrooms where teachers reported high versus low levels of stress (simple slope for high-poverty schools: $B = 0.51$, $p = .16$).

Mediation by Classroom Quality

In order to test the third hypothesis, that classroom quality mediates the relation between teacher stress and child EF, we added each of the CLASS measures separately to the teacher level (Equation 4; with Equation 1 as the child-level equation). Results from two-level hierarchical linear regression models predicting child EF at Time 2 from classroom quality (separate models for each CLASS measure) are depicted in Table 4. None of the CLASS measures were significant predictors of child EF; thus, we found no evidence of mediation by classroom quality. However, note that the interaction of teacher stress with school-level poverty held when we controlled for classroom quality.

Based on theory and the empirical findings reviewed, we additionally tested whether teacher stress is nonlinearly related to classroom quality. In regression models in which each of the CLASS measures was separately predicted by teacher stress and the quadratic term of teacher stress, we did not find evidence for significant curvilinear associations among teacher stress and any of the

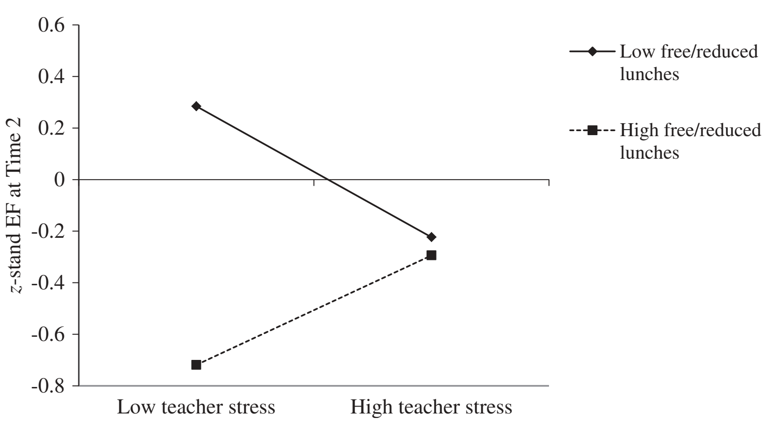

Figure 1. Teacher stress interacts with school-level poverty (indexed by free/reduced lunches) to predict child executive function (EF). When teachers reported high levels of stress (1 *SD* above the mean), child EF did not differ between high- and low-poverty schools. However, when teachers reported low levels of stress (1 *SD* below the mean), school poverty seemed to matter: Low teacher stress was beneficial to child EF in low-poverty schools, but the opposite was true in high-poverty schools (i.e., low teacher stress was not beneficial to child EF).

Table 4. Parameter coefficients and standard errors from multilevel modeling examining teacher stress predicting child EF at Time 2: Investigating mediating classroom-level factors.

	Model 3		Model 4		Model 5	
Variable	*β*	*SE*	*β*	*SE*	*β*	*SE*
Child characteristics (individual level)						
z-stand EF composite score T1	0.62***	0.09	0.63***	0.08	0.63***	0.08
Gender	−0.02	0.13	−0.02	0.13	−0.01	0.16
Age	0.00	0.02	0.00	0.02	0.00	0.02
Teacher characteristics (group level)						
Teacher stress T1	−0.04	0.08	−0.01	0.24	−0.05	0.23
Depression T1	0.20	0.18	0.19	0.19	0.12	0.17
Teacher education	0.07	0.15	0.08	0.16	0.07	0.16
Teacher experience	0.02	0.01	0.02	0.01	0.01	0.01
Classroom characteristics (group level)						
Percent free/reduced lunches	−0.76*	0.37	−0.78*	0.39	−0.89*	0.36
CLASS Emotional Support	0.20	0.17				
CLASS Classroom Organization			0.11	0.16		
CLASS Instructional Support					0.00	0.09
Interaction						
Teacher Stress T1 × Percent Free/Reduced Lunches	2.51*	1.00	2.35*	1.07	1.87*	0.91
Constant	−0.37	1.19	−0.24	1.19	−0.24	1.21
Variance components						
Classroom random effects	0.00	0.00	0.00	0.00	0.00	0.00
Residual variance	0.50	0.07	0.50	0.07	0.51	0.07

Note. EF = executive function; *z*-stand = *z*-standardized; T1 = Fall 2011; CLASS = Classroom Assessment Scoring System.
*$p < .05$. ***$p < .001$.

CLASS measures. We found only linear relations between teacher stress and CLASS Emotional Support ($B = -4.14$, $p < .01$) and CLASS Classroom Organization ($B = -5.10$, $p < .01$).

Discussion

Child EF has been shown to be malleable based on specific experiences both at home and at school. Little is known, however, about classroom and school experiences that challenge or support children's EF and that ultimately may play a crucial role in shaping children's EF. While controlling for baseline child EF and teacher depression, this study investigated the associations between child EF, teacher stress, classroom quality, and school-level poverty in a sample of 5-year-old kindergarten children. We found that teacher stress was linearly related to the change in child EF from fall to spring of the kindergarten year but that this relation was significant only at the trend level. Importantly, in our sample, teacher stress interacted with school-level poverty to predict child EF: Children attending low-poverty schools demonstrated, as expected, larger gains in EF when their teachers reported lower levels of stress. However, the opposite was true in high-poverty schools: Low teacher stress was not beneficial to child EF. Finally, there was no evidence that classroom quality mediated the association between teacher stress and child EF. However, teacher stress was linearly related to emotional support and classroom organization. To the best of our knowledge these are the first findings that relate teachers' well-being (i.e., their perception of their own job-related stress) to child EF. Given the relatedness between EF and other aspects of self-regulation (Bridgett et al., 2015), the implications of this study likely extend beyond EF to other regulatory skills critical to children's school success. We discuss the context-dependent teacher stress effects on child EF and possible reasons for failing to find evidence that classroom quality is a mechanism of this relation.

Teacher Stress Predicting Child EF

To date, only very few studies have explored the relations between teachers' well-being and children's developmental outcomes. Exposure to teacher stress may be regarded as a stressful experience in young children's school life, possibly playing a crucial role in shaping children's self-regulatory abilities, including EF. Our findings corroborate and extend previous findings on the effects of teacher stress on children's socioemotional and motivational outcomes (Pakarinen et al., 2010; Siekkinen et al., 2013; Zinsser et al., 2013). Compared to these previous studies we controlled for a host of teacher characteristics, most important for teacher depression, and for the child outcome at baseline. The high stability in children's EF from fall to spring of the kindergarten year (r = .70) on the one hand, and the small but substantial proportion of variance in child EF that was attributable to between-classroom differences (intraclass correlation coefficient = 0.13) on the other hand, set the boundaries within which teacher stress would have the power to explain additional variance in the growth of child EF. Although the linear effect of teacher stress was only marginally significant, its effect size was similar in magnitude to the effects reported in previous studies (βs = −.19 to −.44), which indicates that teacher stress is a risk factor not only for young children's socioemotional and motivational skills but also for their EF development. Given that EF shows a protracted development throughout middle childhood and adolescence (Diamond, 2002), future studies may test the generalizability of our findings to older and/or younger children. Yet our findings provide evidence of the impact that teacher stress has on children's development during the period in which EF develops most rapidly.

It is somewhat surprising that we did not detect a curvilinear relation between teacher stress and child EF or classroom quality, as was expected in line with the Yerkes–Dodson principle (Arnsten, 2009; Blair & Ursache, 2011; Yerkes & Dodson, 1908). That is, we only found a linear negative association between teacher stress and children's EF (in low-poverty schools) and classroom quality. Thus, our data did not support the notion that moderate levels of stress may enhance, and thus be beneficial for, teacher and/or child functioning (i.e., we could not confirm the upward part of the inverted U that can be thought of as the energizing effect of stress arousal; cf. Hebb, 1955). Although a curvilinear relationship between teacher stress and child outcome measures may be less easy to detect than a curvilinear relationship between teacher stress and teacher performance measures (e.g., classroom quality; cf. Friedman-Krauss, Raver, Morris, et al., 2014), the question still remains why we did not detect either. Future studies are needed to specifically address the questions about the circumstances under which moderate levels of teacher stress may be beneficial for teachers' abilities and/or child functioning.

It is important to note that our results suggest that it is specifically teacher stress that is associated with children's EF, as neither teacher depression, teacher education, nor teacher experience were significantly correlated with child EF. This pattern of associations raises some questions given the notion that EF may be particularly sensitive to caregivers' well-being, as indicated in previous studies showing that mothers' depressive symptoms adversely affect children's developing EF (Hughes, Roman, & Ensor, 2013). Furthermore, studies indicate that teachers' self-reported depression is negatively associated with prekindergarten children's social skills (Mashburn et al., 2006) and with third graders' mathematical achievement (McLean & Connor, 2015). However, we are not aware of any previous research linking teacher depression to child EF.

Future work is needed to clarify the associations among teacher depression, teacher stress, and child EF. Given that the stress measure (CCW-JSI) used in the present study is aimed at specifically capturing stressors at work faced by teachers of young children, it may be more sensitive to and reflect more closely teachers' well-being related to their functioning within the classroom and their relationship with students compared to the more generic depression measure used. Nevertheless, stress may be regarded as an individual correlate of depression, and future studies are needed to disentangle the unique contributions of various aspects of teachers' well-being (i.e., mental health) to different student outcomes. Furthermore, future studies are needed to investigate whether interventions that benefit teacher stress may also improve children's EF—at least in low-poverty schools. For example, it would be useful to test whether interventions that aim to reduce teacher stress (Flook, Goldberg, Pinger, Bonus, & Davidson, 2013; Jennings, Snowberg, Coccia, & Greenberg, 2011; Roeser et al., 2013) translate into changes in child outcomes, specifically child EF, and whether these findings are robust across schools that serve children from high- and low-poverty families.

Moderation by School-Level Poverty

Teaching low-income children may be particularly stressful because low-income children not only are at higher risk for behavioral and academic difficulties (Fantuzzo et al., 1999) but also are more likely to be enrolled in lower quality schools in more disadvantaged neighborhoods with fewer resources as well as face multiple poverty-related risks (Evans, 2004; Yoshikawa & Knitzer, 1997). In line with our hypothesis we found that school-level poverty moderated the relation between teacher stress and child EF. Specifically, we found that the relation between teacher stress and child EF was reversed with regard to school-level poverty. In low-poverty schools, children showed bigger gains in EF in classrooms where teachers reported lower levels of stress (a medium-sized effect). However, our analyses also indicated that in high-poverty schools the association between teacher stress and child EF was not statistically significant. Taken together, these results suggest that in low-poverty schools, as expected, high teacher stress is detrimental to children's EF development. In contrast, in high-poverty schools high teacher stress does not seem to be a risk factor for children's EF (i.e., children in classrooms with high levels of teacher stress were showing better EF compared to children in classrooms with low levels of teacher stress, although this difference was not statistically significant). It should be noted, however, that children in lower income schools, regardless of teacher stress, demonstrated smaller gains in EF than their peers in higher income schools. This finding corroborates recent cognitive neuroscience research suggesting that poverty-related gaps in achievement are accompanied by poverty-related differences in neurocognitive abilities such as EF (Duncan & Magnuson, 2011; Noble, McCandliss, & Farah, 2007). It could therefore be reasonable to assume that the effects of poverty on EF are so potent that they mitigate any effects that teacher stress might have.

Although the results of the moderation analyses may seem counterintuitive, a close inspection of Zinsser and colleagues' (2013) findings reveals a similar pattern: Although they only found significant associations between teacher stress and emotion regulation/prosocial behavior in private child care classrooms (considered to serve higher income children), teacher stress was positively—albeit not statistically significantly (β = 0.18)—related to emotionally regulated behavior in Head Start classrooms (considered to serve children who are at higher socioeconomic risk). Thus, the question arises as to why children in high-poverty schools whose teachers experience high levels of stress demonstrate higher gains in EF than children whose teachers report low levels of stress?

Preliminary post hoc exploratory analyses in our sample indicated that teachers in high-poverty schools reporting low levels of stress responded significantly lower than all of the other teachers on the following two items of the CCW-JSI: "Children with behavior problems are hard to deal with" and "There are major sources of stress in the children's lives that I can't do anything about." Therefore, we are inclined to draw the post hoc conclusion that it may be that these teachers are not as involved in their students' lives as their peer teachers in high-poverty schools reporting high levels of stress. Previous research supports this tentative interpretation of high stress among teachers in high-poverty schools possibly being an indicator of highly involved teachers. Specifically, one study found that teachers who faced higher levels of work-related stress attended the most teacher trainings and were most highly engaged in a comprehensive, classroom-based intervention in Head Start classrooms (net of levels of personal stress) compared to their less work-stressed colleagues (Li-Grining et al., 2010). Similarly, Domitrovich, Gest, Gill, Jones, and DeRousie (2009) reported that Head Start teachers reporting higher levels of emotional exhaustion (but not depression) were more rather than less involved in implementing a new classroom-based intervention with high fidelity. Although these findings seem to point in a similar direction as ours, our interpretation is speculative at best and requires further research.

Mediation by Classroom Quality

According to the prosocial classroom model, teachers' characteristics and students' outcomes are assumed to be bidirectionally related through their influence on classroom quality (Jennings & Greenberg, 2009). In line with this model, we found that the correlational pattern of associations among classroom quality and child EF is largely consistent with emerging research in early childhood education suggesting that typical variation in classroom quality is associated with children's EF development. Indeed, EF at both time points was consistently and modestly correlated with Emotional Support and Classroom Organization but not with Instructional Support. It is interesting that teacher stress showed the same (inverse) pattern of associations with the CLASS measures as EF did, with a slightly higher correlation with Classroom Organization.

Despite these promising correlational patterns, we did not find empirical support for our hypothesis that these dimensions of classroom quality are mechanisms of the relation between teacher stress and child EF. Thus, it seems that the CLASS measures did not capture the processes that are responsible for translating teacher stress into changes in children's EF, at least in the present sample. It is possible that a measure such as the Individualized Classroom Assessment Scoring System (Downer, Booren, Lima, Luckner, & Pianta, 2010) capturing individualized experiences of children in classrooms may yield more promising results. For instance, individual children within the same preschool classroom may have disparate preschool experiences (e.g., Bulotsky-Shearer, Fantuzzo, & McDermott, 2010), as children within a single classroom may be differentially exposed to high-quality interactions with their teacher (e.g., Hamre & Pianta, 2001). In addition, measuring other aspects of teacher functioning, such as dimensions of teacher–child relationships, may also reveal crucial mechanisms of the relation between teacher stress and child outcomes (Spilt et al., 2011). Alternatively, additional mechanisms may link higher teacher stress and lower child EF, such as school- or community-level characteristics that are associated with both higher teacher stress and lower child EF in lower poverty schools. However, it is more difficult to explain how these mechanisms would work for the low-stressed teachers in high-poverty schools. Additional work is needed to fully illuminate the processes that on the one hand are impacted by a teacher experiencing stress and on the other hand are responsible for affecting children's outcomes.

Limitations and Future Directions

It is important to note several limitations of the present study. First, given the small sample size, this study had limited statistical power to detect meaningful classroom-level effects, which raises the risk of Type II error. This is a common challenge in studies in which classrooms are the appropriate level of analysis (Domitrovich, Gest, Gill, Bierman, et al., 2009). As a result, in the current study we used Cohen's (1988) general guidelines for characterizing the strength of effect sizes and found that the trend-level association between teacher stress and child EF was small in magnitude but meaningful. Furthermore, given the small sample size, the interaction findings from this study are based on relatively low cell frequencies and are therefore limited in their generalizability and should be viewed with caution. Future work involving larger sample sizes at the teacher and school levels is needed to fully unpack the role of teacher stress in shaping children's EF in both high- and low-poverty schools.

Second, our study design was nonexperimental, and we cannot speak to the causal effects of teacher stress on child behavior. However, we took care to control for teacher, classroom, and child characteristics that could explain the relation between teacher stress and child EF, thereby improving the strength of our conclusions. Intervention research into the impact of variability in teacher stress on child outcomes, including EF, is needed to corroborate and extend the current findings (cf. the ongoing randomized controlled trial of Improving Classroom Learning Environments by Cultivating Awareness and Resilience in Education; Jennings et al., 2011). Third, and related to the issue of causality, we recognize the bidirectional nature of interactions between children's and teachers' behavior (Jennings & Greenberg, 2009). Although we told our story such that teacher stress predicts changes in child EF, it is also possible that teachers in a classroom with children with low EF (and sometimes higher behavior problems) experience more difficulties maintaining a positive classroom climate and in consequence experience more stress (Friedman-Krauss, Raver, Neuspiel, & Kinsel, 2014). However, this concern is mitigated by the fact that teacher stress was measured prior to child EF and the use of residualized change models. Future work could utilize other methods, such as autoregressive cross-lagged models, to examine the bidirectional nature and possibly the causal ordering of the relation between child outcomes and teacher well-being over time.

Despite these limitations, this study makes innovative contributions to the field of early childhood education and development. This study is a first step in the attempt not only to better understand how teachers' well-being relates to child EF but also to explore sources of discomfort and disturbance within young children's classrooms. However, there is more work to be done to better understand stressful experiences in children's classrooms. Including physiological measures of teacher stress would be informative, as would be identifying other possible classroom and school experiences that challenge children's self-regulation. In addition, including physiological indices of child self-regulation in future analyses will help to identify the specific aspects of the classroom that interact with children's neurobiological processes as well as how they relate to behavioral regulatory processes and academic achievement. For instance, Ahnert, Harwardt-Heinecke, Kappler, Eckstein-Madry, and Milatz (2012) recently found that first graders in nonsupportive compared to supportive classrooms had flatter cortisol profiles, which suggests that classrooms of low quality hindered sufficient downregulation of cortisol levels (i.e., were associated with poorer stress regulation). Moreover, students with conflict-loaded relationships with their teachers were less able to appropriately downregulate stress than students with proximally balanced relationships. It is important to note that as children's stress regulation is intricately linked with EF (Arnsten, 2009; Blair, Granger, & Peters Razza, 2005; Lupien et al., 2007), investigating the interplay of teacher stress with child stress responses and EF will be crucial. In sum, because children's self-regulatory processes and responses to stress experienced in the early years are malleable and likely to shape neural systems regulating the development of the hypothalamic–pituitary–adrenal axis, it is important to understand children's resilience to stress as well as failure to cope with challenges as they are encountered in the kindergarten and elementary classroom.

Conclusion

In support of our hypotheses, self-reported teacher stress predicted, at the trend level, changes in child EF from fall to spring of the kindergarten year. A curvilinear relation between teacher stress and child EF or classroom quality, however, could not be detected. The interaction of teacher stress with school-level poverty needs to be further investigated and has the potential to inform effective approaches to avoiding teacher burnout and supporting highly involved teachers serving low-income children. Furthermore, as we failed to find evidence that classroom quality as assessed by the CLASS mediated the relation between teacher stress and child EF, future research is needed to explore other possible mechanisms. Thus, although our findings are an exciting first step in understanding how teachers' well-being relates to child EF, more research is clearly needed.

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