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Can teacher-child relationships alter the effects of early socioeconomic status on achievement in middle childhood?☆

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ABSTRACT

Using data from the NICHD SECCYD (N = 1053), we used two-level hierarchical linear models with site fixed effects to examine whether teacher-child closeness and conflict moderated associations between two indicators of early socioeconomic status (maternal education and family income) and standardized measures of children's math and reading achievement at 54 months, 1st, 3rd, and 5th grades. Children whose mothers had lower levels of education and conflictual relationships with teachers exhibited lower reading achievement, on average, across elementary school. At the same time, children with less educated mothers who experienced increases in teacher-child closeness and decreases in teacher-child conflict exhibited improvements in reading achievement across elementary school. Finally, low teacher-child closeness elevated the risk for poor math achievement posed by low family income. Implications for intervention design and development are discussed.

1. Introduction

Children born into poverty are more likely to begin formal schooling at risk for school failure and remain at risk for academic underachievement throughout elementary school (Rutter & Maughan, 2002; Sabol & Pianta, 2012). Accordingly, policymakers have highlighted the importance of closing income-based achievement gaps when children are young, through high-quality preschool or early elementary school (Reardon, 2011; Waldfogel, 2016). In response, researchers have sought to identify factors that promote school readiness and academic development for children born into families with low socioeconomic status (SES) (Raver et al., 2011). A number of research studies have found that relational factors in early and middle childhood, such as children's relationships with their teachers, may be critical for supporting academic achievement (McCormick, O'Connor, Cappella, & McClowry, 2013; O'Connor, 2010; Pianta & Stuhlman, 2004; Roorda, Koomen, Spilt, & Oort, 2011; Rudasill, 2011). In general, studies have found that children's academic skill development is supported – both concurrently and prospectively – through teacher-child relationships characterized by high levels of closeness and low levels of conflict (Baker, 2006; Hamre & Pianta, 2001; Maldonado-Carreño & Votruba-Drzal, 2011; McCormick & O'Connor, 2015).

The bulk of research on teacher-child relationships and achievement has examined these associations using either large samples made up primarily of middle and upper income students (e.g., Baker, 2006; Curby, Rimm-Kaufman, & Ponitz, 2009; O'Connor & McCartney, 2007; Roorda et al., 2011), or smaller, within-group samples of low-SES children (Hughes & Kwok, 2007;

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Liew, Chen, & Hughes, 2010; McCormick et al., 2013). Few studies have considered differences in associations for children from low and higher SES families and explicitly examined whether teacher-child relationship quality is a protective factor mitigating the elevated risk for poor academic outcomes faced by children from low SES families. Existing work suggests that high-quality teacher child relationships should benefit all students, regardless of SES (Roorda et al., 2011). Yet, when aiming to apply research findings to efforts to improve academic outcomes for low-income children, it can be more helpful to consider these associations in a risk and resilience framework, guided by ecological theory (Bronfenbrenner & Morris, 1998). In such a model, more so than examining simple associations between teacher-child relationships and academic outcomes, one would be interested in whether teacher-child relationship quality can protect against risk for poor outcomes posed by low SES. Without increased evidence for such a protective effect, it is unclear whether implementing interventions that aim to improve teacher-child relationship quality – spurred by a desire to close early income-based achievement gaps – will actually have the intended compensatory benefits for low-SES children.

In addition, when examining low-income samples, few studies have considered multiple components of family SES, such as maternal education and family income. Although these indicators do overlap with one another for certain families, they also have unique direct and interactive associations with achievement and teacher-child relationship quality (Bradley & Corwyn, 2002; El-Sheikh et al., 2013; Von Rueden, Gosch, Rajmil, Bisegger, & Ravens-Sieberer, 2006). Past studies have generally not found differential effects of teacher-child relationship quality on academic outcomes and learning behaviors (e.g., Cornelius-White, 2007; Garner & Waajid, 2008; Ladd & Burgess, 2001). Yet, prior work has not considered multiple components of SES, typically relying on indicators of free and reduced price lunch eligibility and/or a proxy for family income in their operationalization of SES. Failing to incorporate these distinctions in research studies may mask important implications for targeting and adapting educational programs and policies focused explicitly on teacher-child relationships in elementary school settings serving low-SES children (Harding, Morris, & Hughes, 2015).

Indeed, the components of SES are not perfectly correlated. For example, a family's head of household might be highly educated but have experienced a recent job loss and have a low income (Duncan & Magnuson, 2003, 2012). Exploring the separate components of SES is important because they can have unique relationships with particular developmental outcomes and can influence these outcomes through different processes (Hoff, Laursen, & Tardif, 2002). Indeed, Duncan and Magnuson (2003, 2012) have argued that a key limitation of research linking child SES to future outcomes is the dependence on a sole measure of socioeconomic status. It has only been through recent avenues that researchers have uncovered unique mechanisms explaining associations between differing components of SES (e.g., maternal education, family income) and children's outcomes in middle childhood and into adolescence and adulthood (Dahl & Lochner, 2012; Harding et al., 2015). For example, Gershoff, Aber, Raver, and Lennon (2007) have found that early family income relates to children's academic outcomes through mechanisms such as parental social-emotional competence and material hardship. In contrast, research by Magnuson (2007) suggests that early maternal education predicts children's early achievement through engagement in cognitively stimulating and in-home educational activities. Development of interventions to enhance student outcomes can be stifled when SES is only understood through one singular measure, or even a composite measure of maternal education and family income, because intervention resources may be limited such that they cannot be directed at multiple SES-related risk factors.

In considering these questions, it is particularly important to use rigorous longitudinal methods that allow researchers to look at both average and time-varying associations between SES, teacher-child relationship quality, and academic achievement as children move from infancy to early childhood, and into middle childhood. Accordingly, the current study will use a longitudinal framework to build on previous research and help elucidate whether teacher-child closeness and conflict do protect against or exacerbate the negative effects of two indicators of low SES – maternal education and family income – on standardized measures of children's math and reading achievement in middle childhood.

1.1. Socioeconomic status and academic achievement in a longitudinal framework

It is well established in the literature that low SES in early childhood – measured through indicators like family education and income (Duncan & Murnane, 2011)[1] – places children at-risk for poor achievement outcomes in early and middle childhood (Duncan & Magnuson, 2013a, 2013b; Herbers et al., 2012; Yoshikawa, Aber, & Beardslee, 2012). Emerging research suggests the importance of considering the role that very early SES plays in development. Indeed, children's experiences in infancy and early brain development (Blair & Raver, 2015; Luby et al., 2013) are critical factors in predicting future outcomes (Cohen, Janicki-Deverts, Chen, & Matthews, 2010; Duncan, Morris, & Rodrigues, 2011; Luo & Waite, 2005; Walker, Greenwood, Hart, & Carta, 1994). By measuring SES in infancy, researchers are able to isolate the exogenous effect of early SES, and limit challenges posed by disentangling it from future confounding variables in early and middle childhood.

Harding et al. (2015) note that human capital theories are particularly helpful for understanding the role of maternal education and family income in early academic skill development. These perspectives argue that maternal human capital – developed through higher education – provides the potential for a cognitive environment for a child that better supports early learning (Coleman, 1988). Mothers who have achieved higher levels of education (e.g., attaining a college degree) are better able to use their own cognitive skills in interactions (e.g., using higher levels of vocabulary, modeling positive educational behaviors) that promote their children's

[1] A third component of SES is typically assessed as the status of one's occupation, or level of employment (Duncan & Murnane, 2011). Given little information available about employment in the data used in this study, we do not discuss it explicitly. However, we certainly see understanding employment in greater detail as a direction for future research.

development. A recent study by Duncan, Magnuson, Kalil, and Ziol-Guest (2012) indicates that children in the United States whose mothers have a college degree score more than half a standard deviation higher on early standardized tests than children whose mothers have only a high school diploma.

Similarly, when families have higher incomes, they are able to invest more financially in their children's development, spending money on activities and care that are more likely to be associated with positive academic development (Bianchi, Cohen, Raley, & Nomaguchi, 2004; Kornrich & Furstenberg, 2013; Waldfogel, 2016; Ziol-Guest, Kalil, & DeLeire, 2004). Families with higher incomes are also less likely to experience parental stress (Hill, Morris, Gennetian, Wolf, & Tubbs, 2013) and material hardship (Duncan & Magnuson, 2013a, 2013b). Reardon (2011) has found that, nationally, the gap separating the standardized test scores of children in the 90th percentile of family income and the 10th percentile of family income is 1.25 standard deviations, which is 40% larger than this gap was in 1970. In addition, a recent study by Kornrich and Furstenberg (2013) found that across the period from 1972 to 2007, families' spending on children – particularly on activities thought to relate to academic development – increased substantially among high-income families.

These linkages are concerning because early academic skills are highly predictive of future academic outcomes (Duncan et al., 2007), as well as indicators of educational attainment such as high school completion (Casillas et al., 2012; Hernandez, 2011). Yet, given a number of political and economic factors, it is likely quite difficult to directly address risks posed by SES through unconditional transfers of direct financial support. Researchers interested in promoting resilience among low-income children have looked toward educational interventions as one potential avenue to decrease achievement gaps and promote school and life success across all stages of development (Holmes & Zajacova, 2014; Reardon, 2013).

1.2. Teacher-child relationships and academic achievement

One possible direction for intervention aimed at reducing SES-based achievement gaps is to improve children's relationships with their elementary school teachers through a program that targets emotional support and relationship quality (CASEL, 2013; Driscoll, Wang, Mashburn, & Pianta, 2011; Pianta, Hamre, & Allen, 2012). In the literature, teacher-child relationships have been defined as bidirectional, interpersonal exchanges that take place in proximal microsystems, typically elementary school classrooms (Bronfenbrenner & Morris, 1998; Pianta, 1999). Attachment theorists (e.g., Verschueren & Koomen, 2012) propose that children who experience positive teacher-child relationships, characterized by low levels of conflict and high levels of closeness, are able to rely on teachers as a secure base and a resource for actively exploring the school environment (O'Connor & McCartney, 2007). When children experience high-quality relationships with teachers, they are motivated to actively and appropriately engage in the classroom, thus supporting their academic development (Sabol & Pianta, 2012).

There is a growing evidence base demonstrating correlations between teacher-child relationship closeness and conflict and children's academic achievement (Burchinal, Peisner-Feinberg, Pianta, & Howes, 2002; Pianta, Nimetz, & Bennett, 1997; Pianta & Stuhlman, 2004). Researchers have also considered longitudinal analyses when examining these associations in order to understand concurrent associations between teacher-child closeness and conflict and achievement, as children experience qualitatively different relationships with teachers across elementary school (Maldonado-Carreño & Votruba-Drzal, 2011). It is important to use longitudinal analyses to consider concurrent effects of teacher-child closeness and conflict because children will likely experience qualitatively different relationships with teachers as they move through elementary school (Maldonado-Carreño & Votruba-Drzal, 2011). For example, as children age and transition to the later elementary school grades (e.g., third through fifth grade), they change teachers for different subjects, experience larger class sizes, and have fewer opportunities for one to one interactions with teachers (Rimm-Kaufman & Pianta, 2000). Indeed, empirical evidence suggests that teacher-child relationship quality declines over time in elementary school (Jerome, Hamre, & Pianta, 2009; O'Connor & McCartney, 2007; Pianta & Stuhlman, 2004). In addition, as children move through middle childhood, additional factors, such as relationships with peers, become increasingly important for children's development (Brechwald & Prinstein, 2011). Thus, questions remain about the continuing power of the teacher-child relationship across the course of middle childhood.

A recent study by Maldonado-Carreño and Votruba-Drzal (2011) used individual growth models to examine associations between teacher–child relationships (operationalized as a composite of closeness and conflict) and children's math and reading achievement within a large national sample. Although the authors of this study found no significant associations between change in teacher–child relationship quality and change in standardized achievement scores in elementary school, they did detect significant, positive associations between teacher-child relationship quality and teacher reports of students' academic achievement on average. Notably, however, this study did not consider closeness and conflict as separate dimensions, thus masking potential nuance in interpreting these findings. Moreover, Maldonado-Carreño and Votruba-Drzal (2011) found effects of teacher-child relationship quality on teacher reports of academic achievement, but null effects of teacher-child relationships on standardized measures of achievement. Yet, it is important to address biases posed by using a teacher report of relationship quality to predict a teacher report of a child achievement outcome (Shadish, Cook, & Campbell, 2002).

In such an analytic framework, a significant finding can actually reflect rater effects or mono-method bias (Shadish et al., 2002). For example, because teachers are more likely to have high-quality relationships with children who are behaviorally regulated, they may perceive those children to have higher levels of academic skills than less behaviorally regulated children (O'Connor & McCartney, 2007; Rudasill, Reio, Stipanovic, & Taylor, 2010). Moreover, it should be noted that previous studies have shown small to negligible effects of teacher reports of student-teacher relationship quality on standardized achievement test results in non-risk samples (e.g., Baker, 2006; Buyse, Verschueren, Verachtert, & Van Damme, 2009). Given limitations of prior research studies, McCormick and O'Connor (2015) used individual growth models to consider teacher-child closeness and conflict as separate

dimensions of teacher-child relationship quality in predicting standardized assessments of math and reading achievement in middle childhood within a national sample. Results revealed positive associations between increases in teacher-child closeness and improvements on a standardized measure of reading achievement. Although this study and Maldonado-Carreño and Votruba-Drzal's (2011) study both included measures of child SES as covariates in models, neither explicitly considered how associations might substantively differ for children from low and high SES families.

Taken together, findings from extant research point to the importance of examining teacher-child closeness and conflict as separate dimensions of relationship quality, utilizing longitudinal methods to examine change over time, and assessing outcomes with standardized measures of achievement. The next step in this research then is to go beyond establishing associations and determine whether teacher-child relationship quality can play a protective role in reducing risk for poor academic outcomes.

1.3. Moderation of teacher-child relationships and SES in predicting academic achievement

The literature has consistently hypothesized that teacher-child relationship quality is likely most critical for children who are at the highest risk for poor outcomes (Baker, 2006; Burchinal et al., 2011; Elledge, Elledge, Newgent, & Cavell, 2015; Roorda, Verschueren, Vancraeyveldt, Van Craeyevelt, & Colpin, 2014; Silver, Measelle, Armstrong, & Essex, 2005). Indeed, Hamre and Pianta (2001) describe this theory as the academic-risk hypothesis, suggesting that the teacher-student relationship is important for the learning process and outcomes of students who are at risk for school failure, a group that includes students with low SES. In a broad sense, within the academic risk hypothesis, these students have the most to gain, and the most to lose. When a child from a low SES family experiences a close relationship with his or her teacher, that process should benefit the student more than it would for a child from a higher SES family. In contrast, if the same low SES child experiences a conflictual relationship with his or her teacher, the process will likely have a more negative effect than it would for his or her higher SES peer. Aligned with the academic risk hypothesis, bioecological theory would suggest that teacher-child relationship quality (i.e., closeness and conflict) and SES have independent and interactive influences on children's development that differentiate the negative influence of low SES on academic outcomes (Bronfenbrenner & Morris, 1998).

In this way, the bioecological model suggests that an academic risk framework is helpful for exploring how risk for poor academic achievement in elementary school posed by low SES may be moderated by protective factors like low teacher-child conflict, or high teacher-child closeness. For example, as argued by Harding et al. (2015), children with low maternal education are less likely to engage in cognitively stimulating interactions at home, thus putting them at risk for poorer reading and math achievement in early schooling. However, if they are then paired with a teacher with whom they have a close relationship wherein they engage in high-quality interactions, that in-school process can counteract their lack of this process at home. In contrast, if children are paired with a teacher with whom they have high levels of conflict, such negative interactions may not promote greater cognitive development at school, potentially putting them at even higher risk for poor achievement. Similarly, children who come from a low-income home are at heightened risk for poor achievement because, relative to more affluent families, their parents do not have as many financial and human capital resources to invest directly in their development (Harding et al., 2015). When a child from a low-income household has a close teacher-child relationship, his or her teacher might make greater investments in the child in school. For example, the teacher may be more likely to ensure that the child has sufficient materials to use in the classroom, and receives added attention in learning academic tasks. If the child has a conflictual relationship with the teacher, this type of investment by the teacher is less likely.

Some research has considered the effects of SES on teacher-child relationship quality. In general, children from low SES families tend to have more conflictual and less close relationships with their teachers in elementary school (e.g., Murray & Zvoch, 2011, where SES was conceptualized using school-level measures of eligibility for free and reduced price lunch). At the same time, however, there is within-group research to suggest that teacher-child relationship quality is particularly salient for children from low-income families, where low-income was defined by family income and eligibility for free or reduced lunch (Hughes, Wu, Kwok, Villarreal, & Johnson, 2012). For example, in a study of low-income, urban children from Head Start programs, close relationships with teachers in kindergarten and first grade were associated with higher scores on standardized tests of achievement in first grade (Esposito, 1999). In addition, researchers have noted that those children who are lower-achieving in early elementary school – a factor notably confounded with SES – appear to benefit more from high-quality teacher-child relationships in terms of achievement than students with higher baseline academic skills (Hughes & Kwok, 2007; Liew et al., 2010).

A few studies have explicitly considered the academic risk hypothesis. In their meta-analysis of 99 studies examining teacher relationship quality, Roorda et al. (2011) did find some correlational evidence for this theory. Across studies, the authors found that associations between positive and negative teacher-child relationships and student engagement were medium to large, whereas associations between positive and negative teacher-child relationships and achievement were small to medium. Additionally, associations between teacher-child relationship quality and learning behaviors were larger in samples with more students with low SES. Other studies suggest weaker evidence for the academic risk hypothesis (Cornelius-White, 2007; Garner & Waajid, 2008; Ladd & Burgess, 2001). Yet, few of these studies have examined teacher-child conflict and closeness as separate dimensions when predicting standardized assessments of math and reading achievement. Moreover, more research is needed to determine how distinct components of SES (maternal education and family income) relate to unique protective effects of teacher-child closeness and conflict on academic achievement in elementary school. Increased knowledge of any protective effect would serve to inform thinking related to the power of relationship-based interventions to enhance academic outcomes for students who experienced low SES early in life, and the particular components of early SES that are especially important to consider. Given a large and economically diverse sample, coupled with rich measures of early indicators of SES, as well as teacher-child closeness and conflict and academic achievement

across elementary school, the current study is well poised to provide this evidence.

1.4. The current study

In the current study, we used data from the NICHD Study of Early Child Care and Youth Development (SECCYD) to examine linkages between two indicators of socioeconomic status in infancy (maternal education and family income) and children's academic outcomes in middle childhood. We then sought to determine whether teacher-child relationship closeness and conflict, measured when the children were in elementary school, exacerbated or protected against any associations between indicators of SES and standardized assessments of math and reading achievement in middle childhood. Specifically, we asked the following research questions: (a) Do low maternal education and family income predict math and reading achievement in elementary school?; (b) Do average and time-varying levels of teacher-child closeness and conflict moderate associations between low maternal education and academic achievement?; and (c) Do average and time-varying levels of teacher-child closeness and conflict moderate associations between low family income and academic achievement? By understanding the potentially protective role of teacher-child relationship quality on children's academic achievement in elementary school for children from different types of low-SES families, this study has the potential to inform future theory, intervention development, targeting and scaling.

2. Method

2.1. Participants

This study was conducted with data from the first two phases of the NICHD SECCYD, a prospective study of children from birth through adolescence. In 1991, researchers visited 8986 women who had recently given birth in or near Little Rock, AR; Irvine, CA; Lawrence, KS; Boston, MA; Philadelphia, Pittsburgh, PA; Charlottesville, VA; Morganton, NC; Seattle, WA; and Madison, WI. Of 5416 families who were eligible for the study (i.e., mother healthy, over 18 years of age, and conversant in English; infant a singleton and healthy; family not planning to move within the next year and living in a neighborhood considered safe for visits), researchers called 2352 using a conditional random sampling method that ensured the sample was diverse and representative of the population with regard to ethnicity, education, and family structure. A total of 1364 mothers and children enrolled in the study (NICHD Early Child Care Research Network, 1997). Child-level demographic information is presented in Table 1. Data on school type (e.g., elementary, middle) were not available. However, given research showing that over 95% of elementary schools include fifth grade, we assume that the large majority of students in fifth grade continued to attend an elementary school. Ninety-six percent of first grade teachers were female; information on teacher gender was not available in third and fifth grade. Across grades, the large majority of teachers were White (92%).

2.2. Measures

2.2.1. Teacher-child relationships

The fifteen item Student-Teacher Relationship Scale (STRS; Pianta, 2001) was used to assess teacher perceptions of the quality of the teacher-child relationship in first, third, and fifth grade. Using a 5-point Likert scale that ranged from “1 (*definitely does not apply*)” to 5 “(*definitely applies*)”, teachers rated how applicable statements were to their current relationship with a particular child. The items are based on attachment theory and the Attachment Q-Set (Waters & Deane, 1985). The STRS has been widely used in studies with preschool and elementary school children. It is associated with children's and teachers' classroom behaviors and correlates with observational measures of teacher-child relationship quality (e.g., Howes & Ritchie, 1999). Additionally, STRS scores correlate with Attachment Q-Set ratings of teachers and students such that higher STRS scores are associated with more secure relationships

Table 1
Sample demographic characteristics.

Demographic characteristic	Percent/mean (SD)
Child female	48.28%
Child White	80.41%
Child Black	12.91%
Child Hispanic	6.09%
Child other race	1.98%
Child Asian/Pacific Islander	4.70%
Maternal education at 1 month: less than HS	10.20%
Maternal education at 1 month: HS diploma	21.06%
Maternal education at 1 month: some college	33.38%
Maternal education at 1 month: 4 year college graduate	35.63%
Mother married at 1 month	77.01%
On public assistance at 1 month	11.57%
Income to needs ratio at 1 month	3.59 (3.17)

Note: $N = 1053$.

(Howes & Ritchie, 1999).

This scale contains two subdimensions: closeness and conflict. The closeness subscale consists of 8 items and is an index of the amount of warmth and open communication present in the relationship (e.g., "I share an affectionate, warm relationship with this child"). The conflict subscale consists of 7 items and measures the extent to which the relationship is marked by antagonistic, disharmonious interactions (e.g., "This child and I always seem to be struggling with each other"). Cronbach's αs were 0.94 for conflict at all three time points, compared with 0.93 in previous studies (Hamre & Pianta, 2001, 2005). In the current study, Cronbach's αs for closeness ranged from 0.88 to 0.91 across time points, in comparison with an alpha of 0.86 in a previous study (Hamre & Pianta, 2001). To operationalize the variables for closeness and conflict we calculated a sum of the individual items for each subscale (closeness scores, 8–40; conflict scores, 7–35). The correlations observed between closeness and conflict in the current study were low to moderate ($r = -0.28$ in first grade, $r = -0.35$ in third grade, and $r = -0.32$ in fifth grade). In addition, prior research has found associations between teacher-child conflict in kindergarten and math and language arts report card grades from first grade to eighth grade (Hamre & Pianta, 2001). Past validity studies have suggested that higher conflict in the teacher-child relationship in kindergarten was related to lower report card grades in both math and language later in elementary school. However, closeness in kindergarten was related to positive work habits, as indicated on report cards, from first grade through fourth grade (Hamre & Pianta, 2001).

2.2.2. Math and reading achievement

Reading and math achievement were assessed with the Woodcock–Johnson Psycho-Educational Battery (WJ–R; Woodcock & Johnson, 1989), administered in first, third, and fifth grades by field interviewers. We used W ability scores to examine change over time for two subscales: Letter–Word Identification (reading achievement) and Applied Problems (math achievement). W scores are a special transformation of the Rasch Ability Scale with mathematical properties that facilitate the interpretation of test performance and make it easier to document change over time. W scores provide a common scale of equal-interval measurement that represents both a person's ability and the task difficulty. The W-scale for each test is centered on a value of 500, which has been set to approximate the average performance at age 10 years, 0 months. The W score for any cluster is the average W score for the tests included in the cluster. The developers of the WJ argue that the W score can be considered a growth scale. Notably, we also used assessments of the WJ skills at 54 months to control for children's academic achievement prior to the start of elementary school. The Letter-Word Identification subscale consists of 57 items, with higher values indicating better reading identification skills and word decoding. The Applied Problems subscale includes 60 items with higher scores indicating better skills to analyze and solve mathematical problems.

The WJ–R is a nationally normed and widely used achievement test with demonstrated internal consistency. Average internal consistency from first through fifth grades in the NICHD sample is 0.90 for Letter–Word Identification, and 0.83 for Applied Problems (Duncan et al., 2007). Further, previous studies have also utilized subscales of the WJ as indicators of reading and math achievement. These studies have indicated associations between achievement, as measured through the WJ, and family economic status, parental education, and teacher-child relationships (Burchinal et al., 2002; Davis-Kean, 2005; Dearing, McCartney, & Taylor, 2009). Moreover, Schrank, McGrew, and Woodcock (2001) have shown that the WJ subscales demonstrate significant correlations with a host of other assessments of early skills, such as the Wechsler Preschool and Primary Scale of Intelligence-Revised (Wechsler, 1989), the Wechsler Intelligence Scale for Children – Third Edition (WISC; Wechsler, 1991), and the Stanford-Binet Intelligence Scale – Fourth Edition (Thorndike, Hagen, & Sattler, 1986).

2.2.3. Child characteristics

Child-level demographic characteristics were included as covariates in models. We used child grade at the time of assessment as a proxy for age given that age and grade were highly correlated ($r = 0.97$). All child demographic data, other than age, were collected at baseline, or when the child was 1 month old. We included gender as a dummy variable such that 1 = female, 0 = male. Child race was operationalized with dummy variables indicating whether the child was White or other race (reference group) or Black. We chose these racial categories given that there was quite a large proportion of White students, and Black students made up the second largest contingent of students (see Table 1 for specific information on demographics). Children who were Asian/Pacific Islander or Other Race were included in a much smaller category, labeled Other Race. In addition, because Hispanic designation is an ethnicity and is not mutually exclusive from race, a separate dummy variable was included to indicate whether the child was Hispanic or not.

2.2.4. Family characteristics

We also considered family characteristics in models as predictors of interest (e.g., low maternal education, low family income) or covariates. Family demographic data were collected at baseline, or when the child was 1 month old. Mother's education was represented by a dummy variable indicating whether the mother had a high school education or lower (less than college degree = 1; college degree or more = 0). Family income was represented as a dummy variable wherein 1 = family income < 200% of the poverty level and 0 = family income > 200% of poverty level. There were three reasons we chose to measure SES when children were 1 month old, rather than to consider a later operationalization of the SES components. First, methodologically, it is important to establish temporal precedence, where the main risk factors (i.e., indicators of SES) are measured prior to the outcomes and the moderators of interest. In addition, the most complete data are available at the baseline data collection period and adequately allow us to describe early SES for the broadest range of study participants. Theoretically, a large body of prior research suggests the importance of very early SES for understanding children's later academic outcomes, noting that children's development in infancy and early brain development (Blair & Raver, 2015; Luby et al., 2013) during this time period are critical factors for future outcomes

(Cohen et al., 2010; Duncan et al., 2011; Luo & Waite, 2005; Walker et al., 1994). Given that this early time point is quite salient for future academic outcomes, coupled with the methodological importance of establishing temporal precedence, the earliest SES time point was determined to be an optimal one to include in the study. However, we have also considered the correlation between SES indicators at 1 one month and 36 months and found that the correlations were > 0.80.

Dummy variables indicating whether the child's mother was married (1 = married; 0 = not married) and whether the mother worked full or part-time (1 = works full or part time; 0 = does not work outside the home) were also included as covariates. In addition, receipt of public assistance reflected whether mothers reported receiving food stamps, aid to families with dependent children, or WIC (receipt of aid = 1; no receipt of aid = 0).

2.3. Analytic approach

2.3.1. Missing data

As discussed earlier, analyses for the current study relied on outcomes collected in the first, third and fifth grade. We included the 1053 children and families (of the original 1364 enrolled in the study) who had data for the outcomes for at least one time point. In the sample consisting of non-attriters, the amount of missing data prior to multiple imputation ranged from 0 to 12%. Specifically, there were no missing data on demographic characteristics or the indicators of SES, as these were assessed at the baseline time point. Teacher-child closeness and conflict were missing at rates of 6%, 8%, and 12% in first, third, and fifth grade, respectively. Literacy and math skills were missing at rates of 0%, 2%, 3%, and 4% at 54 months, first, third, and fifth grade, respectively. There were a maximum of 3159 cases (person-periods) in the absence of missing data. The large majority of students within the study sample had information on all three time points – 94% had data on all three times points, 3% of students were missing two time points of data, and 3% of students were missing 1 time point of data. In order to recover lost subjects and cases, we used multiple imputation (MI; Rubin, 1987), imputing ten separate datasets by chained equations using SAS PROC MI in SAS version 9.3 (Royston & White, 2011; Van Buuren, Boshuizen, & Knook, 1999). All of the predictor and outcome variables used in predictive models were included in the imputation procedure. Proper inference for the likelihood-based models relies on the assumption that data were Missing at Random (MAR; Rubin, 1987). We examined the research questions for the current study using both a listwise deletion procedure and the findings aggregated from the multiply imputed samples for the sample of 1126 subjects.[2] We present the findings from the multiple imputation procedure, as they did not differ substantially from the results of the listwise deletion analysis.

2.3.2. Multi-level modeling

Multi-level modeling was used to examine the main research questions for the current study. Hierarchical linear modeling allows one to model change over time in an outcome with repeated measures (Raudenbush & Bryk, 2002; Singer & Willett, 2003). We fitted all models with SAS PROC MIXED and used grade as a metric of time (Singer & Willett, 2003), centering the grade variable in fifth grade (by subtracting 3 from each time point indicator) so that the intercept would represent the math and reading achievement levels when children were at the end of middle childhood. All models adjusted for the level of the outcome variable measured when children were 54 months old (i.e., pre-elementary school). This allowed us to examine how teacher-child closeness and conflict related to math and reading achievement in elementary school, adjusting for the level of academic skills children had when they began school.

In all analyses used to answer the main research questions for the study, repeated measures were nested in students, who were nested in sites. The intraclass correlation indicating the level of variation between children was substantial: 65.27% of variation in math achievement was observed to be between-child, and 64.63% of variation in reading achievement was between-child. In contrast, the between-site variation was quite small and consistent across study years: 0.49% for math achievement and 0.38% for reading achievement. The remaining variation for each of the outcomes was observed to be within-child, or explained by children's individual trajectories. We used a likelihood ratio test to compare a two-level unconditional growth model (Level 1 = repeated measures; Level 2 = students) to a three-level unconditional growth model in predicting math achievement (Level 1 = repeated measures; Level 2 = students; Level 3 = site) and found a significant improvement in model fit ($\chi^2 = 908.12$, $p < 0.01$). We also found reductions in the AIC between the two-level unconditional (AIC = 23,587.65) and three-level unconditional (AIC = 22,682.69) growth models. In line with recommendations from Kwok, West, and Green (2007), Full Information Maximum Likelihood (FIML) was used to estimate this likelihood ratio comparison. We then compared the three-level model to a two-level model with site fixed effects to account for mean differences in the outcome between sites, and observed an additional statistically significant improvement ($\chi^2 = 14.64$, $p < 0.05$) and further small reduction in the AIC (22,670.51). Thus, given the complexity of the model, we decided to use the more parsimonious two-level model with site fixed effects to account for potential site level differences in the outcomes. The decision to use the two-level model with site fixed effects aligns with a recent study by Wu, Kwok, and Willson (2014) demonstrating that model fit and estimation of study parameters can be improved by including relevant higher-level predictors to lower level models.

When running models to estimate parameters of interest and variance components, we used restricted maximum likelihood estimation (REML). REML is similar to maximum likelihood estimation but uses an unbiased estimator considered to be more conservative (Fitzmaurice, Laird, & Ware, 2004). In addition, we included a random slope for time (i.e., Grade), and allowed for a correlation between the random intercept and random slope (ρ). The unconditional growth model is as follows:

[2] We do not include attriters prior to elementary school in any analyses.

$$\text{Level 1: } Yti = \beta 0i + \beta 1i(\text{Grade-3})ti + \varepsilon ti$$

$$\text{Level 2: } \beta 0ij = \gamma 0 + ai + r0i$$
$$\beta 1ij = \gamma 1i + r1i$$

In the Level 1 model, *Yti* is the achievement at time *t* of student *i*. β0*i* is the achievement score in first grade for student *i*. β1*i* is the growth trajectory for student *i* and εti is a random error term that represents the residual (or unexplained) variation in the outcome. In the level 2 model, the students' achievement score in first grade is modeled as a function of the mean achievement score in first grade (γ0), a site fixed effect (*ai*) that adjusts for time-invariant characteristics related to site membership, and a random effect (*r*0*i*) that allows the intercept to vary randomly around the student (Level 2) mean. The growth rate in achievement for student *i* is modeled as a function of the mean growth in achievement (γ1*i*) and a random effect that allows students' trajectories to vary randomly around the student mean trajectory (*r*1*i*). These analyses assume that the residuals at Level 1 and Level 2 are identically distributed normal random variables with a mean equal to zero and a variance of σ2. In addition, because tests of model specifics provided empirical support for a correlation between the random slope and random intercept, we allowed those random effects to covary in all models. When examining model iterations, we found that time was non-linear but followed a quadratic pattern. We also allowed for a quadratic term for time in all models.

2.3.3. Research question 1

First, we used separate multilevel models to examine the associations between indicators of low socioeconomic status when the child was 1 month old (low maternal education and low family income) and standardized measures of math and reading achievement in elementary school. These models adjusted for the child and family characteristics identified earlier, which were collected at baseline.

2.3.4. Research questions 2 and 3

Second, we examined two sets of models – one set examining low maternal education and a second set considering low family income – to answer the main research questions for the study. We first created variables to operationalize closeness and conflict at both Level 1 and Level 2. Level 1 variables are predictors of the intercept, or between-student differences, and Level 2 variables are predictors of the slope, or within-student differences. In other words, time-invariant student means of closeness and conflict represented students' average level of closeness and conflict across elementary school. We centered the time-invariant student means around the sample mean and included those variables as predictors at Level 2. Next, we created time-varying predictors for closeness and conflict centered around the individual students' mean across the full study (i.e., person-centered means). A positive effect of this time-varying predictor represents an increase over and above a student's average level of closeness or conflict across elementary school being associated with a higher achievement score than would be predicted without the gain in the teacher-child relationship quality. Because we found that the correlation between the average levels of closeness and conflict was low to moderate ($r = -0.28$ in first grade, $r = -0.35$ in third grade, and $r = -0.32$ in fifth grade), we decided to include both closeness and conflict as predictors in the same model. In addition to controlling for the level of math or reading achievement at 54 months, models continued to adjust for potential confounding covariates.

Finally, to answer the core research questions for the study, we tested whether effects of low maternal education (in the first set of models), and low family income (second set of models) on children's reading and math achievement differed by average and time-varying levels of teacher-child closeness and conflict. We operationalized this model by creating within-level and cross-level interactions between the SES indicators and the closeness and conflict variables. The interactions of low maternal education/low family income and the average effects of teacher-child closeness and conflict were added to the Level 2 model in separate iterations. Cross-level interactions of SES (Level 2) and closeness and conflict (Level 1) in models predicting math and reading achievement were simultaneously examined. Again, all models adjusted for the linear and quadratic effects of time (measured as grade).

3. Results

3.1. Descriptive statistics

Means, standard deviations, and bivariate correlations for study variables of interest are presented for the full sample in Table 2. Within the full study sample, there were 426 children whose mothers reported low levels of education (e.g., less than a college degree) and 328 with low family incomes (e.g., < 200% of the poverty level). In general, study participants' reading and math achievement scores increased over time whereas teacher-child closeness decreased over time. In contrast, teacher-child conflict increased between first and third grade and then decreased in fifth grade by a nominal amount.

There were notable correlations to consider between the indicators of SES, children's academic skills, and the quality of their teacher-child relationships. First, the indicators of SES were both moderately and positively correlated with one another. However, they appeared to represent different constructs, given that the bivariate correlation between them was 0.43. In addition, low family income and low maternal education were consistently negatively correlated with both math and reading skills, and also consistently negatively correlated with teacher-child closeness and positively associated with teacher-child conflict. The magnitude of the correlations, however, was larger for academic skills than it was for dimensions of teacher-child relationship quality. Taken together, descriptive statistics appeared to confirm earlier literature suggesting that children from low SES families are at higher risk for low

Table 2
Descriptive statistics for variables of interest.

		Descriptives		Bivariate correlations								
		% or mean	SD	1.	2.	3.	4.	5.	6.	7.	8.	9.
1.	Female	0.48	0.50	–								
2.	Mother has h.s. education or lower	0.31	0.46	−0.09	–							
3.	Family income 200% of poverty or less	0.24	0.43	−0.01	0.43	–						
4.	Receipt of public assistance	0.12	0.32	0.05	0.33	0.52	–					
5.	Child Black	0.13	0.34	−0.02	0.22	0.35	0.40	–				
6.	Child Hispanic	0.06	0.24	−0.04	0.09	0.10	0.02	−0.04	–			
7.	Mother is married	0.61	0.49	−0.03	−0.30	−0.44	−0.52	−0.36	−0.08	–		
8.	Mother works part- or full-time	0.56	0.50	0.02	−0.10	−0.11	−0.21	−0.08	0.05	0.03	–	
9.	HOME score at 54 months	45.99	5.46	0.05	−0.41	−0.47	−0.43	−0.39	−0.11	0.04	0.15	–

		Descriptives		Bivariate correlations													
		% or mean	SD	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.
10.	Reading skills at 54 months	99.32	13.86	0.43	–												
11.	Reading skills in first grade	452.96	24.11	0.35	0.55	–											
12.	Reading skills in third grade	493.86	18.73	0.36	0.49	0.75	–										
13.	Reading skills in fifth grade	510.12	17.52	0.38	0.48	0.67	0.86	–									
14.	Math skills at 54 months	103.27	15.89	0.44	0.58	0.46	0.47	0.45	–								
15.	Math skills in first grade	470.99	15.74	0.35	0.47	0.55	0.50	0.49	0.59	–							
16.	Math skills in third grade	497.33	13.19	0.39	0.42	0.52	0.59	0.58	0.53	0.67	–						
17.	Math skills in fifth grade	509.83	12.85	0.38	0.41	0.48	0.54	0.56	0.54	0.69	0.76	–					
18.	Teacher-child closeness in first grade	33.96	5.04	0.20	0.08	0.13	0.06	0.07	0.14	0.09	0.10	0.06	–				
19.	Teacher-child closeness in third grade	33.08	5.15	0.17	0.09	0.07	0.05	0.05	0.11	0.08	0.08	0.06	0.36	–			
20.	Teacher-child closeness in fifth grade	31.85	5.37	0.15	0.01	−0.05	−0.03	−0.03	0.08	0.01	0.04	0.04	0.29	0.33	–		
21.	Teacher-child conflict in first grade	10.92	5.17	−0.19	−0.17	−0.19	−0.17	−0.14	−0.19	−0.19	−0.15	−0.16	−0.28	−0.12	−0.09	–	
22.	Teacher-child conflict in third grade	11.62	6.03	−0.18	−0.13	−0.15	−0.17	−0.17	−0.22	−0.17	−0.17	−0.19	−0.16	−0.35	−0.09	0.47	–
23.	Teacher-child conflict in fifth grade	11.43	5.74	−0.27	−0.13	−0.10	−0.14	−0.15	−0.20	−0.14	−0.14	−0.18	−0.14	−0.15	−0.32	0.43	0.41

Table 3
Individual growth models predicting reading achievement from teacher-child closeness and conflict, moderated by socioeconomic status.

	Panel 1		Panel 2		Panel 3	
	B	*SE*	*B*	*SE*	*B*	*SE*
Fixed effects						
Intercept	445.69**	4.53	436.96**	6.23	436.45**	6.27
Linear effect for time	4.17*	0.71	4.43**	0.78	4.39**	0.78
Quadratic effect for time	− 12.33**	0.32	− 12.29**	0.35	− 12.30**	0.34
Reading skills at 54 months	0.45**	0.04	− 0.45**	0.04	0.44**	0.04
Math skills at 54 months	0.22**	0.04	0.21**	0.04	0.21**	0.04
Female	− 1.56†	0.88	− 1.52	0.91	− 1.61†	0.94
Mother has h.s. education or lower	− 3.27**	1.12	− 2.70*	1.18	− 2.66*	1.17
Family income 200% of poverty or less	− 1.91	1.22	− 1.17	1.28	− 1.24	1.28
Receipt of public assistance	− 1.04	1.82	− 1.47	1.90	− 1.00	1.91
Child Black	− 5.51**	1.63	− 2.97	1.76	− 2.76	1.77
Child Hispanic	2.56	1.96	1.87	2.00	1.49	2.00
Mother is married	1.11	1.30	0.71	1.35	0.68	1.36
Mother works part- or full-time	− 1.25	1.01	− 1.22	1.03	− 1.19	1.03
HOME score at 54 months	0.23*	0.11	0.24*	0.11	0.25*	0.12
Between-child effects						
Teacher-child closeness			− 0.31*	0.15	− 0.21	0.15
Teacher-child conflict			− 0.36*	0.14	− 0.22	0.15
Teacher-child closeness × low maternal education			0.40	0.26	–	–
Teacher-child conflict × low maternal education			− 0.38*	0.18	–	–
Teacher-child closeness × 200% of poverty or less			–	–	0.01	0.25
Teacher-child conflict × 200% of poverty or less			–	–	− 0.04	0.22
Within-child effects						
Teacher-child closeness			0.12†	0.07	− 0.01	0.07
Teacher-child conflict			0.02	0.08	− 0.04	0.08
Teacher-child closeness × low maternal education			0.26*	0.12	–	–
Teacher-child conflict × low maternal education			− 0.28*	0.13	–	–
Teacher-child closeness × 200% of poverty or less			–	–	0.11	0.12
Teacher-child conflict × 200% of poverty or less			–	–	− 0.11	0.13
Random effects and fit statistics						
Random child-level intercept	152.08**	10.03	144.43**	10.34	145.54**	10.42
Random slope for time	50.08**	4.12	48.26**	4.50	49.06**	4.51
Correlation between intercept and slope	12.73*	4.96	11.07*	5.25	11.65*	5.30
Residual error	60.54**	2.92	61.10**	3.26	60.91**	3.25
AIC	22,379.22		20,109.93		20,118.14	
Log likelihood	− 11,163.61		− 10,019.96		− 10,024.07	

Note.
** $p < 0.01$.
* $p < 0.05$.
† $p < 0.10$.

teacher-child relationship quality and poor achievement throughout middle childhood. The differences, however, varied by SES component and outcome of interest.

3.1.1. Unconditional growth model

The results of two-level unconditional growth models – considering both linear growth and quadratic acceleration/deceleration – showed significant grand mean outcome scores in fifth grade for math achievement ($\gamma = 512.27$, $p < 0.01$) and reading achievement ($\gamma = 514.33$, $p < 0.01$). The effects of time and deceleration can be interpreted in fifth grade (when time is equal to 0). In fifth grade, the slope of the line predicting math achievement was 4.22 ($p < 0.01$), while the change in the slope was equal to − 12.26 ($p < 0.01$). This suggests that the rate of change slowed considerably by fifth grade. For the reading outcome, the effect of time is equal to 5.79 ($p < 0.01$) with a deceleration of 6.91 ($p < 0.01$). In fifth grade, the slope of the line predicting reading achievement was 5.79, and the change in the slope was equal to negative 6.91. Furthermore, variance component estimates demonstrated (a) significant variation around the Level 2 intercept (math achievement; $\tau = 116.14$, $p < 0.01$; reading achievement; $\tau = 256.77.77$, $p < 0.01$). There was also a significant random effect for grade in both the math ($\tau = 8.51$, $p < 0.01$) and reading ($\tau = 50.80$, $p < 0.01$) achievement models, and significant correlations between the random slope and intercept in both models (math, $\tau = -10.36$, $p < 0.01$; reading, $\tau = -8.99$, $p < 0.01$).

3.1.2. Research question 1

Results for RQ 1 are presented in the first panel in Tables 3 (reading achievement) and 4 (math achievement). We found that low maternal education when children were one month old ($B = -3.27$, $p < 0.01$) predicted lower overall levels of reading skills in fifth grade, adjusting for covariates. We did not find evidence that family income predicted reading achievement, adjusting for the

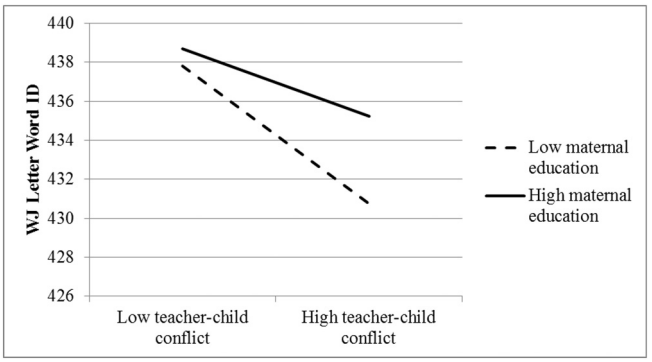

Fig. 1. Average associations between low maternal education and reading achievement, moderated by teacher-child conflict.
Note: Low teacher-child conflict is defined as 1 SD below the mean and high teacher-child conflict is defined as 1 SD above the mean. Estimates are adjusted for covariates.

other indicators of SES. In terms of math achievement, we also found that only low maternal education ($B = -1.30$, $p < 0.05$) predicted the achievement outcome when we controlled for covariates and other indicators of SES.

3.1.3. Research question 2

Given previous research (see McCormick & O'Connor, 2015) documenting effects of teacher-child relationship closeness and conflict on standardized assessments and teacher reports of math and reading achievement, we then tested variation in effects for indicators of SES. First, we considered variation in associations between teacher-child closeness and conflict and achievement, by low maternal education. We found that the average effect of teacher-child conflict moderated associations between low maternal education and reading achievement ($B = -38$, $p < 0.05$; E.S. = 0.21; see panel 2 in Table 3 and Fig. 1). Children from families with low maternal education and higher levels of teacher-child conflict exhibited lower reading achievement, on average, than similar children with lower levels of teacher-child conflict.

In addition, we found that the time-varying effects of teacher-child closeness ($B = 0.26$, $p < 0.05$; E.S. = 0.12) and conflict ($B = -0.28$, $p < 0.05$; E.S. = 0.18) moderated associations between low maternal education and reading achievement (See panel 2 in Table 3 and Fig. 2 for illustration of conflict effect). On average, the magnitude of the positive association between change in teacher-child closeness and change in reading achievement was larger for children with low maternal education. At the same time, the strength of the negative association between change in teacher-child conflict and change in reading achievement was also larger for children with low maternal education. In this way, teacher-child closeness appeared to protect against the negative effect of low maternal education and teacher-child conflict may have exacerbated the deleterious effect of low maternal education in predicting reading achievement. Notably, as illustrated in Table 4, there were no significant moderated effects for math achievement.

3.1.4. Research question 3

Second, we examined the moderating role of teacher-child closeness and conflict in explaining associations between low family income and achievement (panel 3 in Tables 3 and 4). In contrast to maternal education, we did not find any evidence that teacher-child relationship quality moderated associations between low family income and children's reading achievement in middle childhood. However, with respect to math achievement, we found evidence for one significant moderating effect. The time-varying effect

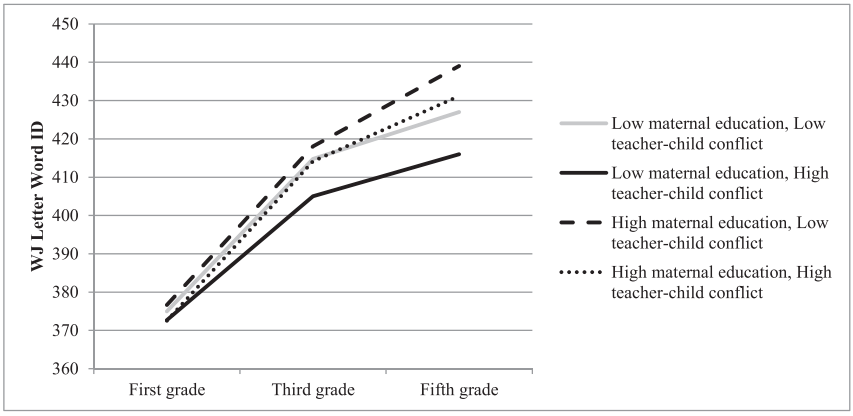

Fig. 2. Associations between low maternal education and reading achievement over time, moderated by teacher-child conflict.
Note: Low teacher-child conflict is defined as 1 SD below the mean and high teacher-child conflict is defined as 1 SD above the mean. Estimates are adjusted for covariates.

Table 4
Individual growth models predicting math achievement from teacher-child closeness and conflict, moderated by socioeconomic status.

	Panel 1		Panel 2		Panel 3	
	B	*SE*	*B*	*SE*	*B*	*SE*
Fixed effects						
Intercept	461.81**	2.85	457.84**	3.96	457.66**	3.97
Linear effect for time	5.60**	0.61	5.56**	0.66	5.47**	0.66
Quadratic effect for time	− 6.98**	0.29	− 6.97**	0.31	− 6.99**	0.31
Reading skills at 54 months	0.15**	0.03	0.14**	0.03	0.14**	0.03
Math skills at 54 months	0.35**	0.02	0.33**	0.02	0.33**	0.02
Female	− 3.27**	0.55	− 3.76**	0.59	− 3.78**	0.59
Mother has h.s. education or lower	− 1.30*	0.60	− 0.69	0.75	− 0.72	0.74
Family income 200% of poverty or less	− 0.47†	0.77	− 0.58	0.82	− 0.54	0.81
Receipt of public assistance	− 1.25	1.14	− 0.89	1.21	− 0.83	1.21
Child Black	− 4.55**	1.02	− 3.79**	1.12	− 3.67**	0.12
Child Hispanic	− 0.07	1.24	− 0.61	1.27	− 0.76	1.27
Mother is married	1.64*	0.81	1.05	0.86	1.07	0.86
Mother works part- or full-time	0.04	0.63	− 0.09	0.66	− 0.08	0.65
HOME score at 54 months	0.16*	0.07	0.14*	0.07	0.15*	0.07
Between-child effects						
Teacher-child closeness			0.01	0.09	0.05	0.10
Teacher-child conflict			− 0.02	0.09	0.02	0.09
Teacher-child closeness × low maternal education			0.08	0.17	–	–
Teacher-child conflict × low maternal education			− 0.05	0.14	–	–
Teacher-child closeness × 200% of poverty or less			–	–	− 0.09	0.15
Teacher-child conflict × 200% of poverty or less			–	–	− 0.16	0.14
Within-child effects						
Teacher-child closeness			− 0.02	0.06	− 0.10*	0.05
Teacher-child conflict			− 0.06	0.06	− 0.11*	0.06
Teacher-child closeness × low maternal education			− 0.01	0.10	–	–
Teacher-child conflict × low maternal education			0.03	0.10	–	–
Teacher-child closeness × 200% of poverty or less			–	–	0.21*	0.09
Teacher-child conflict × 200% of poverty or less			–	–	0.15	0.10
Random effects and fit statistics						
Random child-level intercept	46.19**	4.61	43.05**	4.89	42.49**	4.86
Random slope for time	7.59**	1.97	6.78**	2.16	6.71**	2.15
Correlation between intercept and slope	− 1.95	2.33	− 3.13	2.51	− 3.46	2.50
Residual error	49.09**	2.35	49.65**	2.60	49.56**	2.59
AIC	20,427.80		18,357.57		18,351.28	
Log likelihood	− 10,187.90		− 9143.78		− 9140.64	

Note.
** $p < 0.01$.
* $p < 0.05$.
† $p < 0.10$.

of teacher-child closeness moderated associations between low family income and math achievement ($B = 0.21$, $p < 0.05$; E.S. = 0.15). In other words, the positive association between change in teacher-child closeness and change in math achievement across middle childhood was stronger for children from low-income families, relative to more affluent families. There were no moderated associations between teacher-child conflict and low family income in predicting math achievement, however.

3.1.5. Post hoc analyses

Given the relatively large number of statistical tests examined, we ran the models using the Benjamini and Hochberg (1995) procedure to adjust for the false discovery rate to limit the threat of Type 1 error. It is important to note, however, that multiple comparisons may not be a problem in the current study because we are employing multi-level random effects models to estimate coefficients of interest. Gelman, Hill, and Yajima (2012) argue that multilevel models address the multiple comparisons problem and also yield more efficient estimates, making post hoc corrections less of a concern for the researcher.

4. Discussion

Results of this study advance our understanding of the roles of teacher-child closeness and conflict in explaining longitudinal connections between two related but distinct indicators of early SES (maternal education and family income) and standardized measures of children's math and reading achievement across elementary school. In line with the academic risk hypothesis, we originally theorized that teacher-child closeness would protect against the negative effects of low SES in predicting both reading and math achievement. In contrast, we expected that teacher-child conflict would exacerbate the negative effects of low SES in predicting both reading and math achievement. Given prior evidence showing that both components of SES were negatively related to children's

academic outcomes in elementary school, we did not theorize which SES components in particular might be most salient in these models. Analyses revealed somewhat different results than were anticipated, depending on both the outcome and measure of SES. Indeed, we did find evidence for the role of teacher-child closeness and conflict in moderating associations between low SES during early childhood and academic outcomes during elementary school, but these findings were more consistent for reading achievement, and for low maternal education. There was less evidence that these moderation effects existed when examining math achievement as the outcome of interest or low family income (operationalized at 200% of the federal poverty line) as the predictor of interest. It appears that theories regarding the importance of teacher-child relationship quality for promoting academic achievement among children from low SES households need to be tailored to specific outcomes (math versus reading), and components of SES.

Early maternal education appears to be a particularly salient component of early SES for predicting children's reading achievement in elementary school. Indeed, prior to examining the moderating role of teacher-child relationship quality, baseline covariate models revealed a large and statistically significant effect of early maternal education on children's reading achievement in fifth grade. This finding is aligned with literature examining multiple components of children's SES on academic achievement during early and middle childhood. Specifically, some research demonstrates that, relative to early family income, early maternal education has a larger correlation with academic outcomes in elementary school (Harding et al., 2015; Magnuson, 2007; Magnuson, Sexton, Davis-Kean, & Huston, 2009; Reardon, 2011; Sirin, 2005). This finding indicates that low maternal education in infancy is a particularly salient factor to consider within the academic risk hypothesis, posing the highest level of risk to poor academic outcomes across elementary school.

Indeed, lower maternal education may indicate that families lack the human capital resources necessary to spend engaged in the types of early cognitively stimulating activities (e.g., book reading, conversation) that support literacy development and later reading achievement in middle childhood (Duncan & Magnuson, 2012). In contrast, parents with more education are more likely to be actively engaged in supporting the development of reading skills at home (Kalil, 2015) and better able to match children's developmental needs to the activities they practice at home (Benasich & Brooks-Gunn, 1996; Kalil, Ryan, & Corey, 2012). For effects measured both concurrently and across time, a high-quality teacher-child relationship can be particularly compensatory for the reading achievement of children with low maternal education, given that promotion of these skills is less likely to either be reinforced or matched to children's developmental needs at home.

It appears that successful development of close and non-conflictual teacher-child relationships is particularly beneficial for the development of *reading skills* among children whose mothers had not completed college when they were born. Within a close and non-conflictual relationship, teachers are able to provide children from low SES backgrounds with positive supports and reinforcement, which support development of reading skills (Doll, 1996; Howes & Hamilton, 1993). Indeed, a very typical paradigm for reading and literacy instruction in elementary school is the small reading group, which offers students more individualized supports from teachers and an opportunity to develop a closer and less conflictual relationship with their teacher through that process (Begeny, Krouse, Ross, & Mitchell, 2009; Foorman & Torgesen, 2001).

On a more fundamental level, research demonstrates that elementary school teachers spend the large bulk of their instructional time on activities that promote reading achievement, and less time on activities that promote math achievement (Claessens, Engel, & Curran, 2013). Using data from the Early Childhood Longitudinal Survey – Kindergarten cohort, Claessens et al. (2013) found that teachers reported spending 186.18 min/week on math, compared to 292.33 min/week on reading. Given recent policy and practice emphases on literacy instruction in the early grades (e.g., NCLB Reading First), it is likely that the teachers in this study spent more of their time teaching literacy and related skills than math and numeracy (Phillips & Wong, 2010), thus allowing more time for closer and non-conflictual relationships to translate into bigger gains for reading achievement, versus math achievement. Similarly, when parents do engage in academic activities with children at home, they typically participate in activities that promote literacy and reading, rather than math skill development (Berkowitz et al., 2015). There is a documented gap in the extent to which lower and higher SES families engage in literacy activities at home (Bassok, Finch, Lee, Reardon, & Waldfogel, 2016). As such, in line with the academic risk hypothesis, a child from a low SES household has more room to grow in terms of reading versus math achievement, relative to the more affluent child, who is likely to be engaged in a host of reading – but not necessarily math – activities at home already.

In contrast, this study revealed that associations between teacher-child relationship quality and math achievement did not vary by maternal education, but did vary for one family income model. Changes in teacher-child closeness moderated associations between low early family income and math achievement. Because this result only appeared for one indicator of SES and only on one outcome, we are treating it as an exploratory finding that needs to be considered in future research. However, the result provides some empirical evidence for the academic risk hypothesis, in that low-income families who have less financial capital are more likely to have children with lower math achievement at the beginning of elementary school. However, when these children have close relationships with their teachers, they might experience a compensatory effect on this previous risk factor. In addition, children from low income households are less likely to be accustomed to engaging in the free exploration and engagement that support math skill development and achievement (Fuligni, Howes, Huang, Hong, & Lara-Cinisomo, 2012). Closer relationships with teachers, however, can support them in developing these skills that then promote more rapid growth in math achievement than would be expected in the absence of teacher-child closeness. These results, however, require further exploration in order to build confidence in their veracity.

The broader findings regarding math achievement run somewhat counter to prior research that has examined within-group samples of low-income, racial/ethnic minority children. These studies have generally found robust associations between teacher-child relationship quality and math achievement outcomes (e.g., Hughes & Kwok, 2007; Liew et al., 2010; McCormick et al., 2013). Because these prior studies had no higher SES comparison group, however, they were actually unable to test whether teacher-child relationship quality operated as a protective factor in predicting reading and math achievement groups for economically

disadvantaged groups. Findings from the current study suggest that operationalizing SES-related risk by maternal education may be more appropriate for districts and policymakers interested in targeting relationship-based interventions to those facing the highest risk for poor academic outcomes.

4.1. Limitations and directions for future research

This study used a diverse sample of students to examine variation in links between two components of family SES, two dimensions of teacher-child relationship quality, and standardized assessments of children's reading and math skills across the full period of middle childhood. Even so, this study has some notable limitations. First, we used a teacher report of teacher-child relationship quality to operationalize the main predictor for the study. Relatedly, the teachers who were reporting changed at each time point, thus potentially introducing additional measurement error over time. Future studies in which children are nested in teachers should consider adjusting for teacher-level differences and should extend this research and also consider child-reported and observed measures of teacher-child relationship quality to reduce possible biases posed by using teacher reports (Hughes, 2011). Next, given limitations of the data and scope of this analysis, we were unable to examine mechanisms linking teacher-child closeness and conflict and achievement, and were also unable to test whether mechanisms differed by level of SES.

Further, there are certain limitations to our findings as a result of recruitment and enrollment methods of the NICHD SECCYD. Specifically, children with disabilities, children who lived in dangerous areas, and children whose mothers did not speak English were excluded. Our samples of children from low SES households are not likely to include children who also fall into these recruitment groups, and results may not completely generalize to national samples more broadly. Similarly, we chose to measure SES at study enrollment, both because these data were the most complete and because we wanted to conceptualize early SES as the key predictor in analyses. However, emerging research suggests that using SES at one time point and so early in development might be a limitation, as variation in SES across time may also be an important predictor of children's outcome (Cohen et al., 2010; Duncan, Brooks-Gunn, & Klebanov, 1994; Hill et al., 2013; Luo & Waite, 2005). Future research building on this paper should seek to explore changes in SES over time as they relate to both children's achievement and teacher-child relationship quality. Furthermore, continued longitudinal research might consider including contextual variables, such as neighborhood and school-level resources, that might be conflated with SES in the current study.

Another limitation is that this study only had three time points of longitudinal academic achievement data and a control time point at 54 months. Although we were able to consider non-linearity in these data, we were limited in our ability to detect cubic or higher order trends. Future studies should consider how the form of the relationship for children from low SES households varies depending on developmental stage. For example, it might be that teacher-child relationships are most important for children from low SES households in first grade but become less important as children begin to transition into adolescence at the end of elementary school.

Additionally, although the longitudinal models allowed us to examine average effects and time-varying effects over time, this study is still correlational in interpretation and we cannot infer causality from the findings. Specifically, we still cannot be fully certain about the direction of effects in the current study. Assuming selection bias, it is possible that achievement could actually be driving the observed levels of teacher-child closeness and conflict. Indeed, there was variation in the data collection process regarding when the teacher reports of relationship quality were collected relative to when the WJ assessments were conducted. It will be important for future studies to consider methods for examining the causal effects of teacher-child closeness and conflict on reading and math achievement in elementary school, and examine how those effects differ by levels of SES. For example, random assignment studies that aim to improve relational and emotional supports in the classroom should consider examining treatment effects on math and achievement and testing whether those effects differ by family SES. Future research might also consider quasi-experimental designs that can address selection issues. Finally, the age of the data is a limitation to the study, possibly making the results less generalizable to the population today. Future studies will have to replicate the study's findings to see if results still hold with new public policies (e.g., expansion of publicly available preschool, increased funding for social-emotional learning in public education) in place.

4.2. Implications

Although past research studies have posited that students from low SES families stand to benefit the most from high-quality teacher-child relationships (Hamre & Pianta, 2001), there was limited empirical research validating this theory within a large and socioeconomically diverse sample of students and teachers. The findings from the current study contribute to the literature on teacher-child relationships and academic achievement outcomes in elementary school by providing initial evidence validating the academic risk hypothesis, specifically for children whose mothers had low levels of education in their infancy. Social-emotional learning (SEL) programs have expanded dramatically in recent years and have been targeted at low-income schools, given theories that improving factors like teacher-child relationship quality should protect against risk for poor academic achievement outcomes faced by children from low-SES families. Results do provide some support for the theory that the academic outcomes of children from low SES backgrounds can be supported by such interventions, particularly in terms of reading achievement.

Yet, these findings differ among components of SES. Specifically, low maternal education in infancy appeared to be a salient domain for intervention. Districts and schools rarely have information on student and school-level populations, other than eligibility for free or reduced price lunch. If there are opportunities to collect more information on children's backgrounds, it may support improved targeting of intervention. There are a number of burgeoning interventions known as two-generation programs that target

both low-income parents and children. In the context of a social-emotional learning intervention focused on improving relationships in order to enhance outcomes, schools and developers should also consider strategies for pairing such programming with efforts to increase (to differing levels) levels of maternal education. On a small scale, such a model could include educational information sent home to parents on the social-emotional learning program, or on other more global activities in which schools are engaged (e.g., reading at home, practicing simple math games at home). On a larger scale, a district might consider a more intensive intervention focused on pairing at-school intervention for children with some strategies to engage parents in more formal education (e.g., through a partnership with a local community college). Only by considering maternal education and income as unique components can such implications be understood. Indeed, by virtue of this study identifying differential findings for maternal education as opposed to income, a case can be made for the importance of considering these two components separately in studies examining risks to poor academic outcomes posed by low SES.

Finally, it appears that relationship-based supports differentially benefit the reading achievement of students from low SES households but not their math achievement. This result suggests that interventions like SEL programs are not the only type of intervention that should be considered for low-income students. Indeed, with respect to policy decisions, it is most likely that such supports should be coupled with those interventions that focus explicitly on instructional quality and content, as well as interventions to increase family SES.

Appendix Table A
Skewness and kurtosis for variables of interest.

Variable	Skewness	Kurtosis
Reading skills at 54 months	0.22	3.99
Reading skills in first grade	− 0.09	3.02
Reading skills in third grade	− 1.01	5.57
Reading skills in fifth grade	− 0.95	6.41
Math skills at 54 months	− 0.54	3.75
Math skills in first grade	− 0.11	2.87
Math skills in third grade	− 1.53	8.56
Math skills in fifth grade	− 1.30	8.35
Teacher-child closeness in first grade	− 1.11	4.30
Teacher-child closeness in third grade	− 0.96	3.64
Teacher-child closeness in fifth grade	− 0.67	2.87
Teacher-child conflict in first grade	1.62	5.40
Teacher-child conflict in third grade	1.53	4.69
Teacher-child conflict in fifth grade	1.51	4.66

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