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Process and context: Longitudinal effects of the interactions between parental involvement, parental warmth, and SES on academic achievement

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ABSTRACT

Parents' involvement in their children's education and parental warmth have been linked to many positive child outcomes. In addition to these positive associations, contemporary developmental theory stresses the interaction between different parenting variables and the interaction between parenting and broad contextual factors such as family socioeconomic status (SES). Thus, the purpose of this study was to examine main and interaction effects of parent home-based involvement and parental warmth on achievement outcomes. Additionally, we evaluated whether these variables also interacted with SES to predict students' achievement growth. Using the Early Childhood Longitudinal Study – Kindergarten Cohort of 2010–11 ($N = 2352$), growth of academic outcomes was modeled from kindergarten to the fourth grade. We then used latent variable interaction (Maslowsky, Jager, & Hemken, 2015) procedures to examine interaction effects of our primary study variables. Few significant effects were noted for children's reading and mathematics scores, but more substantial main (home-based involvement) and interaction (parental warmth and SES) effects emerged for science achievement. At high SES levels, warmth negatively predicted growth in science, whereas at lower SES levels, warmth positively predicted growth. Findings are discussed in relation to importance of parent involvement, differential effects across SES contexts, and curricular emphasis in contemporary schools.

1. Introduction

Understanding the influences of parenting on child development is a fundamental goal of developmental psychology and one of the most prominent and empirically supported developmental frameworks informing this goal is ecological systems theory (Bronfenbrenner & Ceci, 1994; Darling, 2007; Darling & Steinberg, 1993). Ecological systems theory is focused on understanding the complex interactions between persons (e.g., children), processes (e.g., parenting behaviors), and contexts (e.g., the emotional warmth of a parent child relationship) on child development (Bempechat & Shernoff, 2012; Bronfenbrenner & Ceci, 1994; Darling, 2007). Aligned with this conceptualization, Bronfenbrenner (1999) made two propositions that clarify the core of ecological systems theory. First, he argued that children's development is influenced by "proximal processes" (p. 5), which refer to repeated interaction of a child with persons or objects in his or her immediate environment. Examples of proximal processes include parent-child activities such as reading, learning, and studying together. Next, Bronfenbrenner (1999) argued that the effects of these processes varied

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"systematically as a joint function of the characteristics of the developing person, the environment – both immediate and more remote – in which the processes are taking place, the nature of the developmental outcomes under consideration, and the social continuities and changes occurring over time" (p. 5). In other words, the specific processes engaged in by parents may have different effects depending on the contexts in which they occur.

Tying this perspective specifically to parenting behaviors, Darling and Steinberg (1993) provided a framework to consider parenting process and context variables. Specifically, these authors described the influences of two distinct, yet interrelated aspects of parent-child relationships: parenting practices and parenting styles. Parenting practices are behaviors that parents engage in, and thus parental involvement in education would fit under this broader heading. Parenting practices include behaviors within the home, such as engaging in learning-related activities with a child or attending school events. Empirical research supports this theoretical link between educationally-focused parenting practices and achievement outcomes (Fan & Chen, 2001; Jeynes, 2005).

Next, parenting styles refer to the emotional climate of the parent-child relationship. Common conceptualizations of parenting styles include the extent to which a parent manages and monitors their child's behavior, as well as parental warmth and responsiveness. The empirical literature also links parenting styles with children's achievement (Darling & Steinberg, 1993; Wang, Dishion, Stormshak, & Willett, 2011). Beyond considering the individual associations of parenting practices and styles with achievement, Darling and Steinberg (1993) proposed that the effects of parenting behaviors (i.e., the process) on child outcomes vary based on the parenting styles or overall tone or climate of this relationship (i.e., the proximal context).

In addition to considering the proximal parent-child relationship context, ecological systems theory also considers the influence of more distal contextual factors. Decades of research on one key broad contextual variable, socioeconomic status (SES), has demonstrated a ubiquitous effect of SES on a variety of child outcomes (Hattie, 2017). For example, a large achievement gap between wealthy and middle-class children with their low-income peers is significant across academic areas and is present at school entry (Reardon & Portilla, 2016). Beyond main effects, SES has been shown to interact with parenting variables, such that the effects of both parenting practices and styles have been shown to be stronger predictors of achievement for children from low compared to high SES homes (Dearing, Kreider, Simpkinds, & Weiss, 2006; Dearing, McCartney, Weiss, Kreider, & Simpkins, 2004; Hill, 2001). These findings illustrate the importance of adopting an ecological perspective in studying parenting, as both proximal (e.g., parental warmth) and distal (e.g., SES) context factors may moderate the influence of parenting behaviors on child outcomes (e.g., Bronfenbrenner, 1999; Darling, 2007; Drillien, 1964).

1.1. Parent involvement in education

One key process level variable that is associated with children's academic development is parental involvement in their child's education. Parental involvement includes behaviors parents engage in to support their child's scholastic endeavors. Parent involvement is widely considered multidimensional, with three forms frequently identified: home-based involvement, school-based involvement, and home-school communication (Epstein, 1995; Fantuzzo, McWayne, Perry, & Childs, 2004; Hoover-Dempsey et al., 2005). Parent's home-based involvement includes helping with homework, reading together, and other generally cognitive stimulating activities such as going to a zoo. Home-based involvement is unique from the other forms of parent involvement due to the focus on parent-child interactions. As such, considering home-based involvement in the context of parenting styles is particularly important.

Research spanning several decades has documented a link between home-based involvement and academic outcomes. In correlational studies, home-based involvement has been positively linked to various academic outcomes (e.g., Fan & Chen, 2001; Jeynes, 2005). For example, in one meta-analysis, home supervision defined as supervision of homework, TV rules, and creating an environment conducive to studying demonstrated a small correlation with academic outcomes (Fan & Chen, 2001), while another meta-analysis that separated parental reading (Hedges's $g = 0.42$) from checking homework (Hedges's $g = 0.08$) found differences in the effect size on achievement depending on the specific component of home-based involvement (Jeynes, 2005).

There are several proposed pathways to explain how home-based involvement as a key parental process contributes to students' achievement, including skill and motivational development models (Pomerantz, Moorman, & Litwack, 2007). A skill development model suggests that involvement provides resources in terms of academic skill development. Motivational models indicate that parental involvement enhances children's motivation toward learning and school. Given these theoretical processes, home-based involvement early in a child's educational career may be particularly important to establish positive skills and motivation trajectories, as early skills are key predictors of later academic functioning (Duncan et al., 2007).

1.2. Parental warmth

As suggested in ecological systems theory, in addition to the process variables such as parents' home-based involvement, another aspect of parenting that has important implications for child outcomes is parental warmth. Parental warmth is considered a proximal context variable within an ecological systems theory framework (Darling, 2007; Darling & Steinberg, 1993). Aligned with theories of mechanisms of parent involvement related to motivation, involvement in the context of a warm and supportive relationship may motivate students by communicating that academic tasks are enjoyable (Pomerantz et al., 2007). In contrast, in the context of a parenting style that is cold or unresponsive to the child's needs, involvement reduces children's motivation for learning because educational activities with the parent may be stressful. From a skill-building perspective, parents' positive behaviors and attitudes may allow children to have comfort and openness with new ideas which is important for learning to occur (Culp, Hubbs-Tait, Culp, & Starost, 2000; Pomerantz et al., 2007). In contrast, a lack of warmth may limit children's attention, persistence, and engagement with educational activities, thus limiting their opportunities to build skills.

Broadly, parental warmth has been linked to positive academic and cognitive outcomes in children; however, findings have been inconsistent across age levels (Culp et al., 2000; Hill, 2001; Pomerantz, Wang, & Ng, 2005a; Simpkins, Weiss, McCartney, Kreider, & Dearing, 2006). For example, Culp et al. (2000) examined maternal warmth on child cognitive outcomes in parents of 114 children in Head Start and found that maternal warmth positively predicted children's scores on the Peabody Picture Vocabulary Test (PPVT-R; Dunn & Dunn, 1981). Furthermore, Simpkins et al. (2006) found that maternal warmth was a small, positive predictor of kindergarten literacy, but not mathematics achievement. Results are inconsistent, however, as in a large, national dataset, parental warmth in kindergarten was not predictive of reading or math achievement in fifth grade (Bodovski & Youn, 2010). Thus, while there is some support for a small, positive effect of warmth on achievement in elementary school, findings are not conclusive. One reason for mixed findings may be that warmth is conceptualized as a proximal context variable within ecological systems theory, and thus its association with academic achievement may function primarily through its interactions with parenting practices (Darling & Steinberg, 1993). Under this model, studies focusing solely on main effects of parental warmth may not elucidate the degree to which parental warmth impacts children's educational development.

1.3. Interactive effects of home-based parent involvement and parental warmth

Although the main effects of home-based involvement and parental warmth are important to consider, ecological systems theory highlights the importance of considering these variables in tandem. Specifically, Darling and Steinberg (1993) proposed that parenting processes such as parent involvement directly influence youth outcomes, but also that parenting styles or the context in which these processes occur moderate the effects of these practices. Empirical findings have substantiated this theoretical proposal. In kindergarten students, Simpkins et al. (2006) examined whether parental warmth moderated the association between mathematics and literacy scores and parent involvement, which included practices such as parent-teacher conferences, classroom visits, and volunteering at school. These authors found that parental warmth moderated the association, such that levels of involvement were more strongly associated with achievement when the parent-child relationship was warm. Furthermore, Steinberg, Lamborn, Dornbusch, and Darling (1992) found that associations between parent involvement, a combination of home- and school-based involvement, and school performance in high school were stronger if parents used an authoritative parenting style characterized by warmth, control, and psychological autonomy versus a non-authoritative parenting styles (Steinberg et al., 1992). In the Steinberg and colleagues study, the size of the association between parent involvement and achievement was larger among families reporting authoritative (r = .23 to .28) versus non-authoritative (r = .09 to .12) parenting. These authors suggested that the climate of the parent-child relationship could "undermine" benefits of parent's involvement in education (p. 1276). Together these findings are suggestive of warmth as a moderator of the association between involvement and achievement, yet research is needed to clarify this with regard to home-based involvement.

1.4. Interactional effects between parenting and SES

Home-based involvement and warmth are also embedded in the larger context of the family's home environment. One of the most important aspects characterizing this environment is family SES. The pervasive impact of SES on student achievement has been well-documented (Chmielewski, 2019; Hattie, 2017). Beyond a main effect, SES also serves a key indicator of the broader family context in which all development occurs. This theoretical perspective has been borne out in empirical studies demonstrating that SES interacts with components of parental involvement and warmth in their influence on achievement (Darling, 2007;Dearing et al., 2004, 2006 ; Hill, 2001). For example, Dearing et al. (2004, 2006) found that parents' levels of education had a significant moderation effect on the association between school-based involvement and literacy performance in the fifth grade. Specifically, the association between school-based involvement and children's scores on a measure of literacy was stronger for children whose mothers had below-average levels of education versus those with high levels of education. With regard to SES as a potential moderator between parental warmth and achievement, Hill (2001) found that parental warmth was a stronger positive predictor of sound-letter correspondence among low-SES families than for high-SES families in a sample of 103 mothers of kindergarten children. The results from Dearing et al. (2004, 2006) and Hill (2001) suggest that SES may play an important interactional role with parent involvement and warmth in predicting child achievement. Thus, although the literature linking parent involvement and achievement suggests small to moderate effect sizes, prior studies that have not considered interactions may not have elucidated the contexts in which these variables are particularly important. Ecological systems theory and the empirical literature examining interactional effects (Dearing et al., 2004, 2006; Hill, 2001) suggest that consideration of interaction effects for these variables is indeed important. Thus, continued efforts to consider these effects holds great promise to increase understanding of parental involvement and warmth and ultimately inform applied efforts in this domain.

1.5. Limitations of prior research

Based on ecological systems theory and the reviewed empirical literature, the current study sought to evaluate the main and interactional effects of home-based involvement, parental warmth, and SES on children's achievement growth in elementary school. In doing so, there are several limitations of prior research we aimed to address. First, prior research has examined the effects of home-based involvement and parental warmth on achievement independently and documented the potential contributions of both aspects of parenting to supporting achievement growth. Yet research examining how parental involvement and warmth work together is limited to only a few studies (e.g., Dearing et al., 2004, 2006; Hill, 2001). Given the strong emphasis on the critical role of considering parenting behaviors as occurring in context from an ecological systems perspective and suggestive findings available in the research on this interaction (e.g., Dearing et al., 2004, 2006; Hill, 2001), additional research is needed. Specifically, prior research has not yet focused on the interaction between parental warmth and home-based involvement, a form of parent involvement that may be particularly influenced by parenting styles.

Another limitation of prior research regards differences in effects of parenting variables across reading, mathematics, and science. The current study presents an important opportunity to examine the associations between parenting variables and reading, mathematics, and science across a longitudinal context. From an ecological systems theory perspective, effects of process and context variables are not thought to be uniform across outcomes, but rather may meaningfully vary depending on which outcome is being studied (Bronfenbrenner, 1999). In the limited research examining interactional effects between parental home involvement, parental warmth, and SES, researchers have primarily examined literacy or mathematics outcomes (Dearing et al., 2004, 2006; Hill, 2001; Simpkins et al., 2006). Highlighting the potential differences across academic domains with regard to interactional effects, Hill found that SES moderated the effects of parental warmth on early literacy but not on mathematics achievement (Hill, 2001). The current study provided an opportunity to examine literacy, mathematics, and science achievement domains in the same study and longitudinally. Differential effects across domains are plausible considering the contextual variations affecting these outcomes. Specifically, there are major differences in the emphasis and time devoted to different subjects in the educational system (U.S. Department of Education, 2018). For example, during the 2017–2018 school year, the average third grade teacher spent roughly 8.3 h per week teaching English, 5.8 h per week teaching mathematics, and only 2.8 h per week teaching science (U.S. Department of Education, 2018). Such large instructional differences could lead to varying effects of home-based variables on different academic domains.

The current study contributed both to the theoretical and empirical literature on how aspects of parenting relate to children's academic achievement. From a theoretical standpoint, the current study brought together key components of ecological systems theory process, proximal context, and distal context in shedding light on how these different components of the home environment work together to predict outcomes. This study extended work on associations between parent involvement and achievement by aligning it with ecological systems theory, which suggests "the impossibility of understanding individual developmental processes in isolation" (Darling, 2007, p. 205). The study also provided additional information on how three components of the home (i.e., parent involvement, parental warmth, and SES) relate to achievement in reading, mathematics, and science across elementary school. This study extended research that has examined each of the parenting variables in their association with academic achievement by examining the simultaneous and interactional associations across multiple academic areas longitudinally.

These considerations are also important from an applied perspective. There have been recent efforts to engage parents and consider how contextual and process variables predict child outcomes (Garbacz, Herman, Thompson, & Reinke, 2017). Recent models of parent engagement depict not only the core predictors, but also the context and mechanisms that are hypothesized to influence child outcomes (Garbacz et al., 2017). The current study provided practical information regarding the application of programs targeting parenting variables. Specifically, by highlighting whether the effects of parent involvement in education are dependent on proximal and distal contexts, the results of this investigation can also inform the development or revision of programs focused on parental involvement.

1.6. Study purpose and research questions

The purpose of the current study was to examine combined and interactional effects between home-based involvement, parental warmth, and SES in predicting reading, mathematics, and science growth from kindergarten to the fourth grade. Based on this overarching goal, the study addressed the following research questions:

1. Do home-based involvement, parental warmth, and SES predict growth patterns in reading, mathematics, and science over time?

We hypothesized that home-based involvement, parental warmth, and SES will all have positive main effects on growth in reading, mathematics, and science from kindergarten to the fourth grade. We further hypothesized that the magnitude of these effects will be small for home-based involvement and parental warmth and large for SES, based on prior research (Dearing et al., 2006; Hattie, 2017; Izzo, Weissberg, Kasprow, & Fendrich, 1999).

2. Based on the prior research on the interrelationships between these variables, we asked three additional questions focused broadly on moderation.
   a. Does parental warmth moderate the association between home-based involvement and growth in reading, mathematics, or science achievement?
   Based on prior research, we hypothesized that warmth will moderate this association (e.g., Simpkins et al., 2006). Specifically, we hypothesized that home-based involvement will be more strongly associated with achievement growth at higher levels of parental warmth. Due to lack of prior research, we considered cross academic domain comparisons exploratory.
   b. Does SES moderate the association between home-based involvement and growth in reading, mathematics, or science achievement?
   Based on prior research, we hypothesized that SES will moderate the association between home-based involvement and achievement outcomes, such that home-based involvement will be more strongly associated with achievement for families with lower levels of SES (Dearing et al., 2004, 2006). Prior research has focused on only on reading, thus we considered effects across academic areas to be exploratory.

c. Does SES moderate the association between parental warmth and growth in reading, mathematics, or science achievement? We hypothesized that SES will moderate the association between parental warmth and achievement. Specifically, we hypothesized that warmth will more strongly predict achievement growth for participants from lower SES backgrounds (Hill, 2001). Given that prior research focused on school readiness, we consider the comparison across academic areas to be exploratory.

2. Methods

2.1. Participants

Participants ($N = 2354$)[1] were drawn from eight waves of the public-use file of the Early Childhood Longitudinal Study – Kindergarten Cohort of 2010–2011 (ECLS-K: 2011; Tourangeau et al., 2018). The ECLS-K: 2011 is a large, nationally representative study administered by the National Center for Educational Statistics (NCES). Children were assessed during data collection waves corresponding to the fall and spring of their kindergarten, first, and second grade years and the spring of their third and fourth grade years. We also utilized items drawn from parent interviews conducted in the fall and spring of their children's kindergarten year. Because of the complex sampling design of the ECLS-K: 2011 and differential nonresponse across participants, we identified and applied the appropriate analytical weight as well as the corresponding cluster and applied them for all analyses. Weighted demographic statistics for the analytic sample can be found in Table 1, and descriptive statistics for achievement data by wave can be found in Table 2.

2.2. Measures

2.2.1. Parenting variables

In order to address the attenuation of associations that occurs due to measurement error, the parenting variables used in the current study were analyzed as latent variables indicated by various items from portions of the parent interviews in the first and second waves of the ECLS-K: 2011, corresponding to the fall and spring of the kindergarten year. This approach was taken to capitalize on a key advantage of structural equation modeling approaches, namely the ability to consider latent variables as opposed to measured variables which inherently contain measurement error (Raykov & Marcoulides, 2006).

2.2.1.1. Home-based involvement. Ten items were included from the *Home Environment, Activities, and Cognitive Stimulation* portion of the parent interview conducted in the fall of participants' kindergarten year. These questions focused on the frequency of parental home-based involvement in various domains and were rated on a 4-point Likert scale ranging from 1 (*Not at all*) to 4 (*Every day*). Item wording for the 10 items included in the final models are presented in Table 4. An 11th item focused on the frequency with parents or other family members read books in a non-English language was not included in the final models based on measurement model evaluation described below. These items are highly similar to items included in the original ECLS-K and used in many studies to measure home-based involvement (Galindo & Sheldon, 2012; Ogg & Anthony, 2019; Tan, Kim, Baggerly, Mahoney, & Rice, 2017; Youn, Leon, & Lee, 2012). In addition, the scale has items that are similar to other measures of home-based involvement (Fantuzzo, Tighe, & Childs, 2000).

2.2.1.2. Parental warmth. Next, a series of questions were drawn from the *Discipline, Warmth, and Emotional Supportiveness* portion of the ECLS-K: 2011 administered during children's kindergarten year. Initially, eight items were included. Based on evaluation of measurement models described below, the final parental warmth construct was indicated by four items focusing on parental warmth (e.g., *My child and I often have warm, close times together*; all items available in Table 4) that were distinguished from the 4 remaining items, which focused on negative parenting attitudes (e.g., *My child does things that really bother me*). The separation of parental warmth and negative parenting attitude items is aligned with prior research suggesting that positive versus negative parenting items relate differently to cognitive or academic outcomes (Culp et al., 2000). All items were rated on a 4-point Likert scale ranging from 1 (*Completely True*) to 4 (*Not at all True*). As with home-based involvement, these items are similar to items included in the original ECLS-K used in various studies to measure parental warmth (Baker & Iruka, 2013; Yan & Ansari, 2016).

2.2.2. Socioeconomic status

A SES variable was created by ECLS-K staff based on information gathered from parents in the base year of the study that combined parental occupational prestige, household income, and parental education. This variable was subsequently standardized within wave. Although data for this variable are presented in quintiles in Table 1, it was included as a continuous variable in all analyses, ranging from -2.33 to 2.44 ($M = -0.05$; $SD = 0.75$).

[1] Although the total initial sample for our study included 18,174 children, the analytic sample (weighted to be representative of kindergartners in the 2010–2011 school year) included 2354 children because some waves (e.g., spring of most children's first grade year) were subsamples of the total sample.

Table 1
Weighted demographic characteristics of participants ($N = 2354$).

Characteristic	Weighted %
Female	49
Child has disability	21
Race	
White, non-Hispanic	52
African American	13
Hispanic	25
Asian	4
Other	6
Region	
Northeast	18
Midwest	23
South	37
West	22
Area	
City	29
Suburb	37
Town	6
Rural	28
School type	
Catholic school	4
Other religious school	4
Other private school	3
Public school	89
Socioeconomic status	
1st quintile	15
2nd quintile	24
3rd quintile	24
4th quintile	19
5th quintile	18

Note. Percentages do not sum to 100 in some cases due to rounding. Socioeconomic status quintiles generated from continuous measure.
All values reported for fall kindergarten.
(Wave 1) except child's disability status, which was reported by parents in the spring of kindergarten (Wave 2).

Table 2
Weighted descriptive statistics for achievement variables across wave (N = 2354).

Wave	Reading		Mathematics		Science	
	M	SD	M	SD	M	SD
Spring kindergarten	67.81	13.50	49.19	12.05	34.05	7.26
Fall 1st grade	76.04	16.76	58.48	15.96	38.20	9.43
Spring 1st grade	93.59	17.55	73.23	16.72	43.71	10.95
Fall 2nd grade	98.34	16.30	78.74	16.43	46.78	10.62
Spring 2nd grade	107.62	14.96	89.92	15.63	52.52	10.71
Spring 3rd grade	116.48	13.79	102.66	14.73	60.12	10.38
Spring 4th grade	122.63	12.43	109.83	14.30	65.89	11.05

2.2.3. Achievement variables

The ECLS-K: 2011 utilized Item Response Theory (IRT) procedures to create vertical scales for all achievement measures, rendering them appropriate for longitudinal analyses across waves. Achievement tests were two-stage tests, including an initial routing test and a follow up test more specifically focused on the child's ability level provisionally estimated from the routing test. The routing test included items of a range of difficulties and enabled an initial estimate of the child's academic skills to be calculated and utilized to generate a follow up tests more targeted at the child's likely academic skill level (Najarian, Tourangeau, Nord, & Wallner-Allen, 2018). Due to the IRT procedures used, scores on different sets of items could be scaled comparably within and across waves. Because they are longitudinally scaled and thus can support latent growth curve analyses, IRT scale scores were used in the current analyses (Tourangeau et al., 2018).

Several other specific procedures related to validity were conducted with all achievement measures. Specifically, all IRT assumptions were checked by ECLS-K staff including the assumptions of unidimensionality, functional form, and local independence.

Furthermore, comparison of various IRT models was conducted to ensure that the best fitting model was utilized. As a result of model comparison, the three parameter logistic model was chosen to model all academic domains. Next, differential item functioning procedures were conducted at each wave of data collection across the child's sex and race/ethnicity. In general, very few items were found to function differently across groups. Finally, although the ECLS-K did not compute score correlations between academic measures and similar external tests (e.g., the Woodcock-Johnson Tests of Achievement – Fourth Edition; Schrank, Mather, & McGrew, 2014), comparison of correlations between subjects and across data collection rounds can provide construct validity evidence. This evidence was supportive of score validity as all across domain scores were moderate to large in magnitude and across data collection round correlations showed the expected simplex patterns (Najarian et al., 2018).

2.2.3.1. Reading achievement. All participating students completed the ECLS-K: 2011 reading assessment in all included waves. The reading assessment covered reading skills across a broad range of ability levels, including such skills as letter recognition, vocabulary knowledge, and reading comprehension. Reliability of theta, which is an IRT analogue to internal consistency reliability, ranged from .87 to .95 (median = .93) across ECLS-K: 2011 waves, and scores ranged from 0 to 155. With regard to validity, the reading battery for the ECLS-K: 2011 was based on the reading frameworks for the National Assessment of Educational Progress (NAEP; National Assessment Governing Board, 2008). Because NAEP is administered starting in fourth grade, extensive work was conducted to extend item content downwards appropriately. As such, various experts were consulted, and curriculum standards were evaluated from five states (TX, CA, NJ, FL, & VA) and the Common Core State Standards.

2.2.3.2. Mathematics achievement. In addition to reading, participating students completed the ECLS-K: 2011 mathematics battery. This test also focused broadly on mathematics skills ranging from basic to complex. Included skills were number sense, measurement, geometry, data analysis, statistics, and algebra. Reliability of theta ranged from .92 to .94 (median = .93) across ECLS-K: 2011 waves and scores ranged from 0 to 146. With regard to validity, the ECLS-K: 2011 mathematics battery was also based on the NAEP mathematics framework extended downwards to lower grades. ECLS-K: 2011 researchers drew on material from the National Council of Teachers of Mathematics (National Assessment Governing Board, 2004), as well as state standards from various states at different grade levels.

2.2.3.3. Science achievement. Finally, students were also administered the ECLS-K: 2011 science test, starting in the second wave of the study during the spring of children's kindergarten year. This test focused on questions about various scientific domains, including the physical sciences, life sciences, and scientific inquiry. Reliability of theta ranged from .75 to .83 (median = .83) across waves and scores ranged from 0 to 96. Content for the science battery was based on the areas identified by the 2011 NAEP science frameworks (National Assessment Governing Board, 2010). Similar to the reading and mathematics batteries, content had to be extended downwards, and various state standards were consulted to facilitate this process.

2.2.4. Control variables

Several control variables were also included in this study. The control variables were selected based on their substantive link with our key predictor and outcome variables. Specifically, although prior research on parental involvement and sex has generally suggested no significant differences (Fantuzzo et al., 2000; Garbacz, McDowall, Schaughency, Sheridan, & Welch, 2015; Manz, Fantuzzo, & Power, 2004), the research on parental warmth is more mixed (Endendijk, Groeneveld, Bakermans-Kranenburg, & Mesman, 2016) and prior research using similar growth model approaches to examine achievement trajectories did include sex as a covariate (Cameron, Grimm, Steele, Castro-Schilo, & Grissmer, 2015). Sex (1 = *Girl;* 0 = *Boy*) was included based on school report and confirmed by participants' parents during interviews in subsequent rounds of data collection. We also included age in months, which was calculated by ECLS-K staff using the exact date of administration and each child's birthday. Calculation of age was exact and adjusted for leap years. Prior research on parenting variables has suggested that increasing school year is associated with lower levels of home-based involvement (Garbacz et al., 2015; Ogg & Anthony, 2019). We also included parents' marital status under the rationale that some research has suggested that married parents are more involved than parents who are not married (Fantuzzo et al., 2000). This variable was based on parental report and was included a dummy variable (1 = *Married;* 0 = *Not Married*). Finally, we included dummy variables for racial/ethnic groups (African American, Hispanic, Asian, and Other) as prior research has documented significant achievement gaps in various educational domains across racial/ethnic groups (e.g., reading and mathematics; see Hemphill & Vanneman, 2011; Hsin & Xie, 2014; Vanneman, Hamilton, Anderson, & Rahman, 2009).

2.3. Procedures

All data were gathered by NCES staff. Achievement tests were individually administered to children by trained and certified assessors. Assessors were trained for all aspects of data collection in a series of training sessions occurring prior to each wave of data collection. Assessment training included interactive lecture introducing study materials, practice in dyads using pre-generated scripts, and written exercises to ensure that assessors understood administration procedures. As part of certification procedures for child direct assessments, trainees administered the ECLS-K achievement measures to real children who were recruited for training purposes. Administration was observed and assessors were scored on various aspects of their performance. If assessors did not achieve a specific criterion of 75% of possible points they were released from the study (Tourangeau et al., 2015). Quality control procedures were also employed throughout data collection. Parent interviews were generally conducted via telephone, and achievement tests were directly administered to students. Other details regarding ECLS-K procedures can be found in the ECLS-K: 2011 User's Manual (Tourangeau et al., 2018).

2.4. Design and data analyses

2.4.1. Sampling design

The ECLS-K used a multi-stage sampling design in which the country was divided into 90 primary sampling units and schools were sampled within these units based on population size. As part of recruiting for the study, letters were first sent to sampled schools and districts describing the ECLS-K procedures and processes. Subsequently, NCES staff called each school to request participation. Once schools had agreed to participate, NCES staff identified children within schools to include in the study and informed consent was gathered from parents via packets that schools distributed (Tourangeau et al., 2015).

2.4.2. Data preparation and missing data handling

Data were extracted from the NCES ECLS-K website utilizing the electronic code book application developed by the ECLS-K. Achievement variables were not highly skewed ($-1.12 \leq$ skew ≤ 1.50 across all achievement variables across waves) or kurtotic ($-0.52 \leq$ kurtosis ≤ 3.79 across all achievement variables across waves). Parent interview data were all categorical and were treated as such in all models. With regard to missing data, for weighted data (i.e., cases that had a positive weight and were thus included in the weighted analyses), percentages of missing values ranged from 0.45% to 1.54% (median = 0.62%) across achievement variables across waves and from 6.70% to 12.97% (median = 6.82%) across parent interview items that were ultimately included in the study. To address these missing data properly, different approaches were used for different analyses. For measurement models the WLSMV estimator was used because it generates overall model fit indices for categorical data unlike maximum likelihood estimators. Because the WLSMV estimator uses pairwise deletion, we used multiple imputation to address missing data properly (Baraldi & Enders, 2010). Based on the recommendation to generate more imputed datasets than the percentage of incomplete cases (White, Royston, & Wood, 2011; 81% of the current sample was missing at least 1 observation), we generated 85 imputed datasets using demographic, achievement, and teacher rated behavioral variables. For all other analyses, robust maximum likelihood estimators were used and as such missing data were handled using full information maximum likelihood procedures (Baraldi & Enders, 2010).

2.4.3. Analysis steps

First, we established the best fitting measurement model for the latent parenting variables. Next, we examined what model of growth best represented the academic achievement variables from kindergarten to the fourth grade. Finally, we integrated the measurement and growth models to address our research questions. For all data analyses we considered statistical significance as $p < .05$.

Step 1: Establish measurement model. First, steps were conducted to establish and evaluate an appropriate, well-fitting measurement model for the included latent variables (i.e., home-based involvement and parental warmth) as a precursor to the inclusion of latent variable interactions (Maslowsky, Jager, & Hemken, 2015). Specifically, we conducted a series of confirmatory factor analyses (CFAs) including two factors allowed to freely correlate for the home-based involvement and warmth variables. To enable evaluation of overall model fit, this CFA was conducted with a robust weighted least squares estimator (the WLSMV estimator of MPlus, Muthén & Muthén, 1998-2018) appropriate for categorical data. Overall model fit was evaluated relative to conventional cutoffs of RMSEA $<.06$; CFI/TLI $\geq .95$ (Hu & Bentler, 1999). Because of the large sample size and the sensitivity of χ^2 values to sample size (Little, 2013), a nonsignificant χ^2 value was not used as an indicator of a well-fitting measurement model.

Step 2: Establish growth curve models. Next, steps were taken to establish and evaluate an appropriate growth curve to characterize growth in achievement from the spring of children's kindergarten year through the spring of their fourth-grade year. Procedures from Grimm and Ram (2009) were followed to test an increasingly flexible and complex set of growth models. First, an intercepts-only model was fit, testing the null hypothesis of no growth across this time period. The primary purpose of this model was to serve as a comparison model for calculation of subsequent models' CFI and TLI statistics (Widaman & Thompson, 2003). Following previous work with the ECLS-K conducted in 1998–99 (Cameron et al., 2015) and the plausibility of a sigmoid-type “s” shaped function to characterize growth in academics during this developmental period, the following nonlinear models were tested: logistic growth, Gompertz curve growth, and Richards curve growth.

These models involved imposing constraints such that estimated model parameters were nonlinear (see Grimm & Ram, 2009; Grimm, Ram, & Estabrook, 2010, 2016; Grimm, Ram, & Hamagami, 2011 for further information on procedures for testing these complex growth models). The logistic and Gompertz models include three parameters: an individually varying total growth parameter indicating the total change in the outcome variable in the study frame; an individually varying rate of approach parameter that characterizes how rapidly changes occur; and an individually varying timing parameter that determines the point at which growth is most rapid. The Gompertz model also includes a universal lower asymptote parameter, which represents the starting point of children's growth trajectories and, unlike the other parameters in the model, does not vary across participants (Grimm et al., 2010). For a complete explication of these models, see Cameron et al., (2015).

The spring kindergarten wave was treated as the first measurement occasion (coded as 0), and subsequent measurement occasions were coded in half year increments relative to the spring of kindergarten (e.g., the spring of first grade was coded 1 and the fall of second grade was coded 1.5). Data were centered at Spring for two reasons. First, science data were not available until the spring of the kindergarten wave, so centering all achievement variables at this wave improved cross-domain comparability. Second, by treating the spring kindergarten wave as the first measurement occasion for growth curve estimation, we ensured that our home-based involvement and parental warmth variables reflected behaviors occurring prior to measured achievement. Because outcomes were continuous and sample weights were applied, a robust maximum likelihood estimator, the MLR estimator of MPlus, was used for these analyses. Each model was evaluated for overall model fit against the aforementioned criteria from Hu and Bentler (1999).

Because of the suboptimal performance of the RMSEA index with low degrees of freedom models (Kenny, Kaniskan, & McCoach, 2015), this index was deemphasized in favor of the CFI and TLI statistics, which are calculated against an intercepts-only model null model. The SRMR index was also used, with adequate fit indicated by SRMR values ≤ 0.08. Models were also compared using the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). Once a final model was identified, it was integrated with the established measurement model in the subsequent step. This process (Step 2) was repeated for each type of achievement included in this study.

Step 3: Integrate models and test latent interactions. Following procedures outlined by Maslowsky et al. (2015), we next integrated the established measurement and growth models. At this stage of analyses we also integrated utilized control variables. To avoid the possibility that the inclusion of extensive control variables might mask meaningful associations, we followed recommendations of Little (2013), who recommended pruning effects of control variables that may arise due to sampling variability, especially when sample sizes are large. Specifically, we first tested a model in which achievement growth factors (i.e., the total growth, rate of approach, and timing parameters, but not the lower asymptote, which is required to be equal across participants) were regressed on all latent factors, all latent variable interactions (i.e., the interactions between home-based involvement and parental warmth; home-based involvement and SES; and parental warmth and SES), and all control variables. Coefficients for control variables that may have arisen due to chance sampling fluctuation were then eliminated to generate Model 1. To inform decisions regarding control variables, we followed Little's (2013) recommendation to prune control effects with *p*-values $> .10$. Then, we compared this model with a model including all latent factors and control variables included in Model 1, but no latent variable interactions (Model 0). These models were compared using the log-likelihood difference χ^2 difference test. If a more complex model evidenced statistically significant superior fit relative to a less complex model (e.g., Model 1 vs. Model 0), the more complex model was retained for interpretation and plotting. If inclusion of added complexity (i.e., additional latent interaction terms) did not result in statistically significant improvements in model fit the simpler, more parsimonious model was retained for interpretation.

All latent interactions were computed using latent moderated structural equations (Klein & Moosbrugger, 2000) with the XWITH command of MPlus (Muthén & Muthén, 1998-2018). Also, we utilized uncorrected log-likelihood difference tests instead of robust difference tests as recommended by Maslowsky et al. (2015) and Gerhard et al. (2015). Because the inclusion of latent interactions requires maximum likelihood estimation, the robust maximum likelihood estimator was used for these analyses, but all categorical variables were specified as categorical as recommended by Rhemtulla, Brosseau-Liard, and Savalei (2012). This final step was repeated for each achievement variable.

For statistically significant results, we also provided several indices to illustrate the size of effects. First, we divided predicted raw score differences between high and low levels of significant predictors across waves by the weighted SD of outcome variables within each corresponding wave. For example, for a statistically significant home-based involvement coefficient on science we calculated the difference between predicted science achievement values of the model for individuals 1 SD above the mean of home-based involvement and 1 SD below the mean of home-based involvement at each wave. We then divided these differences by the weighted standard deviations of science achievement at each wave. Next, to give a sense of how these differences compared to students' long-term academic growth, we also divided predicted raw score differences for statistically significant effect across years by the average weighted yearly growth in achievement across all study participants. This latter calculation showed how differences compared to the average amount of growth students achieved throughout the study period. For example, in the previous example, we divided the predicted raw science score difference by the average yearly science growth across all students to give a sense of how meaningful these differences were.

3. Results

3.1. Measurement model

First, a CFA was conducted to establish an adequate measurement model for home-based involvement and parental warmth. In the initial CFA, all items from the same portion of the ECLS-K: 2011 parent survey were specified to load on correlated unidimensional factors for those sections (i.e., all 11 items from the *Home Environment, Activities, and Cognitive Stimulation* portion of the survey were set to load on the home-based involvement factor, and all 8 items from the *Discipline, Warmth, and Emotional Supportiveness* portion of the survey were set to load on the parental warmth factor). This model did not provide adequate fit to the data; χ^2 (151) = 567.49, $p < .001$; RMSEA = .03; CFI = .85; TLI = .83.

Upon further examination, four of the items from the *Discipline, Warmth, and Emotional Supportiveness* survey appeared to reflect negative parenting attitudes more than parental warmth (e.g., *My child does things that really bother me*). These items also had negative loadings that were generally weaker than loadings from the remaining four items that more specifically focused on parental warmth behaviors (e.g., *I express affection by hugging, kissing, and holding my child*). Thus, we tested a follow-up model with these four negative parenting attitudes items removed. This model fit the data adequately; χ^2 (89) = 182.651, $p < .001$; RMSEA = .02; CFI = .96; TLI = .96; SRMR = .04; but one item (*In a typical week, how often do you or any other family members read books to your child in a language other than English?*) had a very low loading (λ = .10). Because this item's association with home-based involvement is also theoretically questionable, it was dropped for all subsequent analyses. Thus, the final CFA included a parental warmth factor indicated by four items and a home-based involvement factor indicated by 10 items. This model fit the data well; χ^2 (90) = 190.41, $p < .001$; RMSEA = .02; CFI = .96; TLI = .95; SRMR = .04 (Table 3). Standardized loadings ranged from .43 to .80 (median = .56; Table 4) and the interfactor correlation between home-based involvement and warmth was .34.

Table 3
Model fit statistics for measurement model and latent growth models by achievement domain.

Model	χ^2 (df)	RMSEA [90% CI]	CFI	TLI	SRMR[a]	AIC	BIC
Measurement model	190.41 (90)	.02[b]	.96	.95	.04	–	–
Growth models							
Reading							
Logistic	4971.39 (27)	.28 [.27–.29]	.59	.51	–	128,922.86	128,968.95
Gompertz	693.68 (18)	.13 [.12–.14]	.94	.90	.06	116,347.78	116,445.72
Richards	950.49 (23)	.13 [.12–.14]	.92	.89	.12	117,205.16	117,274.29
Mathematics							
Logistic	4734.43 (27)	.27 [.27–.28]	.63	.56	–	126,616.44	126,662.53
Gompertz	442.83 (18)	.10 [.09–.11]	.97	.94	.05	115,192.96	115,290.90
Richards	665.86 (23)	.11 [.10–.12]	.95	.93	.10	115,748.28	115,817.41
Science							
Logistic	3833.53 (27)	.25 [.24–.25]	.66	.59	–	113,590.41	113,636.50
Gompertz	174.41 (18)	.06 [.05–.07]	.99	.99	.04	104,530.15	104,628.09
Richards[c]	–	–	–	–	–	–	–

Note. RMSEA = Root Mean Squared Error of Approximation; CFI = Comparative Fit Index;
TLI = Tucker Lewis Index. SRMR = Standardized Root Mean Square Residual. All χ^2 values were statistically significant.
[a] MPlus did not generate the SRMR statistic for logistic models.
[b] MPlus does not generate confidence intervals for the RMSEA statistic when multiple imputation is utilized.
[c] Model did not converge.

Table 4
Standardized factor loadings for final measurement model.

Item	Loading
Home-based involvement	
Tell your child stories?	.54
Sing songs with your child?	.48
Help your child do arts and crafts?	.49
Involve your child in household chores?	.46
Play games or do puzzles?	.56
Talk about nature or do science projects?	.59
Build something or play with construction toys?	.50
Play a sport or exercise together?	.43
Practice reading, writing, or working with numbers?	.55
Read books?	.58
Parental warmth	
My child and I often have warm, close times together.	.80
Most of the time I feel that my child likes me and wants to be near me.	.77
Even when I'm in a bad mood, I show my child a lot of love.	.67
I express affection by hugging, kissing, and holding my child.	.75

3.2. Growth models

Next, a series of analyses were conducted to establish an adequate growth model characterizing children's growth in achievement across this developmental period. First, growth modeling procedures were applied to reading achievement data. The first model tested was a logistic model, which evidenced poor fit to the data; χ^2 (27) = 4971.39, p < .001; RMSEA = .28 [.27–.29]; CFI = .59; TLI = .51; AIC = 128,922.86; BIC = 128,968.95.[2] Next, a Gompertz model was fit and evidenced somewhat adequate fit to the data as some but not all fit statistics were adequate; χ^2 (18) = 693.68, p < .001; RMSEA = .13 [.12–.14]; CFI = .94; TLI = .90; SRMR = .06; AIC = 116,347.78; BIC = 116,445.72. Finally, a Richards model was fit to the data and evidenced mediocre fit; χ^2 (23) = 950.49, p < .001; RMSEA = .13 [.12–.14]; CFI = .92; TLI = .89; SRMR = .12; AIC = 117,205.16; BIC = 117,274.29. Although not all fit statistics met a priori criteria, the Gompertz model was retained for interpretation because it evidenced the best fit according to both overall and comparative fit indices. Furthermore, fit statistics for this sample were actually better than those in prior research utilizing nonlinear growth curve modeling approaches with the ECLS-K 1998–99 cohort (Cameron et al., 2015), which also found that the Gompertz model was the best fitting model compared to several other nonlinear growth curve models despite some less-than-adequate individual fit statistics. These procedures also identified the Gompertz model as the best fitting model for mathematics, χ^2 (18) = 442.83, p < .001; RMSEA = .10 [.09–.11]; CFI = .97; TLI = .94; SRMR = .05; AIC = 115,192.96; BIC = 115,290.90; and science achievement, χ^2 (18) = 174.41, p < .001; RMSEA = .06 [.05–.07]; CFI = .99; TLI = .99; SRMR = .04; AIC = 104,530.15; BIC = 104,628.09 (Table 3).

[2] Mplus did not report an SRMR value for logistic models for any achievement outcome, likely due to their poor fit.

3.3. Integrated models

Finally, the preceding models were integrated to test our research hypotheses.

3.3.1. Reading achievement

First, integrated models were tested with reading achievement scores. Model 1, which included two-way interactions, demonstrated statistically significant improvement in fit relative to Model 0, which did not include latent variable interactions; D (9) = 17.35, p = .044.[3] Thus, Model 1 was retained for interpretation. Although inclusion of the two-way latent variable interactions was statistically supported, there was only one statistically significant coefficient for latent variables or interactions in the final model. Specifically, the only significant coefficient for a latent variable or interaction was the effect of the interaction between home-based involvement and warmth on the rate of approach parameter ($\beta = -0.12$).

Effect sizes helped elucidate this effect. Specifically, at high levels of parental warmth, there was an initial small positive effect of home-based involvement in kindergarten (0.16 SD; roughly 16% of students' average yearly reading growth[4]). This effect diminished substantially over the remaining waves from a small positive effect in the fall of children's first grade year (0.09 SD; roughly 12% of students average yearly reading growth) to a negligible positive effect in fourth grade (0.03 SD; roughly 2% of students' average yearly reading growth). In contrast, at low levels of parental warmth, home-based involvement had more substantial, although still small, effects. Specifically, there was an initial small positive effect of home-based involvement in kindergarten (0.08 SD; roughly 7% of students' average yearly reading growth) that increased across the next few waves, peaking at 0.21 SD in second grade (roughly 23% of students average yearly reading growth) and tapering to 0.16 SD in fourth grade (roughly 15% of students average yearly reading growth). Thus, there were more substantial, although still small effects of home-based involvement on children's reading growth in contexts marked by low rather than high parental warmth. SES was a large and statistically significant predictor of the total growth ($\beta = 0.32$) and timing ($\beta = -0.29$) parameters, indicating that higher SES was associated with more total growth in reading and acceleration occurring slightly over 2.5[5] months earlier on average. All standardized coefficients can be found in Table 5.

3.3.2. Mathematics achievement

Next, this analytic procedure was repeated for mathematics outcomes. Unlike with reading, Model 1 did not evidence statistically significant improvement in fit relative to Model 0; D (9) = 9.45; p = .40. Thus, Model 0 was retained as the most parsimonious model for interpretation. These coefficients can be found in Table 5. SES was a large and statistically significant predictor of the total growth ($\beta = 0.22$), rate of approach ($\beta = -0.14$.), and timing ($\beta = -0.28$) parameters, indicating that a 1 unit increase in SES was associated with more total growth in reading and acceleration occurring about 2.25 months earlier on average.

3.3.3. Science achievement

For the science achievement model, Model 1 evidenced statistically significant better fit than Model 0; D (9) = 17.24, p = .045. Thus, Model 1 was retained for interpretation. There were more statistically significant coefficients in the science model relative to the reading and mathematics models. First, home-based involvement emerged as a statistically significant predictor of the total growth ($\beta = 0.11$) and rate of approach ($\beta = -0.15$) parameters. This pattern indicates that higher levels of home-based involvement were associated with more total science achievement growth on average, with acceleration happening slightly more gradually and occurring slightly earlier on average (Table 5; Fig. 1). Effect sizes indicated a fairly large effect of home-based involvement in kindergarten (0.27 SD; roughly 25% of students' average yearly science growth) which gradually diminished to a smaller, but still meaningful effect in fourth grade (0.16 SD; roughly 22% of students' average yearly science growth). SES was a large and statistically significant predictor of the total growth ($\beta = 0.22$) and timing ($\beta = -0.30$) parameters, indicating that a 1 unit increase in SES was associated with more total growth in reading and acceleration occurring slightly over 3.5 months earlier on average.

Next, the interaction between parental warmth and SES was a statistically significant negative predictor of total science growth ($\beta = -0.10$). This interaction indicated that at high levels of SES, lower levels of warmth predicted more total science growth relative to higher levels of warmth. In contrast, at lower SES levels, higher levels of warmth predicted more total science growth relative to lower warmth levels (Fig. 2). Effect sizes indicated that at high levels of SES, parental warmth had a large negative effect in kindergarten (−0.34 SD; roughly 31% of students' average yearly science growth) which gradually tapered to a smaller, but still meaningful effect in fourth grade (−0.17 SD; roughly 23% of students' average yearly science growth). In contrast, at low levels of

[3] D = −*2[(*log-*likelihood for Model 0) – (*log-*likelihood for Model 1)]*; Values of D are distributed as χ^2

[4] An example is provided to elucidate effect size calculation. Our final model predicted a raw score difference of 2.13 points in favor of children with higher home-based involvement in the spring of children's kindergarten year. The weighted standard deviation of reading scores at this time point was 13.50, which means that this difference is equivalent to a 0.16 SD advantage in favor of children experiencing higher home-based involvement at this time point and with high levels of parental warmth. Furthermore, we calculated the average yearly growth in reading by subtracting each child's starting reading IRT score from their final reading IRT score and divided that difference by the number of years in the study (4). We then averaged the results across students, which indicated that on average, students grew by 13.69 points in reading per year. Dividing the previously calculated difference by this figure indicates that this difference amounts to roughly 16% of students' average yearly reading growth, which further contextualizes the results.

[5] Calculated by multiplying the raw coefficient by the number of months in a year (12). For example, −0.21 (the raw coefficient of the effect of SES on the timing parameter) * 12 months = 2.5 months.

Table 5
Standardized beta coefficients and standard errors for final models.

	Total growth		Rate of approach		Timing	
	β	SE	β	SE	β	SE
Reading achievement						
HBI	0.05	0.05	−0.03	0.06	−0.06	0.04
PW	0.003	0.05	0.02	0.05	−0.03	0.05
SES	0.32***	0.03	−0. 01	0.04	−0.29***	0.04
HBI x PW	−0.0002	0.05	−0.12**	0.04	0.02	0.04
HBI x SES	−0.03	0.05	0.005	0.05	0.02	0.03
PW x SES	−0.03	0.05	−0.003	0.08	0.03	0.04
Sex	0.15**	0.05	–	–	−0.19***	0.05
Age	–	–	−0.07*	0.03	−0.11***	0.03
African American	−0.42***	0.11	–	–	0.32**	0.11
Hispanic	−0.20**	0.08	–	–	0.24**	0.09
Asian	0.17*	0.07	−0.20†	0.11	–	–
Other	–	–	–	–	0.24**	0.08
Mathematics achievement						
HBI	0.01	0.05	0.04	0.06	−0.06	0.05
PW	−0.03	0.05	0.02	0.05	0.02	0.05
SES	0.22***	0.03	−0.14**	0.05	−0.28***	0.03
Sex	−0.30***	0.04	–	–	–	–
Age	0.10***	0.03	−0.23***	0.05	−0.18***	0.03
Married parents	0.19**	0.07	−0.20*	0.09	–	–
African American	−0.67***	0.08	–	–	0.58***	0.13
Hispanic	−0.30***	0.05	–	–	0.37***	0.09
Asian	0.31***	0.06	–	–	–	–
Other	–	–	–	–	0.21**	0.07
Science achievement						
HBI	0.11*	0.05	−0.15*	0.07	−0.08†	0.05
PW	0.003	0.05	0.02	0.08	0.07	0.04
SES	0.22***	0.04	−0.09†	0.06	−0.30***	0.05
HBI x PW	−0.07	0.04	0.09†	0.06	0.01	0.05
HBI x SES	0.04	0.04	−0.09	0.05	0.02	0.05
PW x SES	−0.10*	0.01	0.12†	0.07	0.002	0.97
Age	–	–	–	–	−0.21***	0.04
African American	−0.87***	0.10	0.72***	0.18	0.38*	0.15
Hispanic	−0.62***	0.10	0.81***	0.18	0.43**	0.13
Asian	−0.34*	0.14	0.80***	0.15	0.28†	0.16

Note. HBI = Home-Based Involvement; PW = Parental Warmth; SES = Socioeconomic Status. Dashes indicate paths that were not included in final models to avoid overcontrol (Little, 2013). Sex variable dummy coded (1 = *Girl,* 0 = *Boy*).
† $p < .10$.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

SES, parental warmth had a small effect in kindergarten (0.06 SD; roughly 6% of students' average yearly science growth) which gradually increased to a small, but meaningful positive effect in fourth grade (0.15 SD; roughly 21% of students average yearly science growth). All coefficients can be found in Table 5.

4. Discussion

The primary purpose of the current study was to examine the main and interaction effects between home-based involvement, parental warmth, and SES in predicting student growth in reading, mathematics, and science from kindergarten to the fourth grade. Parent involvement, warmth, and SES were considered as interactional process and context variables using an ecological systems theory framework. In addition, this study examined the effects of these variables on achievement growth building on prior research that has more commonly used current achievement status as an outcome. Overall, findings indicated that there were few main or interaction effects for our primary variables for reading and mathematics growth outcomes. There were more and more meaningful statistically significant effects, however, for science outcomes. Specifically, the main effect of home-based involvement and the interaction between parental warmth and SES were both statistically significant predictors of growth in science.

4.1. Effects of parenting variables on achievement

With regard to the main effects of this investigation, there are several key findings to discuss. First, a broad pattern emerged

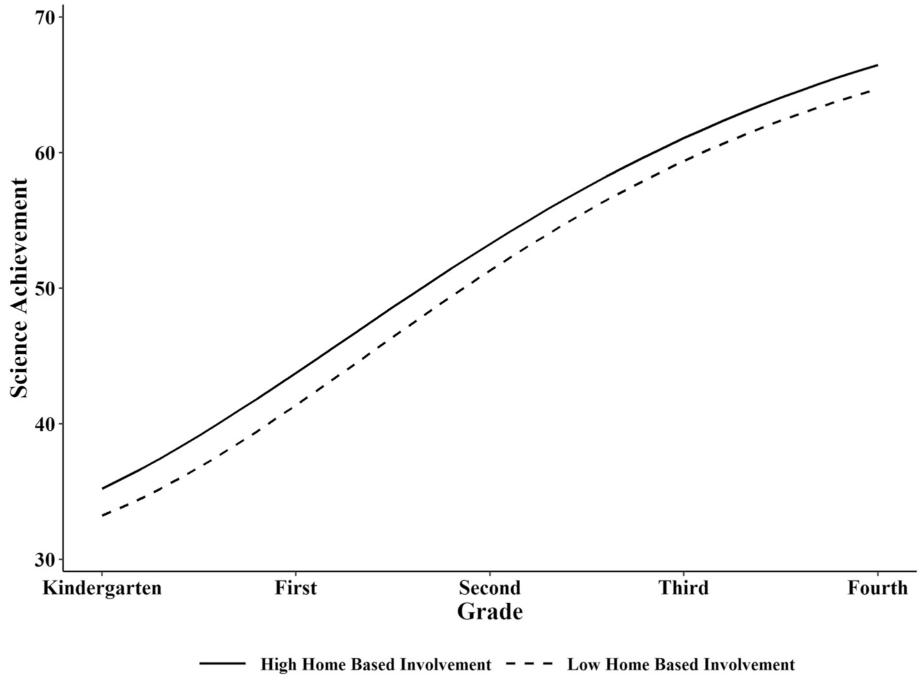

Fig. 1. Main effect of home based involvement on growth in science achievement from the Kindergarten through 4th grade.

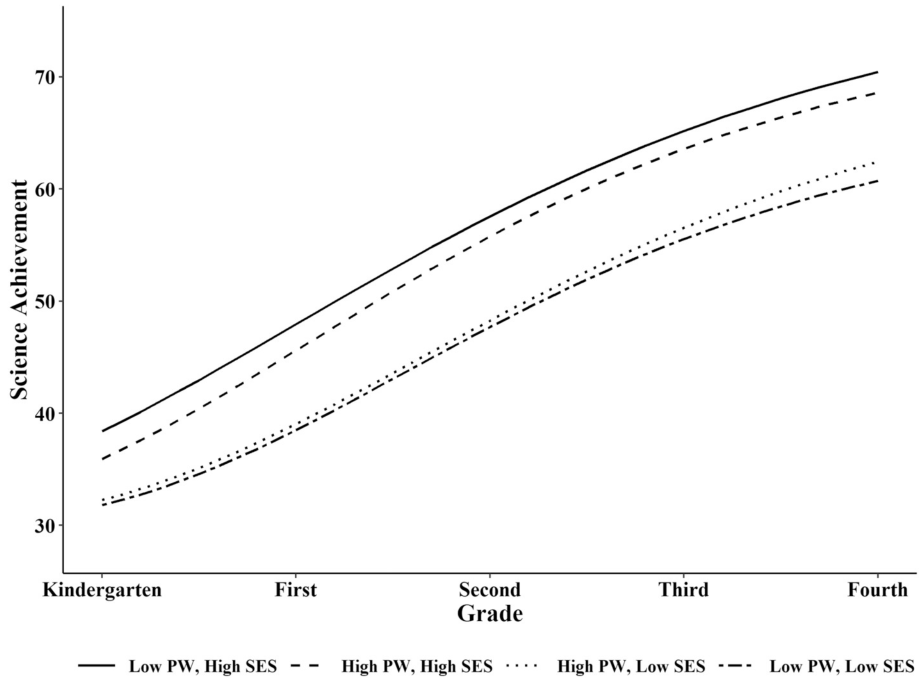

Fig. 2. Interaction effect between parental warmth (PW) and socioeconomic status (SES) on growth in science achievement from Kindergarten through 4th grade.

indicating that home-based involvement had an important and significant association with children's growth in science, but not in reading and mathematics. Related to the finding that home-based involvement was related to science growth, such a pattern has not been observed in previous studies, although limited research has examined reading, mathematics, and science outcomes together, particularly when growth on these variables is measured. The limited research that has separated out reading, mathematics, and science, has found correlations of similar magnitude between parental involvement and science relative to reading and mathematics using both grades and measures of achievement (Fan & Chen, 2001; Keith & Keith, 1993). Specifically, prior research on home-based involvement has suggested a small to moderate effect on achievement outcomes (Fan & Chen, 2001; Jeynes, 2005), and the current study was consistent with this size of effect in science, but not reading or mathematics. To put the size of the effect in context, the effect of home-based involvement on students' total growth indicated that students with high levels of parent involvement ended fourth grade with about 22% of an average year's more growth in science than their peers with low levels of home-based involvement.

The finding that home-based involvement did not have any associations with reading and mathematics growth was unexpected, as previous research has found similarly sized associations between reading and mathematics with parent involvement (Fan & Chen, 2001). One possibility for the different findings in the current study is that most prior research examines the achievement at one point in time and not as growth over time. In prior work that has examined growth patterns, Dearing et al. (2004) found that parental involvement, school-based involvement specifically, predicted growth in children's feelings about literacy, but not growth in literacy performance. Thus, the current findings highlighted the importance of continued longitudinal research on the association between parental involvement and academic growth.

No main effect of warmth was observed for any of the academic areas in the current study. Prior research is suggestive of a positive association between parental warmth and achievement, but is not conclusive. For example, Culp et al. (2000) found that parental warmth was a positive predictor of scores in preschool, but not in kindergarten. In addition, using the ECLS-K of 1998–99, the prior iteration of the ECLS-K program, Bodovski and Youn (2010) found that parental warmth in kindergarten did not relate to achievement outcomes in the fifth grade. In contrast, these authors found that other aspects of the emotional climate, such as parental depression and physical discipline did relate to achievement outcomes. Aspects of warmth may be important for younger students, but these effects may decrease as students move through school and other aspects of parenting may be more important, such as parent management and monitoring. Furthermore, the importance of parental warmth may be more in its moderation of the effects of other variables, as observed in this study and discussed in the following section.

4.2. Interaction effects

In addition to examining main effects, we also examined several interaction effects informed by ecological systems theory. Specifically, we examined whether parental warmth moderated the effects of home-based involvement on achievement, whether SES moderated the effects of home-based involvement on achievement, and whether SES moderated the effects of parental warmth on achievement. With regard to the interaction between home-based involvement and parental warmth predicting achievement, the only significant interaction was for the rate of approach parameter in the reading model. There was not a significant finding for the overall growth or timing parameters in any model. Because there was only a small effect on this parameter and not on other growth parameters, the effects implied by this model are small. Specifically, at low levels of parental warmth, home-based involvement had some small effects on children's reading growth, but at high levels of parental warmth, home-based involvement had negligible effects after an initial small positive effect. Although these implied differences were not large, the fact that no main effect emerged for either of these variables, but the interaction between them did underscores the importance of considering interactions between parenting processes and context.

With regard to parental warmth, although no main effects were observed for any parameter, parental warmth interacted with SES to predict total growth for the science model. Specifically, at high levels of SES, relatively lower levels of warmth were associated with more growth in science compared with relatively high levels of warmth. At high levels of SES, children whose parents reported high levels of warmth obtained lower science scores. The magnitude of this difference was roughly 31% of students' average yearly science growth in kindergarten and 23% of students' average yearly science growth in fourth grade. At lower levels of SES, however, the opposite association occurred such that relatively higher levels of warmth were associated with more growth in science compared with relatively low levels of warmth. The magnitude of this difference was roughly 6% of students' average yearly science growth in kindergarten and rose to 21% of students' average yearly science growth in fourth grade.

The latter findings are expected given prior research in this area indicating that SES moderated the association between parental warmth and pre-reading scores, such that parental warmth was a stronger predictor of pre-reading scores in lower SES families than for higher SES families (Hill, 2001). We anticipated the advantage of warmth at lower SES levels, which was corroborated by our findings. Our study expanded this work by specifically considering science achievement as an outcome and by examining this association longitudinally. An implication of these findings is that in families with lower SES, parental warmth may be an important protective factor for supporting a child's achievement in science.

The finding that lower parental warmth was associated with more growth in families with higher SES was unexpected. Prior research on parental warmth generally supports its link with positive psychosocial outcomes (e.g., Hipwell et al., 2008; Lowe & Dotterer, 2013). As one consideration of this finding, it is important to note that low warmth in this study did not necessarily indicate a complete lack of warmth or parental harshness, but rather must be interpreted according to what parents report on the items. Indeed, most parents reported having a generally warm relationship with their children. For example, across the items used to indicate the warmth variable, 68% to 94% of parents indicated category 4 (*Completely true*). This finding is not uncommon; other studies using parent self-report have found high average levels of parental warmth. For example, Hill (2001) reported an average warmth of 3.36 and above on a scale from 0 to 4. In the current study, the average levels of reported warmth were also moderately high. As such, low warmth in this study should be understood to reflect *relatively* low reported warmth as opposed to *absolutely* low reported warmth. It is possible that if warmth comes at the expense of other positive parenting techniques, such as parental monitoring, this more permissive approach could be counterproductive, especially when children have access to many resources for learning. Such a possibility would be in line with prior research that has found permissive parenting, characterized by high levels of warmth, but low levels demandingness, to be associated with lower levels of achievement than authoritative parenting (e.g., Dornbusch, Ritter, Leiderman, Roberts, & Fraleigh, 1987).

Also in the current study, parental warmth was operationalized as warmth between the parent and child including showing affective and feeling close to the child. Additional aspects of positive parenting beyond the narrow definition of parental warmth should be considered in future studies of parental involvement help explain our findings. For example, how responsive a parent is to the child may relate differently to outcomes than expressions of warmth. Although these cautions should be considered, this finding from the current study does align with ecological systems theory, which suggests that parenting variables, such as warmth that may function as buffers, will be have positive effects in the context of risk (Darling, 2007). A consideration of this finding within an ecological systems theory framework also raises the possibility that such a buffering effect may differ across outcome areas. For example, parental warmth could serve as a buffer in the context of child behaviors, but less so for academic achievement outcomes. In fact, parental warmth has been negatively linked consistently with disruptive child behaviors (Khaleque, 2013; Stormshak, Bierman, McMahon, & Lengua, 2000). Future research could consider how the interactions between parental involvement, parental warmth, and SES may relate to child behavioral outcomes in addition to academic achievement.

It is also notable that the effects of home-based involvement and parental warmth were more substantial for science than reading and especially mathematics. This finding may also be explained by the consideration of the context of the outcome variable, which is also a feature of ecological systems theory. Specifically, the context of science instruction in the United States is starkly different than the context of either mathematics or reading. It is plausible that these results emerged because science as a curricular domain receives far less attention in school-based instruction relative to mathematics and especially reading. For example, during the 2017–18 school year, the average third grade student spent about 6 h less on science related content per week than reading related content (U. S. Department of Education, 2018). Given the strong curricular emphasis in reading and mathematics, one hypothesis is that this heavy focus in school could effectively wash out a substantial portion of the impact of home-based involvement or warmth in these curricular areas. In other words, because school strongly emphasize reading in their curricula, the quality and quantity of reading and mathematics instruction in school is the primary external variable affecting growth in these subjects, effectively reducing the importance of some parenting variables.

Relating the hypothesis of curricular underemphasis in science to our home-based involvement main effect, both skill and motivational pathways can be considered (Pomerantz et al., 2007). It could be that with less emphasis on science in school, parent's engagement in education at home is particularly important to build skills and to highlight the importance of science for children; however, our findings are more likely in support of a motivational model because our home-based involvement variable was not science-specific. As such, it was unlikely that these activities build skills specific to science. Rather, they may have increased children's motivation and enjoyment of school, thereby improving their achievement in this area. Because there is less coverage of science in school, the motivational effects of home-based involvement could be particularly important for science and similarly underemphasized content areas, such as social studies. Future research should explore this hypothesis more directly to answer important questions related to the role of skill and motivational pathways in linking parental involvement with achievement.

4.3. Limitations

There are several important limitations of the current study to consider. One limitation was the focus on two of many potentially important parenting variables. For example, in the domain of parent involvement, many researchers identify school-based involvement and home-school communication to be key domains in addition to home-based involvement. Theory led us to focus on home-based involvement, given the higher likelihood of parent-child interactions for this variable relative to school-based involvement and home-school communication, however, follow-up research could examine if similar outcomes are observed in regarding school-based involvement and home-school communication, as well as the additive effects across domains. In addition, the specific items included on this measure of home-based involvement should be considered in making conclusions. It may be that home-based involvement is multidimensional with differences between activities that are generally cognitively stimulating and those that are more academically focused such as homework, or focused on a particular subject area such as science. Also, although fairly comprehensive for a large, nationally representative, longitudinal study, the home-based involvement measure did differ slightly from other measures used frequently to measure this constructs (e.g., Fantuzzo et al., 2000). For example, one measure that has been used frequently, the Family Involvement Questionnaire (FIQ; Fantuzzo et al., 2000) has more items specific to academic work. However, many of the items used in the current study and the FIQ do overlap conceptually, such as work on reading/writing/numbers, engaging in creative activities. Other studies have used shorter measures (e.g., Hill, 2001 used a four item measure) or have combined several forms of involvement (i.e., home and school on one scale; Simpkins et al., 2006) and have often relied on a measured variable approach as opposed to utilizing latent variable modeling. Taken together, the scale in the current study should be viewed as a measure of home-based involvement that focuses on more general forms of involvement. It may be easier for parents to exhibit warmth and support on these more general activities (Pomerantz et al., 2007) compared to homework where the likelihood of parent and child negative affect and stress may be more likely. Future research on this type of measure of home-based involvement may yield different results.

Likewise, the current study focused on parental warmth, and specifically on the warmth between parent and child. Other aspects of parental support, such as parent responsiveness, encouragement, and praise could also play an important role in predicting achievement. In addition, parenting styles are typically characterized not only by emotional support, but also by the extent to which parents monitor and manage their child's behavior (Darling & Steinberg, 1993). It is likely that parent management behaviors may exhibit a different association with achievement. In fact, prior research has suggested that positive parenting styles and negative parenting styles are not different ends of the same continuum in terms of their association with outcome variables (Culp et al., 2000), and it may be important to consider negative factors, such as parental control or intrusiveness in future research. Although our study focused on two of several possibly important parenting variables, the study makes an important contribution by considering how these key parenting variables work together to predict achievement.

The use of self-report measures could also be considered a limitation. Although most research on home-based involvement relies on self-report, many studies on parental warmth use observational measures (e.g., Pasalich, Dadds, Hawes, & Brennan, 2011; Zhou et al., 2002) or child report (e.g., Wang et al., 2011) to assess this construct. Parental self-report measures are considered susceptible to social desirability bias (Morsbach & Prinz, 2006), which in this context could help explain the typically high scores observed in this study. The use of observational or other-report measures may result in more variability in the levels of warmth, which could help uncover important differences between high and low levels of parental warmth.

4.4. Future research directions and implications

Children's academic growth was influenced through both main effects via home-based involvement and interactional effects for both home-based involvement and parental warmth and especially parental warmth and SES. The fact that these effects were much stronger for one science, compared to reading and mathematics, carries important implications for future research and practice. Two potential hypotheses for this finding warrant further investigation: (a) these effects indicate that these variables have general effects that would be present on all curricular domains but are reduced by a strong emphasis on reading and mathematics in school or (b) that there is something unique to science that is particularly impacted by parenting variables. The first hypothesis could be explored by examining the impact of parenting variables on similarly underemphasized domains such as social studies. If the first hypothesis is true and the reason parenting variables had more impact on science was due to its relative curricular underemphasis, one possible implication is to focus family resources, such as parent involvement, to support academic areas that are not heavily focused on in school. Such a possibility should be explored in future research. The hypothesis that there is something unique to science that resulted in the larger parenting variable effects could also generate important future research. For example, growth across academic areas may vary because different academic domains may be influenced by different key sets of skills that are differently influenced by parenting (e.g., executive function; e.g., Allan, Hume, Allan, Farrington, & Lonigan, 2014; Nguyen & Duncan, 2019; Sasser, Bierman, & Heinrichs, 2015). Such differences in school experiences and developmental growth processes across academic areas may result in differential effects of parenting variables across achievement in these domains. This possibility should be explored in future research.

Also, future research should also examine child level moderators of the association between parenting variables and achievement. Ecological systems theory also stresses that the child is an active contributor to their own development. A number of authors have found that children's competence experience may moderate the association between parent involvement and achievement-related variables (Pomerantz et al., 2005a; Pomerantz, Wang, & Ng, 2005b). In addition, theoretical models (Hoover-Dempsey et al., 2005) suggests that factors such as children's self-efficacy, self-regulation, and motivation mediate this association, and there is evidence that children's approaches to learning mediate this association in the empirical literature (Xu, Benson, Mudrey-Camino, & Steiner, 2010). In addition, children's feelings about literacy, have been shown to mediate the association between parental involvement and achievement (Dearing et al., 2004). These factors are consistent with the “person” aspect of the person, process, and context approach to ecological systems theory and should be more explicitly considered in future research.

Related to the more-meaningful effects of parenting and context variables on science, future research and practice should focus on increasing home-based involvement and attending to levels of parental warmth depending on SES level. A number of evidence-based approaches for improving parent-child relationships have been established to improve behavioral outcomes among youth with externalizing behavior problems (Eyberg, Nelson, & Boggs, 2008). Linking these approaches, such as increasing attention to positive child behaviors, with strategies for increasing home-based involvement could be an important next step to ensuring the parental involvement is optimally beneficial for all students. For example, supplementing academic activities provided to parents for homework with strategies for interacting in a positive and supportive way with their child may help enhance the efficacy of homework and may help highlight key contextual factors or mechanisms for how parent involvement interventions work (Garbacz et al., 2017).

4.5. Conclusions

Taken together, this study illustrated the complicated interplay of factors when considering the impact of parenting variables on academic growth. This study adds to our understanding of how parent involvement, parental warmth, and SES may promote academic achievement. From the standpoint of main effects, the current study demonstrated that home-based parent involvement and parental warmth did not predict achievement growth in reading and mathematics, but that home-based involvement did predict achievement growth in science. In addition, the study demonstrated a small interactional effect between home-based involvement and parental warmth predicting reading growth and a more substantial interactional effect between parental warmth and SES predicting science growth. This latter effect indicated that higher levels of warmth were more beneficial in the context of risk. Such an interplay is expected within an ecological systems theory emphasizing person, process, and context variables. Our results indicated that four variables influenced results: home-based involvement, parental warmth, SES, and curricular domain. It is likely that many other variables also have important main or interaction effects. As such, in addition to the specific insights provided by the study, the findings ultimately illustrate the importance of attending to process and context when considering the influence of parenting variables on students' school functioning.

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