HOW CHILDREN LEARN FROM PARENTS AND PARENTING OTHERS IN FORMAL AND INFORMAL SETTINGS: INTERNATIONAL AND CULTURAL PERSPECTIVES,
2nd Edition

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HOW CHILDREN LEARN FROM PARENTS AND PARENTING OTHERS IN FORMAL AND INFORMAL SETTINGS: INTERNATIONAL AND CULTURAL PERSPECTIVES, 2nd Edition

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For several decades, parent-child cognitive interaction researchers have acknowledged that children learn cognitive skills in the context of their social and early environments. These cognitive skills are often imparted to the children by parents or parenting others in formal or informal settings. Thus, for example, such informal settings as dinner table conversations, walks through grocery stores, museums, or neighborhoods become rich laboratories for children to learn varied cognitive skills ranging from numeracy, concepts, and language. The way in which those learning opportunities are provided by parents, structured by parents and scaffolded by parents may well vary depending on culture, and other socio-demographic variables; and may well vary depending on formal or informal settings.

The aim of this Research Topic is to bring together scholarship from both global north and global south contexts which explores how children learn via parental involvement in formal and informal settings.

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EDITORIAL
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Editorial: How Children Learn From Parents and Parenting Others in Formal and Informal Settings: International and Cultural Perspectives

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Editorial on the Research Topic

How Children Learn From Parents and Parenting Others in Formal and Informal Settings: International and Cultural Perspectives

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The goal of this special Research Topic is to bring together scholarship from diverse perspectives to address how broadly- and narrowly-defined parenting behaviors correlate with child and adolescent cognitive/emotional outcomes. Each contributor to this special Research Topic examines the issue of parenting behaviors and child/adolescent developmental outcomes from different methodological and theoretical orientations. The Research Topic includes 10 peer-reviewed articles, including 2 literature reviews and 8 empirical research articles. In accordance with the objectives of the topic, the contributions come from different nationalities, as parenting has a cultural component. However, while the literature agrees on the possible contribution of parenting to the adaptation of children and adolescents, influencing psychological well-being and cognitive and academic outcomes, little is known about cultural variables and about the association between constructs in different countries. Our contribution aims to stimulate debate in this direction, collecting contributions on the relationship between parenting and the adjustment of individuals at different points in development and, in particular, from different countries, in order to highlight the importance of the cultural context.

LITERATURE REVIEW

In their article, Rollè et al. review the contemporary literature on father involvement and cognitive outcomes in preschool and middle school children. They conclude that father involvement is a multidisciplinary construct and that when, how, and why fathers are involved in their children's lives varies according to SES, ethnicity, education level, and residency. With a somewhat different focus, Trombetta et al. review the extant research on the linguistic environment of twins, with the goal of teasing apart the distinctive features of the home environment language, which potentially accounts for the language performance differences between twins and singletons. They point to the need to consider computational methods and contexts as we make interpretations about the differential linguistic performance between twins and singletons.

EMPIRICAL FINDINGS: PARENTING AND COGNITIVE OUTCOMES IN CHILDREN AND ADOLESCENTS

Suh et al. explore the interactions between mothers and their children from different ethnic backgrounds as they are engaged in block-building type tasks. We learn from their work, for example, that ethnicity is a significant predictor of maternal engagement and the time spent on tasks.

Lara and Saracostti provide a cultural perspective on levels of parental involvement and how these levels are associated with academic achievement in Chilean school age children, and they observed that highly- and medium-involved parents have children with higher academic outcomes.

Based upon the Walker et al. (2005) theoretical model, Jiang et al. extend our knowledge about the correlation between parental theories of intelligence ("incremental theory" vs. "entity theory") and their involvement in children's education. They observed this association in China: a specific cultural context in which parents place an exceptionally high value on education and are actively engaged in their children's education at home. In particular, this study addressed the congruence and discrepancy between parents, highlighted the importance of parental beliefs in parent educational involvement, and revealed the significant role of mothers.

EMPIRICAL FINDINGS: PARENTING AND EMOTIONAL OUTCOMES/MENTAL HEALTH IN CHILDREN AND ADOLESCENTS

In Australia, Waters et al. examine over time the relationship between strength-based parenting and subjective well-being in teens and preteens. Interestingly, the authors suggest that parenting is a significant predictor of the well-being of children in real time but that strength-based parenting does not predict children's future well-being. Considering the decline in strength-based parenting, the authors highlight the importance of supporting parent-child relationships during adolescence to improve their mental health.

Similarly, Calandri et al. found that adolescents with high levels of parental support are less depressed, and this finding holds central for adolescent girls, especially if the support is provided by their mothers. The researchers provide suggestions on designing intervention programs for adolescents and their parents.

The contribution of Bi et al. extends our knowledge about the association between parenting and parent-adolescent relationships in the Chinese cultural context. In particular, the novelty of this study is in providing some empirical evidence about the possible mediating role of beliefs regarding the legitimacy of parental authority and expectations of behavioral autonomy. The authors found that autonomy expectations mediated the effect of parenting style on parent-adolescent conflict, but authority legitimacy mediated the effect of parenting style on parent-adolescent cohesion. In addition, the results are discussed in light of gender differences.

In order to develop more sensitive prevention strategies for problematic mobile use of, Zhu et al. tested the possible mediating roles of perceived discrimination and school engagement in the relationship between parental rejection and problematic mobile use among Chinese university students. The results provide some empirical evidence about the possible role of parents in the development of problematic mobile use, and in particular, the results suggest that perceived discrimination and school engagement can exert sequential mediating effects on the path between parental rejection and problematic mobile phone use.

Finally, the interesting contribution of Hesp et al. demonstrates how seconds can be extended to real-time playful interaction between parents and children in the context of autism spectrum disorder. As commented by the authors, this "investigation opens the door toward the use of agent-based modeling as a cost-effective and ethical way to design and test new therapeutic interventions that stimulate the socio-emotional development of ASD children" (Hesp et al., p. 5).

In conclusion, the contributions presented in this topic tend to reconfirm, in different cultures, the role of parenting in promoting the adaptive development of children and adolescents, highlighting possible similarities but also differences between maternal and paternal function. Future studies will delve into this aspect, finding similarities and differences in the relationships between the contribution of parenting and, in particular, of mothers and fathers, to the psychological development and adaptation of children and adolescents from different cultural background contexts. In addition, the mechanisms that explain the link between parenting and the different constructs investigated can be studied in such contexts, taking into account possible variability on a cultural basis.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

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ORIGINAL RESEARCH
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Parenting Styles and Parent–Adolescent Relationships: The Mediating Roles of Behavioral Autonomy and Parental Authority

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The parent–adolescent relationship has been a classic research topic, and researchers have found that parenting styles (e.g., authoritative, authoritarian) are closely related to various qualities of parent-adolescent relationships (e.g., cohesion, conflict). However, little empirical work has addressed how these variables correlate with each other in mainland China, nor has prior research addressed internal psychological mechanisms. The present study investigated the associations between parenting styles and parent–adolescent relationship factors, examined the mediating effects of adolescents' expectations of behavioral autonomy and beliefs about parental authority, and explored whether adolescent gender moderated these effects. Results from a sample of 633 Chinese adolescents (7th grade: M_{age} = 13.50 ± 0.62 years, 9th grade: M_{age} = 15.45 ± 0.67 years, 11th grade: M_{age} = 17.30 ± 0.75 years) suggested similar levels of parent–adolescent conflict frequency for all parenting styles. However, for parent–adolescent conflict intensity, youth of neglectful and authoritarian parents reported higher levels compared to those with indulgent parents. The highest levels of cohesion with both parents were reported by adolescents with authoritative parents, followed by indulgent, authoritarian and neglect parenting styles. Cohesion with mothers for youth with authoritative or indulgent mothers was higher for girls than boys. Adolescents' expectation for behavioral autonomy mediated the links between parenting style and conflict, whereas adolescents' beliefs about the legitimacy of parental authority mediated the links between parenting style and cohesion; some of these mediating effects differed by gender. Findings highlight the importance of studying potential effects of adolescents' values and attitudes within the family system in specific cultural contexts.

Keywords: parenting style, parent–adolescent relationship, behavioral autonomy, parental authority, gender

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INTRODUCTION

Variations in parenting styles and parent–child relationship qualities are long-standing research topics in developmental and family psychology. Previous research has shown that parenting styles are critical family context factors which are closely related to parent–adolescent relationships (Shek, 2002). Despite the large number of studies on the associations between parenting styles

and parent–adolescent relationships, existing research mainly has focused on the direct effects of parenting styles on parent-adolescent relationships, while the underlying mechanisms through which parenting styles are associated with parent–adolescent relationships have seldom been examined. The present study examined the possible mediating effects of adolescents' expectations for behavioral autonomy and beliefs in the legitimacy of parental authority, on the link between parenting style differences and variability in relationship conflict and cohesion, in a sample of youth from mainland China. We also tested whether the direct and mediated effects differed for girls and boys.

Parenting Styles and Parent–Adolescent Relationships

Parenting style is defined as a constellation of parents' attitudes and behaviors toward children and an emotional climate in which the parents' behaviors are expressed (Darling and Steinberg, 1993). In the field of parenting, Maccoby and Martin's (1983) and Baumrind's (1991) typological approach of conceptualizing parenting has had a tremendous impact. They classified parenting into four types based on responsiveness and demandingness (Maccoby and Martin, 1983; Baumrind, 1991). Authoritative parenting style is characterized as high in responsiveness and demandingness. Authoritative parents provide not only support and warmth, but also clearly defined rules and consistent discipline (Baumrind, 1991). Authoritarian parenting style is characterized as low in responsiveness but high in demandingness. Parents of this style tend to use hostile control or harsh punishment in an arbitrary way to gain compliance, but they seldom provide explanation or allow verbal give-and-take. Indulgent parenting style is characterized as low in demandingness but high in responsiveness. Indulgent parents are responsive to their children and satisfy children's needs, but they fail to set proper disciplinary, exhibit behavioral control, or make demands for mature behaviors. Finally, neglectful parenting style is characterized as low in responsiveness and demandingness. Neglectful parents are parent-centered and they are seldom engaged in child rearing practices. They neither provide warmth nor set rules for their children.

Adolescence is a critical developmental period that requires parents and youth to renegotiate their relationships (Laursen and Collins, 2009). Existing research has shown that variation in parenting styles is related to differences in parent-adolescent relationship features. Overall, most studies with Western samples have consistently found that authoritative parenting style is associated with higher levels of parent–adolescent cohesion (Nelson et al., 2011) and lower levels of conflict frequency (Smetana, 1995), conflict intensity (Smetana, 1995), and total conflict (McKinney and Renk, 2011). In contrast, an authoritarian parenting style is associated with lower cohesion (McKinney and Renk, 2011) and higher conflict frequency (Smetana, 1995; Sorkhabi and Middaugh, 2014), intensity (Smetana, 1995), and total conflict (McKinney and Renk, 2011). For instance, in a sample of American adolescents, Smetana (1995) found that more frequent and intense conflicts were predicted by more authoritarian parenting and less authoritative parenting. Similarly, Sorkhabi and Middaugh (2014) analyzed data from American adolescents who had Asian, Latino, Arab, European or other ethnic background. They found that adolescents of authoritative parents reported less conflict than those with authoritarian parents.

Most previous research on the associations between parenting styles and parent-adolescent conflict and cohesion focused on one or the other (e.g., Smetana, 1995; Nelson et al., 2011; Sorkhabi and Middaugh, 2014). However, conflict is not the opposite of cohesion, nor are increases over time in one necessarily associated with decreases in the other (Zhang et al., 2006). To comprehensively understand the links between parenting styles and these two aspects of the parent-adolescent relationship, both should be examined. Also, most previous research seldom distinguished conflict frequency and intensity or examined them simultaneously. Conflict frequency refers to how often conflict occurs, whereas conflict intensity refers to the magnitude of emotional arousal that occurs during conflict. Prior research on these two aspects of conflict has yielded mixed results. For example, Smetana (1995) found that parenting styles' links with conflict frequency and intensity were very similar. In contrast, Assadi et al. (2011) reported that frequency was lower for authoritative parents and higher for authoritarian parents—but only authoritative parenting was linked to intensity. Thus, conflict intensity and frequency both should be examined.

Another major gap in the literature is that few of the relevant prior studies examined all four parenting styles. We know of only one American study (of adolescent substance abusers) that examined conflict, cohesion, and all four parenting styles (Smith and Hall, 2008). Actually, it's also important to explore the relationships between indulgent and neglectful parenting style and parent–adolescent conflict and cohesion. Especially, neglectful parenting style which is characterized as disengaged from child rearing process may be destructive to parent–adolescent relationships. Thus, in light of the gaps in literature identified above, our first major aim was to explore the associations between all four parenting styles and parent–adolescent conflict (frequency and intensity) and cohesion. Based on prior evidence, we hypothesized that conflict (frequency and intensity) would be highest, and cohesion lowest, for youth with authoritarian parents—and conflict lowest and cohesion highest for adolescents with authoritative parents.

Adolescent Autonomy and Beliefs About Parental Authority

In spite of the numerous prior studies of the link between parenting style and parent–adolescent relationship features, there are surprisingly few that have tested mechanisms that might account for the link. We also addressed this gap in the current study. According to Darling and Steinberg's (1993) integrative model, parenting styles affect adolescents' outcomes by changing the degree to which adolescents accept their parents' attempts to socialize them. When parents use specific styles to rear children, adolescents are not just passive social beings, but play an active role in shaping the parent–adolescent relationship and in interpreting parenting behavior, in ways that

influence their own outcomes. Particularly important to this psychological process are adolescents' attitudes about behavioral autonomy and the legitimacy of parental authority (Darling et al., 2007).

Adolescents' Expectation for Behavioral Autonomy

Autonomy, in contrast to forced behavior, reflects actions that arise from the agency of the self rather than others (Chen et al., 2013). Variations in parenting style are associated with individual differences in adolescents' autonomy beliefs. Authoritative parenting has been shown to be the most beneficial to youth, with regard to fostering healthy normative development of autonomy (Baumrind, 1991). In contrast, authoritarian parents provided too much strictness and supervision for their children, while indulgent and neglectful parents provided insufficient monitoring and guidance. Adolescents with non-authoritative parents are more likely to desire for more behavioral autonomy which is not satisfied in an appropriate way (Bush and Peterson, 2013). It is important to note, however, that not all studies find authoritative parenting to be optimal for youth autonomy—differences in findings that may be due to the sample characteristics or measures being used (e.g., Darling et al., 2005; Chan and Chan, 2009).

The development of adolescents' autonomy, in turn, can have effects on parent–adolescent relationship features. Parents and adolescents expect increasing autonomy with age, but adolescents typically demand autonomy earlier than their parents are ready to grant it (Jensen and Dost-Gözkan, 2015; Pérez et al., 2016). Adolescents' desire for more autonomy than their parents wish to grant them prompts youth to exert more control of their own affairs, and to be more critical of their parents' control behaviors—a pattern that causes conflict and reduces cohesion (Fuligni, 1998; Zhang and Fuligni, 2006).

Adolescents' Beliefs About Parental Authority

In addition to developmental changes in autonomy, adolescence also is a period of youths' changes in attitudes about parental authority—specifically, the extent to which parental assertion of control is seen as an appropriate extension of their role (Darling et al., 2008). Compared to other parenting styles, authoritative parents have children and adolescents who are more likely to endorse the legitimacy of parental authority (Smetana, 1995; Darling et al., 2005; Trinkner et al., 2012). In contrast, authoritarian parents tend to define issues as falling into parental jurisdiction too rigidly, and indulgent and neglectful parents define these too permissively (Smetana, 1995; Baumrind, 2005). In those cases, adolescents and parents may be deprived of opportunities to debate and negotiate appropriate boundaries, which in turn can lead youth to question and doubt the legitimacy of parental authority.

Attitudes about legitimacy of authority are also linked with parent–adolescent relationship features. Adolescents' endorsement of parental authority is associated with greater cohesion and less conflict with parents (Zhang et al., 2006; Jensen and Dost-Gözkan, 2015)—in one study, a pattern found in Mexican, Chinese, Filipino, and European background families (Fuligni, 1998).

In sum, there are well-established links between parenting style, adolescents' beliefs (specifically, about autonomy and parental authority), and parent-adolescent relationship qualities. However, these different constructs have not been examined all together in one study. In addition, although previous studies have examined the associations between parenting styles and parent-adolescent relationships, there was no research that examined whether adolescents' expectation for behavioral autonomy and endorsement of parental authority mediated these associations. Thus, our second aim was to test the hypothesis that expectations for behavioral autonomy and beliefs in the legitimacy of parental authority both would mediate the link between parenting styles and parent-adolescent conflict and cohesion.

The Role of Adolescent Gender

The third and final aim of the current study was to examine potential gender differences in the relationships between parenting styles, parent-adolescent conflict and cohesion, adolescents' expectation for behavioral autonomy and endorsement of parental authority. There is reason to expect differences to be found, although results may differ depending on the parenting styles and parent-adolescent relationship features in question. For instance, Shek (2002) reported an association between parental negativity and greater parent-adolescent conflict, only for girls. These differences may reflect distinct socialization goals for boys and girls, with girls oriented more toward family relationships and compliance, and boys oriented toward autonomy and self-reliance (Shek, 2002; Zhang et al., 2006). Based on previous research, we expected to find stronger associations between parenting style and parent–adolescent relationship features for girls compared to boys. However, given the lack of prior research on beliefs about autonomy and parental authority as mediators, we had no hypotheses regarding gender as moderator of those mediating effects.

Chinese Cultural Context

As a final point, another rationale for the current study was to address the dearth of research on mainland Chinese families published in the international literature. The existing evidence is almost completely dominated by studies of families from Western industrial nations, even though mainland China has the single largest population of children and adolescents in the world—in 2016, 13% or nearly one in eight of the globe's 0–14-year-olds (World Bank, 2017). We know of only one relevant published study of parenting styles and parent–adolescent relationships, which found that authoritative mothers exhibited the highest levels, and authoritarian mothers the lowest levels, of mother-adolescent cohesion (Zhang et al., 2017). Adding to the literature base to include evidence from non-Western nations such as China, serves to extend and deepen knowledge of parent-adolescent relationship processes.

Studying mainland Chinese families also offers a unique opportunity for examining family processes because its culture is so distinct from Western contexts. Two features in particular

stand out. First, China has been unique in the world in its "one child policy" implemented by the government from 1979 until 2016. This led to a significant change in the family, often described as the "4-2-1" family structure (four grandparents, two parents, and one child). In this context, the relationships between parenting styles and parent–adolescent conflict and cohesion in China may be different from those in Western cultures. Second, Chinese culture is rooted in Confucianism, which emphasizes collectivist values such as conforming to social norms, submission to authority, establishing strong relationships with others, and avoiding confrontation (Peterson et al., 2005). In this strict hierarchical framework, individuals' requests for autonomy and any behaviors that potentially threaten group harmony are discouraged, whereas great respect for parental authority is highly valued (Fuligni, 1998). Furthermore, some research has shown that autonomy and authority beliefs among adolescents covary with family relationship features in different ways depending on cultural context. For example, one study reported that conflict intensity with mothers was greater for adolescents with lower respect for parental authority in African American and Latina, but not European American, families (Dixon et al., 2008). Thus, there is a need to broaden the diversity of samples in this literature, to better understand which aspects of the relevant family processes operate similarity, or differently, in distinct cultural contexts.

In sum, the current study addressed three aims in a mainland China sample of families: (1) to explore the links between four parenting styles and parent-adolescent relationship conflict (frequency and intensity) and cohesion, including testing the hypothesis that conflict would be highest and cohesion lowest for authoritarian parents, conflict lowest and cohesion highest for authoritative parents; (2) to test the hypothesis that the links between parenting style and parent–adolescent relationship features would be statistically mediated by adolescents' autonomy expectations and beliefs regarding parental authority; and (3) to test the hypothesis that the links between parenting style and relationship features (explored in Aim 1) would be stronger for girls than for boys—and to also explore gender differences in the mediating effects (hypothesized in Aim 2).

MATERIALS AND METHODS

Participants and Procedure

A total of 633 students (48.5% females, in line with the proportion found in the Chinese population) in the 7th (M_{age} = 13.50 ± 0.62 years), 9th (M_{age} = 15.45 ± 0.67 years) and 11th (M_{age} = 17.30 ± 0.75 years) grades of four schools in Jinan, the capital of Shandong Province in Middle Eastern China, completed self-report questionnaires. Because of the implementation of one child policy in mainland China, 90 percent of them were only children.

Surveys were completed in class through group administration; students were asked not to communicate with each other while completing the survey. Research staff members administered the surveys to the class by introducing the purpose of this study and the voluntary nature of participation, reading instructions and answering any questions that arose during the data collection period. All participants gave written informed consent. Additionally, all parents of participants were notified about the research and were given the opportunity to withdraw their children from study participation. All parents gave written informed consent to allow their children to participate in this study. The Institutional Review Board of Shandong Normal University approved this study procedures.

Measures

Parenting Styles

Parenting styles were assessed using the Chinese version of Steinberg et al.'s (1994) parenting styles questionnaire (Long et al., 2012). Two subscales comprise the measure of parenting: acceptance/involvement and strictness/supervision. The acceptance/involvement subscale (α = 0.84) was the average of 15 items that were used to assess responsive, loving and involved parenting (e.g., "I can count on my parents to help me out if I have some kind of problem."). The strictness/supervision subscale (α = 0.78) was the average of 12 items that was used to assess monitoring and supervision (e.g., "How much do your parents try to know where you go out at night"). The adolescents were required to indicate the strength of endorsement using a 5-point scale ranging from 1 (*completely disagree*) to 5 (*completely agree*) for each item. Confirmatory factor analysis indicated that the measurement of parenting styles (as well as endorsement of parental authority, expectations for behavioral autonomy and parent-adolescent conflict and cohesion) had acceptable construct validity and strong measurement invariance across gender (see Online **Supplementary Materials** and **Supplementary Table S1**).

Endorsement of Parental Authority

Adolescents' beliefs about the legitimacy of parental authority were assessed using Chinese version of Smetana's (1988) questionnaire (Zhang and Fuligni, 2006). Students were presented with a list of 13 topics as individual items such as curfew, choosing clothes, and choosing friends, and were asked whether father or mother could make a rule about each topic. Responses for each topic/item were coded on a 4-point scale ranging from 1 (*It's not OK*) to 4 (*It's completely OK*). These were averaged separately for mother (α = 0.84) and father (α = 0.86).

Expectations for Behavioral Autonomy

Adolescents' expectation for behavioral autonomy was measured based on the questionnaire from Fuligni (1998). Students were presented with a list of 12 behaviors (e.g., "watch as much TV as you want"). Adolescents then indicated the degree of expectation for each item using a 4-point scale ranging from 1 (*expect heavily*) and 4 (*not expect at all*) (α = 0.86). In order to achieve consistency across all instruments so that a high score would reflect a high level of the variable being measured, these entries were reversed score so that 1 was recoded as 4, 2 as 3, 3 as 2, and 4 as 1.

Parent–Adolescent Conflict

Adolescents' perceptions of the incidence and intensity of conflict with their mothers and fathers were measured by the Chinese

version of Issues Checklist (Prinz et al., 1979; Zhang and Fuligni, 2006). Students indicated whether the 16 specific topics (e.g., chores, cursing) were discussed or not with their parents within the past 2 weeks (using a binary scale, *yes* or *no*). Then, for each endorsed topic of discussion, adolescents reported the conflict intensity of the discussion of each topic, using a 5-point scale that varied from 1 (*very calm*) to 5 (*very angry*). To be consistent with previous research (e.g., Fuligni, 1998), conflict frequency was computed by summing the number of discussions rated as containing anger (2 or greater on the 5-point scale). Conflict intensity was obtained by averaging adolescents' rating on those items that were discussed (mother: $\alpha = 0.72$, father: $\alpha = 0.73$).

Parent–Adolescent Cohesion

Adolescents completed the cohesion subscale of the Chinese version of Family Adaptation and Cohesion Evaluation Scales (FACES) II inventory separately for each parent (Olson et al., 1979; Zhang and Fuligni, 2006). This scale included 10 items (e.g., "My mother [father] and I feel very close to each other"). Students' perception of cohesion with parents was rated on a 5-point scale ranging from 1 (*almost never*) to 5 (*almost always*), separately for mother ($\alpha = 0.82$) and father ($\alpha = 0.79$).

Controlled Variables

Grade and socioeconomic status (SES) were controlled for this study. The SES score was computed by averaging the standardized education and occupation of both parents. Parents' education was coded as 1 = equal to or below primary school, 2 = junior high school, 3 = senior high school, 4 = some college or above. The occupation was coded as 1 = peasant or jobless, 2 = blue collar, 3 = professional or semiprofessional. In terms of parents' educational level, approximately 0.8% of the mothers and 0.3% of fathers had completed primary school education or less, and 38.5% of mothers and 57.1% of fathers had a college or university degree. The remainder had either a junior high school education (7.6% of mothers and 5.5% of fathers) or a senior high school education (48.2% of mothers and 31.5% of fathers). The occupational status of mothers and fathers, respectively, was as follows: 6.2 and 2.7% were peasants or jobless, 28.4 and 23.4% had blue collar position, and 64.9 and 73.6% held a professional or semiprofessional occupation.

RESULTS

Descriptive Statistics

We used Harman's single factor test to check the common method bias. The results showed that 30 factors emerged with eigenvalues greater than 1.0 and the first factor accounted for only 16.53% of total variance. Since more than one factor emerged and the first factor did not account for the majority of the variance (Podsakoff and Organ, 1986), common method bias was not a serious concern in the present study.

Cluster analysis with K-means method was used to identify the four parenting styles. Instead of defining parentings styles *a priori* based on subjective cut-off scores (Steinberg et al., 1994), in cluster analysis families are grouped according to their scores on various parenting characteristics (Henry et al., 2005). To validate the cluster solution, we reanalyzed the data with a different cluster method — a hierarchical cluster analysis (Henry et al., 2005; Hoeve et al., 2007). We repeated the hierarchical cluster analysis ten times, applying the standardized Euclidian Distance method as a distance measure and using Ward's algorithm. The cross validation procedure (Mandara, 2003) result in moderate agreements ($k = 0.71$, range: 0.67–0.75).

To label the four groups, we examined the parenting styles by computing a one-way ANOVA on the standardized scores of parenting dimensions with the clusters serving as the factors. The result revealed that the clustering variables significantly differed between the parenting dimensions [acceptance/involvement: $F(3,608) = 472.58$, $p < 0.001$, $\eta^2 = 0.70$; strictness/supervision: $F(3,608) = 280.35$, $p < 0.001$, $\eta^2 = 0.58$]. Authoritative parents were those who scored high on both dimensions (acceptance/involvement: $z = 0.95$, strictness/supervision: $z = 0.76$), whereas neglectful parents scored low on both dimensions (acceptance/involvement: $z = -1.45$, strictness/supervision: $z = -1.06$). Authoritarian parents scored low on acceptance/involvement ($z = -0.61$) but high on strictness/supervision dimension ($z = 0.50$), whereas indulgent parents scored high on acceptance/involvement ($z = 0.15$) but low on strictness/supervision dimension ($z = -0.77$).

Descriptive statistics for study variables are presented in **Table 1**, and bivariate correlations are presented in **Table 2**. Regarding descriptives, the following frequencies were found for the four parenting styles: 152 (24.0% of total sample) authoritarian; 200 (31.6%) authoritative; 83 (13.1%) neglectful; and 177 (28.0%) indulgent. The average scores of beliefs in parents' authority and expectation for behavioral autonomy ranged from 2 to 3, which implied that adolescents reported medium level of endorsement of parental authority and autonomy expectations. The average scores of conflict frequency ranged from 2 to 4 and the average scores of conflict intensity ranged from 1 to 2, which suggested that adolescents reported low level of conflict frequency and intensity. Since the cohesion scored larger than 3 (except girls with neglectful parents), adolescents reported medium-high level of cohesion with parents.

Turning to correlations, although with a few exceptions, overall the adolescents' higher expectation for behavioral autonomy was associated with greater frequency and intensity of conflict, and less cohesion. Adolescents' stronger endorsement of the legitimacy of parental authority was associated with greater cohesion, but less frequent and intense conflict.

Links With Parenting Styles

A series of 4 (parenting styles) × 2 (child gender) analyses of covariance was conducted to explore the links between four parenting styles and parent–adolescent relationships. At the same time, we also explored if adolescents' expectation for behavior autonomy and endorsement of parental authority differed as a function of adolescents' gender and parenting styles. SES and grade served as covariables.

TABLE 1 | Means and standard deviations of all study variables except parenting styles.

	Indulgent		Neglectful		Authoritarian		Authoritative		Group differences
	Male	Female	Male	Female	Male	Female	Male	Female	
Beliefs about mother's authority	2.37	2.16	2.09	1.99	2.37	2.48	2.75	2.71	Aut > Aun & Ind > Neg;
	(0.56)	(0.44)	(0.48)	(0.44)	(0.59)	(0.58)	(0.54)	(0.52)	Ind: M > F
Beliefs about father's authority	2.39	2.12	2.00	1.94	2.34	2.43	2.73	2.70	Aut > Aun & Ind > Neg;
	(0.60)	(0.46)	(0.56)	(0.53)	(0.62)	(0.61)	(0.59)	(0.55)	Ind: M > F
Expectation for behavioral autonomy	2.52	2.45	2.71	2.67	2.50	2.34	2.24	2.14	Neg & Ind & Aun > Aut
	(0.68)	(0.57)	(0.67)	(0.59)	(0.66)	(0.66)	(0.69)	(0.52)	
Frequency of conflict with mother	3.18	3.52	3.93	4.33	3.63	4.33	3.63	3.05	No significant difference
	(3.18)	(2.86)	(2.86)	(3.65)	(3.06)	(3.02)	(3.25)	(2.88)	
Frequency of conflict with father	2.20	2.50	2.63	2.44	2.63	3.00	2.87	2.37	No significant difference
	(2.70)	(2.57)	(2.35)	(2.49)	(3.02)	(2.72)	(2.98)	(2.69)	
Intensity of conflict with mother	1.45	1.47	1.74	1.75	1.62	1.64	1.55	1.43	Neg & Aun > Ind;
	(0.43)	(0.42)	(0.61)	(0.65)	(0.55)	(0.52)	(0.53)	(0.40)	Neg > Aut
Intensity of conflict with father	1.42	1.47	1.79	1.59	1.65	1.61	1.54	1.42	Neg & Aun > Ind
	(0.42)	(0.49)	(0.88)	(0.66)	(0.82)	(0.67)	(0.61)	(0.44)	
Cohesion with mother	3.48	3.70	3.10	2.94	3.34	3.48	3.64	4.03	Aut > Ind > Aun > Neg;
	(0.50)	(0.51)	(0.65)	(0.70)	(0.54)	(0.67)	(0.56)	(0.55)	Ind & Aut: F > M
Cohesion with father	3.53	3.56	3.05	2.95	3.25	3.33	3.76	3.78	Aut > Ind > Aun > Neg
	(0.57)	(0.68)	(0.72)	(0.81)	(0.72)	(0.72)	(0.63)	(0.64)	

Aut, authoritative parenting style; Aun, authoritarian parenting style; Neg, neglect parenting style; Ind, indulgent parenting style. M, male adolescents; F, female adolescents. Bonferroni post hoc tests were used.

TABLE 2 | Correlations for all study variables except parenting styles.

	1	2	3	4	5	6	7	8	9
(1) Beliefs about mother's authority	–	0.91***	−0.45***	−0.19***	−0.11	−0.19**	−0.10	0.32***	0.23***
(2) Beliefs about father's authority	0.89***	–	−0.44***	−0.14*	−0.08	−0.14*	−0.11	0.28***	0.26***
(3) Expectation for behavior autonomy	−0.62***	−0.56***	–	0.30***	0.23***	0.31***	0.22***	−0.27***	−0.24***
(4) Frequency of conflict with mother	−0.21***	−0.19***	0.25***	–	0.73***	0.81***	0.58**	−0.24***	−0.06
(5) Frequency of conflict with father	−0.14*	−0.14*	0.19**	0.70***	–	0.60***	0.74**	−0.09	−0.10
(6) Intensity of conflict with mother	−0.29**	−0.31***	0.31***	0.75***	0.46***	–	0.72***	−0.35**	−0.11
(7) Intensity of conflict with father	−0.23**	−0.30***	0.24**	0.37***	0.54***	0.52***	–	−0.16**	−0.20**
(8) Cohesion with mother	0.42***	0.37***	−0.22***	−0.19**	−0.15**	−0.26***	−0.18**	–	0.40***
(9) Cohesion with father	0.30***	0.41***	−0.15**	−0.14*	−0.15**	−0.26***	−0.35***	0.45***	–

$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$. Numbers above the diagonal refer to girls, and numbers below the diagonal refer to boys.

For adolescents' expectation for behavior autonomy, the main effect of parenting styles was significant [$F(3,597) = 8.74$, $p < 0.001$]. Bonferroni *post hoc t*-tests indicated that adolescents of authoritative parents reported the lower level of expectation for behavioral autonomy ($M = 2.18$, $SD = 0.60$) than adolescents of neglectful [$M = 2.70$, $SD = 0.64$, $t(278) = 4.66$, $p < 0.001$], indulgent [$M = 2.48$, $SD = 0.62$, $t(371) = 3.75$, $p < 0.01$] and authoritarian parents [$M = 2.43$, $SD = 0.66$, $t(344) = 2.79$, $p < 0.05$].

For legitimacy of parental authority, the main effect of parenting styles was significant [mother: $F(3,597) = 30.26$, father: $F(3,597) = 29.62$, ps < 0.001]. Adolescents of authoritative parents reported the highest endorsement of parental authority (mother: $M = 2.73$, $SD = 0.53$; father: $M = 2.71$, $SD = 0.56$), whereas adolescents of neglectful parents reported the lowest endorsement of parental authority (mother: $M = 2.06$, $SD = 0.47$; father: $M = 1.98$, $SD = 0.54$). Adolescents raised by authoritarian (mother: $M = 2.42$, $SD = 0.59$; father: $M = 2.38$, $SD = 0.62$) and indulgent parents (mother: $M = 2.26$, $SD = 0.51$; father: $M = 2.25$, $SD = 0.55$) reported endorsements of parental authority that were between the other two groups (mother: $t > 2.86$, $p < 0.05$; father: $t > 3.52$, $p < 0.01$). The interaction between gender and parenting styles also was significant [mother: $F(3,597) = 2.53$, $p = 0.056$; father: $F(3,597) = 3.03$, $p < 0.05$]. *Post hoc* probing revealed no gender difference for youth with authoritative, authoritarian and neglectful parents. In contrast, for youth with indulgent parents, boys reported greater endorsement of parental authority (mother: $M = 2.37$, $SD = 0.56$; father: $M = 2.39$, $SD = 0.60$) than did girls [mother: $M = 2.16$, $SD = 0.44$, $t(171) = 2.62$, $p < 0.01$; father: $M = 2.12$, $SD = 0.46$, $t(171) = 3.52$, $p < 0.01$].

Turning to intensity of conflict with parents, the main effect of parenting styles was significant [mother: $F(3,595) = 7.49$,

$p < 0.001$; father: $F(3,583) = 3.90$, $p < 0.01$]. Adolescents of neglectful [mother: $M = 1.74$, $SD = 0.62$, $t(253) = 3.99$, $p < 0.001$; father: $M = 1.73$, $SD = 0.81$, $t(245) = 2.58$, $p = 0.06$] and authoritarian parents [mother: $M = 1.63$, $SD = 0.54$, $t(320) = 3.01$, $p < 0.05$; father: $M = 1.63$, $SD = 0.75$, $t(313) = 2.49$, $p = 0.08$] reported more intense conflict than those of indulgent parents (mother: $M = 1.46$, $SD = 0.43$; father: $M = 1.45$, $SD = 0.46$). In addition, adolescents of neglectful parenting also reported more intense conflict with mothers than those of authoritative parenting [$M = 1.49$, $SD = 0.47$, $t(276) = 3.61$, $p < 0.01$]. As for the frequency of conflict with parents, none of the effects was significant.

For cohesion, gender was significantly related to mother–child cohesion [$F(1,597) = 9.07$, $p < 0.01$], with greater cohesion found for daughters than sons (girls: $M = 3.70$, $SD = 0.66$; boys: $M = 3.42$, $SD = 0.59$). For mothers and fathers alike, there was a main effect of parenting styles [mother: $F(3,597) = 37.53$, father: $F(3,597) = 26.49$, $ps < 0.001$]. Adolescents of authoritative parents reported the highest level of cohesion (mother: $M = 3.85$, $SD = 0.58$; father: $M = 3.77$, $SD = 0.63$), followed by indulgent [mother: $M = 3.59$, $SD = 0.52$, $t(371) = 4.20$, $p < 0.001$; father: $M = 3.55$, $SD = 0.63$, $t(371) = 3.15$, $p < 0.05$], authoritarian [mother: $M = 3.41$, $SD = 0.60$, $t(320) = 2.62$, $p = 0.05$; father: $M = 3.29$, $SD = 0.72$, $t(320) = 3.33$, $p < 0.01$] and neglectful parents [mother: $M = 3.05$, $SD = 0.67$, $t(227) = 4.78$, $p < 0.001$; father: $M = 3.02$, $SD = 0.75$, $t(227) = 2.94$, $p < 0.05$]. Finally, the parenting style main effect for mothers was moderated by child gender [$F(3,597) = 1.34$, $p < 0.01$]. Cohesion was higher for girls than boys, only in authoritative [girls: $M = 4.03$, $SD = 0.55$; boys: $M = 3.64$, $SD = 0.56$, $t(195) = 4.77$, $p < 0.001$] and indulgent homes [girls: $M = 3.70$, $SD = 0.50$; boys: $M = 3.48$, $SD = 0.50$, $t(171) = 2.61$, $p < 0.01$].

Mediating Effects

To test our second hypothesis that expectations for behavioral autonomy and beliefs in the legitimacy of parental authority would mediate the links between parenting style and parent-adolescent conflict and cohesion, we used structural equation modeling in Mplus 7.4 (**Figures 1–3**, for the analyses of conflict frequency, conflict intensity, and cohesion, respectively). SES and grade were included as covariables. The categorical parenting style variable was represented as three dummy-coded variables with authoritative parenting as the reference category. Because the autonomy expectations scale had many items, we used a common parceling technique to estimate a highly reliable latent construct for that variable by randomly assigning items into four nearly equal-sized sets of indicators (Little et al., 2002). Finally, latent variables were constructed (using mother and father scales as indicators) for the conflict and cohesion variables, as well as the attitudes about legitimate parental authority variable. All models showed good fit with the data [conflict frequency: $\chi^2 = 160.99$, $df = 56$, CFI = 0.96, TLI = 0.95, RMSEA = 0.055; conflict intensity: $\chi^2 = 167.23$, $df = 56$, CFI = 0.96, TLI = 0.94, RMSEA = 0.058; cohesion: $\chi^2 = 192.55$, $df = 56$, CFI = 0.95, TLI = 0.93, RMSEA = 0.063).

In all three models, adolescents raised in neglectful, indulgent and authoritarian homes (compared to authoritative) reported lower level of beliefs about parental authority and higher expectations for behavior autonomy. Regarding frequency (**Figure 1**) and intensity (**Figure 2**) of conflict,

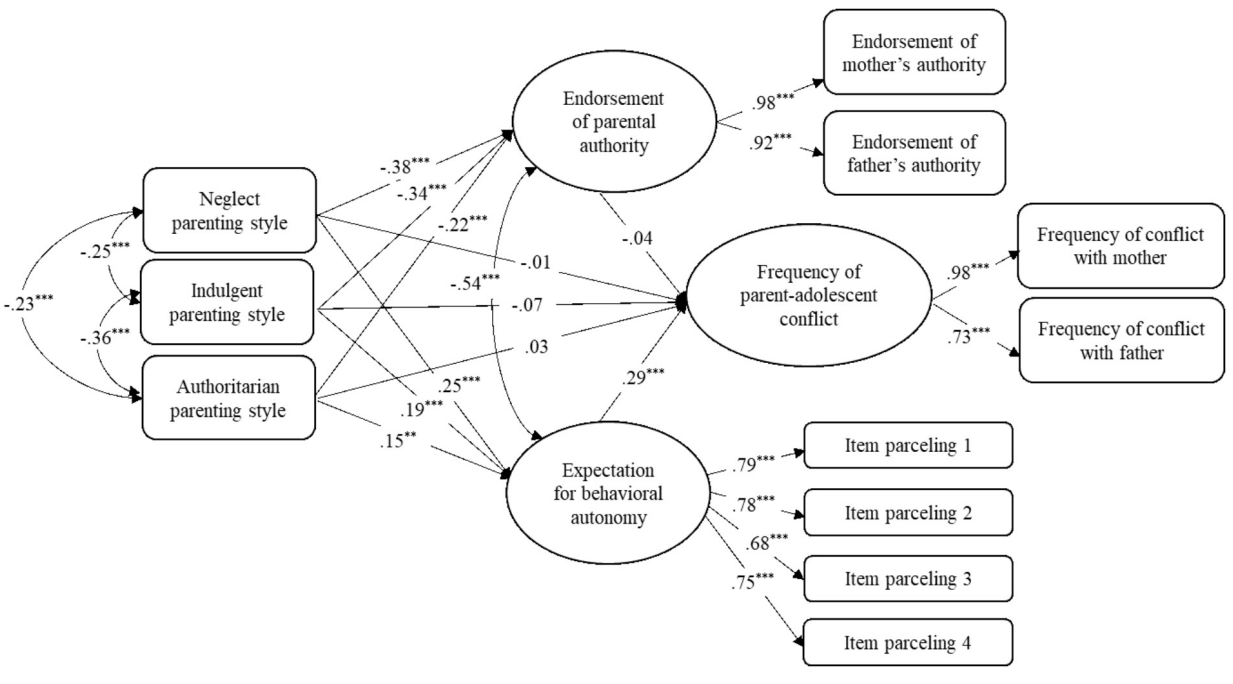

FIGURE 1 | Adolescents' expectation for autonomy and beliefs about parental authority as mediators between parenting styles and the frequency of parent-adolescent conflict. Standardized path coefficients are presented in the model. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

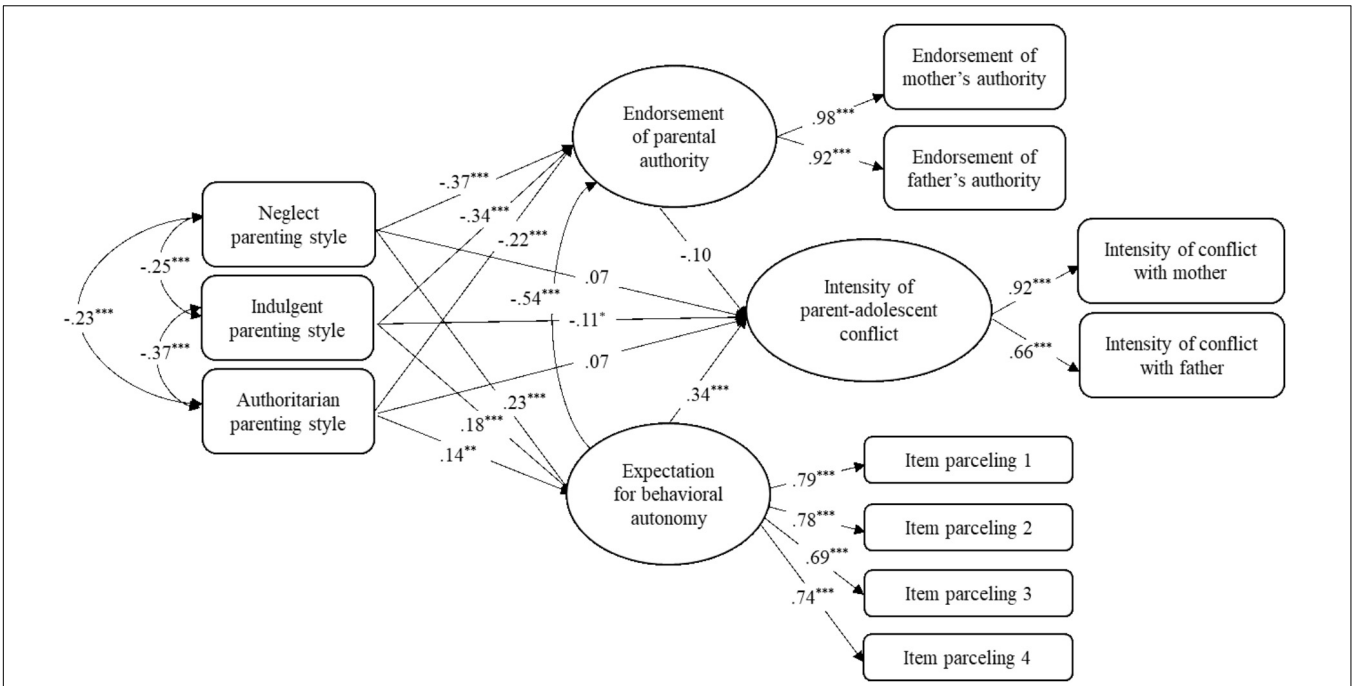

FIGURE 2 | Adolescents' expectation for autonomy and beliefs about parental authority as mediators between parenting styles and the intensity of parent–adolescent conflict. Standardized path coefficients are presented in the model. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

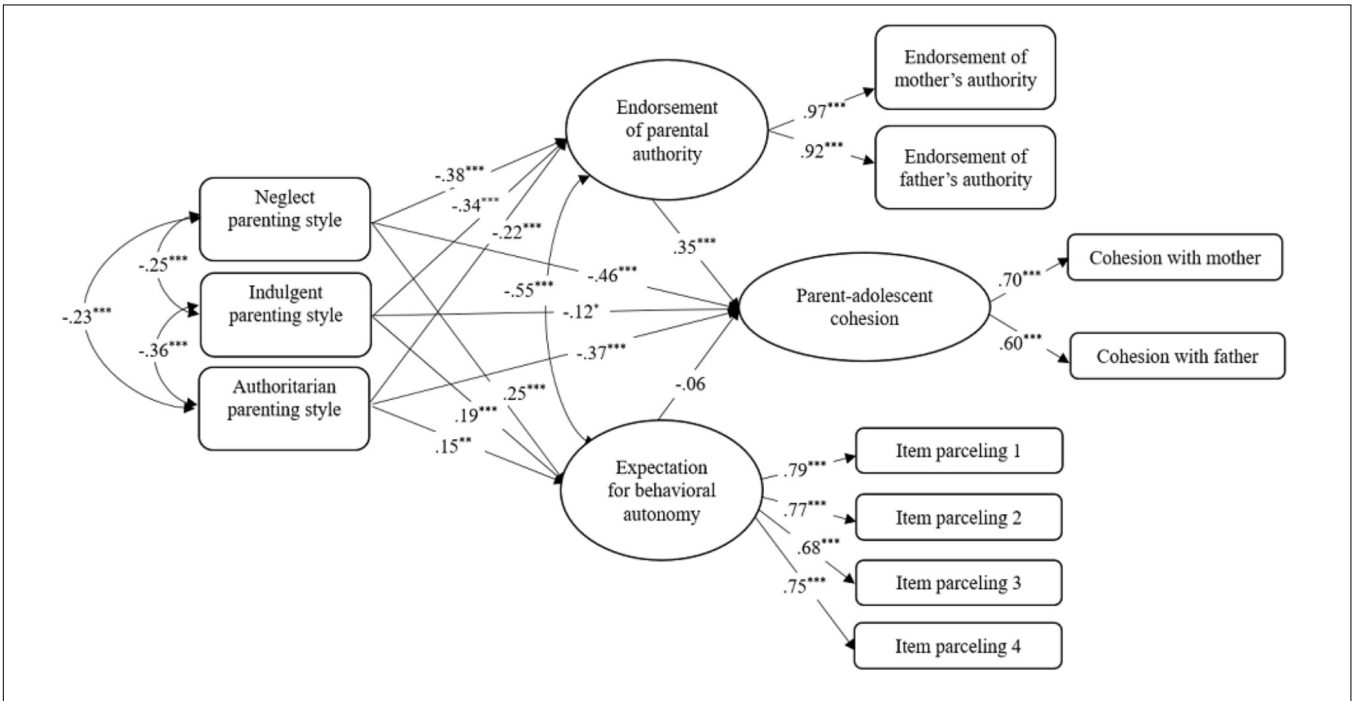

FIGURE 3 | Adolescents' expectation for autonomy and beliefs about parental authority as mediators between parenting styles and parent-adolescent cohesion. Standardized path coefficients are presented in the model. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

greater expectation of autonomy was linked with more frequent and intense conflict, whereas regarding parent–adolescent cohesion (**Figure 3**), greater endorsement of authority was linked with greater relationship cohesion. Also, conflict intensity was lower for youth with indulgent parents and cohesion was lower for youth with neglectful, indulgent or authoritarian (compared to authoritative) parents.

Significance of indirect effects was computed using bootstrapping with 1000 resamples. A bias-corrected bootstrapped 95% confidence interval (CI) showed significant indirect effects from neglectful, indulgent and authoritarian parenting style to the frequency and the intensity of parent-adolescent conflict via adolescents' expectation for behavior autonomy. For conflict frequency, 95% CIs were [0.033,0.126], [0.022,0.102], and [0.014,0.092] for neglectful, indulgent and authoritarian parents, respectively. For intensity of conflict, 95% CIs were [0.042,0.131] [0.027,0.105], and [0.019,0.097] for neglectful, indulgent and authoritarian parents, respectively. There also were significant indirect effects to cohesion via adolescents' beliefs in the legitimacy of parental authority. The 95% CIs were [−0.202, −0.081], [−0.185, −0.071], and [−0.128, −0.0341] for neglectful, indulgent and authoritarian parents, respectively.

Moderating Effect of Adolescents' Gender

Given possible gender differences in paths, we conducted multiple-group analyses. We had hypothesized that the links between parenting style and parent-adolescent conflict and cohesion would be stronger for girls than boys; we did not have hypotheses regarding the mediators however. Chi-square difference statistic ($\Delta\chi^2$) were used to compare fit between models. All structural paths were constrained to be equal for boys and girls and the overall model fit was compared to a model without any constraint. For conflict frequency and intensity, the unconstrained and fully constrained models were not significantly different—suggesting no gender moderation [$\Delta\chi^2(11) = 14.88$, $\Delta\chi^2$ $(11) = 14.96$, $ps > 0.05$]. In contrast, for cohesion, the unconstrained model provided a significantly better fit than the constrained model [$\Delta\chi^2(11) = 23.45$, $p < 0.05$]. To interpret this, we compared path coefficients for boys and girls one by one (see **Figure 4**). The negative prediction of cohesion from neglectful and authoritarian parenting (relative to authoritative parenting) was stronger for girls than boys; this was consistent with our hypothesis. As for the exploration of gender differences in the mediation paths, we found that the negative link between indulgent parenting style and parental authority was stronger for girls than boys, whereas the positive link between endorsement of parental authority and cohesion was stronger for boys than girls.

DISCUSSION

In the current study, we tested the associations between parenting styles and parent-adolescent relationships (Aim 1), examined the mediating effects of adolescents' expectation for behavior autonomy and their endorsement of parental authority on these associations (Aim 2), and also explored the moderating effect of adolescents' gender (Aim 3) in a sample of adolescents from mainland China.

Parenting Styles and Relationships With Adolescents

In studies of Western families, parenting styles are recognized as having predictable associations with parent-adolescent conflict and cohesion. Previous studies have reported that adolescents

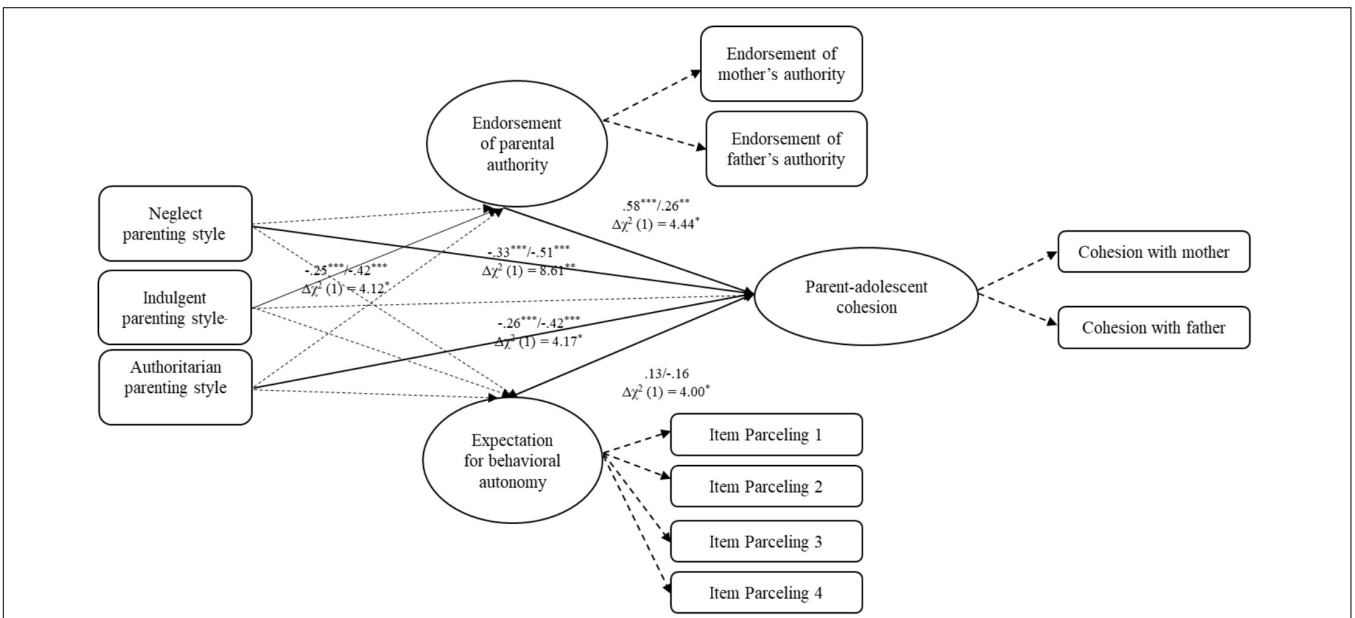

FIGURE 4 | Results of multiple-group structural equation model evaluating the relationships of adolescents' expectation for behavioral autonomy, their endorsement of parental authority and parent–adolescent cohesion across genders. Standardized path coefficients are presented in the model. Covariances, correlations and residuals are not shown. Solid lines indicate the pathway parameters are different between male sample and female sample. Dotted lines indicate the pathway parameters are similar between male sample and female sample. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

of authoritative parents have lower conflict frequency and intensity and higher cohesion than those of authoritarian parents (Smetana, 1995; Assadi et al., 2011; Nelson et al., 2011; Sorkhabi and Middaugh, 2014). In contrast to previous research, the present study showed that adolescents reported similar levels of parent-adolescent conflict *frequency* regardless of parenting style. This result may be attributed to the traditional Chinese culture, which places emphasis on keeping harmonious relationships and avoiding confrontation (Peterson et al., 2005). This unique cultural context may alleviate any links between parenting and frequency of conflict because Chinese adolescents may avoid conflict with their parents.

However, conflict *intensity* did show associations with parenting style. Compared with indulgent parenting styles, adolescents of neglectful and authoritarian parents experienced greater intensity of conflict. Indulgent parents place relatively few demands on the adolescents' behavior, giving them high degree of freedom to act as they wish. In contrast, neglectful parents are characterized as lacking warmth and guidance, whereas authoritarian parents place a high value on obedience and conformity and allow less verbal give-and-take. Conflict may be more intense in neglectful parenting style because the adolescent is making demands on a parent who otherwise is withdrawn and minimizing of the youth's needs. Also, adolescents may be dissatisfied with authoritarian parents' setting broad rules without emotional support, which leads to more intense conflict when it occurs. Other variables might also explain the effect. For instance, adolescents with neglectful parents are more likely to engage in delinquent behaviors (You and Lim, 2015), which itself may lead to more intense conflict.

In addition, the current study found that adolescents raised in authoritative and authoritarian parenting style reported similar levels of conflict intensity with parents. This is inconsistent with previous findings, which showed that Western adolescents raised in authoritarian parenting homes reported more intense parent–adolescent conflict than those raised in authoritative parenting homes (Smetana, 1995). One explanation for this difference in results may be that in Chinese culture, similar to training and tiger parenting, the motivation and intention of authoritarian parenting is to supervise children and promote optimal development, instead of simply controlling them (Chao, 1994; Kim et al., 2013). And Chinese adolescents may perceive positively the parents' intention to supervise their development, resulting in no direct association between levels of parental control and conflict intensity.

With regard to parent–adolescent relationship cohesion, the current study showed that adolescents with authoritative parents reported the highest levels of cohesion. This result extends previously published work in various cultural groups showing greater cohesion for authoritative parenting (e.g., Nelson et al., 2011). Authoritative parenting is characterized by a high degree of warmth and acceptance as well as supervision, but also including the granting of adolescent autonomy (Baumrind, 2005). In Chinese and Western cultures today, adolescents seek greater independence along with support (compared to children)—a balance of youth and parent goals that is best met in authoritative households that promote close relationships. In contrast, neglectful parents' lack of warmth and supervision, which may be interpreted as irresponsibility, may hinder the establishment of cohesive relationships. Indulgent and authoritarian parents provided either limited guidelines or limited support for their children. All these characteristics were likely to reduce parent–adolescent cohesion.

Expectation for Behavioral Autonomy

Our second aim was, in part, to identify potential mediating effects of adolescents' expectations for autonomy. Results showed that adolescents' autonomy expectations mediated the links between parenting styles and both the frequency and intensity of parent–adolescent conflict. Specifically, compared to adolescents in authoritative homes, those in neglect, indulgent, and authoritarian homes reported stronger expectations for autonomy, which in turn were linked with more frequent and intense parent-adolescent conflict. This result was consistent with other studies which explored the relationships between parenting styles, adolescents' expectation for behavioral autonomy and parent-adolescent conflict (Baumrind, 1991; Bush and Peterson, 2013).

Adolescents in authoritative families reported the lowest expectation for behavioral autonomy. This result may be due to that adolescents with authoritative parents have achieved appropriate autonomy, therefore, their desire to acquire more autonomy is not so strong. The salutary effect of authoritative parenting style on adolescents' behavioral autonomy likely reflects the successful attainment of a socialization goal among authoritative parents: to facilitate autonomy and promote self-reliance. This socialization goal is accomplished by respecting their children's needs and recognizing that adolescents legitimately have the right to control some aspects of their lives (Bush and Peterson, 2013).

Compared with authoritative parenting style, non-authoritative parenting styles have some characteristics that are thought to hinder the development of adolescents' behavioral autonomy. Authoritarian parents are characterized as using hostile control or harsh punishment in an arbitrary manner to gain obedience and conformity (Bush and Peterson, 2013). At the same time, authoritarian parents provide limited warmth and responsiveness. In that context, adolescents are more likely to seek greater behavioral autonomy because it is not available to them. Also, indulgent and neglect parents provide few if any rules or discipline. Without sufficient firm control in the form of parental monitoring and guidance, adolescents raised in indulgent and neglect parenting families are more likely to experience high levels of independence before they can manage it themselves (Bush and Peterson, 2013). Also, adolescents in neglectful families lack parental supportiveness and those in indulgent homes are simply spoiled. Such adolescents may have high levels of autonomy, but it is not likely to have been developed through a healthy developmental process with their parents in a way that balances their growing self-determination and connectedness with their parents.

In agreement with previous research (Laursen and Collins, 2009), the current results revealed that adolescents' expectation for behavioral autonomy statistically predicted greater

parent–adolescent conflict—perhaps because parents favor less autonomy than do their teenage children. This parent-youth discrepancy has been found in individualistic and collectivist cultural groups within the United States and in other countries (Smetana, 1988; Pérez et al., 2016). Researchers have interpreted the discrepancy as a developmental phenomenon, in which adolescents' need for autonomy exceeds parental concerns with maintaining order and protecting their children from harm (Jensen and Dost-Gözkan, 2015).

Legitimacy of Parental Authority

The second mediating effect that was tested involved adolescents' beliefs in the legitimacy of parental authority; results suggested some evidence for this effect. Compared with authoritative parenting, non-authoritative parenting was negatively associated with adolescents' beliefs in the legitimacy of parental authority, which in turn were positively related to parent-adolescent cohesion. This finding is consistent with previous research (Fuligni, 1998; Darling et al., 2005; Assadi et al., 2011; Trinkner et al., 2012). Our interpretation is that with increasingly adult-like social cognitions and relationships, adolescents increasing question parental authority as they shift from unquestioning compliance to rational assessment with conditional obedience. Compared to other types of parents, authoritative parents, are more successful with continually renegotiating parental authority as their children "grow up," because they use reasoning and explanations and are responsive to adolescents' perspectives. This ongoing negotiation provides a context for parents and children to articulate and discuss divergent perspectives, which helps legitimize the parents' authority by rationally justifying the boundaries of adolescents' personal jurisdiction.

In contrast, authoritarian parents exert strict and sometimes arbitrary punishment without explanation. Also, they construct the boundaries of parental authority much more broadly than authoritative parents, which promotes resistance in adolescence (Smetana, 1995; Baumrind, 2005). In this context, adolescents struggle to internalize the legitimacy of parental authority. Also, in contrast to authoritative parents, indulgent and neglectful parents provide little information about boundaries or appropriate behavior. Such lax control can undermine parental authority, so that youth increasingly regard parents as not playing an authority role.

Parents who exercise their authority are satisfied when their adolescent children respect them, which helps maintain harmonious relationships in the family (Zhang et al., 2006; Jensen and Dost-Gözkan, 2015). As child-rearing agents, providers of information and rules, and primary sources of support for their children, parents need to establish their authority to better play their parenting roles. However, this occurs in a relationship context with adolescent, and the teenager's endorsement of parents' authority helps the adults meet their psychological needs as well. In such families, parents and youth consider each other's boundaries and areas of control through negotiation and mutual respect, which builds more cohesive relationships.

In the current study, although adolescents' expectations for behavioral autonomy and beliefs in the legitimacy of parental authority are both critical attitude domains, their mediating effects were different: autonomy expectations mediated the effect of parenting style on parent-adolescent conflict, but authority legitimacy mediated the effect of parenting style on parent-adolescent cohesion. Certainly, although they are correlated, conflict and cohesion delineate different aspects of parent–adolescent relationships (Zhang et al., 2006)—and, each may be affected differently by levels of parental authority and adolescent autonomy. The distinction may be particularly strong in Chinese culture which emphasizes conformity and obedience (Peterson et al., 2005). Parent-adolescent conflict was more likely to be linked with adolescents' higher expectations for behavioral autonomy which runs against cultural norms, but cohesion was more likely to be linked with adolescents' greater endorsement of parental authority which is consistent with cultural norms.

Adolescent Gender

Our final aim was to test the hypothesis that the direct link between parenting style and relationship qualities would be stronger for girls than boys—and, to also explore whether there were gender differences in the mediating effects via adolescent autonomy and authority attitudes. The results indicated only a few such effects. Briefly, girls in authoritative and indulgent homes reported more cohesion with mothers than boys, and girls of neglect and authoritarian parenting reported lower level of parent–adolescent cohesion than boys. This may be due to that girls are more responsive and sensitive to social bonds than boys, and that cohesion and parenting style both reflects emotional atmosphere. Therefore, the relationships between parenting styles and cohesion were stronger for girls. Besides, girls of indulgent parents were less likely to endorse parental authority than boys, while endorsement of parental authority had greater effect on parent-adolescent cohesion for boys than girls. To the extent that parents normally set more rules and expect greater obedience of parental authority for girls than boys (Darling et al., 2005; Zhang and Fuligni, 2006), and consequently girls of indulgent parents may be more likely to feel that their parents did not shoulder the responsibility of cultivating them or establish the authority, given indulgent parents did not provide enough supervision and rules. Therefore, girls of indulgent parents endorsed lower level of parental authority. At the same time, since parents expected less conformity and obedience for boys, their endorsement of parental authority was more likely to live up to parents' expectation, which may improve relationships with parents.

Although gender moderated a few paths in the direct and mediating models, overall, the majority of paths were not significantly different for boys and girls across all of the models that were tested. This may be due to that, with the implementation of the one child policy, Chinese parenting styles and socialization practices are becoming increasingly similar for their sole children (Lu and Chang, 2013), resulting in more similar associations between parenting styles and parent–adolescent relationships and also the mediating effects of autonomy and authority for these relationships for boys and girls.

Limitations and Conclusions

Several limitations of this study should be noted. First, the participants were urban adolescents in mainland China which is characterized as collectivist culture, so generalizing the results to other cultures or groups should be done with caution. Second, the correlational design does not permit causal inferences. Longitudinal experimental data are necessary to identify causal relationships among the variables. Finally, we relied on adolescents' self-reports. Previous research found that there were discrepancies between parents' and youth's perceptions on these variables (e.g., Jensen and Dost-Gözkan, 2015), so our findings may not represent what would be found using parents' reports or observers' ratings.

Despite these limitations, the current study has important implications. To our knowledge, this is the first study to examine the mediating effects of adolescents' expectations for behavioral autonomy and beliefs in the legitimacy of parental authority, on the links between parenting styles and parent-adolescent conflict and cohesion. The findings of this study extend existing research and suggest that prevention and intervention efforts are needed to primarily target the reduction of non-authoritative parenting styles, and the promotion of acquiring appropriate levels of autonomy expectations and endorsement of parental authority. Future research should examine other possible mediating paths and sample a wider range of cultural contexts to explore adolescent development and family functioning.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the Institutional Review Board of Shandong Normal University. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Institutional Review Board of Shandong Normal University.

AUTHOR CONTRIBUTIONS

XB conducted the analysis and drafted the manuscript. YY and HL helped in performing the statistical analysis. MW coordinated the data collection and helped in the statistical analysis. WZ conceived and coordinated the study and helped to draft the manuscript. KD-D helped to draft the manuscript. All authors read and approved the final manuscript and the byline order of authors.

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SUPPLEMENTARY MATERIAL

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Relationship Between Parental Rejection and Problematic Mobile Phone Use in Chinese University Students: Mediating Roles of Perceived Discrimination and School Engagement

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In order to clarify the onset mechanism of problematic mobile phone use, and to develop better strategies to prevent and treat problematic mobile phone use, the current study tested the negative impact of parental rejection on problematic mobile phone use and the mediating roles of perceived discrimination and school engagement in this association. The sample consisted of 356 Chinese university students (36.3% male) ranging from 17 to 19 years of age. Participants completed self-report questionnaires assessing parental rejection, perceived discrimination, school engagement, and problematic mobile phone use. The results documented that parental rejection was a direct risk factor for problematic mobile phone use. This association was mediated by perceived discrimination, and there was also a sequential mediating effect in which perceived discrimination led in turn to low school engagement.

Keywords: parental rejection, perceived discrimination, school engagement, problematic mobile phone use, sequential mediating effect

INTRODUCTION

The use of mobile phones has dramatically increased over the last decades across the world. Among adults, 90% in the United States and 93% in the United Kingdom own a mobile phone (PewResearch, 2014; OFCOM, 2016). In China, as of January 2018, about 1.4 billion mobile phone subscriptions had been registered (Statista, 2018), with young adults (aged 18–22 years) being one of the largest and fastest-growing populations of mobile phone users (Chen et al., 2016). However, whereas the mobile phone brings great convenience for the purposes of communication and entertainment, research suggests that problematic mobile phone use is associated with a range of deficits in physical, psychological, and social functioning (e.g., alcohol abuse, anxiety, low academic performance, and addictive social media use; Ha et al., 2008; Sánchez-Martínez and Otero, 2009; Li et al., 2015).

Problematic mobile phone use in its extreme form is considered a form of behavioral addiction including the core components of addictive behaviors, such as cognitive salience, loss of control, mood modification, tolerance, withdrawal, conflict, and relapse (Billieux et al., 2015). Thus, it is important to pay more attention to problematic mobile phone use and its influences and effects.

In the current study, problematic mobile phone use is defined as physiological and psychological discomfort due to inappropriate or excessive use of mobile phones (Xiong et al., 2012). In order to better clarify effective strategies for prevention and intervention, we tested the negative impact of parental rejection on problematic mobile phone use, and the indirect role of perceived discrimination and school engagement in this association, in a sample of Chinese university students.

Parental Rejection and Problematic Mobile Phone Use

Parental rejection refers to the absence or significant withdrawal of the warmth, affection, care, comfort, concern, nurturance, support, or simply love that individuals optimally receive from their parents and other caregivers, and by the presence of a variety of physically and psychologically hurtful behavior and negative affect (Rohner et al., 2005). Several studies have reported the negative impact of parental rejection on depression (Magaro and Weisz, 2006; Xiao et al., 2017), substance use (Stover and Kiselica, 2015; Stogner and Gibson, 2016), and externalizing behaviors (Daganzo et al., 2014; Putnick et al., 2015; Nawaz et al., 2017) across development. However, the association between parental rejection and problematic mobile phone use among late adolescents remains unclear.

According to problem behavior theory (Jessor, 1987), inappropriate parental supervision, rejection, and lack of affection could damage individual perceptions of their environment and then increase the possibility of problem behaviors (e.g., problematic mobile phone use). A small number of studies have highlighted parenting as an influence on mobile phone addiction (Bae, 2015; Deng et al., 2015; Lian et al., 2016). For instance, a longitudinal study including 2218 early adolescents in South Korea reported that lower authoritative parenting was associated with more addictive use of mobile phones (Bae, 2015). Similarly, Lian et al. (2016) showed that negative parenting style significantly increased the severity of problematic mobile phone use in university students. In this context, it is reasonable to hypothesize that ongoing parental rejection experienced by university students would be positively associated with problematic mobile phone use.

Perceived Discrimination as the Mediator

Perceived discrimination refers to the individual's perception of being the target of others' negative attitudes and unfair treatment (Pascoe and Smart Richman, 2009). In this study, we examined the indirect role of perceived discrimination in the association between parental rejection and problematic mobile phone use. Previous research revealed that high parental rejection was significantly correlated with higher attachment anxiety (Grossmann et al., 2005; Hinnen et al., 2009; Pepping et al., 2015). In accordance with attachment theory (Bowlby, 1969) and parental acceptance–rejection theory (Rohner, 2004), individuals with attachment anxiety are more prone to show negative self-cognition and to use hyperactive strategies in response to stress, which leads them to pay more attention to negative signals and to perceive more discrimination. The positive association between attachment anxiety and perceived discrimination has been reported in earlier research (Zakalik and Wei, 2006).

Additionally, perceived discrimination as an important stressor may lead to problematic mobile phone use. When people perceive that they are discriminated against, they feel more stressed, eliciting a series of stress responses that broadly lead to problem behaviors (Lazarus and Folkman, 1984; Pascoe and Smart Richman, 2009). Previous studies have demonstrated that people sometimes select problematic mobile phone use as a way to cope with stress (Chiu, 2014; Nassehi et al., 2016; Gao et al., 2018). Moreover, although no study has directly tested the association between perceived discrimination and problematic mobile phone use, the deleterious effect of perceived discrimination on other additive behaviors, such as substance abuse, has been illustrated (Gibbons et al., 2004; Pascoe and Smart Richman, 2009; Tran et al., 2010). Thus, it is reasonable to postulate that perceived discrimination could promote a higher level of problematic mobile phone use.

Furthermore, two studies have elucidated the role of perceived discrimination as a mediator in the association between stressful events and negative outcomes. Wagner et al. (2012) demonstrated that discrimination could be a key mediator underlying the association between posttraumatic stress and HIV treatment adherence. Bao et al. (2016) reported that family risk could impact sleep disorder through perceived discrimination. Based on existing evidence, we hypothesized that perceived discrimination would work as a mediator between parental rejection and problematic mobile phone use.

School Engagement as the Mediator

School engagement has been defined as a multifaceted construct, including investment and participation in academic activities, identification with positive school-related outcomes, and strategic or self-regulated learning (Jimerson et al., 2003; Wang et al., 2011). Given that acceptance, warmth, supervision, and support from the family may be internalized and have an impact on future adaption in school contexts (Connell and Wellborn, 1991), school engagement as a malleable state could be shaped by family context (Annunziata et al., 2006; Smalls, 2009; Wang and Eccles, 2012). Adolescents with supportive and warm parents are inclined to show higher school engagement and better school performance (Li et al., 2010). By contrast, parental rejection, as a parenting style that lacks parental warmth, support, and other positive expressions (Rohner et al., 2005), may ultimately exert a negative effect on school engagement. In sum, an undesirable parent–adolescent relationship will restrict the development of school engagement (Zhu et al., 2015).

Although several studies have documented that decreased school engagement predicts lower school adjustment and more behavioral problems (Simons-Morton and Chen, 2009; Chase et al., 2014; Wang and Fredricks, 2014; Snyder and Smith, 2015), no study has tested the impact of school engagement on problematic mobile phone use. The current study addressed this gap and further tested whether school engagement could be a mediator between parental rejection and problematic mobile phone use. Previous studies delineating the relationship between school engagement and addictive behavior (e.g., Internet

addiction, substance abuse) provide empirical support for the assumption that low school engagement is associated with problematic mobile phone use. For instance, in a longitudinal sample, Wang and Fredricks (2014) found that youth with lower school engagement showed higher substance use as well as delinquency over time.

Because mobile phones are in some cases portable Internet devices and thus often used by persons addicted to the Internet, some researchers have pointed out that mobile phone addiction is essentially similar to Internet addiction (Eduardo et al., 2012; Han et al., 2017). Evidence showing the predictive effect of lower school engagement on higher Internet addiction (Li et al., 2013; Zhu et al., 2015) suggests that there is an association between school engagement and problematic mobile phone use.

Moreover, Upadyaya and Salmela-Aro (2013) reviewed the associations among different social contexts, school engagement and youth adaption, and asserted that family context could have an impact on youth adaption through school engagement. Empirical studies have also demonstrated that school engagement mediated the association between family factors (e.g., parenting style, parent–child relationship) and individual development (Li et al., 2010; Zhu et al., 2015). Thus, in the current study, we hypothesized that school engagement would play a mediating role in the association between parental rejection and problematic mobile phone use.

Meanwhile, prior research has indicated that perceived discrimination could negatively influence school engagement (Smalls et al., 2007; Dotterer et al., 2009; Brody et al., 2012; Benner and Graham, 2013). Using a three-wave longitudinal design, Brody et al. (2012) found that youth who experienced higher discrimination reported more negative beliefs about the usefulness of schools, lower academic efficacy, and poorer academic achievement, which in turn led to decreases in school engagement. Another study in a sample of 148 African American adolescents demonstrated that racial discrimination could impede school self-esteem and school bonding (Dotterer et al., 2009). Hence, the current study assumed that the association between parental rejection and problematic mobile phone use would be mediated by both perceived discrimination and school engagement sequentially, such that perceived discrimination and school engagement may work together in a chain mediation model.

The Current Study

This study tested the direct effect of parental rejection on problematic mobile phone use as well as the role of two parallel and sequential mediation mechanisms in this association (**Figure 1**). Based on existing theoretical perspectives and empirical evidence, we hypothesized that in our sample of Chinese university students: (a) parental rejection would be positively associated with problematic mobile phone; (b) perceived discrimination would mediate the association between parental rejection and problematic mobile phone use; (c) school engagement would mediate the association between parental rejection and problematic mobile phone use; and (d) perceived discrimination and school engagement would be a sequential mediating mechanism in the association between parental rejection and problematic mobile phone use.

MATERIALS AND METHODS

Participants

We recruited participants from three universities in the southern Chinese province of Guangdong. The sample consisted of 356 university students (36.3% male) ranging from 17 to 19 years of age (mean age = 18.33, *SD* = 0.57). Reflecting the demographics of the area, 30.0% came from rural areas, 13.8% from county seats, 27.6% from small-medium cities, and 28.5% from metropolitan areas. Moreover, 75.1% of participants' fathers and 69.6% of their mothers had less than a junior college education. The average monthly income in 43.3% of recruited families exceeded ¥3000, which represents higher than average personal monthly household income (¥2857) in China (2015).

Measures

Parental Rejection

The measure of parental rejection has been shown to have strong reliability and construct validity (Gerlsma et al., 1992; Gerlsma and Hale, 1997). Respondents were asked to indicate their experiences of parental rejection when they were growing up (e.g., "My parents are very critical of me"; "My parents get annoyed when I want something from them"; "My parents try to change who I am"). All items were rated on a five-point scale ranging from 1 (*never*) to 5 (*frequently recurring*). The responses were averaged across these three items, with higher

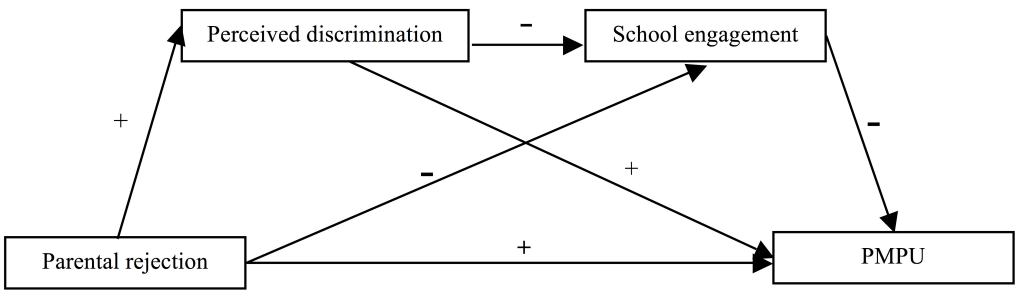

FIGURE 1 | Proposed mechanism of the association between parental rejection and PMPU.

scores indicating higher levels of parental rejection. In the current study, the Cronbach's alpha was 0.76.

Perceived Discrimination

Perceived discrimination was measured by the nine-item discrimination questionnaire developed by Lee and Ferraro (2009). Respondents were asked to indicate their perception of discriminatory experiences on a daily basis (e.g., "Are you treated with less courtesy than other people?"; "Are you treated with less respect than other people?"; "Do you receive poorer service than other people at restaurants or stores?"). All items were rated on a five-point scale ranging from 1 (*never*) to 5 (*frequently recurring*). Item scores were averaged to create a composite score for perceived discrimination, with higher scores indicating higher levels of perceived discrimination. In the current study, the Cronbach's alpha was 0.88.

School Engagement

School engagement was measured by the 23-item School Engagement Scale, which was originally developed by Wang et al. (2011). Respondents were asked to describe themselves in terms of the behavioral, emotional and cognitive components of school engagement (e.g., "How often have you skipped class?"; "In general, I feel like a real part in this school"). All items were rated on a five-point scale ranging from 1 (*never*) to 5 (*frequently recurring*). Item scores were averaged to create a composite score for school engagement, with higher scores indicating higher levels of school engagement. In the current study, the Cronbach's alpha was 0.86.

Problematic Mobile Phone Use

Problematic mobile phone use was assessed using the 17-item Mobile Phone Addiction Index (MPAI; Leung, 2008). Respondents were asked to indicate how often they are bothered by problematic mobile phone use (e.g., "It is difficult for you to turn the mobile phone off"; "You will be upset if your phone is not available"). All items were rated on a five-point scale ranging from 1 (*never*) to 5 (*frequently recurring*). Item scores were averaged to create a composite score, with higher scores indicating higher levels of problematic mobile phone use. In the current study, the Cronbach's alpha was 0.87.

Covariates

We controlled for gender, age, and SES as covariates in statistical analyses. Gender was a dichotomous variable (1 = male; 0 = female). Age was measured by the respondent' s age in years. SES was measured as the average of a respondent's standardized scores on four items (e.g., geographical area, educational level of each parent, family per capita monthly income). Respondents were asked to indicate the type of geographical area on a five-point scale (1 = *rural area*, 4 = *metropolis*) that ranged from less-developed to highly developed. Educational level of each parent was measured on a six-point scale (1 = *less than or equal to elementary school level*, 6 = *graduate level*). Income was measured by family per capita monthly income, a seven-category variable (1 = *less than or equal to ¥190*, 7 = *greater than or equal to ¥3000*).

Procedure

Permission to implement the study was granted by the research ethics committee of corresponding author's university. Verbal consent was obtained from participants. The parents of 14 participants who were younger than age 18 also provided consent. Trained researchers administered the self-report questionnaires to students during class time. The anonymity of the participants' responses was emphasized at the beginning of the data collection session. Participants were also told that they must respond to the questionnaire items by themselves, and that they were free to withdraw at any time during data collection without penalty. The students received partial course credit for participating.

Statistical Analysis

We estimated mediation effects using structural equation modeling (SEM) methods. Models were estimated using Mplus Version 7.0 (Muthén and Muthén, 2012), adopting the full information maximum-likelihood estimation procedure to accommodate missing data. A bootstrapping procedure was used to test the statistical significance of the paths and indirect effects in each model (Erceg-Hurn and Mirosevich, 2008). Model fit was assessed using multiple fit indices including the ratio of chi-square to degrees of freedom (x^2/df), comparative fit index (CFI), root-mean-square error of approximation (RMSEA), and Tucker–Lewis index (TLI). The SEM literature shows that model fit is good when $x^2/df \leq 3$; CFI ≥ 0.95, TLI ≥ 0.95, and RMSEA ≤ 0.06 (Kline, 2011; Hoyle, 2012).

RESULTS

Descriptive Statistics

85.9% of the 356 participants could be identified as problematic mobile phone uses. Means, *SD*s, and correlations of major study variables are displayed in **Table 1**. All the major study variables were significantly inter-correlated. Parental rejection was positively associated with perceived discrimination ($r = 36$, $p < 0.01$) as well as problematic mobile phone use ($r = 0.21$, $p < 0.01$), and was negatively associated with school engagement ($r = -0.18$, $p < 0.01$). Perceived discrimination was positively associated with problematic mobile phone use ($r = 0.28$, $p < 0.01$) and was negatively associated with school engagement ($r = -0.32$, $p < 0.01$). In addition, school engagement was negatively associated with problematic mobile phone use ($r = -0.23$, $p < 0.01$).

TABLE 1 | Descriptive statistics and correlations among major variables ($N = 356$).

Variables	*M*	*SD*	1	2	3
1. Parental rejection	2.06	0.74	1		
2. Perceived discrimination	1.77	0.55	0.36**	1	
3. School engagement	3.78	0.43	−0.18**	−0.32**	1
4. Problematic mobile phone use	2.51	0.64	0.21**	0.28**	−0.23**

**$p < 0.01$.

Mediation Model Test

We found that parental rejection was positively associated with problematic mobile phone use (b = 0.21, $p < 0.001$) before accounting for the mediation variables. Then, we followed a stepwise method to construct the best fitting model for the mediated effects of perceived discrimination and school engagement. First, we evaluated the fit of the parallel mediation model (Model 1) which included: (a) the direct path from parental rejection → problematic mobile phone use, (b) the indirect path from parental rejection → perceived discrimination → problematic mobile phone use, and (c) the indirect path from parental rejection → school engagement → problematic mobile phone use. In this model, all the paths were significant (see **Figure 2**) but the data did not fit the data well (i.e., χ^2/df = 18.46, CFI = 0.88, RMSEA = 0.23, and SRMR = 0.03), implying that the parallel mediation model may be not the best model.

Second, we added the path from perceived discrimination to school engagement (Model 2, see **Figure 3**). This model was fully saturated (i.e., χ^2/df = 0.00, CFI = 1.00, RMSEA = 0.00, and SRMR = 0.00). All the paths in this model were significant except that the association between parental rejection and school engagement did not hold ($b = -0.09$, $p > 0.05$). That is to say, perceived discrimination fully mediated the impact of parental rejection on school engagement.

Next, given that the saturated model (Model 2) was of little use statistically, we dropped the non-significant paths from parental rejection to school engagement (Model 3, see **Figure 4**). Model 3 showed a good fit, χ^2/df = 2.67, CFI = 0.99, RMSEA = 0.07, and SRMR = 0.01, and it did not significantly decrease the model fit, $\Delta\chi^2(1) = 2.67$, $p > 0.05$. Therefore, Model 3 was the final mediated model in which the association between parental rejection and problematic phone use was mediated not just by perceived discrimination, but also by perceived discrimination and school engagement in sequence.

Finally, the indirect effects are reported in **Table 2**. Bootstrapping analyses indicated that the indirect effect of parental rejection on problematic mobile phone use through perceived discrimination was significant and positive (*beta* = 0.07, $p < 0.01$, and 99% CI [0.010,0.160]); and the indirect effect of parental rejection on problematic mobile phone use through both perceived discrimination and school engagement in sequence was significant and positive (*beta* = 0.02, $p < 0.01$, and 99% CI [0.001,0.042]). Additionally, the indirect effect of parental rejection on school engagement via perceived discrimination was significant and negative (*beta* = −0.11, $p < 0.01$, and 99% CI [−0.199, −0.051]). Perceived discrimination appeared to exert an indirect effect on problematic mobile phone use via school engagement (*beta* = 0.04, $p < 0.01$, and 99% CI [0.010,0.094]).

DISCUSSION

The objective of this study was to test the association between parental rejection and problematic mobile phone use, as well as the explanatory mechanisms of this association, in a sample of Chinese university students. As expected, we found that parental rejection was a risk factor for problematic mobile phone use. Tests of mediation showed that students' perceived discrimination might partly explain this risk process. That is, students who experienced more parental rejection were also more likely to perceive that they were discriminated against, leading to more problematic phone use. School engagement appears to be important also, but to a lesser degree. Although school engagement did not act as a mediator when considered alone,

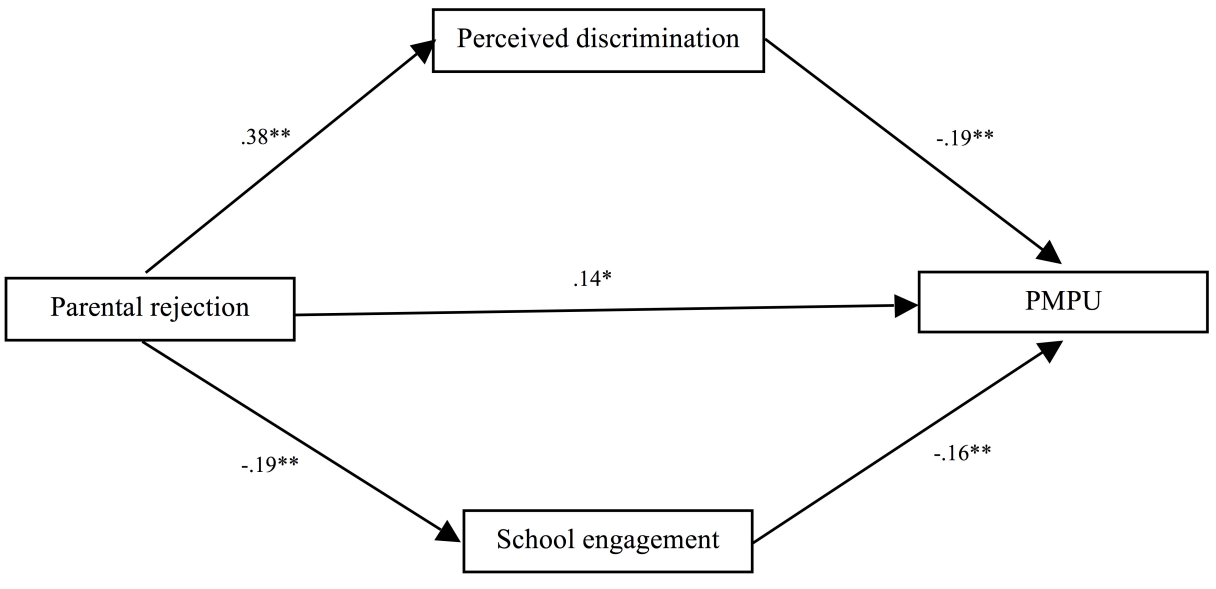

FIGURE 2 | Tests of Model 1 showed parallel indirect effects of perceived discrimination and school engagement in the association between parental rejection and problematic mobile phone use. *Note.* Although not displayed for reasons of clarity, this model also included paths among controlled variables (i.e., age, gender, SES) and each of the variables in the model. PMPU = problematic mobile phone use.

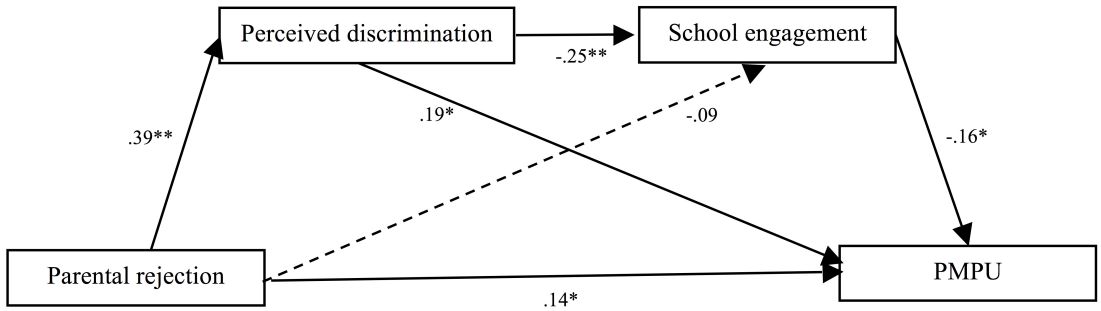

FIGURE 3 | Tests of Model 2 showed the indirect effect of perceived discrimination, and the sequential indirect effects of perceived discrimination and school engagement, in the association between parental rejection and problematic mobile phone use. School engagement, when considered alone, did not act as a mediator. *Note.* Although not displayed for reasons of clarity, tests of this model also included paths among controlled variables (i.e., age, gender, SES) and each of the variables in the model. PMPU = problematic mobile phone use.

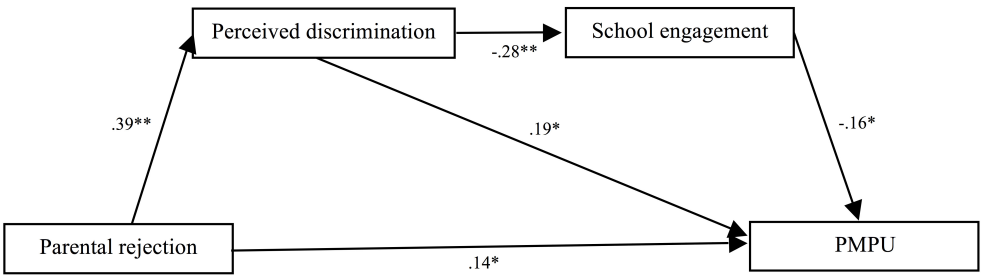

FIGURE 4 | Tests of Model 3 showed that after removing the non-significant path between parental rejection and school engagement, there was an indirect effect of perceived discrimination, and sequential indirect effects of perceived discrimination and school engagement, in the association between parental rejection and problematic mobile phone use. *Note.* Although not displayed for reasons of clarity, tests of this model also included paths among controlled variables (i.e., age, gender, SES) and each of the variables in the model. PMPU = problematic mobile phone use.

TABLE 2 | Indirect effects in the final model.

Pathways	*beta*	99% CI
Parental rejection? perceived discrimination→ PMPU	0.07	0.024,0.141
Parental rejection→ perceived discrimination→ school engagement	−0.11	−0.199, −0.051
Perceived discrimination→ school engagement → PMPU	0.04	0.010,0.094
Parental rejection→ perceived discrimination→ school engagement→ PMPU	0.02	0.001,0.042

PMPU = problematic mobile phone use.

there was a sequential mediating effect in which parental rejection predicted perceived discrimination, which in turn predicted school engagement, which in turn predicted problematic mobile phone use. Next, we discussed each of our research questions in light of this multiple mediation model.

The Direct Association Between Parental Rejection and Problematic Mobile Phone Use

Notably, parental rejection was positively associated with a higher level of problematic mobile phone use. This implies that university students who experience parental rejection may be more inclined to become problematic mobile phone users. This result adds to previous studies that have suggested that parental rejection enhances the risk for maladaptive development, from delinquency to psychopathology (Campo and Rohner, 1992; Miranda et al., 2016; Ramírez-Uclés et al., 2018). Consistent with problem behavior theory (Jessor, 1987), parental rejection may damage the perceived environment and elicit more problematic mobile phone use. Parental rejection could undermine undergraduates' feelings of relatedness to their parents, and further lead to deficits in social competence (Dwairy, 2010). These students may avoid face to face interaction, and in turn select mobile phones to meet the need for communication with others on account of limited social resources and support. However, when mobile phone use helps people alleviate psychological imbalance due to parental rejection, it also drags them into another trap of excessive and unregulated mobile phone use (Kim et al., 2015).

The Indirect Role of Perceived Discrimination

The current study also identified the role of perceived discrimination as a mediator in the link between parental rejection and problematic mobile phone use. Specifically,

parental rejection was positively associated with perceived discrimination, which in turn predicted a higher level of problematic mobile phone use. According to parental acceptance–rejection theory (Rohner, 2004), self-esteem, self-adequacy, worldview, and emotional stability tend to be negatively impacted by parental rejection. On one hand, university students with a higher level of parental rejection may evaluate themselves negatively and internalize a more hostile world view because of impaired self-recognition (Ramírez-Uclés et al., 2018). The process of identity development is one of the major psychosocial tasks of late adolescence (McLean, 2005). Those late adolescents with the experience of parental rejection may be engaged into damaged process of self-definition and fail to forge a sense of identity in the context of previous adversity, leading to low self-esteem (Kenny and Rice, 1995). Those negative thoughts and feelings make them vulnerable to others' negative attitudes toward them, and they then perceive a higher level of discrimination. On the other hand, parental rejection may lead to deficits in social skills and in emotion regulation (Meesters and Muris, 2004; Dwairy, 2010). Late adolescence is a time of social reorganization. Those university students move away form home, and then their peers or other adults come to meet their need for emotional support. Poor interpersonal problem solving caused by parental rejection may lead them easily to be the object of discrimination during the shift in attachment figures.

Furthermore, our findings confirmed the second path of the indirect effect: that perceived discrimination is a risk factor for problematic mobile phone use. This finding is consistent with previous research with regard to the influence of perceived discrimination on addictive behavior (Okamoto et al., 2009; Chia-Chen Chen et al., 2014). Perceived discrimination as a developmental risk could lead to a series of stress responses (McClure et al., 2010; Romero et al., 2014). Prior studies have highlighted that the use of communication devices or technology is useful to relieve stress and negative emotional states (Akin and Iskender, 2011; Tang et al., 2014; Jun and Choi, 2015). For example, Chiu (2014) reported that in a sample of university students, mobile phone use was useful in relieving negative emotions and experiences caused by interpersonal relationship stress. To advance this research, the current study provided evidence that people may use mobile phones excessively to tackle perceived discrimination, which is rooted in parental rejection. The current study is the first to underscore the mediation mechanism underlying the association between parental rejection and problematic mobile phone use.

The Sequential Mediation Mechanism of Perceived Discrimination and School Engagement

The final structural equation model indicated that perceived discrimination was negatively associated with school engagement. This result is consistent with prior research reporting that perceived discrimination decreases youths' school engagement and academic performance (Smalls et al., 2007; Dotterer et al., 2009; Brody et al., 2012; Benner and Graham, 2013). Brody et al. (2012) suggested that perceived discrimination would lead to feelings of devaluation and demoralization, which could cause students to become less inclined to take on conventional values and pursuits. This process may make students who have experienced discrimination view school as a useless and irrelevant social organization, further diminishing their belief in the importance of academics and the value of studying at school, their school-related self-esteem, and their educational aspirations (Thames et al., 2013; Unnever et al., 2016). In addition, perceived discrimination fully mediated the impact of parental rejection on school engagement. The insignificant association between parental rejection and school engagement implies that relative to parental rejection, perceived discrimination plays a more proximal and pronounced role in the prediction of school engagement. It is reasonable because perceived discrimination may interfere with identity development, which is a major task for late adolescents (Kenny and Rice, 1995). And then this identity-related dysfunction is likely to further affect individual development (e.g., decreased school engagement). Moreover, students in our study have moved away from family to university, and this shift could decrease the impact of parents on school activity. These results highlight the importance of testing the role of perceived discrimination in shaping student adjustment in the context of risk.

Moreover, we found that increased school engagement was significantly associated with less problematic mobile phone use. Several studies have reported the protective role of school engagement on maladaptive behavior (Li et al., 2013; Wang and Fredricks, 2014; Zhu et al., 2015). In alignment with social control theory (Hirschi, 1969), adolescents with higher school engagement are more likely to learn and to meet conventional expectations; hence, they may show a lower level of problematic mobile phone use. Furthermore, the present study found that school engagement worked as a mediator in the relationship between perceived discrimination and mobile phone addiction. Because of this process, a sequential mediation path appeared. That is, parental rejection could influence problematic mobile phone use through both perceived discrimination and school engagement. University students who experience parental rejection, which primes them to perceive more discrimination, may be inclined to become less engaged at school and ultimately become a problematic mobile phone user. This study integrates family, cognitive, and school factors that directly and indirectly influence problematic mobile phone use.

Limitation

Some important limitations of this study should be noted when considering the findings. First, the data were collected through self-report, which may increase the shared method variance and limit objectivity. Although Rohner et al. (2009) suggested that children's reports of parenting are more reliable than parents' reports, it is still necessary for future research to use multiple methods (e.g., multiple informants, interviews, observations) to obtain a more objective index. Second, this study used a cross-sectional design. Although the final model contributes to our understanding of the factors that may influence problematic mobile phone use, it cannot verify temporal change or allow

causal inferences. Some theoretical frameworks have suggested that there may be a reciprocal process in the association between parenting and children's behavior (Patterson, 1982; Reid et al., 2002). Future research should adopt longitudinal designs and use cross-lagged models with all data obtained from all measures at all time points to test the directions of paths (Cole and Maxwell, 2003). Third, the current study did not test the mechanism by which parental rejection is associated with mobile phone usage time and different types of usage behavior. Usage behavior does not necessarily produce addiction indicators (Hong et al., 2012). To achieve a comprehensive understanding of our model, it is necessary to pay more attention to understanding the predictors of mobile phone usage time and usage behavior in the future. Last, we only tested the impact of parental rejection as a risk factor for problematic mobile phone use in a sample of university students. In fact, mobile phones have gradually become an essential part of life for much younger children and adolescents. Vernon et al. (2018) reported that mobile phone use was directly associated with increased externalizing behavior and decreased self-esteem in a sample of adolescents aged between 13 and 16 years old. Thus, it is also important to discuss and compare the effect of parental rejection on problematic mobile phone use among people in different developmental periods. Finally, research is needed to replicate our results in more diverse samples.

CONCLUSION

The study shows the roles of perceived discrimination and school engagement in shaping problematic mobile phone use among university students who experience parental rejection. Specifically, perceived discrimination and school engagement can exert sequential mediating effects on the path between parental rejection and problematic mobile phone use. The results reveal the onset mechanism of problematic mobile phone use from the perspectives of parenting, personality, and school, and also provide empirical support for the association between parenting and problematic mobile phone use. It is hoped that these results will have applied value in preventing and treating problematic mobile phone use by reducing university students' perceived discrimination and increasing their school engagement.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the Research Ethics Committee at South China Normal University guidelines, the Research Ethics Committee at South China Normal University with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Research Ethics Committee at South China Normal University.

AUTHOR CONTRIBUTIONS

JZ, RX, and WZ conceived and designed the research. RX and JZ performed the research. JZ, RX, and YC analyzed the data. JZ, RX, YC, and WZ contributed to the writing of the manuscript.

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The Discrepancy of Parents' Theories of Intelligence and Parental Involvement

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In families, mothers and fathers may hold the same or different levels of theories of intelligence. This congruence and discrepancy may influence parental involvement in children's education. The current study examined how both parents' theories of intelligence and the direction and degree of the discrepancy of parents' intelligence theories influence maternal and paternal involvement separately. We measured 1,694 matched pairs of parents' theories of intelligence and educational involvement, and examined the relationships using linear regressions and polynomial regressions with response surface analysis. The results showed that (1) the mother's intelligence theory positively related to both paternal involvement and maternal involvement, but the father's intelligence theory only positively related to paternal involvement; (2) when the parents' theories of intelligence reached congruence, the parents' theories of intelligence are positively related to both maternal and paternal involvement; (3) when the parents' theories of intelligence have discrepancy, the maternal involvement is higher while the mother's intelligence theory's level is more incremental than father's; and (4) when the parents' theories of intelligence have discrepancy, more discrepancy of parents' theories of intelligence is related to more paternal involvement. This study revealed the significance of mother's role in education, highlighted the importance of parents' congruence and discrepancies in beliefs, examined how parents' beliefs impact their own behavior and their couple's behavior.

Keywords: parental involvement, parents' congruence and discrepancy, polynomial regression with response surface analysis, theory of intelligence, Chinese parents

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INTRODUCTION

The theory of intelligence (implicit theory of intelligence, intelligence mindset) (Dweck and Leggett, 1988) refers to beliefs that people hold concerning the nature of intelligence, namely, the changeability of intelligence (Hong et al., 1999). Specifically, there are two main types of theories of intelligence: the incremental theory and the entity theory. The incremental theory assumes that intelligence is malleable and changeable, most notably through effort and persistence, while the entity theory assumes that intelligence is fixed and not easily changed (Dweck and Leggett, 1988).

Based on empirical research, Walker et al. (2005) put forward a theoretical model, considering that the parent's theory of intelligence was an important psychological factor influencing parental involvement.

Parental involvement, namely, parents' engagement in their children's education, is a variety of behaviors that parents perform to promote their children's academic achievement and psychological development in their homes and schools (Seginer, 2006). Theoretical studies such as the models by Walker et al. (2005) and Hornby and Lafaele have described the link between parental theory of intelligence and parental involvement. These studies have contended that, on the one hand, parents who hold an incremental theory of intelligence most likely emphasize the role of effort, motivate children to accept shortcomings, encourage them to think about the mechanisms underlying specific questions, and are more involved in education. On the other hand, parents who hold an entity theory of intelligence believe strongly in the preeminence of ability over effort and often lack confidence, which leads to actions that minimize external judgments. Furthermore, these parents regard children's difficulties with learning as reflecting low ability, which leads to decreased parental involvement (Walker et al., 2005; see the model of the barriers to parental involvement, Hornby and Lafaele, 2011). However, those models only hypothesized such a relationship.

Researchers have used data to provide evidence for the close relationship between parental theory of intelligence and parental involvement. Studies have shown that primary-school students' parents who hold more incremental theories reported higher frequency of engagement in math- and reading-related activities with their children (Muenks et al., 2015); mothers who view their children's performance as more important than learning were more likely to choose easy activities for their children than were mothers who view learning as more important (Ames and Archer, 1987; Stipek et al., 1992); mothers who were induced to hold an entity theory displayed a higher frequency of unconstructive involvement (Aunola et al., 1999; Moorman and Pomerantz, 2010).

However, although previous research has revealed the relationship between the parent's theory of intelligence and parental involvement from both theoretical and empirical perspectives and helped us understand why there are individual differences in involvement frequency, these studies are still insufficient. First, the studies above concentrated only on the relationship between one parent's theory of intelligence and his or her own involvement in the child's learning. However, an individual's behavior is influenced not only by his or her own beliefs but also by the environment. According to the family system theory, the family is a complete system (an emotional unit), and family members are a component of that system. Consequently, every member of the family mutually interacts with others (Bowen, 1966, 2010). Previous studies have also supported this interaction. For example, a study of 622 dual-earner mothers in the United States demonstrated that mothers' global expectations and beliefs about the allocation of family work and their recognition of the father's educational ability influenced paternal involvement (maternal gatekeeping; Allen and Hawkins, 1999). Zvara et al. (2013) discovered that fathers demonstrated greater direct engagement in their child's healthcare when mothers held more nontraditional beliefs about gender roles. Based on this evidence, we can draw the conclusion that paternal and maternal involvement relates to each parent's theory of intelligence; however, until now, no studies have examined whether both parents' theories of intelligence together relate to one parent's involvement.

Second, the abovementioned studies have neglected the effect of the congruence and discrepancy of parents' theories of intelligence on paternal and maternal involvement. Obviously, there are individual differences in theories of intelligence. Therefore, there might be a discrepancy in parents' theories of intelligence within a family (Bosma et al., 1996); in one family, both parents may hold incremental theories at the same level, whereas in another family, the father may hold an incremental theory while the mother holds an entity theory. Accordingly, there may be a substantial difference between the two families with regard to the parental involvement modes. We can reasonably assume that parents' theories at different levels might negatively affect their motivation to be involved in their children's education, and high incremental theories held by both parents might lead to a higher level of involvement in the family. Conversely, complete congruency can also be a problem (Carlson et al., 1991). If both parents believe that intelligence is unchangeable, they may be unwilling to be involved in their children's learning, which is worse than if one parent believes that intelligence can be changed. Some studies in similar fields have provided secondary evidence for this situation. One study focused on family members' (father, mother, adolescent) perceptions and beliefs about the nature of autonomy and its development and on their degree of congruence or discrepancy within the family (Cicognani and Zani, 1998). Another two studies examined how parents' discrepancies in childrearing beliefs impact coparenting (Egeren and Hawkins, 2004; McHale et al., 2004). However, the details regarding the impact of the congruence or discrepancy of parents' theories of intelligence on paternal and maternal involvement remain to be revealed.

In addition to the two issues above, in China, both parental involvement and the theory of intelligence might have particular connotations because of the cultural context. Evidence has shown that Chinese parents place an exceptionally high value on education and are actively engaged in their children's education at home (Zhang and Carrasquillo, 1996; Lizza and Huang, 2008; Huntsinger and Jose, 2009; Wang and Gao, 2013), which contributes to the frequency of parental involvement. Furthermore, within collectivist culture, Chinese parents are more likely to encourage students to learn existing knowledge rather than to create new things when tutoring their child in their studies (Lizza and Huang, 2008; Shao and Zhang, 2010). In terms of the theory of intelligence, in cross-cultural studies, researchers have found that Chinese parents always pay more attention to competing and obtaining good grades, while Western parents emphasize the individual's growth, encouraging students to compare their achievement only with themselves (Tobin et al., 1989; Zhao, 2005; Li, 2007), which means that more Chinese parents might hold entity theories rather than incremental

theories. Consequently, researching the relationship between the parent's theory of intelligence and parental involvement in the Chinese context can allow us to better understand the differences and changes in the relationship within a distinct context. However, no such studies have been conducted to date.

Present Research and Hypothesis

Based on the limitations of the previous research, the current study will focus on two major issues: the relationship between Chinese parents' theories of intelligence and paternal/maternal involvement, separately, as well as the effect of the congruence and discrepancy of Chinese parents' theories of intelligence on paternal/maternal involvement, separately. Some researchers have argued that incremental and entity theory are two ends of one dimension of the intelligence theory spectrum (Blackwell et al., 2007; Claro et al., 2016; Haimovitz and Dweck, 2016), whereas others have suggested that the absence of an entity theory does not indicate the presence of an incremental theory (Jose and Bellamy, 2012; Shaari et al., 2017). We acknowledged the former in the current study. The originality of the study lies in analyzing potential differences between the maternal and paternal theories of intelligence and their contribution to parental involvement.

The previous research in this area usually assesses discrepancies with difference scores (univariate or multivariate), which have long been criticized for their questionable psychometric properties, such as unknown reliability and validity (Laird and Weems, 2011). Furthermore, it is hard to disentangle the effect of a difference score and the effects of the initial report variables on the outcome variable using the difference scores method (Edwards and Parry, 1993). In addition, traditional regression and difference scoring methods can only supply limited information (Wen et al., 2005; Edwards and Cable, 2009; Human et al., 2016). To better resolve the issues mentioned above, researchers utilize a method called response surface analysis (RSA). RSA has been used in generalization studies to describe nuanced relationships between two variables in a three-dimensional perspective (specifically, congruence and discrepancy with regard to outcomes). RSA is applied mainly to the study of outcomes of self-observed rating discrepancies in multisource feedback (Edwards and Parry, 1993) and is a straightforward approach that enables the simultaneous examination of the independent predictive ability of two perspectives as well as whether their congruence and discrepancy are consequential. Moreover, this approach could avoid the potentially problematic psychometric properties of the difference score method (Ostroff et al., 2005).

Therefore, in the current study, we use RSA to determine the relationship between parents' theories of intelligence and parental involvement. RSA can examine how (a) the congruence, (b) the degree of the discrepancy, and (c) the direction of the discrepancy between father's and mother's theory of intelligence relate to paternal/maternal involvement. To summarize, RSA can provide the simultaneous and nuanced assessment of the united effects of paternal and maternal theories of intelligence on parental involvement within a single model (Cohen et al., 2010; Shanock et al., 2010).

In the current study, we conducted RSA twice, for paternal and maternal involvement as dependent variables separately, and used 1,694 matched pairs of Chinese parents as the object of our research. Based on previous studies, this study proposes the following assumptions: (1) fathers' and mothers' theories of intelligence relate not only to their own involvement but also to their involvement as a couple, and higher incremental theories are linked to higher levels of parental involvement; (2) the congruence of parents' theories of intelligence relates to maternal and paternal involvement separately: specifically, higher incremental theories are linked with higher involvement; and (3) the discrepancy of fathers' and mothers' theories of intelligence relates to maternal and paternal involvement separately: specifically, the parent who holds a more incremental theory is more involved (the direction of discrepancy matters), and greater discrepancy between parents' theories of intelligence is related to lower engagement (the degree of discrepancy matters).

MATERIALS AND METHODS

Ethics Statement

All procedures in this study were approved by the Institutional Review Board of the Collaborative Innovation Center of Assessment toward Basic Education Quality, Beijing Normal University. Written informed consent to participate in the study was obtained from the parents of all the child participants before evaluation.

Participants and Procedure

The study started with a total of 2,895 pairs of Chinese pupils' fathers and mothers. We cooperated with the Education Bureau to conduct this survey. We selected 35 public primary schools from all the schools in Baoding City, Hebei Province, and 5 public primary schools in Beijing. A total of 1,951 fourth-grade students were from 48 classrooms in Baoding's rural area, and 944 fourth-grade students were from 26 classrooms in Beijing. Beijing is the capital of China, and Hebei Province borders Beijing and is located in the middle-eastern part of China. Data were collected in December 2016. The parents' questionnaires were taken home by the students, and the mothers and fathers completed the questionnaires at home separately. On the next day, the students returned the questionnaires to the school, where we collected them. Delayed questionnaires and receipts were sent back in one week.

The final sample included 1,694 pairs of mothers (27–54 years old, M = 36.46, SD = 3.93) and fathers (28–61 years old, M = 37.78, SD = 4.26) of Chinese pupils (864 boys, 830 girls; 9–11 years old, M = 9.39, SD = 0.50). We deleted samples based on the following rules: (1) questionnaires that were not answered by parents (588 pairs of parents deleted). In general, 79.69% of 2,895 pairs of questionnaires were answered by parents; (2) parents of students with intellectual disabilities, because the child's disability might be related to parental involvement (Ferguson, 2002) (4 pairs deleted); (3) parents who did not

live with their children, because parental involvement may be significantly lower if the parents and children live separately (Peña, 2000) (509 pairs deleted); and (4) parents for whom the deficiency rate of responses was above 1/3 (100 pairs deleted). The children belonging to the deleted questionnaires and the undeleted questionnaires had no significant differences in academic scores in the fall semester of 2016.

The mothers predominantly had a junior high-school education or technical secondary school education (41.6%), followed by a bachelor's degree and above (18.4%), a middle-school education or secondary vocational school education (16.1%), a 3-year college education (12.8%), and a primary-school education or below (11.2%). Fathers also predominantly had a junior high-school education or technical secondary school education (47.2%), followed by a bachelor's degree and above (18.5%), a middle-school or secondary vocational school education (14.6%), a 3-year college education (12.5%), and a primary-school education or below (7.2%). The annual disposable income of the family is calculated as the average of the mother-reported and father-reported data. Most of the students' families (42.2%) had an average annual disposable income of 30,001–100,000 Chinese yuan; 9.9% had an income of below 7,200; 21.7% had an income of 7,201–30,000; 20.2% had an income of 100,001–300,000; and 6.0% had an income above 300,001. According to the China Statistical Yearbook [CSY] (2017), the median per capita annual income in China was 20,883 Chinese yuan, and the per capita net income was 52,530.4 Chinese yuan in Beijing and 19,725.4 in Hebei Province in 2016 (China Statistical Yearbook [CSY], 2017), which is approximately consistent with our data.

Measures

Theories of Intelligence

The intelligence theory scale used was the Hong Kong version (Chen and Wong, 2014), a short version of the original questionnaire designed by Dweck (Dweck, 2000). The scale included 8 items, 4 that measured the incremental view and 4 that measured the entity view. An example item measuring the incremental view was "Everyone can significantly change his/her ability." An example item measuring the entity view was "People can learn new things but cannot change their basic ability." The parents rated each item from 1 (totally disagree) to 5 (totally agree). We reverse-scored the 4 items that measured the entity view and then calculated an average score of the total 8 items as the theory of intelligence score. Therefore, a higher total score indicates a higher incremental view, and a lower total score indicates a higher entity view. Cronbach's α was 0.638 for the fathers' reports and 0.664 for the mothers' reports.

Parental Involvement

The 30-item scale of the "Parental involvement in primary-school children's education questionnaire" (parent version) was formulated by Wu et al. (2013) (e.g., "I communicate with teachers regarding my child's homework") and was used by Wei et al. (2016). Fathers and mothers were separately asked about the frequency with which they performed each item during the last half of the year rating, using a 4-point Likert scale ranging from 1 (never) to 4 (usually). The average of the 30 items is the parent's involvement score. Cronbach's α was 0.928 for the mothers' reports and 0.944 for the fathers' reports.

Demographic Information

We collected demographic information from the schools and parents to rule out confounding variables. The schools provided the living settlement (urban or rural), children's gender and age. Other demographic information, such as family disposable income and parents' education level, was collected in the parents' questionnaire, because previous studies have found that parental involvement is related to the child's gender (Carter and Wojtkiewicz, 2000), the child's age (Monique and Lefevre, 2002), the family living area and SES (Hickman et al., 1995).

Data Analyses

We first cleaned the data with SPSS 22.0. All missing values (after deleting parents whose deficiency rate was above 1/3) were interpolated with the expectation-maximization (EM) estimation of missing data method (Allison, 2002). Then, we examined whether parental involvement varied with educational level, family disposable income, children's gender and age and examined whether mothers' and fathers' theories of intelligence were related to parents' involvement using Pearson correlation analyses.

After the preliminary analyses, we conducted an initial regression to investigate the pure relationship between one parent's theory of intelligence and the other parent's involvement. We included the father's theory of intelligence and the mother's theory of intelligence as independent variables in the regression and controlled the demographic variables for maternal and paternal involvement as dependent variables separately. To test multicollinear problems of variables, we performed a collinearity diagnosis. All the VIF values were below 10 (1.00–2.25), showing that there is no multicollinearity in the initial regressions (Neter et al., 1990).

Then, to prepare for RSA, multigroup latent variable modeling with Mplus 7.11 was conducted to ensure that the intelligence theory scale was equal for both mothers and fathers (Vandenberg and Lance, 2000).

Next, focusing on the discrepancy of the fathers' and mothers' reports, this study used the RSA method to analyze the data. RSA was conducted in three steps. First, we examined whether there were differences between mother- and father-reported theories of intelligence using standardized scores (Shanock et al., 2010). Then, to test for relationships between parents' theory of intelligence and parental involvement, a polynomial regression was conducted. The general form of the polynomial regression is $Z = b_0 + b_1X + b_2Y + b_3X^2 + b_4XY + b_5Y^2 + e$, where Z is a dependent variable (maternal/paternal involvement), X is the mean-centered independent variable 1 (mother's theory of intelligence), and Y is the mean-centered independent variable 2 (father's theory of intelligence). Thus, the outcome variable is separately regressed on each of two independent variables (X and Y) with unstandardized beta coefficients b_1 and b_2, respectively, the interaction between the two independent variables (XY)

with b_4, and the squared term for each of the two independent variables (X^2 and Y^2) with b_3 and b_5, respectively.

We then evaluated the results with regard to four surface test values (a_1–a_4) (response surface pattern; Edwards and Parry, 1993) and examined the significance, which provided us with information on congruence and discrepancy. Values a_1–a_4 are derived from polynomial coefficients. Accordingly, $a_1 = (b_1 + b_2)$, $a_2 = (b_3 + b_4 + b_5)$, $a_3 = (b_1 - b_2)$, $a_4 = (b_3 - b_4 + b_5)$. We concentrate on whether (a) the congruence (a_1, a_2), (b) the degree of the discrepancy (a_3), and (c) the direction of the discrepancy (a_4) between two independent variables relate to dependent variables (Cohen et al., 2010; see Shanock et al., 2010 for a detailed explanation of the method). In the current study, we examined each of the four RSA coefficients to assess (1) a_1: whether the parental involvement level has a relationship with parents' theories of intelligence when the levels of the father's and mother's theories of intelligence are congruent; a significantly positive a_1 illustrated that a high-level theory of intelligence related to a high level of involvement; (2) a_2: whether the relationship of a_1 is linear or nonlinear; a significant a_2 represents a nonlinear relationship, and an insignificant a_2 indicates a linear relationship; (3) a_3: whether the direction of discrepancy in the theory of intelligence, such as when the level of one parent's theory of intelligence is higher than that of the other, is related to parental involvement; a significantly positive a_3 for the father shows that when the level of the father's theory of intelligence is higher than the mother's, paternal involvement is higher; and (4) a_4: whether the degree of discrepancy in theory of intelligence is related to parental involvement; a significantly positive a_4 indicates that more discrepancy relates to more involvement.

The corresponding graphical depictions of RSA help illustrate the nature of the effects by presenting the relationship in three-dimensional space. Specifically, the two lines in the figure reflect different combinations of the father's and mother's theories of intelligence, i.e., congruence versus discrepancy. The line from the corner where both parents' theories of intelligence are low to the corner where both parents' theories of intelligence are high is the line of congruence, namely, "the line of perfect agreement." Coefficients a_1 and a_2 represent the slope and curvature of the line Y = X, respectively. The line from the corner where the father's theory of intelligence is low and the mother's theory of intelligence is high to the corner where the father's theory of intelligence is high and the mother's theory of intelligence is low is considered "the line of discrepancy." Coefficients a_3 and a_4 represent the slope and the curvature of line Y = −X, respectively. Using the RSA coefficients and corresponding figures, therefore, we examined how the congruence and discrepancy of parents' theories of intelligence relate to maternal and paternal involvement.

RESULTS

Preliminary Analyses

The results of the Pearson correlation (two-tailed) with the means and standard deviations of the measures are shown in **Table 1**.

As shown in **Table 1**, the child's gender was not significantly correlated with any of the study variables. However, educational level, family disposable income, and living settlement were correlated with both theories of intelligence and involvement variables. Both maternal and paternal involvement are correlated with the father's and mother's theories of intelligence.

Multigroup Latent Variable Modeling

The multigroup comparison result indicated that the mother's and father's responses to the same questionnaire regarding the theory of intelligence fit the factor mean invariance model (complete invariance model, $\chi^2 = 592.47$, $df = 52$, CFI = 0.91, TLI = 0.91, RMSEA = 0.08; $\Delta df = 2$, $\Delta\chi^2 = 0.32$, $\Delta p > 0.5$; see Byrne et al., 1989; Vandenberg and Lance, 2000; Cheung and Rensvold, 2002).

Discrepancies in Mothers' and Fathers' Theories of Intelligence

The results of the examination of differences between mother- and father-reported theories of intelligence are shown below.

As seen in **Table 2**, only 38.9% of the 1,694 pairs of parents reached congruence in parents' theories of intelligence; in other words, there were numerous discrepancies between the parents' theories.

Initial Regression

First, we conducted linear regression twice to determine the pure relationship between parental theory of intelligence in pairs and parental involvement for maternal and paternal involvement, separately, as dependent variables. Due to the insignificance of the correlation between the child's age/gender and parental involvement, we only considered family disposable income, parents' educational level, and living settlement in the regression as control variables. We adopted hierarchical regression to control demographic variables by using the "enter" opinion in SPSS 22.0.

Partly consistent with the Pearson correlations, after controlling for the family disposable income, parents' educational level, and living settlement, maternal involvement was positively related to the mother's theory of intelligence ($\beta = 0.06$; $p < 0.05$); paternal involvement was related to both the mother's theory of intelligence ($\beta = 0.10$; $p < 0.01$) and the father's theory of intelligence ($\beta = 0.09$; $p < 0.01$).

Polynomial Regression

We conducted polynomial regression twice to separately analyze maternal and paternal involvement as dependent variables. Control variables were family disposable income, parents' educational level, and living settlement. We adopted the hierarchical regression to control demographic variables by using the "enter" option in SPSS 22.0. From the polynomial regression, we obtained five polynomial coefficients (b_1–b_5).

Then, we calculated four response surface coefficients (a_1–a_4) and significance to explore whether congruence and discrepancy between parents' theories of intelligence were related to maternal and paternal involvement. These coefficients and

TABLE 1 | Intercorrelations, means, and standard deviations.

Variables	1	2	3	4	5	6	7	8	9
1. Child's age	–								
2. Child's gender	−0.01	–							
3. Parents' educational level	−0.51*	−0.03	–						
4. Family disposable income	−0.52*	−0.03	0.60**	–					
5. Living settlement	−0.05*	0.00	−0.69**	−0.55**	–				
6. Mother's theory of intelligence	−0.04	−0.04	0.21**	0.22**	−0.15**	–			
7. Father's theory of intelligence	0.02	−0.04	0.18**	0.20**	−0.18**	0.30**	–		
8. Maternal involvement	−0.02	−0.03	0.23**	0.22**	−0.23**	0.16**	0.08**	–	
9. Paternal involvement	0.03	−0.03	0.14**	0.06*	−0.17**	0.11**	0.14**	0.33**	–
M	9.39	1.49	3.17	5.38	1.62	3.31	3.30	2.53	2.34
SD	0.50	0.50	1.39	2.00	0.48	0.51	0.53	0.45	0.48
Observed range	9-11	1-2	1-6	1-10	1-2	1.25-5	1.5-5	1-4	1-4

*Note. Parents' educational level was represented by the highest level of education obtained by either parent. For example, when a mother had a junior high-school education and a father had a bachelor's degree, we selected bachelor's degree as the couple's educational level. Living settlement was the family's living area (1 = urban; 2 = rural). *$p < 0.05$. **$p < 0.01$ (two-tailed).*

TABLE 2 | Levels of parents over, under, and in agreement with theories of intelligence.

Theory of intelligence	*n* (%)
Mother > Father	527 (31.1)
Mother = Father	659 (38.9)
Mother < Father	508 (30.0)

their significance of polynomial regression and response surface are presented in **Table 3**. Further, the three-dimensional response surface of the relationship is provided in **Figures 1**, **2** as a visual illustration of the results.

RSA Effects With Maternal Involvement

The RSA plot (response surface) in which the dependent variable is maternal involvement is shown in **Figure 1**. In **Figure 1**, the X-axis represents the mother's theory of intelligence, the Y-axis represents the father's theory of intelligence, and the Z-axis represents maternal involvement. The lines Y = X and Y = −X vertically cut off the response surface, producing two curves that are shown in **Figure 3**. As shown in **Table 3**, regarding congruence, the a_1 and a_2 surface test coefficients indicated that maternal involvement has a significant relationship with the congruence of parents' theories of intelligence. A significantly positive a_1 indicates that when the father and mother hold the same level of theory, the stronger their beliefs are in the incremental theory they hold, and the higher maternal involvement will be ($a_1 = 0.07$, $p < 0.01$). An insignificant a_2 means that the relationship of congruent parental theories of intelligence and maternal involvement is linear ($a_2 = 0.04$, $p > 0.05$). We can also see the trend from the near point to the remote point in **Figure 1** and the dashed line in the left graph of **Figure 3**.

Next, we focused on whether the direction of discrepancy makes a difference (e.g., whether mother-reported theory of intelligence levels that are higher or lower than father-reported levels make a significant contribution to maternal involvement). A significantly positive a_3 reflects that maternal involvement is higher when the discrepancy is such that the level of the mother's theory of intelligence is higher than that of the father, as shown in the right corner of **Figure 1**, and higher than the left corner, where the level of the father's theory of intelligence is high combined with a low level of the mother's theory of intelligence ($a_3 = 0.07$, $p < 0.01$). That is, when a mother holds a stronger incremental theory of intelligence than the father, maternal involvement is higher than when the mother holds a stronger entity theory of intelligence than the father. We can also see a trend from the left point to the right point in **Figure 1**. In the right graph of **Figure 3**, the trend of the transversal above line Y = −X is illustrated as a dashed line.

Finally, to investigate whether the degree of discrepancy between mother- and father-reported theory of intelligence matters, we calculated the a_4 surface value. We found no relationship between the degree of discrepancy in parents' views on intelligence and maternal involvement: $a_4 = -0.07$, $p > 0.05$.

RSA Effects With Paternal Involvement

The RSA plot (response surface) in which the dependent variable is paternal involvement is shown in **Figure 2**. In **Figure 2**, the X-axis represents the father's theory of intelligence, the Y-axis represents the mother's theory of intelligence, and the Z-axis represents paternal involvement. The lines Y = X and Y = −X vertically cut off the response surface, producing two curves that are shown in **Figure 4**. The results indicate that the congruence of parents' theories of intelligence has a substantial effect on paternal involvement. A significantly positive a_1 illustrates that when fathers and mothers hold the same level of theory, the incremental theory that they hold is stronger, and paternal involvement will be greater, similar to maternal involvement ($a_1 = 0.13$, $p < 0.01$). Coefficient a_2 is also insignificant, similar to the mother's relationship; therefore, the relationship between congruent parental theories of intelligence and paternal involvement is linear ($a_2 = 0.03$, $p > 0.05$). We can also see the

TABLE 3 | Initial regressions, polynomial regression and response surface results for parental theories of intelligence (IT) as independent variables of maternal and paternal involvement.

		Initial regression		Polynomial regression	
Dependent variables		**Maternal involvement**	**Paternal involvement**	**Maternal involvement**	**Paternal involvement**
		β (SE)			
Constant		2.47 (0.09)***	2.60 (0.09)***	2.48 (0.09)***	2.59 (0.09)***
Family disposable income		0.02 (0.01)**	−0.02 (0.01)**	0.02 (0.01)**	−0.02 (0.01)**
Parents' educational level		0.03 (0.01)*	0.02 (0.01)	0.03 (0.01)***	0.02 (0.01)*
Living settlement		−0.10 (0.03)***	−0.16 (0.03)***	−0.10 (0.03)***	−0.15 (0.03)***
Mother's IT (b_1)		0.09 (0.02)***	0.06 (0.02)**	0.07 (0.02)*	0.10 (0.03)*
Father's IT (b_2)		−0.004 (0.02)	0.09 (0.02)***	−0.01 (0.03)	0.03 (0.03)
Mother's IT squared (b_3)		-	-	0.01 (0.03)	0.01 (0.03)
Product of parents' IT (b_4)		-	-	0.06 (0.04)	−0.08 (0.04)*
Father's IT squared (b_5)		-	-	−0.03 (0.03)	0.12 (0.03)***
Model coefficients	R	0.28	0.22	0.29	0.24
	R^2	0.08	0.05	0.08	0.06
	Adjusted R^2	0.08	0.05	0.08	0.06
Surface test coefficients	a_1	-	-	0.07*	0.13**
	a_2			0.03	0.04
	a_3			0.07*	0.07
	a_4			−0.07	0.20***

Note. b_1–b_5 *depict coefficients of the polynomial regression equation.* a_1–a_4 *depict coefficients of the response surface test.* β *= Unstandardized coefficients for variables. SE = Standard error.* R^2 *is the cumulative variance accounted for. *p < 0.05. **p < 0.01. ***p < 0.001 (two-tailed).*

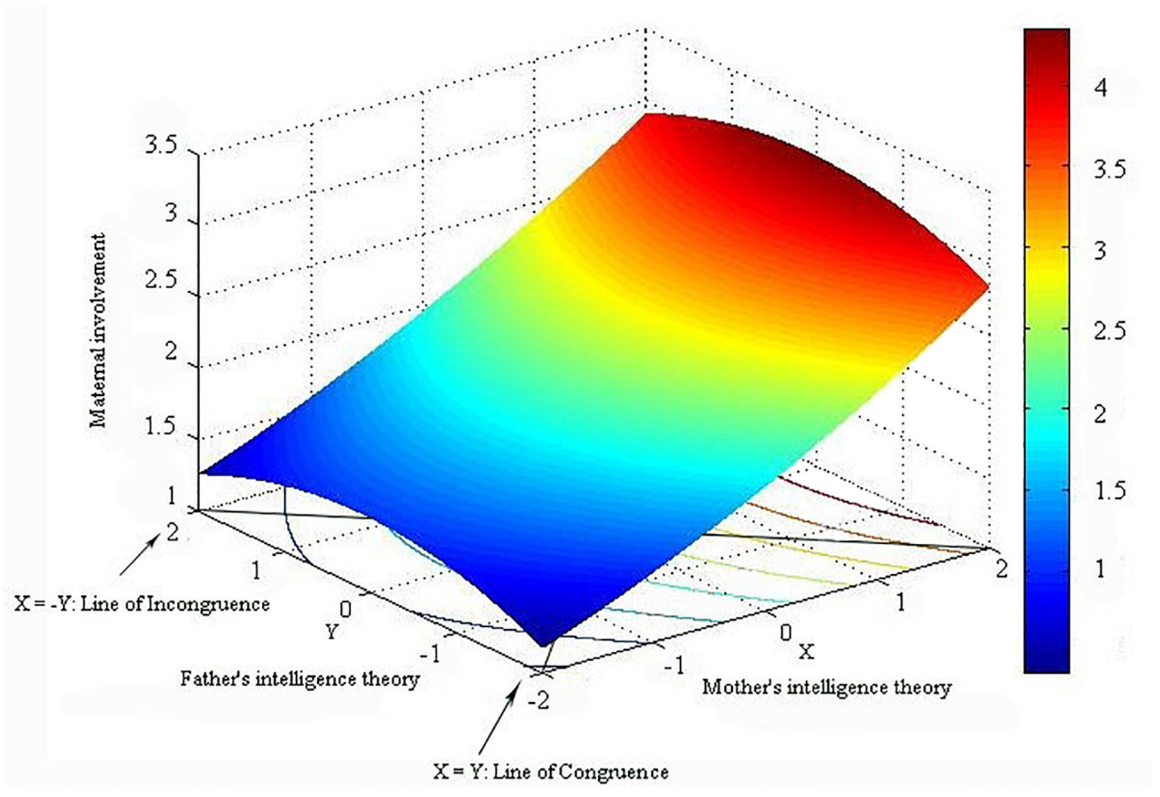

FIGURE 1 | Three-dimensional results of the response surface of maternal involvement. *Note*. X-axis: level of mother's theory of intelligence. Y-axis: level of father's theory of intelligence. Z-axis: maternal involvement level.

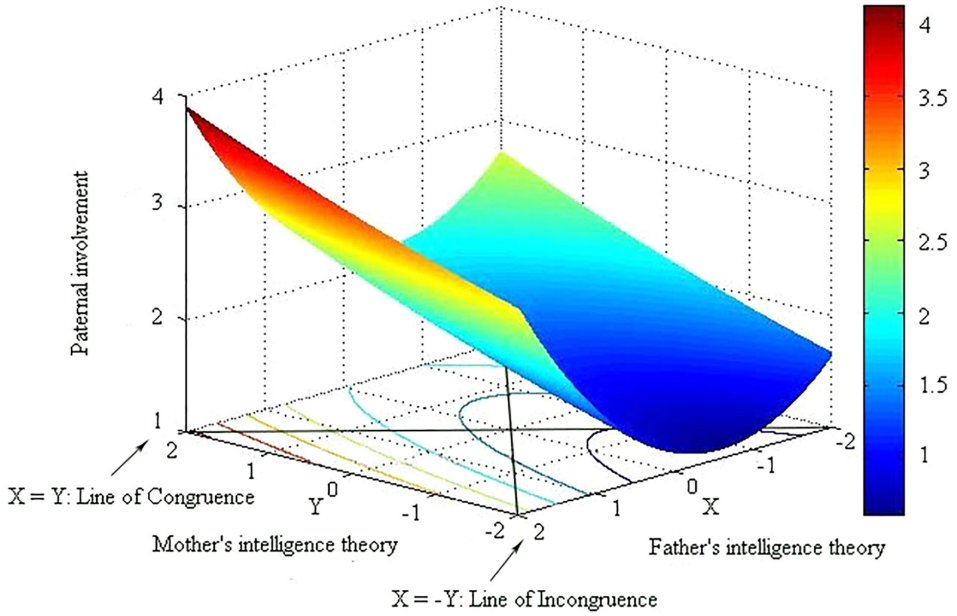

FIGURE 2 | Three-dimensional results of response surface of paternal involvement. *Note*. X-axis: level of mother's theory of intelligence. Y-axis: level of father's theory of intelligence. Z-axis: paternal involvement level.

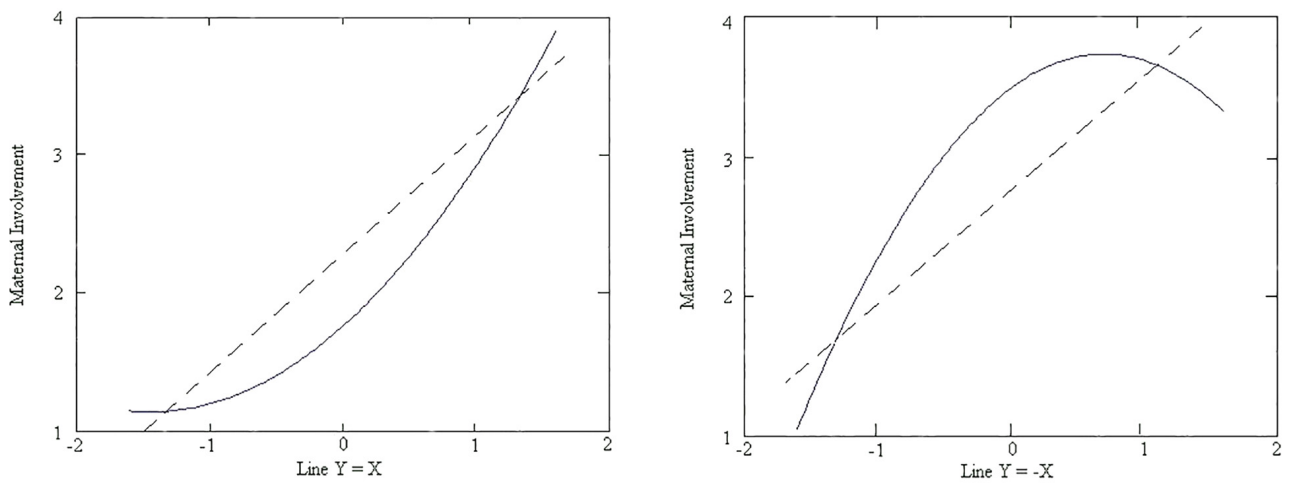

FIGURE 3 | Transversal of the surface of maternal involvement above the line Y = X (left), transversal and the trend of the surface of maternal involvement above the line Y = –X (right).

trend from the right point to the left point in **Figure 2** and the dashed line in the left graph of **Figure 4**.

Next, we focused on whether the direction of discrepancy created any difference in results. In contrast to maternal involvement, the direction of theory of intelligence has no relationship with paternal involvement. Coefficient a_3 (the slope of line Y = −X) is not significant ($a_3 = 0.06$, $p > 0.05$).

Finally, we examined whether the degree of discrepancy between mother- and father-reported theory of intelligence related to paternal involvement. A significantly positive a_4 ($a_4 = 0.21$, $p < 0.01$) indicates a U-shaped curve of paternal involvement on the line of Y = −X; in other words, paternal involvement would be significantly low when the mother's theory of intelligence and the father's theory of intelligence are congruent (the middle point of the line Y = −X, which is also the only point at which X = Y on the line Y = −X) and would increase significantly as the degree of discrepancy between the mother's and father's theory of intelligence increases (from the middle point to the two ends). As shown in **Figure 4** (right), from left to right on the curve, paternal involvement

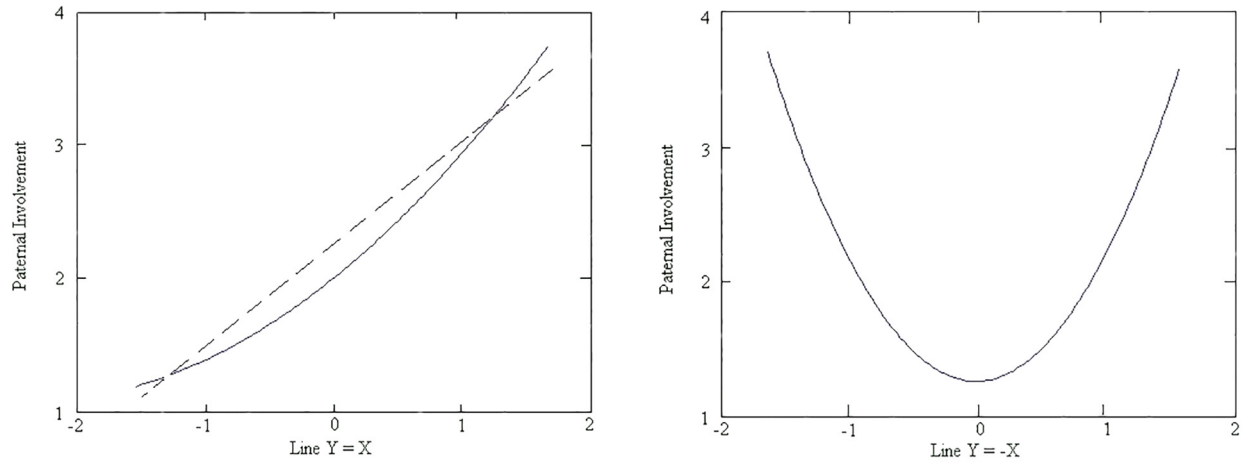

FIGURE 4 | Transversal of the surface of paternal involvement above the line Y = X (left), transversal and the trend of the surface of paternal involvement above the line Y = –X (right).

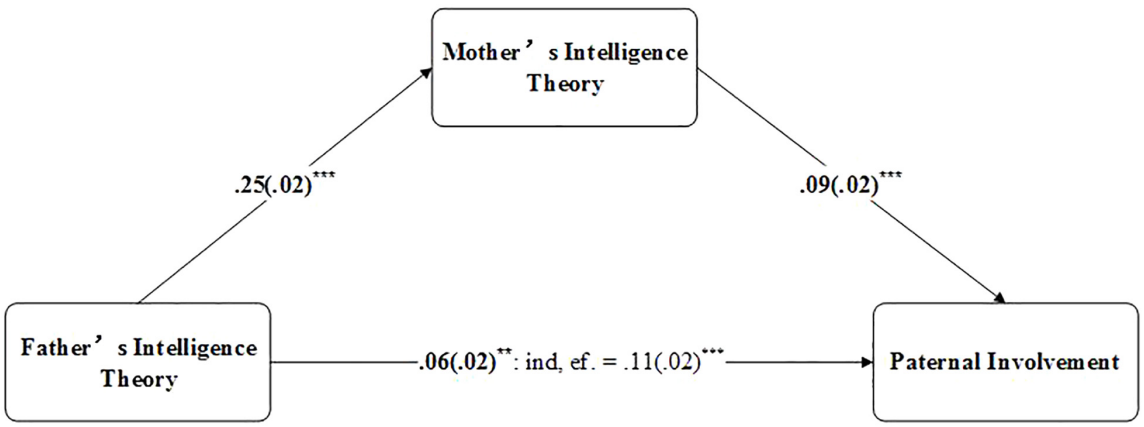

FIGURE 5 | Summary of one distinct mediation model. *Note*. The independent variable was the father's theory of intelligence, the dependent variable was paternal involvement, and the mediator was the mother's theory of intelligence. The paths from the predictor to the dependent variable report the beta coefficient for the direct effects in bold characters and the indirect effects of the predictor (ind. ef.) with standard errors in brackets. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$ (two-tailed).

first decreases, then increases, and then reaches the lowest point when it is in the middle of the line (where parental theories of intelligence are mostly in agreement), which means that paternal involvement is relatively high when father- and mother-reported theories of intelligence are incongruent. We can also see the trend from the near point to the remote point in **Figure 2** and the right graph of **Figure 4**, which shows that paternal involvement is lowest when parental theories of intelligence reach agreement.

The results generally demonstrated that (1) when parental theories of intelligence were at the same level, both paternal and maternal involvement increased with the increase of parents' incremental theory; (2) the direction of discrepancy of parental theories of intelligence was related to maternal involvement; and (3) and the degree of discrepancy of parental theories of intelligence was related to paternal involvement.

DISCUSSION

The current study aims to determine whether parental theories of intelligence relate to parental involvement as a couple, then focuses on the effect of the congruence and discrepancy between parental theories of intelligence on parental involvement separately.

The results first showed that the mother's theory of intelligence was positively related to both paternal involvement and maternal involvement, while the father's theory of intelligence was related only to paternal involvement. The congruence and discrepancy studies showed that, on the one hand, when parental theories of intelligence were at the same level, both paternal and maternal involvement increased with the increase in the level of parents' incremental theory. On the other hand, when there was discrepancy between parental theories of intelligence, the direction of

discrepancy was related to maternal involvement, and the degree of discrepancy was related to paternal involvement. Specifically, maternal involvement is higher when the discrepancy is such that the mother holds a stronger incremental theory than the father and is lower when the mother holds a stronger entity theory than the father; paternal involvement increased when the discrepancy between parental theories of intelligence was greater and decreased when the discrepancy was smaller.

Parental Theories of Intelligence Together Are Related to Parental Involvement Separately

The current study found that maternal involvement was positively related to the mother's theory of intelligence and that paternal involvement was positively related to the father's theory of intelligence. Because a higher theory of intelligence score represents a more strongly held incremental theory, the results illustrated that a parent who holds a stronger incremental theory would desire to be more involved in their children's education. This result is consistent with those of previous studies (Ames and Archer, 1987; Stipek et al., 1992; Aunola et al., 1999; Pomerantz and Dong, 2006; Moorman and Pomerantz, 2010). As discussed above, the underlying mechanism should be that parents who emphasize the role of effort motivate their children to accept their shortcomings and encourage them to think about the principle underlying tasks; thus, they are more involved in their children's education. In contrast, when parents regard their children's difficulties with learning as reflecting children's low innate abilities, low levels of involvement occur.

In regard to the relationships between one parent's involvement and the other's theory of intelligence, the results are partly inconsistent with our hypothesis – paternal involvement was positively related to the mother's theory of intelligence, whereas maternal involvement was not related to the father's theory of intelligence. One explanation for this finding is the different roles that fathers and mothers play in family education. Based on the identity theory (Degarmo, 2010; Adamsons and Pasley, 2013), when an individual becomes a father or a mother, there are multiple social roles (such as breadwinner, daily caregiver, protector, etc.) that correspond to each parent. Individuals evaluate these roles according to social standards and social expectations and then form self-meaning identity criteria and behave consistently with these standards (Stryker and Serpe, 1994). In China, Confucianism provides a complete ethical system that draws distinctions for the gender equality standards: males are mainly responsible for the activities outside of the family (raising a family, earning the family income, etc.), while females deal with the affairs inside the family (raising the children, doing the housework, etc.) (Wu et al., 2013). When fathers and mothers both engage in the education of their children, this coparenting style reveals that mothers aim to control the educational activities via a practice known as maternal gatekeeping. Maternal gatekeeping is mothers' preferences and attempts to restrict or encourage fathers' involvement in their children's care (Allen and Hawkins, 1999; Schoppe-Sullivan et al., 2008; Maddenderdich and Leonard, 2010; Zvara et al., 2013). The negative hindrance effect of mothers on fathers' parenting is called the "gate-closing" effect, whereas the positive promotion effect of mothers on fathers' parenting is called the "gate-opening effect" (Mcbride and Rane, 1998; Fox and Bruce, 2001; Maurer et al., 2001; Trinder, 2008). Similarly, another study has indicated that parents have had an influence each other's parenting interactively (Xing et al., 2017), providing evidence for the existence of the gatekeeping effect in families.

In the current study, the gatekeeping theory might reasonably explain the observed results. Because mothers "control" the fathers' engagement in education, paternal involvement is significantly positively related to the mother's theory of intelligence, but maternal involvement is not related to the father's theory of intelligence, which reflects the important position of the mother's belief in family education. Moreover, such a "maternal gatekeeping" theory illustrates that maternal behaviors and attitudes might mediate paternal beliefs and involvement (Deluccie, 1995; Adamsons and Pasley, 2013). To further improve the understanding of "maternal gatekeeping" in the current study, we conducted mediation analysis. According to the theory of maternal gatekeeping, mothers may control fathers' behavior based on the father's beliefs (Gaunt, 2008). Therefore, we hypothesize the independent variable as the father's theory of intelligence and the dependent variable as paternal involvement. The two potential mediators were the mother's theory of intelligence and maternal involvement. Six regression analyses were then performed to test the potential mediators, and variables considered as covariates were controlled for in regression equations (Wen et al., 2005).

The results showed that only the mother's theory of intelligence is a partial mediator, as shown in **Figure 5**. The mother's theory of intelligence partially mediated the relationship between the father's theory of intelligence and paternal involvement, which supports the existence of maternal gatekeeping to some degree. Nonetheless, future study is needed to measure the impact of "maternal gatekeeping" using scales.

Maternal-Paternal Congruence Is Related to Maternal and Paternal Involvement

In terms of the effect of congruence, as we speculated, we found that when the father and mother hold a theory at the same level, the incremental theory that they hold is stronger, the maternal and paternal involvement will be greater. These results are in accord with our hypotheses. As we speculated, because of the systematic nature of family, when family members' beliefs are in agreement, the impact of the beliefs could increase parental interaction. Thus, under such circumstances, maternal and paternal involvement relate to the level of both maternal and paternal theories of intelligence.

On the one hand, the congruence of parents' incremental theories of intelligence represents a positive educational

environment in the family. As we theorized, when parents hold incremental theories, they concentrate more on the growth of their child's ability, i.e., their child's improvement with effort. Furthermore, when parents hold a theory at the same level (reach a state of congruence), the effect of their theories might improve due to the augmented interaction in the family. However, on the other hand, we must consider the negative aspect of congruence. Our results suggest that congruence may be harmful to involvement when both parents agree that ability is unchangeable. This congruence of high entity theory produces an inactive educational environment in the family; both the mother and father allow the child to pursue performance rather than learning, which could be even worse than the existence of discrepancies. If parents hold divergent beliefs, there is a chance that they may discuss this issue and find a way to resolve the problem, while complete agreement on an entity theory might lead to no discussion. A similar assumption was made in another study. Human et al. (2016) thought that high levels of congruence in the family could be problematic to children's development, which serves as a warning.

Maternal-Paternal Discrepancy Is Related to Maternal and Paternal Involvement

Regarding discrepancy, in the current study, we found only partial support for our hypotheses. The direction of discrepancy is important for maternal involvement. When the mother's theory of intelligence is more incremental than the father's theory, maternal involvement is higher than when the father's theory of intelligence is more incremental than the mother's. This discrepancy can also be explained by the different roles of mothers and fathers at home (Stryker and Serpe, 1994; Degarmo, 2010; Adamsons and Pasley, 2013; Wu et al., 2013), as discussed above. As the person responsible for education (Cowan and Cowan, 1988), the mother pays attention to the father's theory of intelligence. When a mother who holds an incremental theory finds that the child's father might hold an entity theory, to try to influence the father's theory, she might engage more in education, thus demonstrating her theory to the child's father. Consequently, the direction of the discrepancy was related only to maternal involvement.

With regard to the degree of discrepancy, paternal involvement increases as the degree of discrepancy increases, which might also be partly explained by the gatekeeping theory. When the level of the mother's theory of intelligence is higher than the father's (mother's theory of intelligence is also higher than the zero point), the larger the discrepancy grows, and the more the mother will encourage father to engage in educational activities because the mother is "the expert of domestic work" in the family, thereby leading to increased paternal involvement (Allen and Hawkins, 1999). By contrast, when the mother's theory of intelligence is lower than the father's (the mother's theory of intelligence is also lower than the zero point), maternal involvement will be less than the baseline value. In such circumstances, due to the lack of efficacy in involvement, mothers may therefore withdraw from educational activities, and consequently, they would no longer control the fathers' parenting (Gaunt, 2008). Therefore, as the level of the father's incremental theory increases, paternal involvement also increases, showing the positive relationship between the degree of discrepancy and paternal involvement.

Limitations and Future Study

The limitations of our study provide directions for future studies. First, the current study is a cross-sectional study. Through the use of polynomial regression with RSA, we can determine only the correlation between parental theories of intelligence and parental involvement. Parental theories of intelligence relate to parental involvement (Hoover-Dempsey and Sandler, 1995, 1997; Moorman and Pomerantz, 2010; Muenks et al., 2015), and there might be an interaction between parental involvement and parents' theories of intelligence. For example, a father who engages more in his children's education may realize that his children's ability could change through learning or training, which could change his theory of intelligence, thereby contributing to an increase in engagement. Therefore, a longitudinal or intervention study is necessary for the future.

Second, the dependent variable in the current study is the frequency of parental involvement, but the quality of parental involvement is also important. For example, some empirical evidence shows that parental theories of intelligence were related to the quality of parental involvement (Stipek et al., 1992; Moorman and Pomerantz, 2010). Thus, we should pay more attention to the quality of parental involvement. In future studies, we will research whether the congruence and discrepancy of fathers' and mothers' quality of parental involvement relate to parents' theories of intelligence.

Third, the generalizability of this study to other populations is less clear. However, the objective of this study was to determine the relationship between parents' theory of intelligence and parental involvement in Chinese culture. Future studies could investigate the relationship between parental theory of intelligence and parental involvement in other cultural contexts.

CONCLUSION

In general, this study found the following: (1) the mother's theory of intelligence related to both paternal and maternal involvement, while the father's theory of intelligence related to paternal involvement only; (2) the congruence of parental theories of intelligence related to both paternal and maternal involvement; (3) the direction of discrepancy of parents' theories of intelligence related to maternal involvement; and (4) the degree of discrepancy between parents' theories of intelligence related to paternal involvement. To summarize, the current research described a detailed picture of the relationship between parents' theories of intelligence and parental involvement; revealed the significance of the mother's role in education;

shed light on the importance of psychological factors in family members' interaction; emphasized the importance of the congruence and discrepancy (direction and degree) between family members' beliefs in educational processes; and contributed to the literature in developmental area by utilizing a rigorous statistical approach – RSA.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of "the Institutional Review Board of the Collaborative Innovation Center of Assessment toward Basic Education Quality, Beijing Normal University" with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Institutional Review Board of the Collaborative Innovation Center of Assessment toward Basic Education Quality, Beijing Normal University. Written informed consent to participate in the study was obtained from the parents of all the child participants before evaluation.

AUTHOR CONTRIBUTIONS

KJ: conception and design of the study and analysis and interpretation of the data. JL and CL: analysis of the data. XG and HZ: manuscript revision. BL, ZL, and LL: substantial contributions to the design of the study and final approval of the manuscript version to be published. Data collection was performed by all of the authors.

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BRIEF RESEARCH REPORT
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Effect of Parental Involvement on Children's Academic Achievement in Chile

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Parental involvement in school has been demonstrated to be a key factor for children's academic outcomes. However, there is a lack of research in Chile, as well as in Latin American countries in general, leaving a gap in the literature about the generalization of findings outside developed and industrialized countries, where most of the research has been done. The present study aims to analyse the associations between parental involvement in school and children's academic achievement. Cluster analysis results from a sample of 498 parents or guardians whose children attended second and third grades in 16 public elementary schools in Chile suggested the existence of three different profiles of parental involvement (high, medium, and low) considering different forms of parental involvement (at home, at school and through the invitations made by the children, the teachers, and the school). Results show that there are differences in children's academic achievement between the parental involvement profiles, indicating children whose parents have a low involvement have lower academic achievement. Findings are in line with international research evidence, suggesting the need to focus on this variable too in Latin American contexts.

Keywords: parental involvement profiles, children's academic achievement, elementary education, family and school relations, child development

INTRODUCTION

On an international scale, parental involvement in school has long been heralded as an important and positive variable on children's academic and socioemotional development. From an ecological framework, reciprocal positive interactions between these two key socializing spheres – families and schools – contribute positively to a child's socioemotional and cognitive development (Bronfenbrenner, 1987). Empirical findings have demonstrated a positive association

between parental involvement in education and academic achievement (Pérez Sánchez et al., 2013; Tárraga et al., 2017), improving children's self-esteem and their academic performance (Garbacz et al., 2017) as well as school retention and attendance (Ross, 2016). Family involvement has also been found to be associated with positive school attachment on the part of children (Alcalay et al., 2005) as well as positive school climates (Cowan et al., 2012). Research has also evidenced that programs focused on increasing parental involvement in education have positive impacts on children, families, and school communities (Jeynes, 2012; Catalano and Catalano, 2014).

Parent-school partnership allows for the conceptualization of roles and relationships and the impact on the development of children in a broader way (Christenson and Reschly, 2010). From this approach, families and schools are the main actors in the construction of their roles and forms of involvement, generating new and varied actions to relate to each other according to the specific educational context. The main findings in the family-school field show a positive influence of this partnership, contributing to academic achievement and performance, among other positive consequences (Epstein and Sander, 2000; Hotz and Pantano, 2015; Sebastian et al., 2017).

There is also strong support from international research showing the positive influence of parental involvement over academic achievement, as has been demonstrated in a variety of meta-analyses across different populations and educational levels (Castro et al., 2015; Jeynes, 2016; Ma et al., 2016). Moreover, although there is a wide range of parental involvement definitions, some more general and others more specifics, there is a consensus among research results about the positive influence of parental involvement over child academic achievement. For example, in the meta-synthesis of Wilder (2014), where nine meta-analyses are analyzed, this influence was consistent throughout the studies, regardless the different definitions and measures used.

However, most of the studies on parental involvement in education hail from anglophone countries and are based on cross-sectional and correlational designs (Garbacz et al., 2017) while in Latin America research remains scarce. In a recent systematic review of the literature on parental involvement in education in Latin America, only one Mexican study from 1998 was found which was also heavily influenced by interventions from the United States (Roth Eichin and Volante Beach, 2018). Chile has acknowledged the importance of collaborative relationships between families and schools developing a National Policy for Fathers, Mothers and Legal Guardians Participation in the Educational System (Política de Participación de Padres, Madres y Apoderados/as en el Sistema Educativo) in 2002 which was recently updated in 2017 (Ministerio de Educación, Gobierno de Chile, 2017). Since the publication of this policy various local initiatives have sprouted in the country seeking to strengthen school family relations (Saracostti-Schwartzman, 2013). Nevertheless, the majority of research in the country has thus far been of a qualitative nature with a focus on describing relations between family members and their schools, and identifying tensions between these two spheres (Gubbins, 2011).

Thus, this study seeks to advance the analysis of the effects of parental involvement in school on the academic achievement of Chilean students. The study aims to analyse how different parental involvement profiles (based on the main forms of parental involvement identified in literature) influence children's academic achieved. Parental involvement can take a wide variety of forms, among them, communication between family and school, supporting learning activities at home and involvement in school activities have been highlighted (Schueler et al., 2017), these are included in this study using the scales proposed by Hoover-Dempsey and Sandler (2005).

MATERIALS AND METHODS

Participants and Procedure

The study included 498 parents or guardians whose children attended second and third grade in 16 public schools with high levels of socioeconomical vulnerability (over 85% according to official records of the schools) within three different regions in Chile (Libertador Bernando O'Higgins, Maule and Araucanía). Parents and guardians were aged between 20 and 89 years old (M = 35.02, SD = 7.02 for parents, M = 59.27, SD = 11.74 for grandparents and M = 43.14, SD = 15.41 for other guardians) and students between 7 and 12 (M = 8.30, SD = 0.93). The majority of them were mothers (83.9%). The majority of fathers and mothers had completed high school (33.1 and 40.6%, respectively), followed by elementary education (28.1 and 23.3%, respectively), no education completed (17.3% for both), professional title (7.2 and 6.8%, respectively) and university title (4.4 and 4.6%, respectively).

This study is part of a wider project focusing on the effectiveness of interventions aimed at strengthening the link between families and schools. This study has the approval of the Ethics Committee of the Universidad de La Frontera and the Chilean National Commission for Scientific and Technological Research (Acta 066-2017, Folio 036-17). Prior to data collection, after obtaining permission from the schools, informed consent forms were signed by the students' legal guardians to authorize their participation. The data referring to the students (evaluation of learning outcomes) was compiled through official school records. The data referring to the families (parental involvement) was collected in paper format during parent teacher meetings at the end of the school year considering their behavior during the preceding year. Two research assistants trained for this purpose were present for the applications.

Instruments

Parental involvement was assessed using the five scales proposed by Hoover-Dempsey and Sandler (2005) that aim to measure the level of family involvement in children's education in elementary school from the point of view of the fathers, mothers and/or guardians. Scales have been adapted and validated by a panel of experts in Chile (Reininger, 2014).

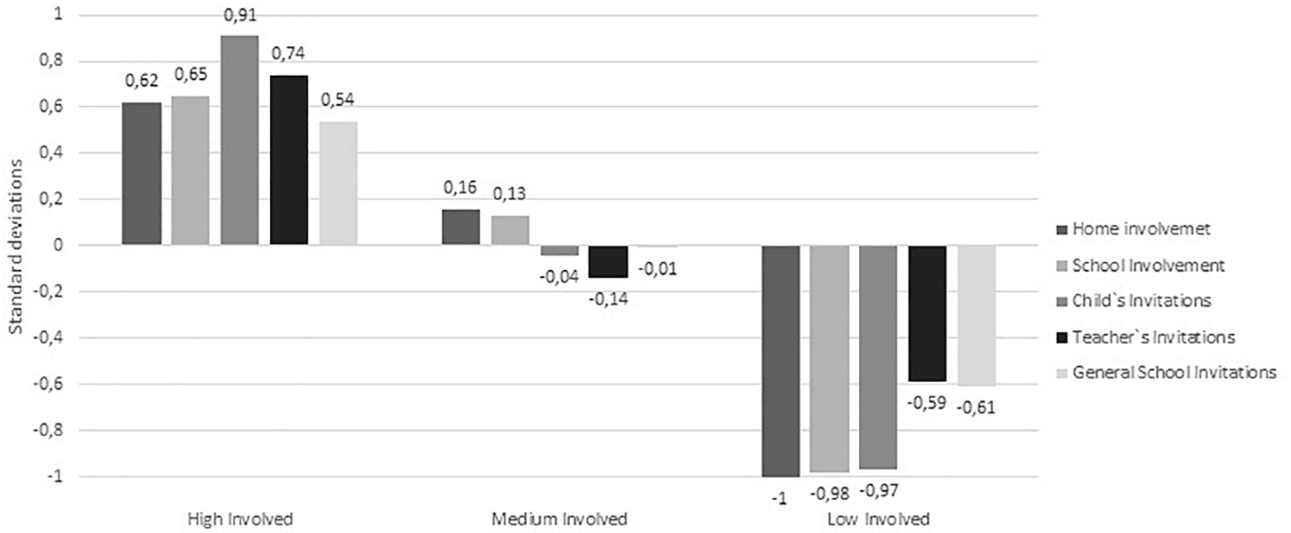

FIGURE 1 | Parental involvement profiles.

Scales included in this study are: (1) Parental involvement activities at home [five items, such as "*someone in this family (father, mother and/or guardian) helps the child study for test*" or "*someone in this family (father, mother and/or guardian) practices spelling, math or other skills with the child*"]; (2) Parental involvement activities at school (five items, such as "*someone in this family attends parent–teacher association meetings*" or "*someone in this family attends special events at school*"), (3) Child invitations for involvement (five items, such us "*my child asks me to talk with his or her teacher*" or "*my child asks me to supervise his or her homework*"); (4) Teacher invitations for involvement (six items, such as

TABLE 1 | Demographic information of the clusters.

	Cluster 1: High involved parents	Cluster 2: Medium involved parents	Cluster 3: Low involved parents
Parent's age			
M (SD)	36.84 (9.72)	35.63 (8.42)	37.63 (10.28)
Mother's education %			
No education completed	19.0	18.1	19.0
Elementary education completed	25.2	21.9	31.0
High school completed	43.0	44.8	43.1
Professional title	10.4	7.1	4.3
University title	2.2	8.1	2.6
Father's education %			
No education completed	22.6	16.7	19.8
Elementary education completed	27.8	30.5	36.8
High school completed	36.1	38.6	34.0
Professional title	11.3	7.6	4.7
University title	2.3	6.7	4.7
Child's age			
M (SD)	8.38 (0.98)	8.20 (0.86)	8.39 (0.97)
Child's %			
Female	40.3	42.1	39.7
Male	59.7	57.9	60.3
Child's grade %			
2°	43.8	50.9	49.2
3°	56.3	49.1	50.8

"*my child's teacher asks me to help out at school*" or "*my child's teacher asks me to talk with my child about the school day*"); and (5) General school invitations for involvement (six items, such as "*this school staff contact me promptly about any problem involving my child*" or "*parents' activities are scheduled at this school so that we can attend*"). The first four scales have a four-point Likert response scale, that indicate the frequency of the items, from 0 (*never*) to 3 (*always*). The last scale has a 5-point Likert scale response, indicating the grade of agreement with the items, from 1 (*strongly disagree*) to 5 (*strongly agree*). Scales can be consulted as **Supplementary Tables 1–5**. Internal consistency of all scales was adequate (α = 0.79, α = 0.72, α = 0.72, α = 0.85, and α = 0.87, respectively).

Students' academic achievement was evaluated thought the final average grade obtained at the end of the school year, recorded in a scale from 1 (*minimum achievement*) to 7 (*maximum achievement*).

RESULTS

Hierarchical cluster analysis was used to identify parental involvement profiles based on the five subscales of parental involvement scale (typified to avoid the influence of the different scale responses), applying the standardized Euclidian Distance method and using Ward's algorithm. Cluster analyses results showed that the optimal solution was the grouping of the participants into three groups. In **Figure 1** the typified scores of each of the variables considered to calculate the groups are shown.

To label the groups, we examined the family involvement profiles by computing a one-way ANOVA on the standardized scores of the five parental involvement scales with the clusters serving as the factors. The result revealed that the clustering variables significantly differed between the involvement scales [Parental involvement at home: $F(2,497) = 147.83$, $p < 0.001$, $\eta 2 = 0.37$; Parental involvement at school: $F(2,497) = 148.82$, $p < 0.001$, $\eta 2 = 0.38$; Child invitation for involvement: $F(2,497) = 225.34$, $p < 0.001$, $\eta 2 = 0.48$; Teacher invitation for involvement: $F(2,497) = 84.77$, $p < 0.001$, $\eta 2 = 0.26$; General school Invitation for involvement: $F(2,497) = 53.38$, $p < 0.001$, $\eta 2 = 0.18$]. Scheffe *post hoc* multiple comparisons showed the differences were statistically significant between all the parental involvement profiles in all variables, with the first cluster scoring higher than the second and the third in all the scales, and the second higher that the third. Based on these differences and the scores, the first cluster was labeled as *High involved parents*, representing 144 parents (28.9%) that scored above the mean in all the involvement scales (from 0.54 to 0.91 standards deviations). The second cluster was named *Medium involved parent*s, including 228 parents (45.8%) that have scores close to the media in all the involvement scales (from −0.14 to 0.16 standards deviations). Finally, the third cluster was classified as *Low involved parents*, including 126 parents (25.3%) that scored below the mean in all the involvement scales (from −0.61 to −0.91 standards deviations). **Table 1** shows demographic information for the clusters.

Finally, ANOVA results showed that there were significant differences in academic achievement scores between the three clusters of parent involvement profiles, $F(2,430) = 5.37$, $p = 0.003$, $\eta 2 = 0.03$. Scheffe *post hoc* multiple comparisons showed that high ($M = 5.97$, SD = 0.49) and medium ($M = 6.00$, SD = 0.50) involved parents had children with higher academic achievement than low involved parents ($M = 5.8$, SD = 0.47). Complementarily, results from correlations between parental involvement and academic achievement scores support these results, showing a significant and positive correlation ($r = 0.14$, $p = 0.003$).

DISCUSSION

From the results presented, we can conclude the existence of three different profiles of parental involvement (high, medium and low) considering different scales of parental involvement (at home, at school and through the invitations made by the children, the teachers and the school). Secondly, results showed that there were differences in academic achievement scores between the parent involvement profiles, where high and medium involved parents had children with higher academic achievement than low involved parents.

As shown, international literature reveals that the degree of parental involvement is a critical element in the academic achievements of children, especially during their first school years highlighting the need to generate scientific evidence from the Chilean context. Most of the studies in this area come from anglophone countries (Garbacz et al., 2017) while in the Latin American context research is still scarce. Results from our study corroborate that parental involvement can contribute alike in other cultural contexts, pointing to the need to also implement policies to promote it.

In this context, Chile has acknowledged the importance of collaborative relationships between parents and schools leading to the development a National Policy for Father, Mother and Legal Guardian Participation. Nevertheless, most of the research in the country has thus far been of a qualitative nature with a focus on describing family-school relations and identifying tensions between these two spheres (Gubbins, 2011). Thus, this study seeks to make progress in the analysis of the effect of parental involvement and children's and academic achievements of Chilean students.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the Chilean National Commission for Scientific and Technological Research with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Ethics Committee

of the Universidad de La Frontera and the Chilean National Commission for Scientific and Technological Research.

AUTHOR CONTRIBUTIONS

MS developed the study concept and the study design. LL substantially contributed to the study concept, and performed the data analysis and interpretation. MS and LL drafted the manuscript. All the authors approved the final version of the manuscript. They also agreed to be accountable for all aspects of the work.

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SUPPLEMENTARY MATERIAL

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Empathy and Depression Among Early Adolescents: The Moderating Role of Parental Support

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Early adolescence is a period of development of emotional competence, but also of increasing vulnerability for the onset of depressive symptoms. While literature underscored that empathy promotes social relationships and psychological well-being over the life course, the possible role of high empathy levels as a risk factor for depression has been under investigated, especially among early adolescents. Moreover, although parenting practices are known to influence both empathy and depression in adolescence, few studies investigated if parenting moderates the relationship between empathy and depression. Therefore, the aims of the study were: (1) to investigate the relationships between affective and cognitive empathy and depression; (2) to investigate the moderating role of perceived paternal and maternal support on the associations between affective and cognitive empathy and depression; (3) to examine if the relationships among affective and cognitive empathy, maternal and paternal support and depression vary as a function of early adolescents' gender. The study involved 386 Italian students aged between 12 and 14 (*M* age = 13, *SD* = 0.3, 47.9% girls) who completed an anonymous self-report questionnaire, including measures of cognitive and affective empathy, paternal and maternal support and depression. Results showed that with a mean level of affective and cognitive empathy, higher maternal support was related to lower depression for girls, whereas higher paternal support was related to lower depression for both boys and girls. Both maternal and paternal support moderated the relation between empathy and depression. In particular, maternal support moderated the non-linear relation between affective empathy and depression and the relation was further moderated by early adolescents' gender: boys with low affective empathy reported lower depression in a context of high maternal support. Paternal support moderated the linear relation between cognitive empathy and depression, independently of early adolescents' gender: boys and girls with high cognitive empathy reported higher depression in a context of low paternal support. The results of the study suggested that high empathy might be a risk factor for depression during early adolescence and mothers and fathers have a differential moderating role in relation to the affective and cognitive dimensions of empathy, also in relation to early adolescents' gender.

Keywords: depression, empathy, maternal support, paternal support, early adolescence

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INTRODUCTION

Early adolescence is a period of great developmental challenges: the pubertal transition is associated with many physical and psychological changes, that can be linked with the increase of emotional and social competence, but also with the increasing vulnerability for depressive symptoms, especially for girls (Hamilton et al., 2014). Literature has repeatedly stressed that rates of depressive symptoms start to increase from early adolescence onwards (Rudolph, 2002; Olino et al., 2014; McLaughlin and King, 2015). Also gender differences in depression begin to emerge during early adolescence (around 12–13 years of age) and become more pronounced across adolescence, with girls twice as likely to be depressed as boys (Hankin et al., 2007; Avenevoli et al., 2008). While most studies investigated risk and protective factors of depression in middle and late adolescence (see Cairns et al., 2014 for a review), there is a lack of knowledge on correlates of depressive symptoms in early adolescence. Identifying these factors is relevant to implement timely interventions to contrast depression and promote positive developmental trajectories among early adolescents.

Empathy and Depression

Empathy has been defined as an emotional response to the affective state or situation of other people and it is considered a multidimensional construct, including the ability to recognize and understand another's feelings (cognitive dimension) and to share and vicariously experience those emotions (affective dimension) (Feshbach, 1997; Hoffman, 2008). Empathy emerges in the early childhood and become more complex during the individual development (Eisenberg et al., 2013). Early adolescence is a particularly critical period for empathy development (van Lissa et al., 2014). The great number of physical and psychological changes, the improvement of abstract thinking and the changes in moral reasoning, combined with individual and social transitions, constitute significant challenges that have important implications for empathy development (Allemand et al., 2015).

Many studies have stressed the positive role of empathy in increasing interpersonal and mental health outcomes (Chow et al., 2013). Affective and cognitive empathy are related to adolescents' interpersonal functioning, promoting prosocial behavior (Van der Graaff et al., 2018) and inhibiting aggressive and externalizing problem behaviors (Laible et al., 2004). Empathy results as an adaptive characteristic especially when both cognitive and affective dimensions are moderate and well regulated; this type of empathy is related with the greatest social benefits, because it allows to understand others' emotions and to get affectively involved without becoming overwhelmed (Tully et al., 2016). Low empathy is instead associated with more conflicts, aggressive behaviors and bullying (Jolliffe and Farrington, 2004; Gini et al., 2007). Individuals with low empathy cannot imagine the consequences of their behavior and the potential harm they might cause. Recent research has also highlighted the critical role of high levels of empathy among adolescents and adults. Some studies found that extreme sympathy and compassion, as a response to other people's suffering, may lead to consequent prolonged and exhausting empathic reactions (Smith and Rose, 2011; Oakley et al., 2012). This situation of personal distress is related to withdrawal, avoidance of empathy-inducing situations, and depression (Schreiter et al., 2013). In particular, high empathy may increase the risk for depression, if associated with particular individual and contextual characteristics which act as moderators or mediating factors (Hoffman, 2000; Hodges and Biswas-Diener, 2007; O'Connor et al., 2007; Tone and Tully, 2014). Among individual factors, gender is significantly related to empathy; not only girls generally report higher empathy, especially affective, than boys (Allemand et al., 2015), but high levels of affective empathy have a stronger and more significant association with internalizing symptoms in girls than in boys (Bell et al., 2005; Gambin and Sharp, 2016). Contextual variables also have an effect on the relationship between empathy and adjustment problems in adolescence. In particular, recent studies examined the role of family environment variables, in particular parenting practices (Tone and Tully, 2014; Green et al., 2018) and conflict with parents (Van Lissa et al., 2017) as moderating factors in the relation between empathy and depression. The relationship between empathy and depression is therefore complex and there is a need to deepen knowledge about variables that act as moderators, especially among early adolescents.

Maternal and Paternal Support and Depression

During early adolescence, the changes in family relationships can play a significant role in the improvement of adjustment problems. Contemporary studies have stressed that during early adolescence, girls and boys are surprisingly resilient in facing the normative challenges typical of the period, especially if they can count on the support of some caring adults (Steinberg, 2001; Tuggle et al., 2014). Among family factors, a central role is played by parental support, defined as the amount of acceptance or warmth that parents express to their children (Bean et al., 2006; Adams and Laursen, 2007). Supportive parents play a decisive role in promoting the healthy adjustment of their adolescent offspring (Rueger et al., 2010). While low levels of parental support may increase psychological distress and emotional problems (Demaray et al., 2005), high levels of parental support may promote those beliefs such as acceptance, self-esteem, trust and confidence in others, that are negatively associated with depressive feelings (Helsen et al., 2000; Colarossi and Eccles, 2003; Newman et al., 2007).

Most studies aggregated maternal and paternal support into a unique measure; therefore, there is a need of investigating the specific contribution of mothers' and fathers' support on adolescents' adjustment (Di Maggio and Zappulla, 2014). While maternal support is acknowledged to be a protective factor against adolescents' depression (Vaughan et al., 2010), recent literature has given greater attention also on the role of fathers in adolescents' development and adjustment (Day and Padilla-Walker, 2009; Graziano et al., 2009; Babore et al., 2016).

In particular, a good quality of father involvement and support can have a positive influence on adolescents' management of stressful or sad situations, may improve adolescents' life satisfaction and decrease the risk of depression (Antonopoulou et al., 2012). Indeed, maternal and paternal support may vary in terms of quantity and quality and may be functionally different on the base of individual adolescents' characteristics, such as their gender (Moilanen et al., 2015). As stressed by Colarossi and Eccles (2003), to better understand the effects of family support on adolescents' healthy adjustment it is essential to analyze the interactions between the gender of the support provider (for example, mother vs. father) and the gender of the recipient (girl vs. boy adolescents). Findings of Colarossi and Eccles (2003) indicated that boys perceived significantly more support from fathers than girls, while no gender differences were found in perception of support from mothers, who were perceived as higher supportive than fathers both by boys and girls. Moreover, mother support was negatively associated to depressive feelings especially in girls, while father support had larger effects on boys' depression. These results suggest that the effect of parental support may be particularly strong in a same-sex couple (mother-daughter or father-son).

Maternal and Paternal Support as Moderators of the Relationship Between Empathy and Depression

In light of the examined literature, the association between parent-adolescent relationships and early adolescents' adaptive emotional socialization appears to be very complex. Family variables can influence early adolescents' adjustment not only directly, but also through moderation and mediation effects. As suggested by Tone and Tully (2014), excessive empathy in combination with maladaptive parenting might be linked to increased risk for internalizing problems. Nonetheless, only a little research examined this topic. Zahn-Waxler and Van Hulle (2012) postulated that children and adolescents with high empathy might develop pathogenic guilt when parents are unsupportive and excessively demanding, and this can result in an increased likelihood of depression. Other studies specifically examined the moderating or the mediating role of maternal support on the relationship between empathy and depression, whereas the role of paternal support remains largely unexplored. In particular, Green et al. (2018) demonstrated that in the context of a negative mother–adolescent relationship, high affective empathy acts as a risk factor for depressive symptoms among adolescents. Finally, Soenens et al. (2007) examined maternal support in relation to adolescents' empathy dimensions, in particular maternal support as mediator of the intergenerational similarity between mothers' and adolescents' empathy-related responding. They found that maternal support mediates the relation between maternal and adolescent cognitive empathy, thus suggesting that cognitive empathy is transmitted from mothers to adolescents through maternal supportive rearing style. To our knowledge, no studies have yet considered the moderating role of both maternal and paternal support in the relation between empathy and depression among early adolescents.

The Present Study

The present study expanded the existing literature on the association between empathy and depression and on the moderating role of maternal and paternal support during early adolescence. In particular, the aims were:

(1) to describe levels of depression, affective and cognitive empathy, paternal and maternal support in a group of early adolescents, taking into account gender differences. Consistently with results of previous literature, we expected that girls report higher depression (Olino et al., 2014; McLaughlin and King, 2015), higher empathy (Allemand et al., 2015), and lower paternal support (Colarossi and Eccles, 2003) than boys.

(2) to investigate the relationships between empathy (both affective and cognitive) and depression; moving from studies that indicated the adaptive role of moderate levels of empathy with respect to adjustment (Tully et al., 2016), we expected that both extremely high and extremely low affective and cognitive empathy would be associated with higher depression. The role of extreme levels of empathy was examined by considering the quadratic associations between empathy (both affective and cognitive) and depression.

(3) to investigate the potential moderating role of paternal and maternal support, as perceived by early adolescents, on the associations between empathy (both affective and cognitive) and depression; both maternal and paternal support were expected to be linked to lower depression (Vaughan et al., 2010; Antonopoulou et al., 2012). Moreover, we expected that both maternal and paternal support moderated the associations between affective and cognitive empathy and depression (Tone and Tully, 2014; Green et al., 2018). In particular, we expected that the association between extreme levels of empathy and depression was weaker when perceived parental support was high. As for differences between paternal and maternal support, the study was explorative in nature and no specific hypothesis was formulated.

(4) to examine if the relationships among empathy (affective and cognitive), maternal and paternal support and depression vary as a function of early adolescents' gender. In particular, we investigated if the gender of early adolescents moderates: (a) the relationship between empathy and depression (two-way interactions); (b) the relationship between paternal/maternal support and depression (two-way interactions); (c) the relationship between empathy and depression as moderated by paternal/maternal support (three-way interactions); all these analyses were exploratory in nature and no specific hypotheses were formulated.

MATERIALS AND METHODS

Participants

A convenience sample of 7 middle schools located in urban centers in the North-West of Italy was selected to participate in the study. The research project was presented to each school and a total of 26 s year[1] classes were enrolled. The sample was composed of 386 early adolescents aged between 12 and 14 (M age = 13, SD = 0.3) (N = 185, 47.9% girls). The majority of participants (N = 328, 85.2%) lived with both parents and had brothers or sisters (N = 329, 85.2%). Parents' level of education was medium-high (high school diploma for 25.3% of mothers and 20.4% of fathers; degree for 25.3% of mothers and 19% of fathers). The majority of parents were employed full time (56.1% of mothers and 83.8% of fathers).[2]

Procedure

Participants completed an anonymous self-report questionnaire, administered by trained researchers in the schools during classroom time, without teachers present. Completed questionnaires were turned in immediately to researchers. Participants did not receive benefits for participating in the study. The study was approved by the Bioethics Committee of the University of Turin (Italy) and written informed consent was obtained from the parents of the participants before the questionnaire was administered. Parental consent was given for 96% of the students originally contacted to participate in the study.

Measures

Empathy

Students were asked to complete the scale How I feel in different situations (HIFDS, Feschbach et al., 1991, Italian validation Bonino et al., 1998). It is composed of 12 items investigating cognitive empathy (6 items) (e.g., "I can sense how my friends feel from the way they behave") and affective empathy (6 items) (e.g., "When somebody tells me a nice story, I feel as if the story is happening to me") on a 4-point Likert scale from 0 (never true) to 3 (always true) (the score of each scale ranged from 0 to 18). In this study, Cronbach's alfas were 0.79 for affective empathy and 0.76 for cognitive empathy, respectively.

Paternal and Maternal Support

Students completed the scale of parental support formulated by Kerr et al. (2010). It is composed of 10 items evaluating the perceived support, closeness, help and encouragement from mothers (5 items) and fathers (5 items) (e.g., "When I am angry, sad or worried, my mother/father can make me feel better"). The agreement is expressed on a 4-point Likert scale from 0 (not agree) to 3 (agree very much) (the score of each scale ranged from 0 to 15). In this study, Cronbach's alfas were 0.82 for maternal support and 0.87 for paternal support, respectively.

Depression

Students completed the CESD-10 (Center for Epidemiological Studies Scale- short version 10 items) in the Italian validation (Pierfederici et al., 1982). The scale evaluates the frequency of depressive symptoms during the past week on a 4-point Likert scale from 0 (rarely or none of the time) to 3 (most or all of the time) (range 0–30, Cronbach's alfa = 0.69). A cut-off score of 10 indicates the presence of clinically significant depressive symptoms.

Statistical Analysis

A preliminary check on missing data indicated that the percentage of missing response for the study scales was less than 10%. The MCAR (Missing Completely at Random) test (Little, 1988) showed non-significant results for affective empathy, cognitive empathy and paternal support, thus missing were imputed in SPSS with the EM (Expectation-Maximization) procedure. Since the MCAR test showed significant results for depression and maternal support, indicating that missing were not completely at random, the imputation was carried out through the Regression procedure. Preliminary descriptive analyses included t-tests for gender differences in study variables, Cohen's d as a measure of t-test effect size, and Pearson's bivariate correlations. Then, according to the aims of the study, we ran two regression models to predict depression. In the first model, the focal predictor was affective empathy (both linear and quadratic) and gender, maternal and paternal support were moderator variables, whereas in the second model the focal predictor was cognitive empathy (both linear and quadratic) and gender, maternal and paternal support were, as before, the moderator variables. Both models included main effects, as well as all two-way and three-way interactions. The focal independent variables (affective and cognitive empathy) and maternal and paternal support were mean centered prior to analyses (Aiken and West, 1991), whereas gender was dummy coded (1 = boy). To interpret significant interactions with linear variables, we plotted the effects and performed a simple slope analysis. For moderating continuous variables (maternal and paternal support) we tested the effects at low (mean −1 sd) and high (mean +1 sd) levels of the moderator.

Following the approach suggested by Dawson (2014), a significant interaction that included a quadratic term was examined only if the increase of explained variance obtained after the introduction of this term and its linear counterpart was statistically significant. Then the interaction effect was plotted and both simple slope and slope difference tests were performed. The indirect method was followed: the moderators were centered around low and high values and the regression model was re-run using these new variables in turn (Dawson, 2014). All statistical analyses were performed with SPSS Statistics 25.

RESULTS

Descriptive Analysis

Means and standard deviations of study variables are reported in **Table 1**. As for depression, the majority of participants

[1] In the Italian school system, there is a first cycle of education that lasts 5 years (primary school, from 6 to 11 years of age) and a second cycle that lasts 3 years (middle school, from 11 to 14 years of age).

[2] Family structure and parental levels of education were in line with Italian population data (ISTAT, 2016).

TABLE 1 | Descriptive statistics and bivariate correlations among study variables.

	M (*SD*)	1	2	3	4	5	6	7
1. Depression	7.2 (4.1)	1						
2. Linear AE	7.6 (3.7)	0.12*	1					
3. Quadratic AE	–	0.02	0.21**	1				
4. Linear CE	9.8 (3.7)	0.05	0.48**	0.05	1			
5. Quadratic CE	–	−0.05	−0.04	0.33**	−0.09	1		
6. M_SUP	11.5 (3.3)	−0.26**	0.17**	−0.08	0.16**	−0.02	1	
7. P_SUP	10.8 (3.8)	−0.34**	0.02	−0.02	0.11*	0.07	0.48**	1

*AE, Affective Empathy; CE, Cognitive Empathy; M_SUP, Maternal Support; P_SUP, Paternal Support. *p < 0.05, **p < 0.01.*

(N = 300, 77.7%) had a score lower than 10, which represent the critical cut-off for the presence of clinically significant depressive symptoms; 68 early adolescents (17.6%) reported a score ranging from 10 to 15 and the remaining (N = 18, 4.7%) had a score higher than 15. Depression scores were higher for girls than for boys. Girls also reported higher affective empathy than boys, whereas boys reported higher paternal support than girls (**Table 2**). Bivariate correlations among study variables indicated that depression was positively related to affective empathy and negatively to paternal and maternal support. The two components of empathy were positively correlated. Affective empathy was positively related to maternal support, whereas cognitive empathy was positively related to both maternal and paternal support. Finally, maternal and paternal support were positively interrelated (**Table 1**).

Affective Empathy and Depression: Moderation Analysis

Results of the first regression model are reported in **Table 3**. The model explained 20% of the variance in depression scores. Significant coefficients were observed for maternal support, paternal support, as well as for the two-way interaction maternal support X gender, and for the three-way interaction quadratic affective empathy X maternal support X gender. The increase in the explained variance after entering both linear and quadratic terms of the 3-way interaction was statistically significant [ΔR^2 = 0.017; $F_{(2,\ 368)}$ = 3.88, $p < 0.05$]. Paternal support was negatively related to depression, regardless of the gender of the adolescents or their level of affective empathy (none of the interactions involving paternal support was statistically significant). Higher levels of paternal support were associated to lower levels of depression. Regarding maternal support, results indicated that its association with depression was moderated by gender: high levels of maternal support were related to lower depression only for girls. The simple slope was in fact significant for girls (b = −0.431, t = −3.734, $p < 0.001$), but not for boys (b = 0.179, t = 1.326, p = 0.186; **Figure 1**).

The significant three-way interaction between quadratic affective empathy, maternal support and gender indicated that gender moderates the influence of maternal support on the relationship between affective empathy and depression (**Figure 2**). The simple slope analysis revealed that only the slope of boys with high maternal support was statistically significant [ΔR^2 = 0.018; $F_{(2,\ 368)}$ = 4.11, p = 0.017]. With slope difference analyses, we compared girls with high (mean +1 sd) and low (mean −1 sd) maternal support, as well as boys with high (mean +1 sd) and low (mean +1 sd) maternal support, obtaining a significant difference only between boys with high and low

TABLE 2 | Gender differences in study variables.

	Girls		Boys		Student's $t_{(df)}$	*p*	Cohen's d
	M	*SD*	*M*	*SD*			
Depression	8.16	4.35	6.35	3.67	$-4.39_{(384)}$	0.0001	0.45
Affective empathy	8.72	3.57	6.48	3.56	$-6.16_{(384)}$	0.0001	0.63
Cognitive empathy	10.13	3.57	9.51	3.77	$-1.66_{(384)}$	0.098	0.17
Maternal support	11.43	3.28	11.57	3.39	$0.41_{(384)}$	0.681	0.04
Paternal support	10.06	3.97	11.39	3.53	$3.49_{(384)}$	0.0001	0.36

TABLE 3 | Multiple regression analysis with moderating effects of maternal support, paternal support, and gender on the relationship between affective empathy (linear and quadratic) and depression.

	B	*SE B*	β	*p*
Intercept	7.760	0.358		
Gender	−0.876	0.519	−0.107	0.092
Linear AE	0.130	0.097	0.118	0.180
Quadratic AE	0.003	0.019	0.013	0.865
M_SUP	**−0.431**	**0.115**	**−0.351**	**0.0001**
P_SUP	**−0.259**	**0.095**	**−0.240**	**0.007**
Linear AE X gender	−0.037	0.129	−0.023	0.776
Quadratic AE X gender	−0.031	0.028	−0.097	0.270
M_SUP X gender	**0.610**	**0.177**	**0.363**	**0.001**
P_SUP X gender	−0.265	0.159	−0.165	0.096
Linear AE X M_SUP	−0.030	0.034	−0.100	0.372
Linear AE X P_SUP	−0.007	0.028	−0.027	0.792
Quadratic AE X M_SUP	0.011	0.006	0.230	0.066
Quadratic AE X P_SUP	0.003	0.005	0.064	0.549
Linear AE X M_SUP X gender	0.076	0.047	0.193	0.105
Linear AE X P_SUP X gender	−0.016	0.038	−0.039	0.678
Quadratic AE X M_SUP X gender	**−0.020**	**0.009**	**−0.333**	**0.020**
Quadratic AE X P_SUP X gender	0.009	0.008	0.136	0.235

AE, Affective Empathy; M_SUP, Maternal Support; P_SUP, Paternal Support. Full model R^2 = 0.20; $F_{(17,\ 368)}$ = 5.55, $p < 0.001$; Model with only the linear term of gender, affective empathy, maternal and paternal support variables) R^2 = 0.16; $F_{(4,\ 381)}$ = 18.705, $p < 0.001$; statistically significant betas ($p < 0.05$).

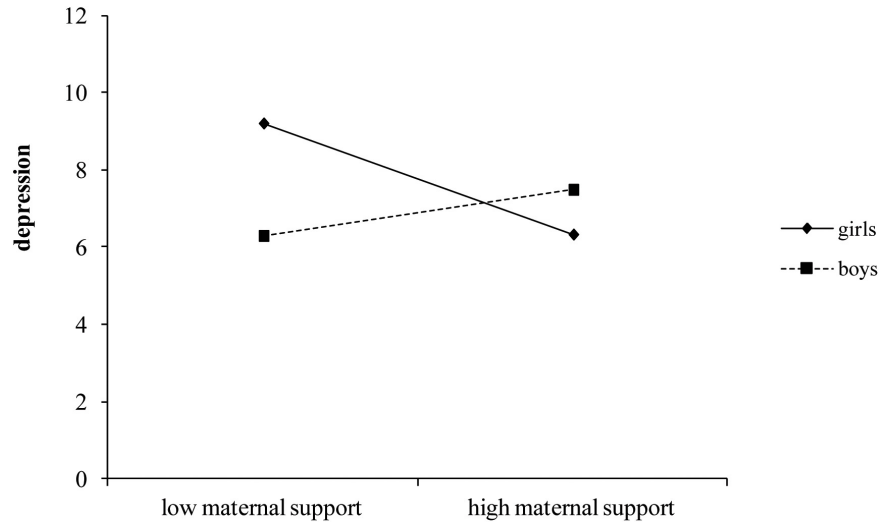

FIGURE 1 | Moderating effect of gender on the relationship between maternal support and depression (controlling for affective empathy).

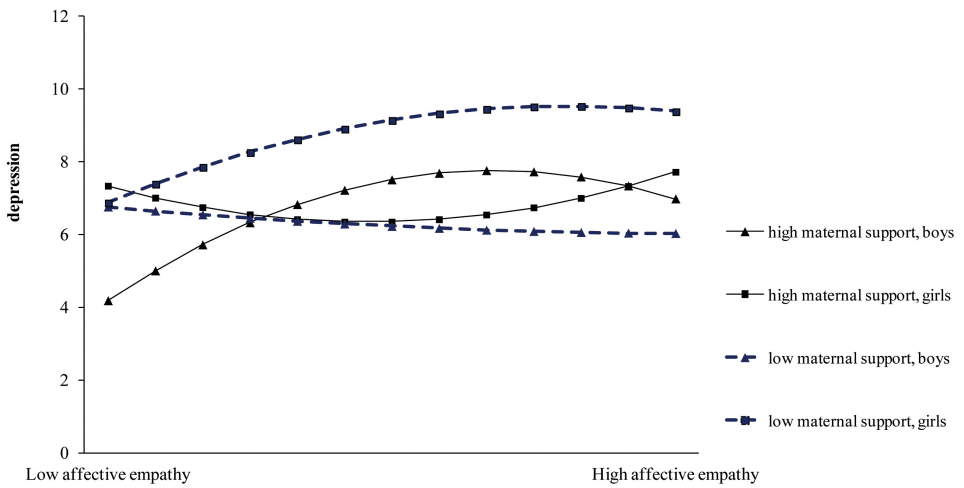

FIGURE 2 | Moderating effect of maternal support and gender on the curvilinear relationship between affective empathy and depression.

support [$\Delta R^2 = 0.018$; $F_{(2,\ 368)} = 4.23$, $p = 0.015$]. To summarize, only among boys with high maternal support, affective empathy was related to depression. In particular, boys with a high maternal support and a low affective empathy shown the lowest scores on depression.

Cognitive Empathy and Depression: Moderation Analysis

Results of the second regression model are reported in **Table 4**. The model explained 21% of the variance in depression scores. Significant coefficients were observed for gender, cognitive empathy, maternal support, paternal support, as well as for the two-way interactions maternal support X gender, cognitive empathy X paternal support, and quadratic cognitive empathy X maternal support. The increase in the explained variance after entering both linear and quadratic terms of the last 2-way interaction was not statistically significant [$\Delta R^2 = 0.009$; $F_{(2,\ 368)} = 2.07$, $p = 0.127$], thus this interaction was no further examined.

As found in the previous model, high levels of maternal support were related to lower depression only for girls (simple slope for girls, $b = -0.470$, $t = -3.983$, $p < 0.001$; simple slope for boys, $b = 0.007$, $t = 0.060$, $p = 0.953$; **Figure 3**), and, as before, paternal support was negatively related to depression, regardless of the gender of the adolescents.

Moreover, higher depression was related to being girls and to having high cognitive empathy scores. This last positive association was present both for the average level of paternal support, as indicated by cognitive empathy main effect, and for low level of paternal support, as shown by the simple slope analysis of the interaction between cognitive empathy and

TABLE 4 | Multiple regression analysis with moderating effects of maternal support, paternal support, and gender on the relationship between cognitive empathy (linear and quadratic) and depression.

	B	*SE B*	β	*P*
Intercept	7.926	0.358		
Gender	**−1.304**	**0.497**	**−0.159**	**0.009**
Linear CE	**0.198**	**0.083**	**0.178**	**0.018**
Quadratic CE	0.001	0.018	0.003	0.966
M_SUP	**−0.470**	**0.118**	**−0.382**	**0.0001**
P_SUP	**−0.224**	**0.092**	**−0.207**	**0.015**
Linear CE X gender	−0.126	0.114	−0.084	0.269
Quadratic CE X gender	−0.004	0.025	−0.014	0.870
M_SUP X gender	**0.477**	**0.167**	**0.284**	**0.004**
P_SUP X gender	−0.109	0.145	−0.068	0.452
Linear CE X M_SUP	0.002	0.025	0.007	0.934
Linear CE X P_SUP	**−0.054**	**0.025**	**−0.174**	**0.034**
Quadratic CE X M_SUP	**0.011**	**0.005**	**0.234**	**0.042**
Quadratic CE X P_SUP	−0.004	0.005	−0.083	0.362
Linear CE X M_SUP X gender	0.028	0.040	0.068	0.488
Linear CE X P_SUP X gender	−0.014	0.039	−0.032	0.713
Quadratic CE X M_SUP X gender	−0.012	0.007	−0.215	0.085
Quadratic CE X P_SUP X gender	0.005	0.007	0.064	0.490

CE, Cognitive Empathy; M_SUP, Maternal Support; P_SUP, Paternal Support. Full model: $R^2 = 0.21$; $F_{(17, 368)} = 5.89$, $p < 0.001$; Model with only the linear term of gender, cognitive empathy, maternal and paternal support variables) $R^2 = 0.16$; $F_{(4, 381)} = 18.210$, $p < 0.001$; statistically significant betas ($p < 0.05$).

paternal support. In fact, high levels of cognitive empathy were related to higher depression in a context of low perceived support from fathers (simple slope for low paternal support, $b = 0.403$, $t = -3.146$, $p < 0.01$) but there was not an association for high paternal support, simple slope: $b = -0.007$, $t = -0.057$, $p = 0.954$; **Figure 4**).

Summary of Results

To sum up, the results of the study indicated that:

(1) with a mean level of affective and cognitive empathy, higher maternal support was related to lower depression for girls, whereas higher paternal support was related to lower depression for both boys and girls.
(2) maternal support had a moderating role in the quadratic relation between affective empathy and depression and the relation was further moderated by early adolescents' gender: boys with low affective empathy shown the lowest scores on depression in a context of high perceived maternal support.
(3) paternal support had a moderating role in the linear relation between cognitive empathy and depression, independently of early adolescents' gender: high levels of cognitive empathy were related to higher depression when boys and girls perceived lower support from fathers.

DISCUSSION

The study was aimed at investigating the relationships between empathy (both affective and cognitive) and depression in early adolescence, examining the moderating role of maternal and paternal support and taking into account early adolescents' gender differences. The study suggested that the association between empathy and depression is complex and parental support plays a central role with some differences between boys and girls.

With regard to the first aim, our descriptive results were consistent with previous studies, indicating higher depression (Olino et al., 2014; McLaughlin and King, 2015) and higher

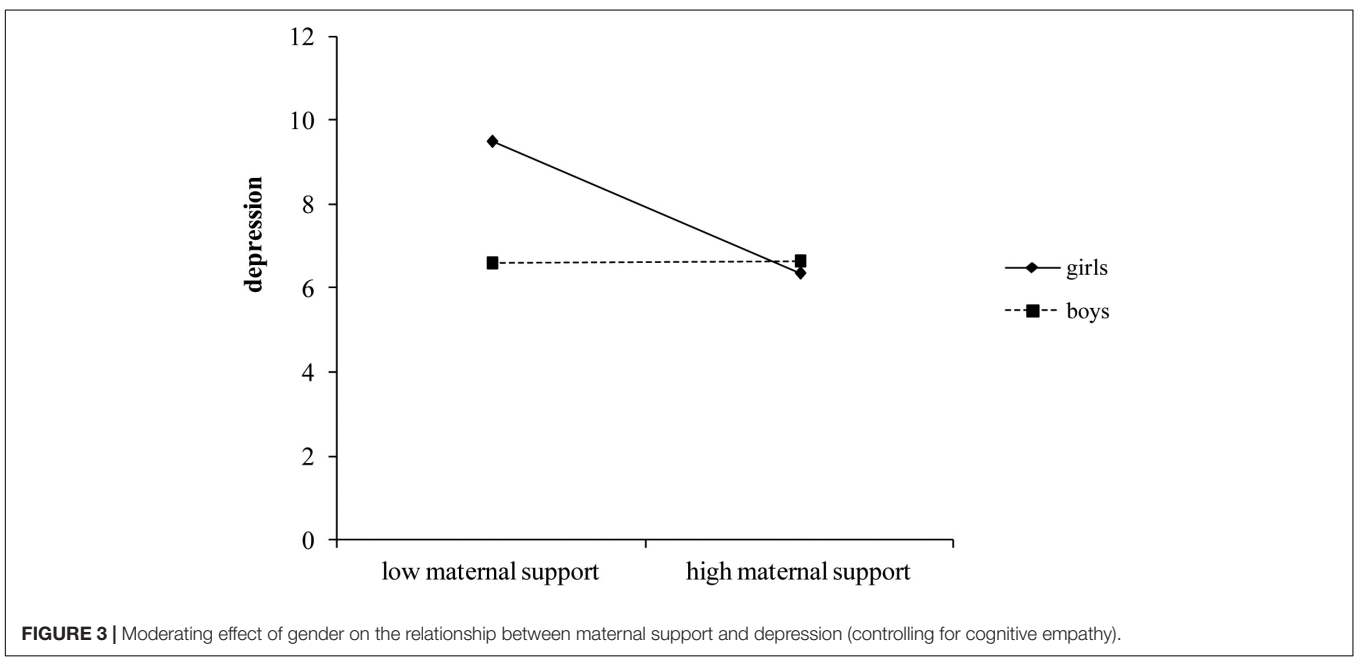

FIGURE 3 | Moderating effect of gender on the relationship between maternal support and depression (controlling for cognitive empathy).

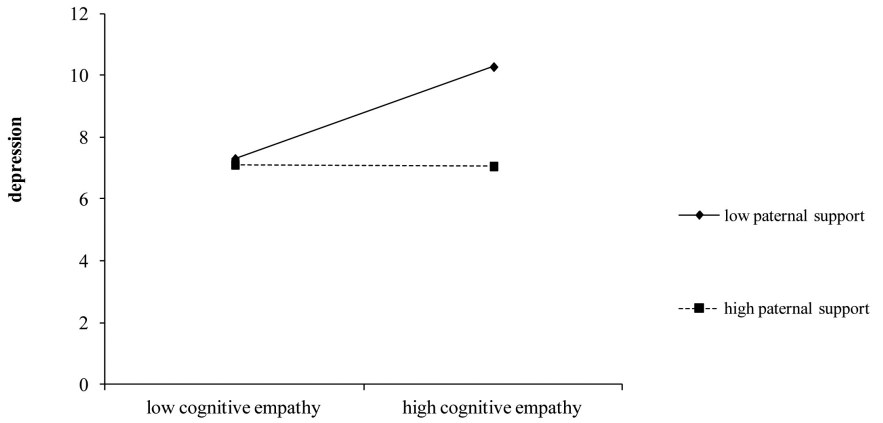

FIGURE 4 | Moderating effect of paternal support on the relationship between cognitive empathy and depression.

affective empathy (Allemand et al., 2015) among girls. Also in our sample of early adolescents, girls seem therefore more at risk than boys to experience depressive symptoms, and more prone to share and vicariously experience others' emotions than their male peers. This difference in levels of affective empathy could be explained with reference to cultural models that encourage girls to be sensitive to other's emotional difficulties and to place more importance to intimacy than boys in peer relationships (Rubin et al., 2006). Moreover, we found that boys reported higher paternal support than girls, consistent with previous literature, suggesting that paternal warmth and closeness are perceived as particularly salient in the son-father couple (Colarossi and Eccles, 2003).

Concerning the second aim, the hypothesis that extreme levels of empathy would be associated with higher depression was partially confirmed, in line with previous studies highlighting the links between excessive empathy and internalizing problems (Oakley et al., 2012; Schreiter et al., 2013; Tully et al., 2016). Even though empathy is acknowledged to be an important life skill and is related to psychological well-being and positive adjustment (Laible et al., 2004; Chow et al., 2013), the present study suggests the potential risk associated with extreme and excessive form of empathic responses, in absence of a moderating role of parenting.

As for the third aim, we found that both maternal and paternal support were protective against depression when associated with a mean level of affective and cognitive empathy. In line with previous studies (Tone and Tully, 2014; Green et al., 2018), we found that both maternal and paternal support moderated the associations between empathy and depression. The hypothesis that the association between extreme levels of empathy and depression would be weaker when perceived parental support was high was partially confirmed.

Interesting results emerged when considering the specific role of paternal and maternal support and early adolescents' gender as further moderating variable (fourth aim). First of all, the role of maternal support on depression seems to be more influential for girls, whereas the role of fathers seems to be equally important for both boys and girls. On the one hand, this result is consistent with research highlighting the strong effect of parental support in the mother-daughter couple (Colarossi and Eccles, 2003). On the other hand, our findings stressed the central role played by fathers in the relationship with their offspring, especially during early adolescence (Day and Padilla-Walker, 2009; Antonopoulou et al., 2012; Babore et al., 2016). Secondly, maternal and paternal support seem to differentially moderate the two components of empathy (affective and cognitive), in relation to early adolescents' gender. On the one hand, boys with low levels of affective empathy refer lower depression when they can rely on a high maternal support. On the other hand, boys and girls with high cognitive empathy reported lower depression when they perceived high paternal support. This differential role of maternal and paternal support in relation to the different dimensions of empathy is in line with the study of Miklikowska et al. (2011), where a greater maternal influence on adolescents' empathic concern and a greater paternal influence on perspective taking were found. These differences might be due to differential parenting styles: while paternal support is more likely to act through a process of cognitive sharing of problems and search for solving strategies, maternal support is more likely to be linked to a process of affective sharing of emotions. Our results are therefore preliminary and the topic deserves further investigation.

The present study expands the existing literature on the complex associations between empathy and depression and the moderating role of maternal and paternal support during early adolescence. The strength of this study lies in considering the nonlinear relation between empathy and depression. This type of analysis allowed to go beyond the role of maternal support when girls report mean levels of empathy and to highlight the importance of maternal support for boys with extremely low levels of affective empathy. Nonetheless, the study had some limitations. First of all, the sample is not representative, thus limiting the generalizability of results. Second, the cross-sectional nature of the research allows to investigate the association between variables, but it limits the possibility to interpret the directionality of the relations. Third, our study only relied on self-report measures and this would have partially biased the study results.

To overcome these limitations, further research should involve a larger and representative sample in order to confirm the preliminary results of the present study. Longitudinal investigation would be useful to investigate the directionality of the relation between empathy and depression and the moderating role of parenting variables. Further longitudinal research would be also useful to study the specific protective role of paternal and maternal support with respect to subsequent depressive symptoms. Finally, further research should integrate self-report measures of parenting with maternal and paternal points of view to clarify the moderation role of parental support on the links between empathy and depression.

Our results have relevant implications for prevention and intervention to contrast depression in early adolescence. Recent research highlighted the need of individuating key variables of children and adolescents depression in order to implement effective programs specifically targeting this population (Bernaras et al., 2019). Empathy and parental support might be two core elements to consider in prevention programs specifically targeting early adolescents. On the one hand, programs of empathy promotion for early adolescents must take into account that empathy is a life skill relevant for positive interpersonal relationships. On the other hand, there must be an awareness that extreme forms of empathy could expose early adolescents, especially girls, to a greater risk of depression, if not associated to the promotion of protective factors in the family context. Community-based interventions should be focused on the promotion of parenting abilities, in particular parental support, that might contrast depressive feelings, especially when early adolescents report extremely high levels of empathy involvement. As for clinical interventions, moving from the consideration that early adolescents with extreme empathy are more likely to develop depressive symptoms when parents are less supportive, clinicians should pay attention to parental support as a key variable of intervention. In particular, a final consideration concerns the role of paternal support with respect to early adolescents' depression. In light of the results of the present study, it seems appropriate to help fathers to be aware of the importance of being highly supportive toward their offspring to contrast depressive feelings associated with high levels of empathy, especially in the cognitive component.

ETHICS STATEMENT

The study was approved by the Turin University Bioethical Committee (Prot. n. 3175 del 1/2/2016) and parental and personal consent were required before the questionnaire was administered.

AUTHOR CONTRIBUTIONS

EMC conceived the study and wrote the manuscript. ST provided statistical analysis and interpretation of the results. FG provided statistical analysis and wrote the manuscript. TB collaborated in writing introduction and discussion of the manuscript and editing of the manuscript. ELC had project supervision and monitored the progress of the study.

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Children's Block-Building Skills and Mother-Child Block-Building Interactions Across Four U.S. Ethnic Groups

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Play offers an unparalleled opportunity for young children to gain cognitive skills in informal settings. Block play in particular—including interactions with parents around block constructions—teaches children about intrinsic spatial features of objects (size, shape) and extrinsic spatial relations. In turn, early spatial cognition paves the way for later competencies in math and science. We assessed 4- and 5-year-old children's spatial skill on a set of block-building constructions and examined mother-child block building interactions in 167 U.S. dyads from African American, Dominican, Mexican, and Chinese backgrounds. At both ages, children were instructed to copy several 3D block constructions, followed by a "break" during which mothers and children were left alone with the blocks. A form that contained pictures of test items was left on the table. Video-recordings of mother-child interactions during the break were coded for two types of building behaviors – test-specific construction (building structures on the test form) or free-form construction (building structures not on the test form). Chinese children outperformed Mexican, African American, and Dominican children on the block-building assessment. Further, Chinese and Mexican mother-child dyads spent more time building test-specific constructions than did African American and Dominican dyads. At an individual level, mothers' time spent building test-specific constructions at the 4-year (but not 5-year) assessment, but not mothers' initiation of block building interactions or verbal instructions, related to children's performance, when controlling for ethnicity. Ethnic differences in children's block-building performance and experiences emerge prior to formal schooling and provide a valuable window into sources of individual differences in early spatial cognition.

Keywords: spatial skills, spatial cognition, STEM learning, ethnic minorities, block building

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INTRODUCTION

Spatial cognitive skills involve perceiving spatial information, such as object shape and relative location, and mentally and/or physically manipulating objects in space. Spatial skills are foundational to later success in Science, Technology, Engineering, and Mathematics (STEM) subjects and careers (Caldera et al., 1999; Assel et al., 2003; Chen, 2009; Wai et al., 2009;

Uttal and Cohen, 2012; Lombardi et al., 2017). Consequently, interest in the early development of spatial skills has grown. Indeed, variation in preschoolers' and even infants' spatial skills relates to later math and spatial cognition (Lauer and Lourenco, 2016; Verdine et al., 2017).

Everyday play with blocks provides children with valuable opportunities to acquire spatial cognitive skills in informal settings, well before formal exposure to science and math subjects. During block building, children perceive and learn about intrinsic features of objects, such as how objects vary along dimensions of size, pattern, symmetry, and shape (Casey and Bobb, 2003; Verdine et al., 2014). Furthermore, block play supports children's representations of extrinsic spatial relations (e.g., in, behind; Reifel, 1984) and mental rotation skills (Wexler et al., 1998) because children actively manipulate spatial relations by aligning and rotating blocks and placing them on top of or next to one another. Parent-child block building can further promote children's spatial skill development through hands-on and verbal guidance (Lombardi et al., 2017; Borriello and Liben, 2018) and spatial language (Ferrara et al., 2011; Pruden et al., 2011), which facilitate children's attention to spatial concepts and aid spatial learning.

Block building is not only a vehicle for children to develop spatial skills, but block-building assessments that require children to copy specific block constructions have been shown to reliably index children's spatial skill and predict later STEM performance, including mathematics (Verdine et al., 2014, 2017).

In light of the importance of block building as an activity that promotes spatial skill and a window into young children's spatial skill performance, we tested U.S. children from African American, Dominican, Mexican, and Chinese backgrounds on a set of block constructions and investigated mothers' spontaneous interactions with children around block building. We tested children from diverse ethnic backgrounds because of longstanding differences in later STEM performance. By observing children separately and together with their mothers, we asked whether ethnic differences exist in children's block-building performance early in development and if so, whether ethnic differences relate to parent-child block-building interactions.

Block Building and Parental Supports

Block building offers children rich opportunities to learn and practice spatial skills, and block building with parents might further scaffold children's spatial skill development. Parents have been shown to use gestures and teach children efficient spatial strategies during block building interactions (Lombardi et al., 2017). Block building also elicits parent spatial language, which relates to children's spatial language and spatial skill (Pruden et al., 2011; Miller et al., 2017). In fact, playing with blocks elicits more spatial language from parents than other everyday activities, such as drawing, playing house, dressing up, throwing a ball, or playing with animal figurines or food and kitchen toy sets (Ferrara et al., 2011). Furthermore, dyadic block-building activities that center around constructing structures from pictures prompt even more parent spatial language than free-form block construction (Ferrara et al., 2011; Borriello and Liben, 2018). Thus, differences in mother-child block building may contribute to individual and ethnic differences in children's block building and spatial skill.

Research Gaps: Ethnic Differences in Block Building and Parental Supports

Ethnic differences in STEM are well-documented. Asian students receive higher standardized test scores and average grades in STEM high school subjects (Reardon, 2008; Nord et al., 2011) and are twice as likely as their Black and Latino counterparts to obtain degrees in STEM fields (Chen, 2009). The 2011 National Assessment of Educational Progress (NAEP) math assessment revealed that 4th and 8th grade Asian students score higher than Black and Latino students (Gonzalez and Kuenzi, 2012). Even by school entry, Asian kindergarteners' math performance is higher than that of Black and Latino kindergarteners (Sonnenschein and Sun, 2017).

However, ethnic differences in children's block-building performance and parent-child block-building interactions remain largely unexplored, although these skills and interactions may be foundational to children's later STEM performance. A greater percentage of Chinese than Latino 4- to 6-year-olds in the United States engaged in block building at home at least once a week (56.4 vs. 45.9%; Sonnenschein et al., 2018). In contrast, when Black, Latino, and Asian parents were asked how often their children played with blocks, although in the context of many other activities, no differences were found (Sonnenschein and Sun, 2017). Thus, whether ethnic differences exist between Black, Chinese and Latino children in block-building performance and parent-child block-building behaviors remains relatively unexplored.

Differences in parent practices and involvement in other domains hint at potential ethnic differences around block building as well. Chinese mothers are explicit and systematic about teaching their children at home (Huntsinger et al., 2000), and use concrete expectations and plans to promote children's learning (Sonnenschein et al., 2018). Therefore, Chinese mothers may intentionally allot time for block building and provide support for block-building activities and spatial skill development. Alternatively, Chinese mothers may only consider formal, practice-oriented (e.g., workbooks) activities as educational (Huntsinger and Jose, 2009). If so, they may be unlikely to engage with their children during block building.

Current Study

We examined 4- and 5-year-old children's spatial skills and interactions with mothers around block building. We included U.S. dyads from African American, Dominican, Mexican, and Chinese backgrounds to extend beyond the dominant focus on European-American dyads (e.g., Ferrara et al., 2011; Lombardi et al., 2017; Borriello and Liben, 2018). Three aims guided this study.

First, we examined within- and between-group ethnic differences in 4- and 5-year-olds' block-building performance. We tested children's ability to replicate a set of structures an experimenter built as children watched. We asked whether ethnic differences in spatial skills around block building exist already by 4 and 5 years of age. We were uncertain about the patterns we might obtain. One possibility is that children at young ages, prior to the onset of formal schooling, do not differ in their block-building performance because within-group variation swamps between-group differences. Alternatively, Chinese children may surpass children of Latino and African American backgrounds already by 4 years of age, or at least by the time they reach 5 years, thereby aligning with ethnic and racial differences in STEM that have been documented in school-aged children.

Second, we investigated whether mothers and children from different ethnicities differ in their block-building interactions. To address this aim, we left dyads alone in a room with blocks without instructions, to reduce social desirability and pressure on mothers to encourage children's block building or build with their children. We left a sheet of images of test structures on the table and visible to dyads. Based on previous findings that Chinese parents are more intentional about teaching their children (Huntsinger et al., 2000; Sonnenschein et al., 2018), we expected Chinese mothers and children to engage in more block building overall, especially test-specific constructions. Furthermore, we expected Chinese mothers to initiate interactions and provide instruction around block building more than Latino and African American mothers because Chinese mothers may be most likely to view dyadic block building as a teaching opportunity. We also expected mothers' and children's building behaviors during the interaction to covary, such that if mothers engaged in test-specific constructions, children would do so, and if mothers engaged in free-form constructions, children would do the same.

Third, we examined associations between mother-child block construction behaviors and independent assessments of children's block-building performance. Do mothers' behaviors during block-building interactions relate to children's block-building skill? We expected mothers who provide high instructional support and hands-on guidance during block building to have children with high performance in block building.

MATERIALS AND METHODS

Participants

Participants were 167 African American (n = 36), Dominican (n = 43), Chinese (n = 51), and Mexican (n = 37) mothers and their children (83 boys, 84 girls) recruited from hospitals and clinics in the New York City metropolitan area. Criteria for participation included: (1) mother being at least 18 years old at the time of her child's birth, (2) child being healthy and full term at birth, and (3) child living with mother since birth. African American mothers were predominantly fourth generation immigrants (61.1%) and Dominican mothers were first (72.1%) and second (27.9%) generation immigrants. Chinese and Mexican mothers were the more recent immigrant groups with 100% being first generation. African American and Dominican mothers completed an average of 12.03 (SD = 1.38) and 12.57 (SD = 2.06) years of formal education, respectively. Chinese mothers completed an average of 10.94 (SD = 2.80) years of formal education, whereas Mexican mothers completed the fewest years of formal education with an average of 7.97 (SD = 3.50) years. In addition, 63.5% of the 4-year-old children were in Pre-K at the time of their participation and by the time children were 5 years of age, 84.4% were in kindergarten. We obtained written informed consent from participants, parental consent for children, and signed consent to share videos on Databrary.org, an online open data-sharing platform for researchers to access video data.

Mothers and children visited our lab when children (N = 167) were age 4 (M = 4.20, SD = 0.15) and 5 years (M = 5.15, SD = 0.15). At each age, children engaged in a block-construction assessment that was developed by the third author, during which children were required to replicate 3D block constructions that were built by the experimenter as children watched. The assessment was followed by a 5-minute "break" where the mother-child dyad could play with the blocks. A video camera recorded children's performance and mother-child block-building behaviors during the break.

Block-Building Assessment

The experimenter presented the child with two identical sets of differently colored blocks (red and blue) that contained all the pieces required to construct the assessment items. The child was allowed to choose which set of blocks to use, and the experimenter used the other set of blocks. The experimenter then built a sample block construction before beginning the assessment and asked the child to build the same construction immediately following. The first easy pretest item ensured the child understood the task before proceeding with the actual assessment.

The experimenter then continued with the block construction assessment, first demonstrating how to build each block construction with her set of blocks and then asking the child to replicate the construction with his or her blocks. Children were tested on a set of 12 test-items of increasing difficulty (**Figures 1A,B**). The experimenter marked down the child's performance on a scoring sheet, and proceeded to the next item. If the child received three consecutive items incorrect or completed all assessment items, the test ended. Children's performance was indicated by the number of items they built correctly. Test items for the 4- and 5-year assessment were tested in a pilot study and deemed to be appropriate at each age and for all ethnic groups.

Mother-Child Block Building

After the assessment, mothers were told that children would have a short 5-minute "break." The experimenter stated that "(*Child's name*) *is going to have a short break now and I thought it'd*

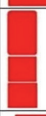
A

Date: _____ Participant ID # _____

Child Gender: _____ Child Ethnicity: _____

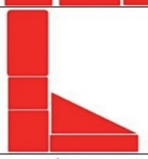
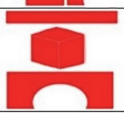
4 Year Old
Block Assessment Task – Part 1
積木評估活動 – 第一部分

□ Balanced
□ English dominant
□ Cantonese dominant
□ Mandarin dominant

		Right 對	Wrong 錯
Sample Item: **Little House** 小房子			
Problem A1: **Little Tower** 小塔			
Problem A2: **Little Bridge** 小橋			
Problem A3: **Tall Tower** 高塔			
Problem A4: **Rocket Ship** 火箭船			
Problem A5: **Choo-choo train** 列車			
Problem A6: **Long Bridge** 長橋			

Date: _____ Participant ID # _____

Child Gender: _____ Child Ethnicity: _____

		Right 對	Wrong 錯
Problem A7: **Big Bridge** 大橋			
Problem A8: **Tower** 塔			
Problem A9: **House** 房子			
Problem A10: **Smiley Face** 笑臉			
Problem A11: **Dog** 狗			
Problem A12: **Big Tower** 大塔			

B

Date: _____ Participant ID # _____

Child Gender: _____ Child Ethnicity: _____

5 Year Old
Block Assessment Task – Part 1
積木評估活動 – 第一部分

□ Balanced
□ English dominant
□ Cantonese dominant
□ Mandarin dominant

		Right 對	Wrong 錯
Sample Item : **Tower** 小塔			
Problem A1: **Rocket Ship** 火箭船			
Problem A2: **Long Bridge** 長橋			
Problem A3: **Big Tower** 大塔			
Problem A4: House 房子			
Problem A5: Dog 狗			
Problem A6: Tower 塔			

Date: _____ Participant ID # _____

Child Gender: _____ Child Ethnicity: _____

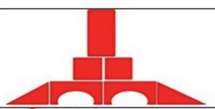
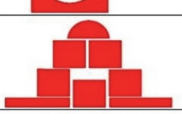
		Right 對	Wrong 錯
Problem A7: Big Tower 大塔			
Problem A8: Big Tower 大塔			
Problem A9: Small Castle 小城堡			
Problem A10: Big Tower 大塔			
Problem A11: Big Smile 大笑臉			
Problem A12: Big Tower 大塔			

FIGURE 1 | Block-building assessment scoring sheets at the **(A)** 4-year assessment, and **(B)** 5-year assessment.

be nice for you to join him/her while I go get some things done in the other room." We chose not to directly ask mothers to play with their children to reduce demand characteristics and to maximize variability. This low-demand situation was thought to better capture what might occur in a natural home environment.

Both sets of blocks were left on the table between mothers and children. Additionally, the scoring sheet that contained pictures of the test-specific constructions was left on the table. The experimenter then left the mother and child for 5 min with the camera recording. Mothers and their children were unaware that they were being video-recorded. After the 5-minute mother-child "break," the experimenter returned and continued with a different assessment.

Coding of Mother-Child Interactions

The video-recorded mother-child block construction break was coded using INTERACT Software (Mangold, 2015). Of the 5-minute break, 4 min were coded, starting when mother sat down next to the child. The full 5 min were not coded because dyads differed in the amount of time they took to settle down at the table. From videos, we coded the degree to which the mother or child led the block-building interactions; how much hands-on time child and mother spent building with the blocks; and mothers' verbal instruction around block building.

The degree to which mother or child led in the block building (termed *initiation*) was coded on a 5-point Likert scale (1 = Child initiates and engages in building >90% of the time; 2 = Child initiates and engages in building 70–90% of the time; 3 = Child and mother equally initiate building; 4 = Mother initiates and engages in building 70–90% of the time; 5 = Mother initiates and engages in building >90% of the time.). Coding of initiation yielded a single score for the interaction.

Children's and mothers' time spent block building were coded separately based on the total duration (in seconds) each person spent actively building. The onset of a block building bout was defined by touching and moving a block and ended when the child or mother stopped touching and moving a block. We further analyzed time spent building into two types of construction activities: test-specific construction and free-form construction. *Test-specific construction* was coded when mothers and/or children built a test item on the scoring sheet. Mothers and children were considered as building a test-specific item if they referred to the scoring sheet and built something that looked exactly like or similar to an item on the scoring sheet (mistakes were allowed). This included time spent disassembling the item after it was built. *Free-form construction* was coded when mothers and/or children built something with the blocks other than the test items. Mothers' *Verbal Instruction* on how to build with the blocks was coded using a time sampling approach. The block-building interaction was divided into 10-second intervals and coders marked each interval on whether mothers offered instructions around building to the child or not. Ten percent of videos were randomly selected and coded for inter-observer reliabilities. Kappa coefficients for measures ranged from 0.80 to 0.92.

RESULTS

Neither gender, preschool status, nor mother education related to mother or child block building. Therefore, models collapse across these variables.

Individual and Ethnic Differences in Children's Performance

Children's performance on block building at ages 4 and 5 years is displayed in **Figures 2A,B**. At both ages, children of all ethnicities varied substantially in their performance—ranging from 0 items correct to the maximum of 12 items correct.

To test ethnic differences in children's performance, we conducted a 4 (Ethnicity) × 2 (Child Age) MANOVA, with the total number of correct items at each age serving as dependent variables. As hypothesized, Chinese children exceeded Mexican, Dominican, and African American children (all p's < 0.05), as indicated by a main effect for Ethnicity, $F(3,163) = 23.41$, $p < 0.001$. This pattern maintained at both ages, although Mexican children outperformed African American children by age 5 years, $p = 0.022$. The Age × Ethnicity interaction was not significant, $F(3,163) = 0.97$, $p = 0.41$. Because difficulty of test items increased at the 5-year assessment, we did not examine age-related changes.

Individual and Ethnic Differences in Mother-Child Block-Building Activities

Initiation

At both ages, mothers and children were balanced in leading the block-building interaction, as seen in the normal distribution around the mid-point of the 5-point scale ($M = 3.18$, $SD = 1.05$ and $M = 3.20$, $SD = 1.12$ at 4- and 5-year assessments, respectively). At the 4-year assessment, 39.4% of parent-child dyads were balanced on initiation (scores of 3); children led sometimes or all the time in 23.1% of dyads (scores of 1 and 2); and mothers led sometimes or all the time in 37.5% of dyads (scores of 4 and 5). At the 5-year assessment, 34% of parent-child dyads showed balance, 25.6% had children leading all the time or sometimes, and the remaining 40.4% were characterized by mother leading. A 4 (Ethnicity) × 2 (Child Age) MANOVA indicated no ethnic or age differences, as seen in non-significant main effects of Ethnicity, $F(3,145) = 0.56$, $p = 0.65$, and Age, $F(1,145) = 0.002$, $p = 0.96$. The Ethnicity × Age interaction was also not significant, $F(3,145) = 1.06$, $p = 0.37$. Thus, distribution of initiation ratings replicated across age and the four ethnicities.

Mothers' Block Building

Mothers varied in the time they spent building with their children during the break, ranging from 0 to 204 s. A minority of mothers did not engage in any construction activities at the 4-year assessment (10.8%) and 5-year assessment (18.0%). **Figures 3A,B** display individual mothers' construction activities at the two child ages.

We tested ethnic differences in mothers' overall time in block building in a 4 (Ethnicity) × 2 (Child's Age) MANOVA. Counter to hypotheses, Chinese mothers spent significantly

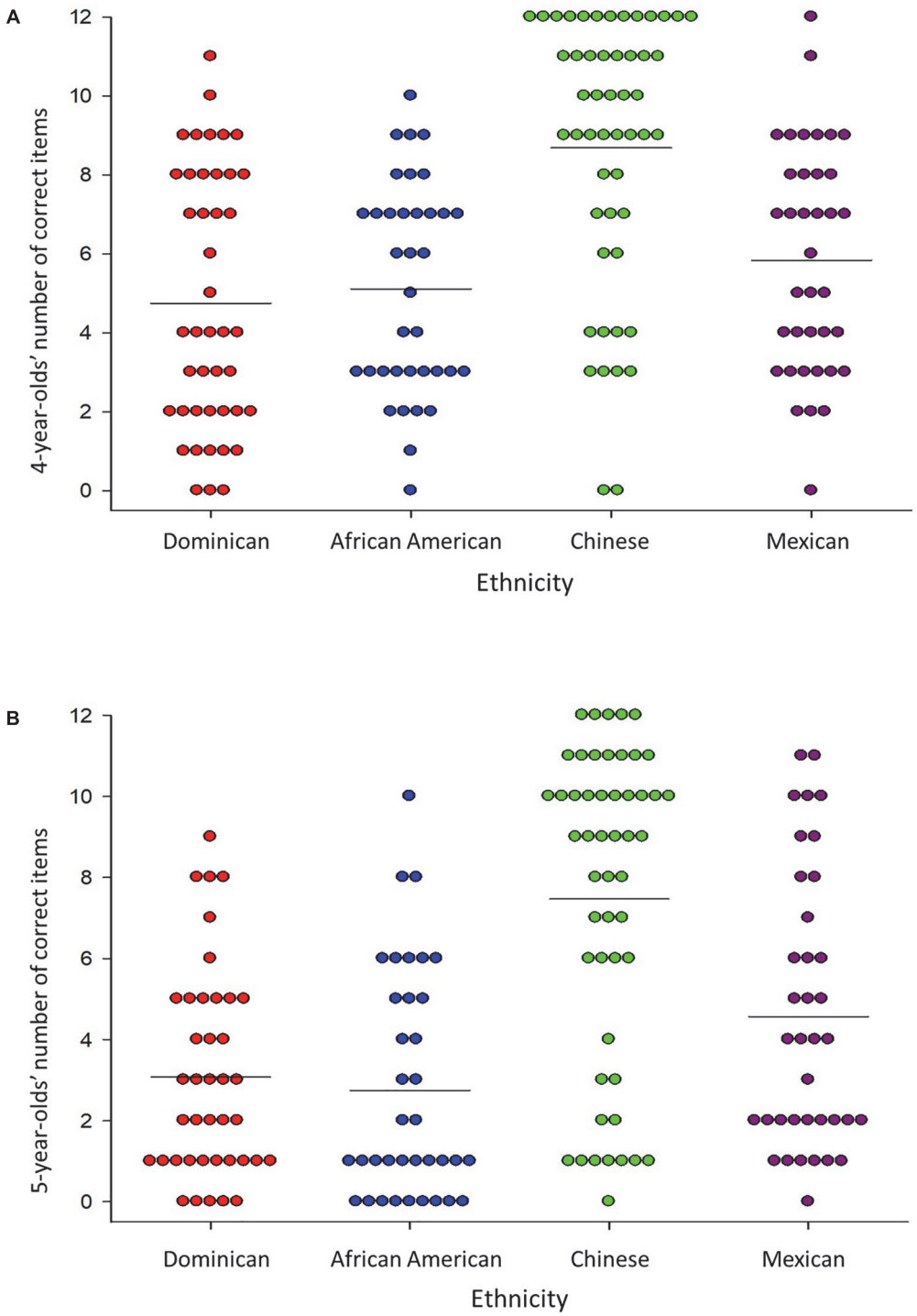


FIGURE 2 | Number of correct items for children from each ethnic group at the **(A)** 4-year assessment, and **(B)** 5-year assessment. Each dot represents a child, and horizontal lines denote averages.

less time building than did Dominican mothers collapsing across the two ages, as revealed in an Ethnicity main effect, $F(3,163) = 3.74$, $p = 0.012$. An Ethnicity × Age interaction, $F(3,163) = 2.67$, $p = 0.049$, revealed that when children were age 4, Chinese mothers spent less time building than all other mothers, p's < 0.02. However, when children were 5 years of age, Chinese mothers were the only group to increase time spent on building, and consequently no longer differed from the other mothers,

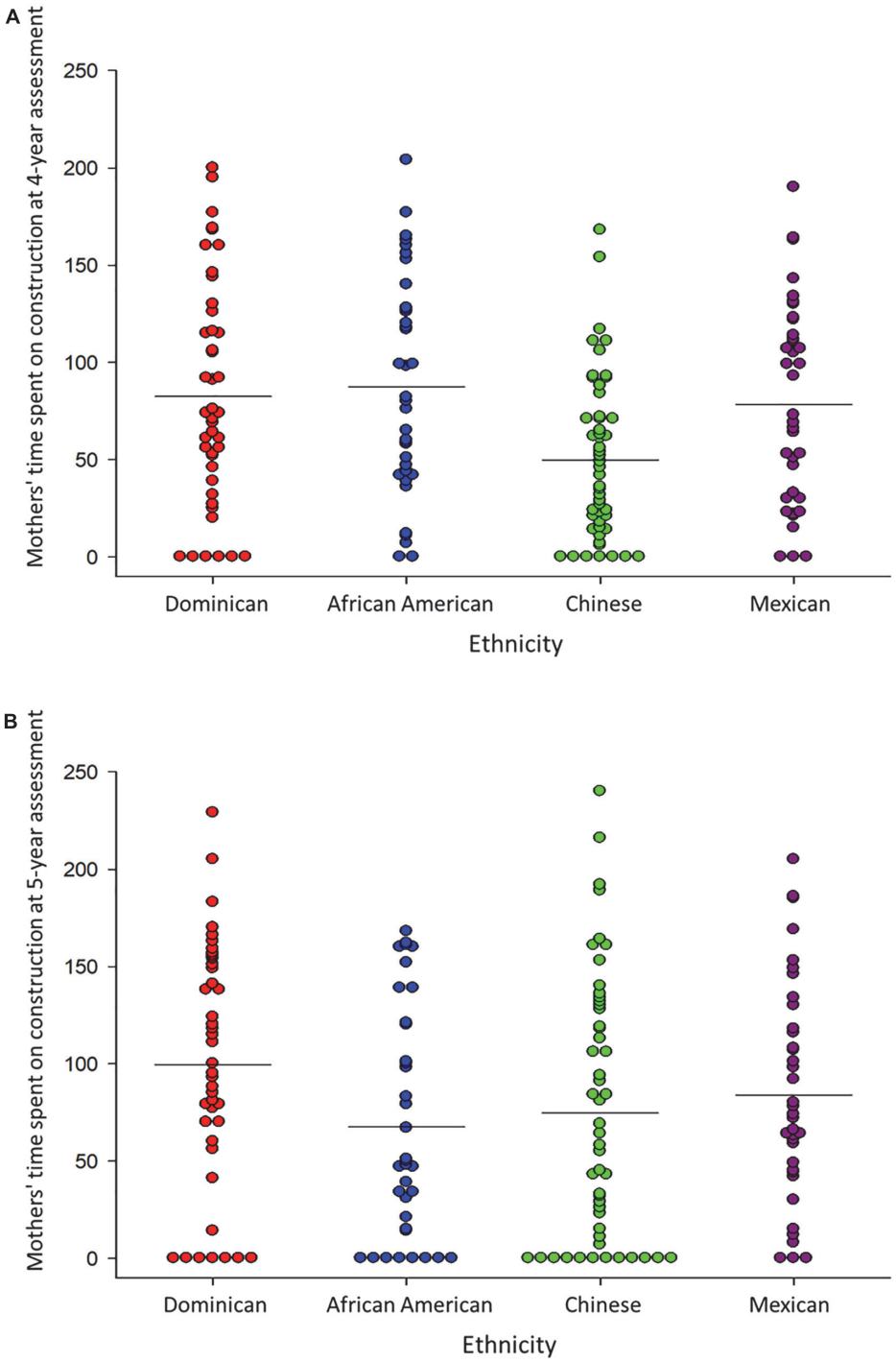


FIGURE 3 | Overall time spent on construction activities by mothers from each ethnic group at the **(A)** 4-year assessment, and **(B)** 5-year assessment. Each dot represents a mother, and horizontal lines denote averages.

p's > 0.05. African American mothers spent significantly less time than Dominican mothers in overall building when children were 5 years of age, $p = 0.024$.

Most centrally, we tested age and ethnic differences in the two types of mothers' construction activities in a 4 (Ethnicity) × 2 (Construction Type: test-specific vs. free-form) × 2 (Child's Age) MANOVA. Mothers spent more time on free-form construction than test-specific construction overall, $F(1,163) = 11.60$, $p = 0.001$. However, mothers of the 4 ethnicities differed in how they distributed time between the two construction types, as seen in

a Construction Type × Ethnicity interaction, $F(3,163) = 9.35$, $p < 0.001$. African American and Dominican mothers spent more time building free-form structures than test-specific structures, p's < 0.001, and spent more time on free-form construction than Mexican and Chinese mothers collapsing across the two ages, p's < 0.01, although African American mothers decreased their time on free-form construction over child age, $p = 0.021$.

In contrast, Mexican mothers spent more time building test-specific structures than free-form structures, $p = 0.05$, and exceeded mothers of the other ethnicities on this type of construction, all p's < 0.01. Further, Mexican mothers increased their time spent on test-specific structures between the two ages, $p = 0.009$. Like Mexican mothers, Chinese mothers engaged in more test-specific structures than free-form structures with their 4-year-olds; although, they built more free-form structures when children were 5 years of age, $p = 0.032$. Ethnic differences in patterns of change were confirmed in a 3-way Ethnicity × Construction Type × Child Age interaction, $F(3,163) = 4.31$, $p = 0.006$.

Children's Block Building

Figures 4A,B display individual children's construction activities at the two ages. Children, varied dramatically in their time spent building, ranging from 0 to 240 s.

Ethnic differences in children's overall construction was tested in a 4 (Ethnicity) × 2 (Child's Age) MANOVA. Children of the four ethnic groups marginally differed in their overall block building across both ages, $F(3,163) = 2.59$, $p = 0.055$. Overall, African American children spent significantly less time building than did Dominican and Chinese children, and Mexican children spent less time building than did Chinese children, all p's < 0.05. An Ethnicity × Age interaction, $F(3,163) = 3.02$, $p = 0.032$, revealed that although ethnic differences were not seen at the 4-year assessment, $F(3,163) = 0.71$, $p = 0.55$, ethnic differences emerged by the 5-year assessment, $F(3,163) = 4.94$, $p = 0.003$. Like their mothers, Chinese children were the only group to increase time spent on block building between the two ages, $p = 0.005$.

We further tested age and ethnic differences in the two types of children's constructions in a 4 (Ethnicity) × 2 (Construction Type) × 2 (Child's Age) MANOVA. Paralleling the behaviors of mothers, children spent more time building free-form structures than test-specific structures overall, $F(1,163) = 34.07$, $p < 0.001$, but increased in test-specific structures between the two ages, Age × Construction Type, $F(1,163) = 7.06$, $p = 0.009$.

Children of the four ethnicities differed in how they distributed their time across the two construction types, with patterns mirroring those seen in mothers, as revealed by a 2-way Construction Type × Ethnicity interaction, $F(3,163) = 11.43$, $p < 0.001$. Like their mothers, Mexican (p's < 0.01) and Chinese children (p's < 0.05) spent more time building test-specific structures compared to Dominican and African American children, and Mexican children specifically spent more time on test-specific structures than free-form structures overall, p's < 0.01. Reciprocally, Dominican children spent more time building free-form structures than Mexican and Chinese children, p's < 0.05, but did not differ from African American children on this type of construction. The 3-way interaction was not significant, $F(3,163) = 1.09$, $p = 0.354$.

Mothers' Verbal Instructions

Mothers varied in how often they verbally instructed children around block building, ranging from 0 to 24 intervals ($M = 3.06$, $SD = 4.12$ and $M = 4.10$, $SD = 5.98$, at 4- and 5-year assessments, respectively). Ethnic differences in mothers' instruction was tested in a 4 (Ethnicity) × 2 (Child's Age) MANOVA. Mothers of the four ethnic groups differed on their instruction, as seen by a main effect of Ethnicity, $F(3,163) = 30.32$, $p < 0.001$. Again, counter to hypotheses, Chinese mothers provided *less instruction* to their children ($M = 0.91$, $SE = 0.46$) than did Dominican ($M = 4.22$, $SE = 0.50$) and Mexican ($M = 7.45$, $SE = 0.54$) mothers when collapsing across ages, p's < 0.001, and marginally less instruction than African American mothers ($M = 2.63$, $SE = 0.54$), $p = 0.10$.

Mexican mothers provided their children with the *most instruction* compared to African American, Dominican, and Chinese mothers, p's < 0.001. Furthermore, an Ethnicity × Age interaction, $F(3,163) = 6.96$, $p < 0.001$, revealed that Mexican mothers were the only group to significantly increase their instruction to children from the 4-year assessment ($M = 4.97$, $SD = 4.96$) to the 5-year assessment ($M = 9.92$, $SD = 7.84$), $p < 0.001$. The increase in Mexican mothers' instruction was confirmed in a main effect of Age, $F(1,163) = 6.88$, $p = 0.01$.

Mother-Child Associations During Block Building

We next examined associations between mothers' and children's behaviors during block building, with focus on initiation, instruction, and the two forms of block building (test-specific and free-form structures).

Initiation and Child Block Building

At the 4-year assessment, high initiation, representing mothers leading the block-building interaction, did not relate to children's time spent on test-specific construction, $r = 0.13$, $p = 0.10$, or free-form construction, $r = -0.076$, $p = 0.34$. However, when associations between initiation and children's building were investigated by ethnicity, initiation related to children's time spent building test-specific items for Dominican, $r = 0.35$, $p = 0.028$ and African American children, $r = 0.53$, $p = 0.001$, at the 4-year assessment. At the 5-year assessment, mothers' initiation of block building related to children's time spent building test-specific structures, $r = 0.17$, $p = 0.039$, and negatively related to children's time spent building free-form structures, $r = -0.21$, $p = 0.01$. However, both associations were only seen in Chinese dyads, $r = 0.52$, $p < 0.001$, and $r = -0.44$, $p = 0.002$.

Mother Construction Type and Child Construction Type

As hypothesized, mothers' and children's block-building activities correlated in specific ways at both ages. Mothers' time spent building free-form structures related to children's time spent building free-form structures at the 4-year assessment, $r = 0.52$, $p < 0.001$, and 5-year assessment, $r = 0.65$, $p < 0.001$.

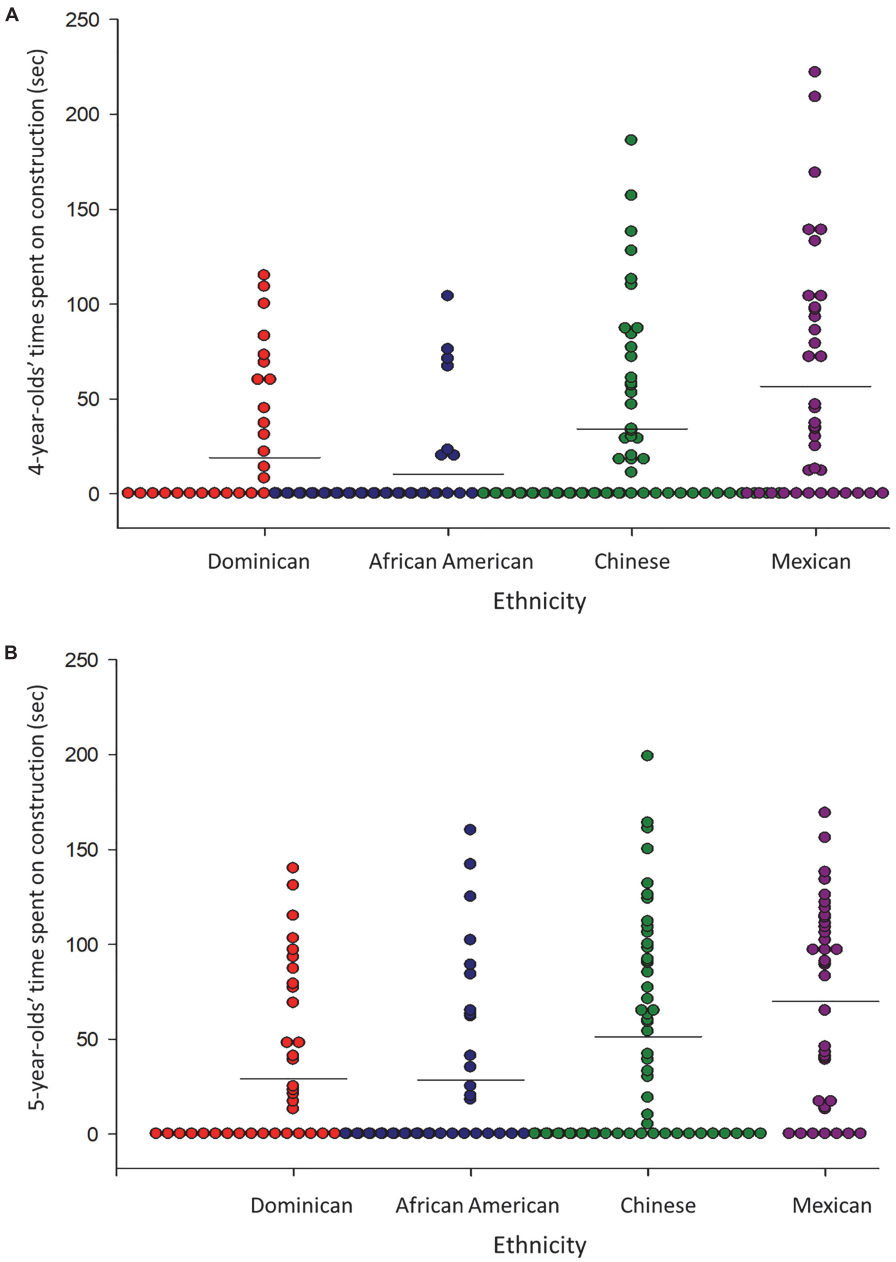


FIGURE 4 | Overall time spent on construction activities by children from each ethnic group at the **(A)** 4-year assessment, and **(B)** 5-year assessment. Each dot represents a child, and horizontal lines denote averages.

Similarly, mothers' time spent building test-specific structures related to children's time building test-specific structures at the 4-year assessment, $r = 0.57$, $p < 0.001$, and the 5-year assessment, $r = 0.56$, $p < 0.001$. Associations were consistent and significant across all four ethnicities. At both assessments, mothers' time spent building free-form structures related inversely to children's time spent building test-specific structures, just as mothers' time spent building test-specific structures related inversely to children's time spent building free-form structures.

Instruction and Child Block Building

Instruction by mothers related to children's time spent building test-specific structures at the 4-year assessment, $r = 0.34$, $p < 0.001$. This association was seen across Dominican children, $r = 0.46$, $p = 0.002$, African American children, $r = 0.43$, $p = 0.009$, Chinese children, $r = 0.35$, $p = 0.01$, and Mexican children (marginally), $r = 0.29$, $p = 0.08$. Similarly, at the 5-year assessment, Instruction related to children's time spent building test-specific structures, $r = 0.39$, $p < 0.001$. This association again maintained across Dominican children, $r = 0.49$, $p = 0.001$,

African American children, $r = 0.62$, $p < 0.001$, and Mexican children, $r = 0.39$, $p = 0.018$, and Chinese children (marginally), $r = 0.26$, $p = 0.069$.

Associations Between Block-Building Interactions and Child Performance

Regressions next tested associations between the independent variables of mothers' initiation, instruction, test-specific construction, and free-form construction in relation to children's performance during the independent block-building assessment at each assessment age (**Table 1**). Ethnicity variables (with Chinese as referent group) were included in each model. The independent variables explained 26.3% of the variance in children's block-building performance at the 4-year assessment, $R^2 = 26.3$, $F(7,152) = 7.76$, $p < 0.001$. African American, Dominican, and Mexican ethnicity status negatively related to children's block-building performance compared to the Chinese reference group, $B = -0.34$ to -0.43, p's < 0.001. Furthermore, mothers' time spent building test-specific structures related positively with children's block-building performance when holding other independent variables constant, $B = 0.17$, $p = 0.038$. In contrast, neither initiation, $B = -0.11$, $p = 0.16$, nor mother's instruction, $B = -0.13$, $p = 0.13$, related to child performance. For the 5-year assessment, independent variables accounted for 24.2% of the variance in children's block-building performance, $R^2 = 24.2$, $F(7,148) = 6.76$, $p < 0.001$. Ethnicity variables were significant for the African American group, $B = -0.46$, $p < 0.001$, and Dominican group, $B = -0.37$, $p < 0.001$ (but not Mexican, $B = -0.19$, $p = 0.067$), relative to the Chinese referent group at the 5-year assessment. By the 5-year assessment, mother's time spent building test-specific structures no longer related to children's performance, $B = 0.023$, $p = 0.78$, nor did initiation or instruction.

DISCUSSION

Informal opportunities to play with blocks arm children with spatial-cognitive skills that are foundational to school readiness. Ethnic differences in children's block-building performance were already seen when children were 4 and 5 years of age; mothers' and children's block-building behaviors corresponded in highly specific ways; and mothers' and children's block building differed by ethnicity, with U.S. Chinese and Mexican dyads, the most recent immigrant groups, being more likely to emphasize task-specific construction than free-form construction compared to U.S. Dominican and African American dyads.

A first aim was to test ethnic differences in children's spatial skills based on a block-building assessment. Block building offers children opportunities to manipulate object relations, and has been shown to support later STEM performance in math cognition (Verdine et al., 2017). Chinese children showed higher performance relative to other children even before beginning formal schooling, a finding that mirrors the Asian advantage in early math skill prior to school entry (Sonnenschein and Sun, 2017), and extends work to an informal, yet cognitively important activity in early childhood—building 3D block constructions. Still, within-group variation was striking, with children in every ethnic group ranging from failing most items to mastering the entire set of items. Thus, attention to within-group heterogeneity is critical to any investigation of cultural differences.

When examining mothers' and children's block-building interactions, dyads of the four ethnicities did not differ in terms of who initiated and led the block building, although they differed on how mothers and children distributed their time between building task-specific and free-form structures. Mexican and Chinese mothers built more test-specific structures than other mothers, whereas African American and Dominican mothers built more free-form structures. These recent immigrant mothers may have spent relatively more time on test-specific construction because of Mexican mothers' high endorsement of children's achievement (Suizzo, 2007) and belief that children learn by following parents' directions (Keels, 2009), and Chinese mothers' emphasis on teaching (Huntsinger and Jose, 2009) and view of themselves as active facilitators of children's learning (Sonnenschein et al., 2018). In contrast, the 3+ generation African American mothers and longer-resident U.S. Dominican mothers may have favored free-form construction because of acculturation to cultural messages around the importance of children's choice in play and sense of agency (Keller, 2003), and avoidance of drill and practice-oriented teaching methods (Huntsinger and Jose, 2009).

However, Mexican and Chinese mothers diverged in their use of instruction around block building. Although Mexican immigrant mothers used high instruction with their children, Chinese immigrant mothers did not, perhaps because Chinese children already demonstrated high proficiency on block building and needed little further support. In fact, by the time children were 5 years of age, Chinese mothers pulled back from their initially high emphasis on building test-specific structures to building free-form structures with their children, whereas Mexican mothers remained relatively high on test-specific constructions.

A final question concerned whether and how mother-child block building interactions relate to children's block-building performance. When investigating associations between mother and child block-building behaviors and children's block-building performance at an *individual* level, beyond ethnicity, mothers' time spent building test-specific items related to children's block-building performance at the 4-year assessment specifically, whereas verbal instruction and initiation did not. The association between mothers' task-specific construction and children's performance suggests that visually-perceptible, hands-on-guidance by adults may aid children's block-building skill and understanding of spatial relations more than verbal instruction at young ages. Indeed, how people use their bodies and hands reflects what the mind is doing (Kita et al., 2017); draws children's attention to where to look and how to act (Zukow-Goldring and Arbib, 2007); and plays a functional role in spatial and mathematical cognition specifically (Hostetter and Alibali, 2019).

Notably, this research contains limitations that suggest promising avenues for future inquiry. First, children's block-building performance for each test item was coded as correct or incorrect, with no attention to how close children came

TABLE 1 | Summary of Multiple Linear Regressions Analyses for Variables Predicting Children's Performance.

	4 years of age (n = 160)			5 years of age (n = 156)		
Variable	***B***	***SE B***	β	***B***	***SE B***	β
Constant	9.45	0.87	–	7.88	0.97	–
Dummy coding of the African American group	−2.92	0.73	−0.35***	−4.36	0.79	−0.46***
Dummy coding of the Dominican group	−3.32	0.70	−0.41***	−3.21	0.78	−0.37***
Dummy coding of the Mexican group	−2.51	0.73	−0.30***	−1.74	0.94	−0.19†
Mother building test-specific items	0.02	0.01	0.17***	0.00	0.01	0.02
Mother building free-form items	−0.00	0.01	−0.05*	−0.00	0.01	−0.05
Verbal Instructions	−0.11	0.07	−0.13	−0.11	0.06	−0.17†
Initiation	−0.36	0.25	−0.11	−0.12	0.25	−0.04
R^2		0.26			0.24	
F		7.76***			6.76***	

*$p < 0.05$; ***$p < 0.001$; †$p < 0.10$.

to succeeding and which types of spatial errors led to failure. Attention to the real-time unfolding of children's strategies as they work through spatial problems will help inform educational curricula and guide interventions in informal settings such as the home environment.

Second, the session was brief and focused on only one aspect of parent support—mothers' verbal and physical behaviors during block building in a lab setting. Whether and how parental support for spatial learning manifests in the day-to-day lives of young children remains open to investigation. Indeed, parents' everyday spatial talk at home (such as naming shapes and referring to spatial dimensions and features), relates to children's abilities to identify spatial relations in images and mentally transform shapes (Pruden et al., 2011). Furthermore, many factors contribute to what and how parents interact with their children around spatial activities, including parents' skills, beliefs, anxieties, and so forth.

Third, findings may not generalize to other U. S. Chinese, Mexican, Dominican or African American samples or to populations studied by other researchers. For example, the current sample of recent immigrant Chinese mothers averaged fewer than 11 years of education, which might also explain their lower than expected rates of verbal instruction to children. We are currently expanding focus to children's spatial skills and everyday experiences around spatial toy play, home literacy, and home numeracy activities as potential contributors to children's spatial cognitive skills. Additionally, differences in the lexical and grammatical structures of home languages, which varyingly highlight spatial features, relations, and motions (e.g., Choi and Bowerman, 1991; Choi et al., 1999), may contribute to ethnic differences in children's spatial skills.

The current study provides a first step toward unpacking the potential sources of ethnic and individual differences in children's early STEM-related experiences and performance. Efforts to educate parents and teachers about the cognitive benefits of block building may go a long way in supporting children's early spatial skills and thus promoting their math and science understanding. Indeed, play with blocks is compatible with learning rather than a distraction from learning. Elucidating the home environment factors that relate to children's spatial cognition will help inform parents, educators, and policymakers about ways to support the building blocks for STEM learning in U.S. children from different ethnic, racial, and socioeconomic backgrounds.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the University Committee on Activities Involving Human Subjects of New York University with written informed consent from all participants. The protocol was approved by the University Committee on Activities Involving Human Subjects of New York University.

AUTHOR CONTRIBUTIONS

EL coordinated the data collection. EL and DS contributed equally to the data analysis. EL led preparation of figures. DS led preparation of the draft of the manuscript. FN aided in the conceptualization, measurement, and design of the study. CT-L supervised the work, provided critical feedback to shape the research design and analysis, and contributed to manuscript writing and revision. All authors read and approved the final manuscript.

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Socio-Emotional Concern Dynamics in a Model of Real-Time Dyadic Interaction: Parent-Child Play in Autism

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We used a validated agent-based model—Socio-Emotional CONcern DynamicS (SECONDS)—to model real-time playful interaction between a child diagnosed with Autism Spectrum Disorders (ASD) and its parent. SECONDS provides a real-time (second-by-second) virtual environment that could be used for clinical trials and testing process-oriented explanations of ASD symptomatology. We conducted numerical experiments with SECONDS (1) for internal model validation comparing two parental behavioral strategies for stimulating social development in ASD (play-centered vs. initiative-centered) and (2) for empirical case-based model validation. We compared 2,000 simulated play sessions of two particular dyads with (second-by-second) time-series observations within 29 play sessions of a real parent-child dyad with ASD on six variables related to maintaining and initiating play. Overall, both simulated dyads provided a better fit to the observed dyad than reference null distributions. Given the idiosyncratic behaviors expected in ASD, the observed correspondence is non-trivial. Our results demonstrate the applicability of SECONDS to parent-child dyads in ASD. In the future, SECONDS could help design interventions for parental care in ASD.

Keywords: autism, dyadic play, social skills, play initiation, child-parent, dynamical model, complexity

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1. INTRODUCTION

> *"(...) if you give a man a fish he is hungry again in an hour. If you teach him to catch a fish you do him a good turn."*
>
> Mrs. Dymond, by Ritchie (1885, p.342)

Children who are suffering from moderate to severe forms of Autism Spectrum Disorders (ASD) are oftentimes caught in a vicious circle: their difficulties acquiring social skills deprive them of further opportunities to develop these skills. Over the past few decades, many researchers have aimed to increase therapeutic benefits for these children (for a review, see Walton and Ingersoll, 2013). The question remains how to approach the complications that arise in real-time social interactions between children with ASD and their surroundings and how to minimize cumulative negative effects on social development. ASD is a class of neurodevelopmental disorders where

children typically experience socio-emotional difficulties when interacting and communicating with others (American Psychiatric Association, 2013; Yenkoyan et al., 2017; Sharma et al., 2018; Wadsworth et al., 2018). The common approach of linear modeling cannot capture the reciprocal and iterative causal influences characteristic of these ongoing interactions—including those between a child and its caregiver. A growing number of researchers advocate the application of non-linear dynamics ("the complexity approach") to social and developmental psychology (e.g., Schlesinger and Parisi, 2001; Smith and Conrey, 2007; van Geert, 2011). In particular, agent-based models have been successfully employed to translate psychological theory into specific mechanisms of action for the agents in question. These models can be directly compared with the target system to directly test their plausibility (as we do in section 2.5; for a review on agent-based-model validation, see Gräbner, 2018). As such, agent-based modeling is a crucial tool that connects psychological theories to complex real-life examples. This research allows us to demonstrate how dynamical interactions between a child and its caregiver help to understand the idiosyncratic phenomenology associated with ASD (Waterhouse, 2013; Vivanti et al., 2014; Byrge et al., 2015; Hahamy et al., 2015).

A detailed understanding of the dynamics involved in social interactions of children with ASD is necessary for designing therapeutic interventions that foster their social development. Since a predominant component of a child's social interactions involves their caregivers, this relationship warrants special attention. We need to empower caregivers of children with ASD to engage these children in ways that work effectively toward key developmental milestones. By taking into account idiosyncratic and atypical socio-emotional functioning (Vivanti et al., 2014; Hahamy et al., 2015), we can provide caregivers with instructions that are carefully tailored to their particular child. The saying referenced above highlights the cumulative and non-linear nature of social impairments in children with ASD and—by extension—the clinical relevance of our complexity-oriented research. Of course, the experience of playing together ("give a man a fish") is valuable in itself for the development of social skills inherent in play. It is known to have therapeutic effects on children with ASD (see the evidence summarized by Hull, 2015). However, it is also necessary for a child to learn how to initiate play ("teach him how to catch a fish"). Social initiation has been shown to be a pivotal response class for children with autism (Koegel and Koegel, 2006): improvement on this skill results in measurable overall improvements of the child's development. Unfortunately, a caregiver who always takes the initiative to play together will deprive their child from opportunities to practice play initiation. Balancing these two learning goals (playing together and play initiation) will therefore be a recurring theme throughout this article.

In sum, we adopt the complexity approach as we construct an agent-based model of parent-child play in the case of a child with severe ASD. Our primary goal is to translate psychological theory to empirical and clinical work in ASD, by modeling the micro-dynamics of dyadic playful interaction.

1.1. A Complexity-Based Approach to Developmental Psychology

"The whole is other than the sum of its parts."

Koffka (1999, p.176)

Over the last few decades, complexity-based approaches have become increasingly prevalent in social and developmental psychology (Thelen and Smith, 1994; Schlesinger and Parisi, 2001; Smith and Conrey, 2007; Spencer et al., 2011; van Geert, 2011). This research has focused on the ways in which socio-emotional developmental trajectories emerge from interactions between components: a child and its social environment. Through self-organization, such a dynamical system can exhibit behaviors that are not reducible to any of its sub-systems—the child, its parents, siblings, et cetera. If we focus on one of these sub-systems—for example, the child—we find that its socio-emotional functioning in turn relies on interactions between sub-personal components, such as socio-emotional concerns, drives, and appraisals. Looking at child development from this perspective demonstrates the futility of the nature-vs.-nurture debate. The complexity perspective allows us to model the ongoing transactional effects of nature on nurture and vice versa. A number of recent analyses (e.g., Kunnen et al., 2012) addressed the interconnectedness between different levels under study in emotional development (internal, individual, dyadic, and group-wide) on various timescales associated with perception, learning, and development. While the behavior of children inherently depends on their social context, it tends to be treated merely as a set of additional variables by mainstream statistical analyses in developmental psychology. In contrast, dynamic systems approaches place a stronger emphasis on the reciprocal dependency between the child and other social components of the system (such as another child or parent). In this way, agent-based models have been successfully employed to characterize emergent behaviors (see Gräbner, 2018, for a recent review).

When modeling the time course of processes occurring within and between individuals, dynamic treatments outperform more common approaches that focus on statistical relationships between population-based, inter-individual distributions of two or more variables. The standard practice of psychology involves using statistical models to explain inter-individual variability (even when applied to time-series of individuals) and derive conclusions about individuals, which are treated as specific cases of the general models. Group-to-individual generalizations are only appropriate if data on individuals (over time) asymptotically follow the same distribution as data across individuals in the population (at any point in time). For more in-depth discussions on the statistical assumption of *ergodicity*, we refer to Molenaar (2004), Valsiner et al. (2009), and Toomela and Valsiner (2010). According to large swathes of empirical and theoretical work, this assumption is invalid for most measurable variables of psychological processes occurring within and between individuals (see, e.g. Molenaar, 2004; Kelderman and Molenaar, 2007; Molenaar and Campbell, 2009; Hamaker, 2012; Koopmans, 2015; Beltz et al., 2016; Hamaker and Wichers,

2017; Fisher et al., 2018). In fact, group statistics rarely represent individual cases and processes (a misconception also referred to as the ecological fallacy). For example, the average visiting frequencies at theme and amusement parks are structurally different from the visiting frequencies of individual visitors and families, as the latter are governed by idiosyncratic preferences[1]. Sample-based statistics are therefore likely to occlude interaction processes in parent-child dyads, especially given the idiosyncrasy of ASD (e.g., Vivanti et al., 2014; Hahamy et al., 2015). In contrast, agent-based models focus on the reciprocal causal relationships that characterize processes within a particular child and its environment, both on the short-term (e.g., real-time interactions) and on the long-term (e.g., development). The interaction across time scales is an important direction for future research, because it allows for modeling long-term therapeutic outcomes based on specific parental strategies on the time scale of individual sessions.

1.2. A Matter of SECONDS: Agent-Based Modeling of Socio-Emotional Concern Dynamics

A logical starting point for understanding social interaction is that of the dyad. We employed a validated agent-based model of socio-emotional concern dynamics, which has been developed and successfully applied to several kinds of dyads (e.g., child-peer play and student-teacher coupling; Steenbeek and van Geert, 2005, 2008, 2013; Schuhmacher et al., 2014). For future reference, and with consent from the original authors of this model (the co-authors on this paper), we give this agent-based model the acronym *SECONDS* (Socio-Emotional CONcern DynamicS). Steenbeek and van Geert (2013) have used it to model dynamical scaffolding in teacher-student dyads in order to help develop teaching strategies for finding the optimal "scaffolding distance" of learning (i.e., the difference in difficulty level between the teacher's explanation and the current level of understanding of the child). SECONDS involves dynamic, iterative relationships between socio-emotional concerns, drives, appraisals, and behaviors of each member of the dyad.

As implied by its acronym, SECONDS generates real-time interaction data on timescales of seconds. It has been shown to produce plausible real-time data of playful dyadic interaction between children (Steenbeek and van Geert, 2005, 2008; Steenbeek et al., 2014). To our knowledge, there are no applied alternatives available for this type of dyadic interaction other than SECONDS. Besides observational validation, the plausibility of agent-based models like SECONDS also hinges on the theoretical considerations motivating the constituent components and their connections. The methodological considerations underlying the validation of dynamical models forms a recurrent theme throughout this article. The criteria for model validation in process-oriented dynamical modeling approaches differ significantly from those of standardized statistical methods and verbal theorizing typical in the field of developmental psychology. Given that our core goal in conducting this research has been to translate from theory to practice, the concept of plausible representation and other methodological concepts associated with model-validation in dynamic systems modeling are unpacked in sections 2 and 4, with a special focus on our particular application in developmental psychology.

Previous empirical validation of SECONDS involved the context of child play between peers and the interaction between a teacher and a child in an instructional setting. In principle, it can be adjusted to model impaired socio-emotional capacities, with potential applications for the design of therapeutic interventions. With this translational research, we aimed to explore this possibility, theoretically and empirically. We therefore extended SECONDS to playful interaction between a parent and a child with ASD.

2. MATERIALS AND METHODS

2.1. SECONDS: An Agent-Based Model of Dyadic Interaction

As an agent-based model, SECONDS (Steenbeek and van Geert, 2005, 2008) entails a model of agency. Gräbner (2018) provides a recent and comprehensive review of the methodology of agent-based models and their empirical validation. Such models focus on the mechanism of action, where a mechanism is defined as a system of connected components. SECONDS specifies the components and connections necessary to describe how an agent influences itself and how agents influence one another, as primarily inspired by the emotion theory proposed by Frijda (1986). It characterizes agency as an interaction between socio-emotional concerns, drives, appraisals, and behaviors of each agent. Together, these components and their interactions generate an emergent sequence of events (i.e., a discontinuous time series). Direct relationships between these components define second-to-second interactions while influences across the session are incorporated via a memory component. We introduce SECONDS by describing the influences within an agent ($Self \Rightarrow Self$), between agents ($Self \Rightarrow Other$), and emergent influences ($Self \Leftrightarrow Other$), as shown in **Figure 1**. In this context, we refer to the agent as an child or a parent, but in principle SECONDS applies to any agent whose mechanism of activity depends on socio-emotional concerns. In **Table 1**, we also provide a technical summary of SECONDS that highlights the relevant parameters (a_{1-9}). The size of time steps was set to be four seconds, corresponding with the observational resolution of the coding system. Where applicable, we also added footnotes concerning associated concepts in dynamic systems theory.

2.1.1. Influencing Oneself

Agency involves specific goals or motives, which can be derived from the *concerns*[2] of an agent combined with its context. The

[1] Alternatively, we can illustrate how group statistics occlude crucial information on individual events with the following silly parable: "A man tries to shoot a pigeon, but he hits a tree to the left instead. After a while, the bird returns to its favorite branch, but the man's second shot veers off to the right. After concluding that the bird must be dead on average, the man returns home satisfied." The point of this parable is that central tendencies, with the average taken as typical example, can lead to paradoxical or meaningless conclusions when applied to temporal variability, i.e., to processes.

[2] Concerns specify the system's attractor states, toward which it tends to gravitate.

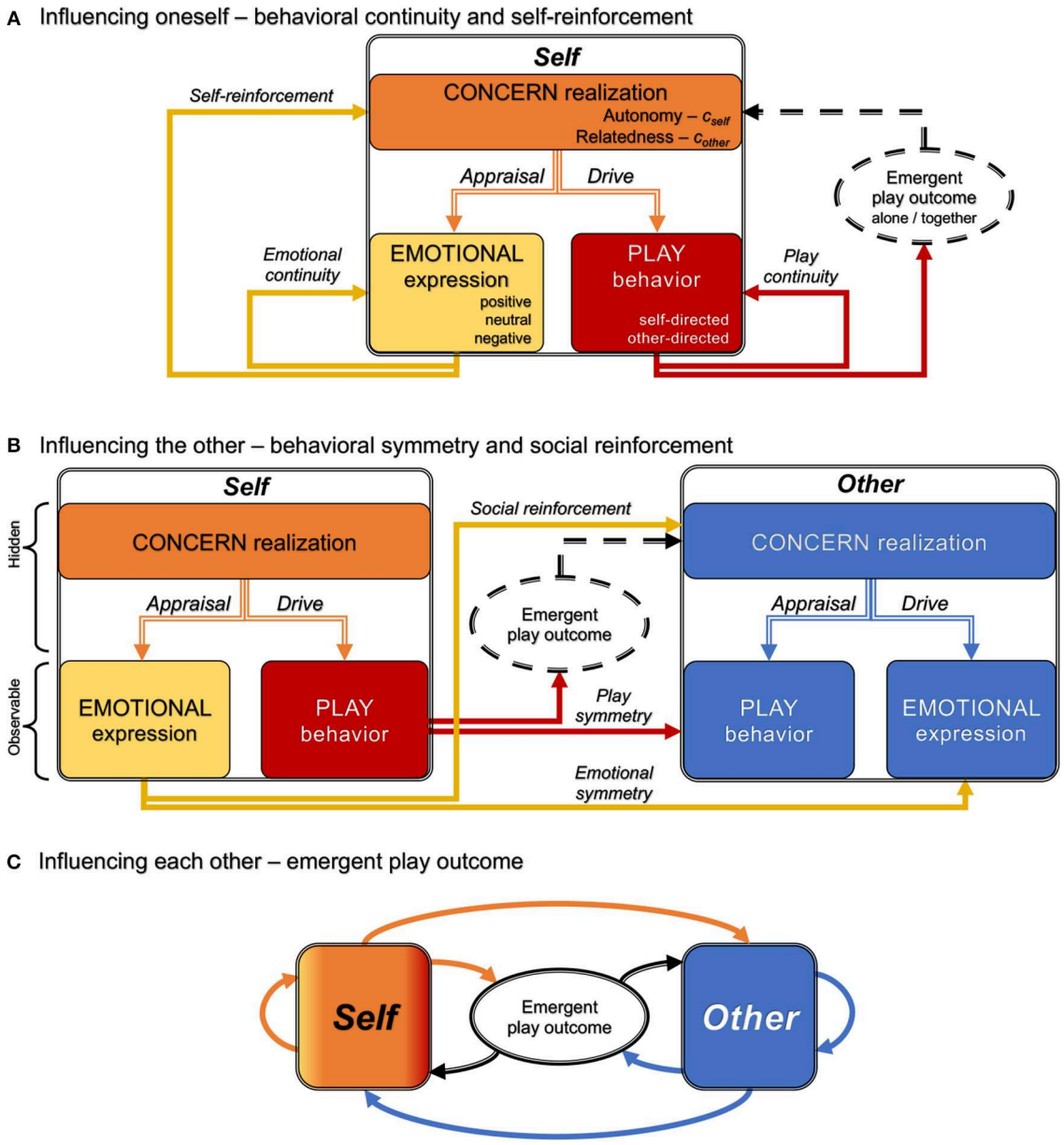

FIGURE 1 | These panels illustrate Socio-emotional Concern Dynamics (SECONDS) from the perspective of one agent (*Self*) in playful interaction with another agent (*Other*). For clarity, we first decompose SECONDS into influences of the agent on itself (*Self* ⇒ *Self*) in **(A)**, and on the other agent (*Self* ⇒ *Other*) in **(B)**. Finally, in **(C)**, we illustrate the full model of how their mutual influences give rise to the emergent play outcome (*Self* ⇔ *Other*). **(A)** The agent monitors the realization of its socio-emotional concerns of autonomy and relatedness (c_{self}, c_{other}; orange box). The degree of realization of the agent's concerns produces corresponding appraisals and drives, which influence its emotional expressions (positive, neutral, or negative; yellow box) and play behaviors (self- or other-directed; red box), respectively. Emotional expressions tend to persist into the future (emotional continuity) and to modify the agent's own concerns (self-reinforcement). Play behaviors also tend to persist into the future (play continuity) and contribute to playing alone or together in the emergent play outcome (dashed ellipse), thus impacting the agent's concern realization (dashed black arrow). **(B)** We emphasize a crucial distinction between external active states, which are observable to the other (*Other*; blue), and internal states of the agent, which are hidden from the other. Emotional expressions tend to be mirrored by the other (emotional symmetry) and modify the other's concerns (social reinforcement). Play behaviors tend to be mirrored by the other (play symmetry) and contribute to the emergent play outcome (dashed ellipse), thus impacting the other agent's concern realization (dashed black arrow). **(C)** The full picture of how the recurrent play dynamics between *Self* (left; orange box and arrows) and *Other* (right; blue box and arrows) give rise to the emergent play outcome (middle; solid black ellipse and arrows). In panel c, the emergent play outcome is fully specified (indicated with solid lines), while it is only partially specified in panels a and b (indicated with dashed lines). See **Table 1** for a more technical summary of SECONDS.

current implementation of SECONDS focuses on the tension between socio-emotional concerns of relatedness vs. autonomy. In the work of Frijda (1986), the relatedness concern pertains to "identity striving" which entails a focus on closeness and connectedness. In SECONDS, initial concerns are represented by parameters that indicate to which extent the child experiences relatedness and autonomy (c_{other}, c_{self}) as rewarding. Together with a specific context such as dyadic play, concerns specify which immediate actions are relevant: self- or other-directed *play behavior*[3]. For a child in such a dyad, self-directed play is mostly relevant to its autonomy concern and other-directed play to its relatedness concern. Since these are (approximately) mutually exclusive, the concerns in effect define the proportion between these behaviors that is experienced as optimally rewarding by the child (i.e., $c_{other} + c_{self} = 1.00$)[4]. While concerns are relatively stable characteristics of a child (i.e., initial conditions for each simulated interaction), they are also influenced by real-time changes in the emotional content of an interaction through self- and social reinforcement (parameters a_1, a_2 in **Table 1**; explained below). As for the initial values of these concerns in the context of dyadic play, typically developing children have been found to be more concerned with relatedness than with autonomy ($c_{other} \approx 0.70$, $c_{self} \approx 0.30$; Steenbeek and van Geert, 2005, 2008).

Aiming for an optimally rewarding balance, the child infers the extent to which its socio-emotional concerns are currently being met or realized (see **Figure 1A**). *Concern realization* is the perceived match between outcomes in the current session (salient in memory) and preferred session outcomes (set by the child's concerns)[5]. The sensitivity of concern realization is modulated by a_3 – it effectively summarizes the situation from the perspective of the child: "how am I doing?" The child's reactions to that evaluation consist of behavioral *drives* and *emotional appraisals*, respectively (a_4, a_7 in **Table 1**)[6]. If a child infers its preferred outcomes are being realized, no additional drive is required and positive emotional appraisal results. If a child infers a departure from its preferred outcomes—that results in a compensatory *drive* toward either self- or other-directed play behavior and a negative emotional appraisal (for more reading material on the role of appraisals in emotion theory, see e.g., Moors et al., 2013).

The levels at which these appraisals lead to a positive or negative *emotional expression* are known to vary between children (parameter a_7 Oatley and Jenkins, 1996). When a child expresses positive or negative emotions, that tends to increase or decrease, respectively, its own concern for its current play behavior. Here positive emotional expressions are considered rewarding and negative expressions as discouraging a certain play behavior, as a form of self-reinforcement (a_1 in **Table 1**).

Finally, there is continuity in the agent's behaviors: the tendency to persist in previous play behavior (play continuity; a_5 in **Table 1**) and emotional expressions (emotional continuity; a_8 in **Table 1**). In the literature, the notion of continuity has been described as behavioral momentum (Nevin, 1996), although that concept is defined on a somewhat larger timescale than the concept of continuity in SECONDS.

2.1.2. Influencing the Other

A crucial distinction exists in SECONDS between external active states, which are observable to the other agent, and internal states, which are hidden from that agent (see **Figure 1B**). So only emotional expressions and play behaviors can directly impact the other agent, in the following three ways:

1. The play behavior of one member of the dyad contributes to the emergent play outcome, which determines the extent to which the concerns of the other member are realized.
2. When one member of the dyad expresses an emotion, that influences the other's concern for the play behavior associated with that emotion. Drawing parallels with self-reinforcement, social reinforcement involves positive or negative emotional expressions of one agent that are experienced by the other agent as encouraging or discouraging of associated play behavior (a_2 in **Table 1**).
3. The agents demonstrate behavioral symmetry: the tendency to imitate the play behavior (a_6 in **Table 1**) and emotional expressions of the other (a_9 in **Table 1**), which has been referred to as contagion in the literature (Levy and Nail, 1993). As the multi-agent extension of continuity, the tendency toward symmetry influences the drive of the child toward a specific type of play behavior or emotional expression.

2.1.3. Influencing Each Other

The emergent play outcome is only determined in the fully recurrent socio-emotional concern dynamics (SECONDS) of dyadic interaction, as we summarize in **Figure 1C**. Crucially, the concerns of both agents can change gradually through the accumulation of positive and negative emotional experiences associated with acting out those concerns. Therefore, while concerns shape their actions (a_3 in **Table 1**), the results of those actions shape their concerns (a_{1-2} in **Table 1**). Such circular causality is a crucial property of complex adaptive systems, which underwrites the fact that these emergent behaviors can only be captured fully by recurrent formulations (see **Figure 1C**).

The full dependencies for the changes in concerns listed in **Table 1** ($\Delta x_{1,t}$) show that SECONDS implements a simple form of recurrent belief-updating, in line with recent trends in cognitive neuroscience of predictive processing, reinforcement learning, and active inference (Friston et al., 2017; Sutton and Barto, 2017; Gallagher and Allen, 2018). As we described above, concerns are updated indirectly through emotional appraisals that represent the match or mismatch between session outcomes and the concerns of each agent (or, equivalently, their preferences).

[3]Behaviors are the state of the agent in action space.

[4]Later on, when we introduce the parental play strategy, we dissociate these two concerns partially through selective satiation.

[5]Concern realization characterizes the match between the system's current state and its attractor state. More advanced formulations could implement allostatic concern realization: locally departing from one's concerns to attain concern realization on longer time scales (e.g., a child isolating itself intentionally to attract the attention of its parent).

[6]Drives and appraisals represent the pull on the agent toward particular action states.

2.2. Modeling Child Play Behavior in ASD

In dynamical modeling, we must align the features of our model with those of the target system, which in our case was a child with ASD. Our working assumption was that psychological processes of children with ASD are fundamentally similar to those of typically developing children (as defined in SECONDS), but with a number of atypical features (i.e., parameter settings) that give rise to behaviors characteristic of ASD (see also section 4.2). To apply SECONDS to children with ASD, we implemented the current clinical diagnostic criteria for this class of disorders from the DSM5 (American Psychiatric Association, 2013). A key theoretical question was which parameters of SECONDS (such as the relatedness concern) correspond to certain DSM5 criteria. Our answer therefore consists of a conceptual justification of the ways in which we implemented characteristics of ASD in SECONDS. These implementations can be viewed as a hypotheses to be explored using an agent-based model like SECONDS.

According to the DSM5, ASD is a class of disorders that share distinct impairments in social interactions and communication, typically characterized by repetitive behavior and restricted interests. We divided this definition in three aspects that correspond with the dynamic model: (1) deficits in emotional processing regarding self and other (i.e., affective communication), (2) deviant socio-emotional concerns, and (3) tendency toward repetitive behaviors. These represent only one particular realization that we derived from the ASD literature. Our specific choices here are debatable: we can use SECONDS to test them against observations and competing alternatives. For now, they simply served to demonstrate how SECONDS can be used to model ASD phenomenology:

1. Characteristic of ASD are deficits in processing information concerning one's own emotions (e.g., Hill et al., 2004) as well as the emotions of others (e.g., Bal et al., 2010). As described in the DSM5 (American Psychiatric Association, 2013), other issues are deficits in the sharing of emotions by means of facial expressions or non-verbal behavior. Using SECONDS, these deficits of emotional processing and communication were modeled as follows:
   a. Hampered interpretation of actual outcomes in terms of perceived concern realization (relatively low a_3). Reduced general intelligence also impairs such interpretations because they require accurate monitoring of overall session outcomes in terms of personal concerns.
   b. Hampered expression of emotions following appraisal (relatively low a_7).
   c. Hampered adjustment of one's concerns based on the emotional expressions of the parent (relatively low a_2).
2. Children with ASD often exhibit deviant socio-emotional concerns, showing more interest for inanimate objects and less interest in peers or adults compared to typically developing children (e.g., Dawson et al., 1998). Children with ASD seem to have a less strong need for relatedness with others in play than their typically developing peers. We set the initial relatedness concern of the child (c_{other}) relatively low ($c_{other} = c_{self} = 0.50$), compared to typically developing children (whose play has been successfully modeled in SECONDS using $c_{other} \approx 0.70$; Steenbeek and van Geert, 2013). Most likely, such a reduced relatedness concern is partially the result of long-term social difficulties related to the deficits in emotional processing described above. The major point of interest here was not the exact value of the parameter, but whether this value falls within the range of children with ASD.
3. As described earlier, ASD is characterized by repetitive behavior and restricted interests. Such deficits correspond to a stronger tendency for behavioral continuity in the case of ASD compared to typical development. For example, it is more difficult for children with ASD to disengage visual attention, once focused (Landry and Bryson, 2004). A second behavioral problem is concerns lack reduced mirroring of the other's behavior. Compared with typically developing children, children with ASD show deficits in imitation (for a review, see Williams et al., 2004) and joint attention (for a review, see Bruinsma et al., 2004). In SECONDS, these behavioral deficits are represented by the two non-intentional constructs of symmetry and continuity. We assumed that a child with ASD would show relatively strong continuity (relatively high a_5, a_8) and relatively weak symmetry (relatively low a_6, a_9) for both the play behaviors and emotional expressions.

2.3. Modeling Parental Play Behavior

We proceed to explain how we modeled similarities and differences between parent and child as they interact during free play sessions that emulate a school playground environment (see section 2.5 for a description of the observed dyad). In this setting, it was reasonable to assume the parent imitates childlike play because he or she wants the child to gain social skills that carry over to future playful interactions with peers. The simulated parent imitated natural childlike playful behavior, while also trying to realize parenting goals (as described in section 2.3.2). Indeed, such approximate symmetry derives support from observations that parents of preschool children with autism showed similar levels of overall synchrony during parent-child interactions (Siller and Sigman, 2002). There is also evidence of compensatory parental behaviors: higher levels of directiveness were observed in parents of children at high risk of developing ASD in comparison with parents with low-risk children (Wan et al., 2012, 2013).

2.3.1. A Dissociation Between Playful Interaction and Displays of Parent-Child Affection

In view of our focus on modeling free play, we assumed that play interactions unfold approximately independently from displays of parent-child affection. Keeping adjustments to SECONDS to a bare minimum, we only considered other-directed behaviors that were play-related in the observational coding system. SECONDS allowed us to turn this simplification into a testable hypothesis: we tested whether such playful dyadic interactions could be modeled with SECONDS (as outlined in **Figure 1**), without explicitly considering parent-child displays of affection. This dissociation is theoretically plausible because relatedness and autonomy are in reality multidimensional, rather than

antagonistic. We focused on the childlike play dimension of relatedness (which is the opposite of autonomy in this context) and not the affectionate ("cuddling") dimension of relatedness. For example, a child can engage in solitary play while receiving affection from its parent. We derived that theoretical focus on play from the target system, which emulated a school playground session intended for free play specifically. Indeed, the observed dyad presented in section 2.5 exhibited a clear dissociation between the mother and child exchanging hugs and the mother and child actively playing together. For example, the child would walk around with a toy and receive a hug on the way, but it would continue playing solitarily throughout. In such instances, he maintained play autonomy by excluding his mother from the play process, despite the displays of affection. Furthermore, recent observational work by Steiner et al. (2018) suggests that, in the context of children at risk for developing ASD, parental directiveness in parent-child play interactions emerges very early on and appears to be largely independent of the child's level of socio-emotional development. It suggests that parents develop a certain style concerning their level of synchrony and directedness that is rather stable and independent of the emotional valence of a particular interaction (as also supported by Clarke-Stewart, 1973).

2.3.2. Parenting Goals During Play Interactions

We departed from the original dynamic symmetry of SECONDS (as in Steenbeek and van Geert, 2005, 2008) by assuming the parent also had one-sided external control over the dynamics, which he or she could use to attain certain parenting goals. In other words, the parent had a certain power over the child—being an adult and educator—that the child did not have over the adult. The ensuing dynamics were somewhat asymmetric: the parent could maintain goals pertaining to the child's development and shape their play interactions accordingly. Note that such power does not require conscious awareness or decision-making by the parent on the level of different strategies. Parents can intuitively influence the play dynamics toward certain parenting goals, enacting more or less stable parental play strategies. Interventions could help parents to become aware of such patterns and adjust them to fit specific parenting goals.

Given the approximately childlike engagement of the parent mentioned before, we kept the basic architecture of SECONDS for the parent the same as for the child, presented in **Figure 1**. To leave it intact, we refrained from adjusting parental play behaviors *ad-hoc*. Instead, we devised plausible ways to attain parenting goals in SECONDS by adjusting the components and changing their causal relationships. Firstly, we made minimal adjustments that affected only the parameters of the model. For example, the parent could start with a relatively high relatedness concern, thus encouraging positive experiences of relatedness in the child. Secondly, we included extra conditions in the generative model, such as a tendency toward symmetry conditional on the child's behavior. Thirdly, we removed certain outcomes: the parent refrained from showing negative emotions when the urge arises, creating a safe environment for the child. To demonstrate modeling of implicit parental influences during play, we defined four complementary ways in which a simulated parent could work toward particular parenting goals without changing the basic architecture of SECONDS:

1. Given a parenting outcome goal, the parent can adjust his or her concerns to those of the child, allowing for scaffolding of concerns as described below (adjusting just initial concerns c_{self}, c_{other}, or also changes in concern f_1 in **Table 1**).
2. The parent can selectively mirror the child's play behaviors, depending on the outcome goal (i.e., a_6 in **Table 1** becomes conditional on the child's behavior).
3. The parent's concerns can be satisfied selectively, introducing a motivational bias that works toward the outcome goal (i.e., a_3 in **Table 1** becomes conditional on play outcome).
4. The parent can use positive emotional expressions to encourage the child when it behaves in ways that are consistent with the parenting goal (i.e., adjusting f_4 in **Table 1**).

Of course, these mechanisms are by no means exhaustive, but we could use them to simulate two parents that worked toward different outcome goals. The first parent was play-centered, in the sense that he or she focused on maximizing the amount of play during the session. The only outcome goal was playing together in order to increase the child's relatedness concern. The second parent was initiative-centered, in the sense that he or she focused on maximizing the amount of initiative-taking by the child. The main outcome goal here was to elicit initiations by the child, while playing together was a secondary outcome goal. To explain our motivation for simulating a play- and an initiative-centered parent, we provide observational background in the following section.

2.3.3. Parental Imitation and Scaffolding in Play Interactions

There is a large body of research on play between parents and children with ASD that demonstrates contingent imitation of the child's play behavior increases attention and social responsiveness in children with autism (e.g., Dawson et al., 1998). El-Ghoroury and Romanczyk (1999) conducted research on dyadic play of family members with a child with ASD. They found that, in comparison to siblings, parents more often attempted to initiate play toward (their) autistic children. At the same time, autistic children more often initiated play toward their siblings than toward their parents. The results also indicated that the number of parental attempts increased with the severity of developmental delay of the children, while this pattern was not present for the siblings. This may reflect an attempt by the parents to compensate for the social deficits of their children, but the siblings elicited more initiatives from the children with ASD by giving them more space. Findings of Freeman and Kasari (2013) also indicated that imitative parental play strategies correspond with better outcomes for child-initiated play. In the context of parent-child dyadic play in general, they found that fewer commands and suggestions by the parent were associated with longer periods of joint engagement. These studies focused on imitation of play actions and the complexity of play exhibited by the child. In SECONDS, imitation can be conceived on a more abstract level as imitation by the parent of the directionality of play exhibited by the child. Self-directed play behavior of the child

could be answered with self-directed play by the parent. Such imitation can be implemented in SECONDS via the parameter of behavioral symmetry, where higher symmetry of the parent will result in more imitation. The parent could also imitate the child by adjusting his or her relatedness concern to mirror the proportion of self- and other-directed behavior shown by the child.

An extension of the concept of imitation would be that of scaffolding, a term coined by Wood et al. (1976) and also indicated in the introduction. More recently, Steenbeek and van Geert (2013) implemented scaffolding by using SECONDS to model the dynamics within teacher-student dyads. The teacher aims to match the level of the student approximately, but always stays on a somewhat higher level located within what Vygotsky and Cole (1978) called the zone of proximal development. The teacher tries to maintain an optimal scaffolding distance for learning. Research has shown that for typically developing children scaffolding by the parents is essential for development (e.g., Hammond et al., 2012). Given their learning deficits, the bandwidth of effective scaffolding would be expected to be relatively small for children with ASD. Still, even without any training, mothers of children with ASD have been observed to apply verbal scaffolding that was appropriate to the developmental level of their children (Konstantareas et al., 1988). In research by Pierucci (2014), mothers of young children with ASD were taught to apply scaffolding techniques more effectively in parent-child play, which was found to increase social engagement of these children.

In the context of SECONDS, we conceptualized scaffolding in terms of the relatedness concerns. The parent could keep their relatedness concern at a level just slightly higher than that of the child. Since the real-time level of the child's relatedness concern is not directly observable, the parent would need to make an estimate based on the child's previous and current behaviors. The parent could then aim to find the optimal distance for scaffolding the relatedness concern. However, such optimization is not straightforward if there are multiple conflicting outcome goals. To demonstrate this point, we defined two parental outcome goals (hinted at in section 1). The first is playing together with the child ("give a man a fish") and the second is helping the child to practice play initiation ("teach him to catch a fish"). Unfortunately, playing together and play initiation are two learning outcomes that compete with each other in this setting. For example, if the parent can maximize the amount of joint play by initiating it (i.e., a large scaffolding distance in the relatedness concern), but that approach deprives the child of opportunities to practice the initiation of play. We now proceed to describe the precise adjustments for both the play- and initiative-centered parent, while highlighting their differences.

2.3.4. The Play-Centered Parent

The play-centered parent maximized the time spent playing together through the following four mechanisms (introduced in the previous section):

1. Initially, this parent was much more concerned with relatedness than the child: $p_{other,initial} = 0.65$, $c_{other,initial} = 0.50$, a large scaffolding distance compared to the initiative-centered parent. Over the course of each session, this parent aimed to scaffold the child's concerns by being more concerned with relatedness: $p_{other} > c_{other,initial} = 0.50$. This lower bound was based on the child's initial concern, because real-time changes are harder to estimate for the parent (see **Figure 1B** for the distinction between hidden and observable components of each agent). In the simulations, we confirmed that this parent was more concerned with relatedness than the child throughout each session.
2. This parent exhibited strong selective symmetry toward playing together: he or she tended to imitate the child more strongly in other-directed play than in self-directed play (i.e., a_6 was conditional on the child's behavior).
3. This parent encouraged the child's other-directed behavior through positive emotional expressions and implicitly discouraged the child's self-directed behavior by avoiding positive emotional expressions during such behavior. He or she refrained from showing negative emotions during all interactions. We implemented these adjustments by changing f_4 in **Table 1**.
4. Satiation of this parent's concerns took much longer for relatedness than for autonomy (i.e., a_3 in **Table 1** was conditional on play outcomes), introducing a bias toward other-directed play.

2.3.5. The Initiative-Centered Parent

The initiative-centered parent maximized the time spent playing together as a result of the child's initiations, while maximizing joint play was only of secondary importance. This parent tended more toward imitation of the child and was less selective than the play-centered parent, increasing the number of opportunities for the child to elicit play. The four mechanisms were set as follows:

1. Initially, this parent was slightly more concerned with relatedness than the child: $p_{other,initial} = 0.55$, $c_{other,initial} = 0.50$, a small scaffolding distance compared to the play-centered parent. Over the course of the session, the parent aimed to scaffold the child's concerns by always being slightly more concerned with relatedness: $c_{other} + 0.01 < p_{other} < c_{other} + 0.15$. This parent intended to maintain a scaffolding distance that provides an optimal balance between both outcome goals: eliciting initiations of the child and playing together.
2. This parent exhibited relatively weak selective symmetry, with only a slight preference toward mirroring other-directed play behaviors. Their overall tendency toward symmetry was fairly strong, such that this parent imitates the child.
3. The selective use of positive emotional expressions was limited and they do not discourage playing alone by withholding positive emotional expressions. Being an adult, this parent did refrain from showing negative emotions during play.
4. Satiation of this parent's concerns took slightly longer for relatedness than for autonomy, introducing a slight bias toward other-directed play.

In this way, two different parents were modeled to be either play-centered or initiative-centered, representing different outcome

goals. The parameter settings for the child with ASD were identical in both dyads. Naturally, the simulated dyads are only two of the many possibilities, and therefore they were used for exploratory purposes, and should in no way be considered exhaustive. Parents and children with ASD show large inter-individual differences, such that we expected to observe large differences between these two simulated dyads, but also between both simulated dyads and a real parent-child dyad. We sought to determine whether the differences between the two simulated dyads conform to our expectations (section 2.4) and whether the simulated parents constitute plausible representations of a real parent-child dyad in the context of ASD, based on an observed parent-child dyad (section 2.5).

2.4. Comparison Between Simulated Dyads With Play- and Initiative-Centered Parents

We compared the two parent-child dyads simulated in SECONDS across 2,000 simulation sessions on the distributions of seven variables that summarized session outcomes concerning play and initiation. Six of these summary variables represented the total time allocated to play and initiation[7]. Proportional (dimensionless) time allocation was chosen for comparison with observations because it is more robust than frequency measurements, which depend on the time resolution of the observations and simulations. The expectations for the differences between the two parents on all seven variables are summarized together in **Table 2**.

Firstly, for common play events we measured the proportion of time spent during each session: both parent and child playing *together* and both playing *alone*. Obviously, we expected the play-centered parent to spend more time playing *together* with the child than the initiative-centered parent. Both playing *alone* depended strongly on the tendency of the parent (who has a stronger relatedness concern) to imitate the child when it chose to play alone. Such space was expected to provide the child more opportunities to initiate play. Therefore, we expected the initiative-centered parent to allocate more time to both playing *alone* than the play-centered parent.

Secondly, for each member of the dyad we also measured attempts to initiate play and joint play resulting from these attempts in each session. In SECONDS, we defined attempts at initiation by the child ($attempt_{child}$) or parent ($attempt_{parent}$) as instances where one engaged in other-directed play behavior (i.e., communicating the desire to play together), while the other engaged in self-directed play behavior. A successful play initiation occurred when the play invitation of child or parent was followed by playing *together* for some time. The entire duration of that initiated joint play was added to $success_{child}$ or $success_{parent}$, depending on who took the initiative. In this way, we compared play behaviors and initiations of the child and its parent. Attempts at initiating play by the child showed how much space was given to the child to engage in these attempts. Successful initiation of play by the child indicated how much experience they gathered in mastering this pivotal response class described before. We expected the child to show more attempts at playing together and more play resulting from these attempts for the initiative-centered parent. We expected the play-centered parent to show more attempts at playing together and more play resulting from these attempts.

Thirdly, we also compared the relatedness concern of the child at the final time step of the simulations in SECONDS ($c_{other,final}$), which summarized motivational changes in the child with respect to the initial situation ($c_{other,initial} = 0.50$). Since experiences of playing *together* tend to increase one's relatedness concern, we expected $c_{other,final}$ to be higher for the play-centered parent than for the initiative-centered parent.

Crucially, resulting play outcomes emerged from the dynamic coupling between the behaviors and emotional expressions of the child and its parent (see **Figure 1C**). These outcomes were not linear or additive outcomes of the parameters, and it was necessary to run simulations with SECONDS for both play- and initiative-centered parents to test whether the expected outcomes would be obtained.

2.5. Case-Based Model Validation Using Real-Time Play Data of a Mother-Child Dyad

For model validation, we employed a single in-depth case study of free play between a child with ASD and its mother. Each 1-h session consisted of phases simulating different activities during a school day, resulting in 29 video-recorded episodes of free play, lasting about 15 min each. During these episodes, the mother and child freely engaged in play, using a variety of available toys. No learning goal was formulated for this phase. This single real dyad (observed for 29 sessions) was compared with the two virtual dyads we simulated using SECONDS (for 2,000 sessions each) on the six types of events described in section 2.4: both playing *together* and *alone*, play initiation attempts by the parent and child ($attempt_{child}$, $attempt_{parent}$), joint play resulting from attempts of the parent and child ($success_{child}$, $success_{parent}$).

We realize an $n = 1$-study like ours will be raising some eyebrows for those accustomed to standard research practices in psychology. However, complexity-based approaches actually favor model validation on a case-by-case basis over group statistics (Molenaar and Campbell, 2009). In the Discussion (section 4), we provide an in-depth justification of this methodological choice. For now, we note that a single case study is a valid and informative starting point if it is explanatory[8]. Our study can provide reliable information on a whole class of cases because it met the following three specific criteria for explanatory case studies (Flyvbjerg, 2006; Yin, 2009):

1. It answers a "how" question: we sought to model the mechanism that explains play dynamics between a child with ASD and its parent.
2. It examines a contemporary phenomenon in context: the social deficits exhibited by children with ASD are well-documented today (i.e., contemporary) and we considered interactions with its own caregiver (i.e., in context) in helping the child to habituate to the pattern of schooling in general.

[7]These six externally observable variables were also measured for comparison with the real mother-child dyad.

[8]It is intentionally called an "explanatory" case study (not "exploratory"), since we aimed to explain the studied case.

TABLE 1 | A simplified technical summary listing the coupled equations of Socio-emotional Concern Dynamics (SECONDS) between *Agent x* and *Agent y*, described by individual variables x_{1-5} and y_{1-5}, respectively, and joint variable z.

Variables	*Agent x*, *Agent y*	Partial dependencies for *Agent x*				Full dependencies for *Agent x*
Concerns	x_1, y_1	Initial concerns	$[c_{self}, c_{other}]$	=	x_{1,t_0}	$\Delta x_{1,t} = f_1(x_{3,t}, x_{4,t}, y_{4,t})$
		Continuity	$x_{1,t}$	$\rightarrow$	$x_{1,t+1}$	
		Self-reinforcement	$x_{3,t} \cdot x_{4,t}$	$\xrightarrow{a_1}$	$x_{1,t+1}$	
		Social reinforcement	$x_{3,t} \cdot y_{4,t}$	$\xrightarrow{a_2}$	$x_{1,t+1}$	
Concern realization	x_2, y_2		$x_{1,t} - x_{5,t}/t$	$\xrightarrow{a_3}$	$x_{2,t}$	$x_{2,t} = f_2(x_{1,t}, x_{5,t}) + \omega$
Play behavior	x_3, y_3	Drives	$x_{2,t}$	$\xrightarrow{a_4}$	$x_{3,t+1}$	$x_{3,t+1} = f_3(x_{2,t}, x_{3,t}, y_{3,t})$
		Continuity	$x_{3,t}$	$\xrightarrow{a_5}$	$x_{3,t+1}$	
		Symmetry	$y_{3,t}$	$\xrightarrow{a_6}$	$x_{3,t+1}$	
Emotional expression	x_4, y_4	Appraisals	$x_{2,t}$	$\xrightarrow{a_7}$	$x_{4,t+1}$	$x_{4,t+1} = f_4(x_{2,t}, x_{4,t}, y_{3,t})$
		Continuity	$x_{4,t}$	$\xrightarrow{a_8}$	$x_{4,t+1}$	
		Symmetry	$y_{4,t}$	$\xrightarrow{a_9}$	$x_{4,t+1}$	
Memory	x_5, y_5	Retention	$x_{5,t}$	$\rightarrow$	$x_{5,t+1}$	$x_{5,t+1} = x_{5,t} + z_t$
		Storage	z_t	$\rightarrow$	$x_{5,t+1}$	
Play outcome	z	Emergence	$x_{3,t} \cdot y_{3,t}$	$\rightarrow$	z_t	$z_t = \text{AND}(x_{3,t}, y_{3,t})$

*The individual variables are Concerns (continuous vectors x_1 and y_1, length two), Concern realization (continuous vectors x_2 and y_2, length two), Play behavior (binary vectors x_3 and y_3, length two), Emotional expression (categorical x_4 and y_4, taking values [-1,0,1]), and Memory (count vectors x_5 and y_5, length two). The joint variable is the Play outcome (binary vector z, length two). For each of the variables of Agent x, we list the partial dependencies (third column) and full dependencies (fourth column). Partial dependencies involve a single variable (e.g., Drives involve x_2), a multiplicative interaction between two variables (e.g., Social reinforcement involves x_3 and y_4), or the difference between two variables (Concern realization compares x_5 and x_1). Arrows with a_{1-9} indicate relevant parameters of SECONDS that modulate the connection strengths of the corresponding dependencies. For example, the impact of Social reinforcement on x_1 is regulated by a_1, et cetera. Full dependencies are listed as explicit simple functions (e.g., z is the AND function of x_3 and y_3) or more complex functions omitted for readability (f_{1-4}). Every time step, Concerns change by $\Delta x_1 = f_1(x_3, x_4, y_4)$. Concern realization is defined by a difference function $f_2(x_1, x_5)$ plus random variability ω, which generates the stochastic properties of SECONDS. Categorical outcomes of Play behavior and Emotional expression are generated from continuous input using step functions f_3 and f_4. All the equivalent relations for Agent y can be obtained by switching variables x_{1-5} and y_{1-5}. See **Figure 1** for a graphical illustration of SECONDS.*

3. There is no experimental control over the explained phenomenon: the play sessions were structured as a school break consisting of free play without specific goals.

The amount of data that was necessary to make even this single-case comparison was overwhelming: time-series of over 26,000 data points were collected for the real dyad. Of course, we do not claim that a single case is sufficient: case-based model validation is a cyclical process. Collecting more such in-depth cases in the future can reveal patterns across sessions and within the population of children with ASD, revealing inter-individual as well as intra-individual differences.

Observational data were gathered from free play sessions occurring in the context of an intervention study (unrelated to the model at hand, see Steenbeek et al., 2017) in which a 9-year-old boy diagnosed with severe (classical) ASD practiced school activities together with his mother in biweekly sessions over 18 months. He was able to verbalize some of his intentions, although it cost him significant amounts of effort. Due to the severity of his symptoms, the boy was exempt from any form of education (both regular and special) by the Dutch government at the age of five. His parents have been more or less obliged to give him home-schooling, which they have been doing partly in the context of the Autism Project, a collaboration between researchers from the University of Groningen and the Hanze University of Applied Sciences.

Free play sessions were about 15 min each (with some variation). Coding was event-based and exhaustive. One session out of 29 was used for reliability training between two independent observers, which led to a substantial inter-rater reliability of $\kappa = 0.68$ on subsequently coded sessions, corresponding with 89 percent inter-observer agreement. These video fragments were first coded in terms of whether the parent and child were playing together or not. Periods of not playing together were then coded in terms of whether both parent and child were playing alone or whether one of them was trying to initiate play. To maximize inter-observer reliability, the operational definition of play initiation was taken to be a verbalized communication of a desire to play together. Finally, the resulting time-series were used to measure the percentages

of time allocated to the six types of events listed in section 2.4: both playing *together* and both *alone*, attempts to initiate play by the child and its parent ($attempt_{child}$, $attempt_{parent}$), and play resulting from initiations by the child and its parent ($success_{child}$, $success_{parent}$). Video recordings were not detailed enough to track emotional expressions with high reliability, so we have left overt emotional expressions out of the analyses. In translating the simulation output to real observations, we assumed an initiation attempt would be verbalized when it persisted for at least two simulation time steps. This correction accounted for the fact that the observational coding system was limited to verbalized attempts, while SECONDS included both verbal and non-verbal other-directed play behaviors.

For both simulated dyads and the observed dyad, we compared their smoothed distributions (i.e., kernel density estimates) across sessions on these variables. Furthermore, we quantified the fit between each distribution and the observed dyad in terms of the Kullback-Leibler divergence (*KLD*), a well-established information-theoretic measure of statistical divergence (Kullback and Leibler, 1951). *KLD* is given in information units of *nats* (the equivalence of bits, but based on powers of *e*): the smaller *KLD*, the better the observed fit.

For a baseline comparison, we used beta distributions—a common tool in Bayesian statistics for describing probability distributions of proportions (such as our variables). A naive observer who knows nothing about the system at hand – except that it has four possible states—could use the reasonable starting point of beta distributions with an expectation value of 25 percent for each of the four different states of the system: (1) *together*, (2) *alone*, (3) $attempt_{child}$, and (4) $attempt_{parent}$. Naively speaking, playing together would be attributed equally to $success_{child}$ and $success_{parent}$, each with a long-term expectation value of 12.5 percent. Further technical details are provided in a footnote[9]. These reference distributions served a twofold function. First of all, they allowed us to check whether our simulated dyads indeed exhibited similarities to the types of behaviors we would typically expect from the target system. Secondly, these reference distributions provided us with null hypotheses that allowed us to test whether SECONDS actually helped to provide a better fit with the observed distributions. That step allowed for an interpretation of *KLD* values in terms of more common statistical methods. We calculated the *p*-values of the set of reference distributions for both simulated dyads by transforming *KLD* values back to probabilities and normalizing: $p_0 = e^{KLD_0}/(e^{KLD_0} + e^{KLD_{model}})$, where p_0 is the likelihood of the reference distributions (with KLD_0) given the observations and an alternative set of distributions generated by SECONDS (with KLD_{model}).

[9]The relevant probability distribution for a dynamic system that has four possible states is a 4-dimensional Dirichlet distribution, producing four marginal beta distributions. The beta distribution is a special case of the Dirichlet distribution. It has been used for modeling behaviors of random variables on finite intervals across disciplines. In Bayesian statistics, the beta distribution is commonly used to characterize one's prior knowledge about a probability or a proportion. In our case, we used it to specify the null hypotheses on the interval between 0 and 100 percent. The beta distribution has two parameters α and β, which we set such that the expectation value of four variables was 25 percent on the long term ($\alpha = 2$ and $\beta = 6$). Furthermore, playing *together* was sub-divided into $success_{child}$ and $success_{parent}$, such that the latter two variables had a baseline long-term expectation value of 12.5 percent (obtained using $\alpha = 2$ and $\beta = 14$). In absence of additional information, the naive observer would also need to guess the variance (set by the proportion between α and β).

3. RESULTS

3.1. Comparison Between the Two Simulated Parents-Child Dyads

The differences between the two simulated parents corresponded with our expectations (as shown in **Table 2**). The most important difference between these two simulated parents was apparent in the distribution across simulations of the time attributed to *alone* and to $attempt_{child}$ (as shown in **Figure 2**). Here $attempt_{child}$ is a percentage of the time that remains after *alone* is accounted for. Longer periods of solitary play were related to more initiative-taking by the child, as shown by linear regression analyses (play-centered parent: $attempt_{child} = 0.62\% + 0.14 \cdot alone$, $R^2 = 37\%$; initiative-centered parent: $attempt_{child} = 4.0\% + 0.28 \cdot alone$, $R^2 = 13\%$). For the play-centered parent, *alone* and $attempt_{child}$ were close to zero most of the time, but the few higher values of *alone* were also related to higher values of $attempt_{child}$. As expected, the initiative-centered parent was more effective than the play-centered parent in eliciting play initiation attempts by the child.

TABLE 2 | Comparison of the two simulated parent-child dyads in terms of our expectations for the relative ordering of the medians, across 2,000 simulated play sessions.

	Expectations	**Simulated dyads**		
		Play		**Initiative**
variable	Ordering of medians (**play** … **initiative**)	Median [95% CI]		Median [95% CI]
together	(**play** > **initiative**)	40.9% [40.0–42.7%]	>	34.2% [33.3–35.1%]
alone	(**play** < **initiative**)	4.0% [3.6–4.0%]	<	18.2% [17.3–19.1%]
$attempt_{child}$	(**play** < **initiative**)	0.9% [0.4–0.9%]	<	4.4% [4.0–4.4%]
$success_{child}$	(**play** < **initiative**)	0.0% [0.0–0.0%]	<	6.7% [6.2–7.6%]
c_{inv}	(**play** > **initiative**)	0.567 [0.564–0.571]	>	0.520 [0.518–0.522]
$attempt_{parent}$	(**play** > **initiative**)	47.6% [46.2–48.9%]	>	29.8% [28.4–31.1%]
$success_{parent}$	(**play** > **initiative**)	34.2% [32.9–35.1%]	>	20.4% [19.6–21.3%]

Play: dyad with play-centered parent

initiative: dyad with initiative-centered parent

We also provide 95% confidence intervals (CI) for these medians based on the sample size (n = 2,000).

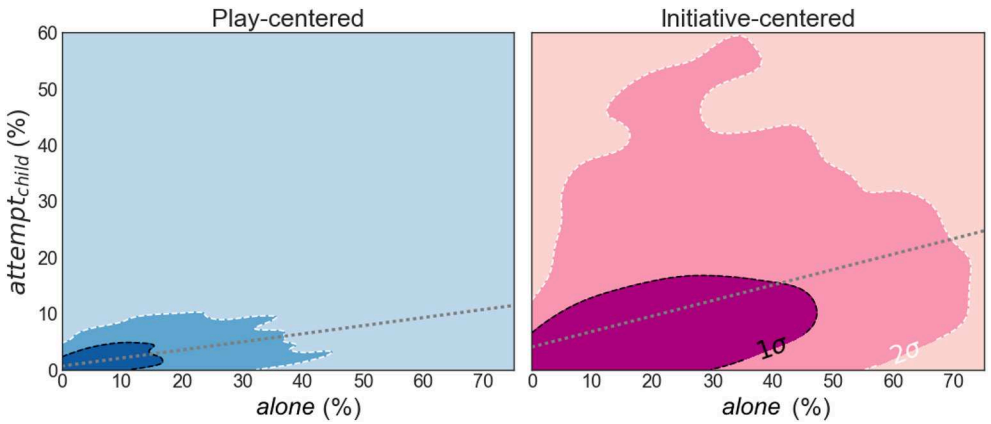

FIGURE 2 | A comparison between the two dyads with either a play-centered parent (blue, left panel) or an initiative-centered parent (pink, right panel): density plots across 2,000 simulated sessions of the time spent both playing *alone* (percentage of session time; horizontal axis) versus attempts to initiate play by the child (*attempt*$_{child}$; percentage of session time; vertical axis). High density regions are darker than low density regions. 1- and 2-σ confidence intervals are indicated with dashed lines: 68 percent of the sessions fall within the black contours; 95 percent of the sessions fall within the white contours. Within each dyad, the more time is spent both playing alone, the more time is typically spent initiating play by the child – as we illustrate with simple linear regression (gray dotted lines; play-centered parent: $attempt_{child} = 0.62\% + 0.14 \cdot alone$, $R^2 = 37\%$; initiative-centered parent: $attempt_{child} = 4.0\% + 0.28 \cdot alone$, $R^2 = 13\%$). As expected, this comparison shows that the play-centered parent allows for less solitary play and fewer attempts to initiate play by the child overall, compared to the initiative-centered parent.

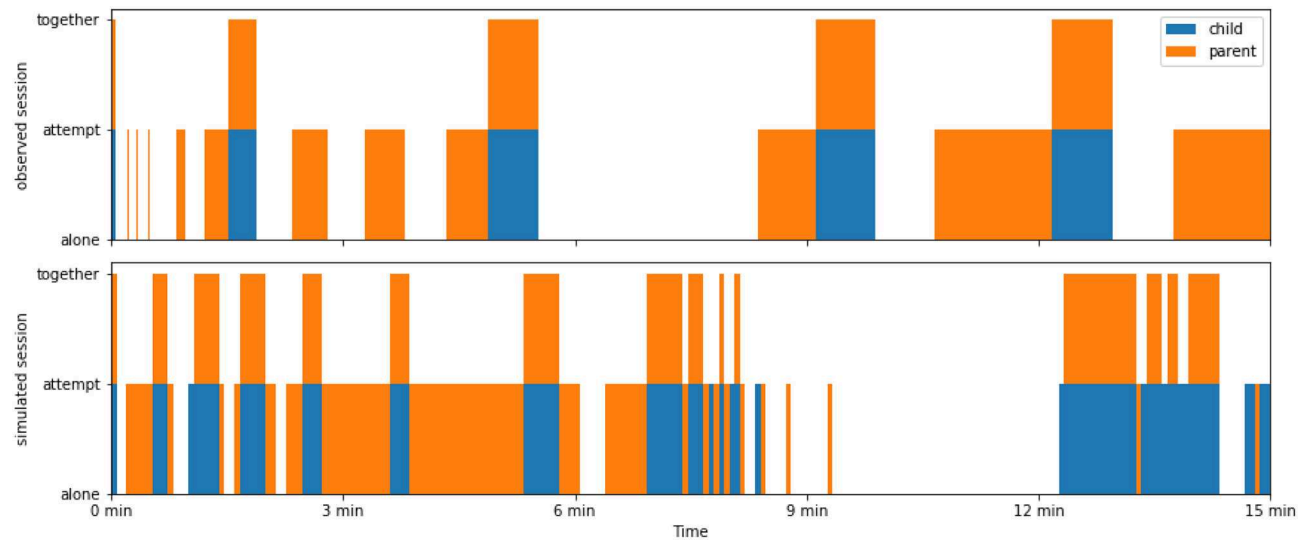

FIGURE 3 | An illustrative comparison of the play dynamics of parent and child as they unfold over the course of 15 min in one example of an observed session (upper panel) and one of a session simulated with SECONDS (lower panel; involving the initiative-centered parent). These stacking plots indicate with colored areas when the parent (orange) and child (blue) are engaging in other-directed play behavior. The absence of blocks indicates they are both playing *alone*, single blocks (either orange or blue) indicate one of them is attempting to initiate play (*attempt*$_{child}$ or *attempt*$_{parent}$), and two stacked blocks (orange *and* blue) indicate they are playing *together*. The qualitative similarities between these panels are striking. However, both the observed dyad and the simulated dyads exhibit large variability across sessions, so a comparison across sessions as shown in **Figure 4** is crucial.

3.2. Comparison Between Simulated and Observed Parent-Child Dyads

Our data represent three different parent-child dyads in the context of ASD (two virtual, and one real). As for real parent-child dyads, we expected to find both similarities and differences. In **Figure 3**, we illustrate the ensuing dynamics by comparing an observed and simulated play session (with the initiative-centered parent). While correspondence between these example sessions is obvious, both the real dyad and simulated dyads showed large variation across sessions. Therefore, we also examined distributions across sessions in order to evaluate the plausibility of the simulated dyads.

Across sessions, simulated and observed dyads exhibited qualitative similarities as well as differences (as shown in

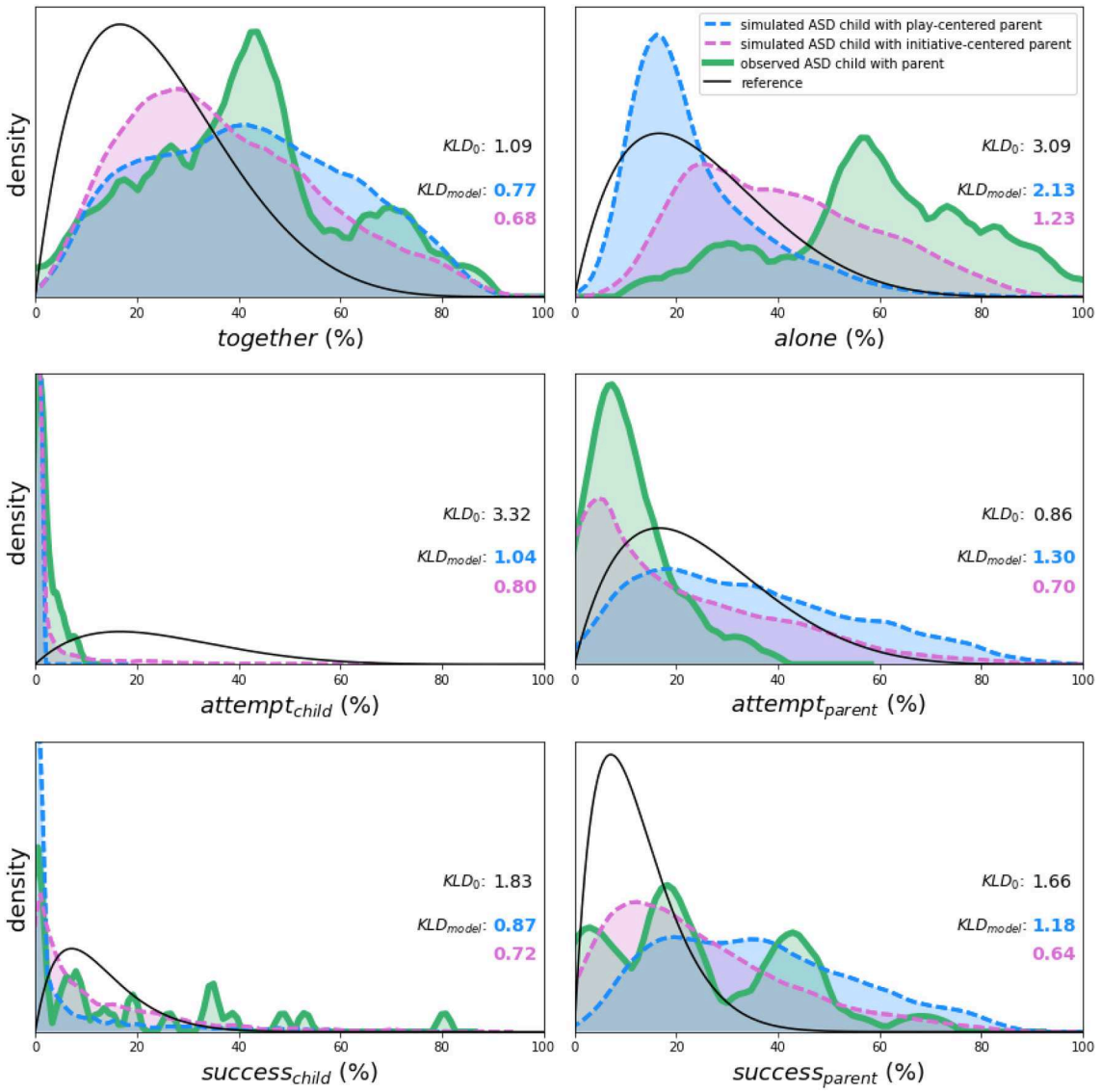

FIGURE 4 | Comparison of kernel density plots (similar to histograms) on all six variables between two simulated parent-child dyads (blue and pink dashed lines), one observed parent-child dyad (green solid lines) across play sessions in the context of ASD, and reference beta distributions (black line). Simulated distributions summarize 900,000+ time series data points generated by SECONDS – 225 time points over 2,000 sessions for each of the two dyads: a play-centered parent (blue) and an initiative-centered parent (pink). Observational distributions summarize over 26,000 time series data points gathered from one observed dyad (29 sessions; green). A qualitative, visual comparison of the distributions for simulated and observed dyads suggests surprisingly strong correspondences. We quantify the fit between each distribution and the observed dyad in terms of the Kullback-Leibler divergence (*KLD*; in information units of nats). The lower *KLD*, the better the fit. Most conveniently, *KLD* values are additive across variables, allowing us to estimate total model fit through summation. The simulated dyads have total KLD_{model} of 7.28 and 4.76 *nats* for the play- and initiative-centered parents, respectively. Therefore, they outperform the reference distributions, which have a total KLD_0 of 11.83 *nats*, and the initiative-centered parent provides the best fit overall.

Figure 4). This observation is itself noteworthy—these two virtual dyads simulated in SECONDS showed a plausible degree of similarity to an actual parent-child dyad, especially given the idiosyncrasies associated with ASD (e.g., Vivanti et al., 2014; Hahamy et al., 2015). Moving beyond a subjective qualitative comparison, we also conducted a statistical comparison between simulated and observed distributions. Most conveniently, *KLD* values are additive across variables. For the reference distributions, we obtained total $KLD_0 = 11.83$ *nats*. For the simulated dyads with play- and initiative-centered parents, we obtained total $KLD_{model} = 7.28$ and 4.76 *nats*, respectively. These values indicate that both dyads with play- and initiative centered parents showed a smaller divergence from observations than the reference distributions. Comparing the reference KLD_0 with KLD_{model} as described in Section 2.5, we obtained $p_0 = 0.046$ and 0.0048 in favor of the simulated dyads with play- and

initiative-centered parents, respectively[10]. We calculated these p-values mostly for the benefit of the reader, so we did not decide on any particular α-value of significance. In any case, we can conclude that (1) both simulated dyads provided a better fit to observations than the reference null distributions and (2) among the simulated dyads, the one with an initiative-centered parent provided a better fit than the one with a play-centered parent.

4. DISCUSSION

We successfully extended SECONDS—an agent-based model of socio-emotional concern dynamics developed for child-peer play—to the case of parent-child play in ASD. With our settings and minor adjustments, SECONDS produced session data for two parent-child dyads that (1) showed agreement with our theoretical expectations in an internal model comparison—see section 2.4—and (2) produced play and initiation time distributions with a plausible degree of similarity to observational data of a real mother-child dyad with ASD—see section 2.5. We found strong, non-trivial correspondence between the two simulated dyads and the single observed dyad (as compared to null reference distributions). Overall, the overlap is strong enough to show that our two simulated dyads are plausible representatives of what we aimed to model. In section 4.1, we explain what plausibility means in the context of case-based validation of process-oriented models and in section 4.2 we discuss the generalizability of our results.

Our primary modeling goal was to construct a psychologically informed agent-based model that could generate plausible real-time descriptions of play between a child with ASD and its parent. The scientific heavy-lifting was done on the theoretical level, since few (if any) such models have been developed before. Since observational validation would need to happen on a case-by-case basis (as we explain in section 4.1), we measured whether time series of interactions within a particular observed parent-child dyad would fall within a plausible range of correspondence with two simulated dyads. Our research provides a proof of principle for dynamical modeling of real-time decision-making in child-parent dyadic play in ASD[11].

4.1. The Case for Case-Based Model Validation

Our argument follows the consensus view among complexity-oriented researchers in psychology that process-oriented models for psychological phenomena can usually not be validated on the basis of inter-individual variability (Toomela, 2007; Byrne and Ragin, 2009; Castellani and Hafferty, 2009). In section 1.1, we explained that aggregated data can only be used for processes under the statistical assumption of ergodicity, which is often violated in psychological phenomena (Molenaar, 2004), and even more so in heterogeneous conditions like ASD. If researchers instead accumulate single cases, that is likely to lead to insightful clustering that reveals relevant similarities and differences (as shown by Castellani and Hafferty, 2009). At least one case study like ours is needed to decide whether that would be a worthwhile endeavor[12]. Presenting our simulations without a comparison to a particular case would diminish the relevance of our publication as a proof of principle[13]. To the best of our knowledge, the extant literature does not provide time-serial data on parent-child play in ASD. Our report provides a starting point for other investigators who wish to study real-time interactions between adults and children with ASD, or other types of dyads[14].

As surprising as it may sound, we can draw robust conclusions on the plausibility of our simulated dyads from this single parent-child dyad. The child in our study was representative of children with severe ASD in a qualitative sense, which does not require correspondence with summary statistics of all children with severe ASD. In process-oriented modeling, plausible representation means that a second pair from the same population (parent-child dyads with ASD) would typically differ from the first pair within approximately the same range as our simulations. Given the detail of our observational data (over 26,000 data points) and the heterogeneity of ASD, it is surprising that our attempt showed such strong correspondence. One line of work would involve fitting the parameters of SECONDS until they produce the exact behaviors of the observed dyad.

4.2. Generalizability: Processes Vs. Parameters

SECONDS was developed as a generic model which could be applied to different cases by using different values for a generic set of parameters (such as $c_{other,self}$ and a_{1-9} in **Table 1**). We demonstrated that the conceptual makeup of SECONDS can be generalized (1) to children with severe ASD and (2) to parent-child dyads. The first result suggests that children with severe ASD engage in play based on psychological processes that are fundamentally similar to those of typically developing children (i.e., socio-emotional concern dynamics), albeit operating under different parameters. This result provides support for the increasingly common approach of modeling ASD and other psychiatric conditions as atypical expressions of general neurocognitive mechanisms (e.g., Constant et al., 2018).

[10] As an additional check, we also performed an analysis using a different (though much less reasonable) null hypothesis: a uniform probability distribution. That yielded the same result: namely that SECONDS produces a better fit by a large margin.

[11] Generating sample-based statistics, such as population averages, can be a secondary aim of agent-based modeling. Such population statistics result from the capacity of SECONDS to generate empirically valid case-specific time series for a range of parameter values that simulate dyads from a particular population. However, that secondary aim can only be pursued after the first aim has been achieved: to demonstrate that SECONDS is capable of generating time series descriptions that come sufficiently close to real parent-child dyads in ASD to warrant further work. It is this first aim that we pursued, in the form of taking a step in the presentation, simulation, and empirical validation of SECONDS.

[12] Gathering over 26,000 data points on this single dyad was extremely labor intensive and only this single case was available for such intensive observation—as part of a pilot study preparing for a broader group of ASD children, aimed at improving the scaffolding dynamics in school contexts.

[13] Of course, the observed dyad should be randomly selected. It should not be selected as a function of arbitrary correspondence with an already existing model simulation.

[14] Given that ASD has been so extensively studied in the scientific community, we would encourage researchers to email the corresponding author (c.hesp@uva.nl) in case they have access to data that could be used for similar modeling work.

The second result suggests that free play between parent and child can be modeled as if the parent imitates childlike behavior. Since all kinds of specifics of the parent-child relationship can have considerable influence on the dynamics of play, this finding is non-trivial.

In evaluating the generalizability of SECONDS, there are two levels at play: (1) the psychological processes represented by its computational architecture and (2) the specific range of parameter settings used for modeling populations of interest. In complexity-oriented approaches, generalizability refers primarily to the first level: it requires theoretical justification and incremental observational validation, both of which we present in this paper. Generalizability refers only secondarily to the second level, which requires empirical work beyond what we present here. In principle, every individual dyad from a population can be represented by a dyad-specific parameter set (such as $c_{other,self}$, a_{1-9} in **Table 1**). Determining which range of parameter settings provide the best explanation for the population of parent-child dyads with ASD is an empirical matter that inevitably requires studying more cases.

4.3. Disentangling Causal Multiplicities With Agent-Based Models

Understanding the causal structure of underlying processes is important for improving predictions of socio-emotional concern dynamics in individual children with ASD. A higher level of specificity can help to develop personalized treatments that maximize therapeutic benefits for each individual. ASD symptoms involve a multiplicity of causal factors due to the reciprocal relationships between social, cognitive, and affective processes. When multiple sets of parameters explain the same data, the corresponding models are called *degenerate*. In section 2.2, we discussed how reduced processing of emotional information and a low relatedness concern both explain reduced other-directed play behaviors. Since these two issues are interactive, we assumed both are typically present in children with severe ASD. There are other such degeneracies that reflect the idiosyncratic nature of ASD (Vivanti et al., 2014; Hahamy et al., 2015). For example, a lower relatedness concern and language deficits can both reduce a child's verbalized attempts to initiate play. In our observational setting the parent often waited for an explicit verbal invitation from her son for educational purposes, which made it more difficult for the child to initiate play. During the coding of the data, such blockage of the child's behavior was observed multiple times and his subsequent responses appeared to depend on the strength of his desire to play together. Communication deficits related to ASD can be taken into account more explicitly in future versions of SECONDS by incorporating both a non-verbal and verbal channel of interaction (see section 4.4).

The observation that similar behaviors may result from a multiplicity of causes is a strength, rather than a weakness of SECONDS and comparable agent-based models. Complex adaptive systems (like humans) can meet external and internal demands most efficiently when they possess the flexibility to respond in multiple ways to any given problem (e.g., Den Hartigh et al., 2016). If we implement process-oriented explanations in agent-based models (such as SECONDS), we can interrogate these models to produce specific predictions on intra-individual variability, which population-oriented models are not capable of. For example, we can predict the ensuing temporal dynamics for an individual child given a particular treatment option. This specificity helps (1) researchers to tease apart the degeneracies mentioned above and (2) clinicians to provide effective treatments that are tailor-made for the individual child.

4.4. Recommendations for Further Development

Our observations were limited to verbalized attempts at initiation to maximize inter-observer reliability, while SECONDS generated other-directed play behaviors in general. Gestures are often used as communication by children, and even more so by those on the ASD spectrum who have language impairments (true for the child in our study). As mentioned in section 2.5, we translated the simulation output to observations by assuming that attempts at initiation were verbalized when they persisted over two successive time steps in the simulations. That tension between verbal and non-verbal communication could be resolved by including non-verbal communication in the observational coding system. As a result, less time would be categorized as both playing *alone*—likely producing better correspondence with SECONDS (as outlined in **Figure 4**). Although such changes would introduce higher observer ambiguity, that same ambiguity also more closely resembles the world as experienced by the members of the dyad. A more interesting option would be to incorporate speech directly in SECONDS in terms of two communication channels: non-verbal and verbal, where a strong drive to play together can motivate a verbally impaired child to make the additional effort to speak. The relatively clear verbal channel would typically require a stronger drive than the relatively noisy non-verbal channel. The level of language skill of a child then sets the amount of effort required for the verbal channel, while the child's relatedness concern will influence the amount of effort invested. Verbal and non-verbal communication are characterized by different levels of ambiguity, which could be quantified directly using Bayesian statistics (as in predictive processing; Clark, 2013).

More generally, SECONDS lends itself well for integration with state-of-the-art Bayesian accounts of neurocognitive function and predictive processing (Clark, 2013) because it already implements a form of belief-updating for concerns ($\Delta x_{1,t}$ in **Table 1**). Furthermore, Ridderinkhof (2017) presented a conceptual integration of predictive processing and the emotion theory on which SECONDS was based (Frijda, 1986). Given recent simulation work on emotions (Allen et al., 2019; Smith et al., 2019), we believe it to be especially promising to integrate SECONDS with *active inference*—a complexity-oriented Bayesian framework (Friston et al., 2017; Hesp et al., 2019). Active inference can be used to model emergent functions and multi-scale integration (Ramstead et al., 2019), an adequate framework for socio-emotional development as in SECONDS. For example, Smith et al. (2019) presented an active inference

model of emergent emotional state inference and emotion concept learning. As mentioned, a more explicitly inferential (i.e., Bayesian) formulation of SECONDS would allow for modeling the different degrees of uncertainty associated with verbal and non-verbal communication channels. It could also be used to model recent theorizing on the neurocognitive underpinnings of ASD (Parr et al., 2018). For example, researchers (e.g., Constant et al., 2018) have argued that overly precise (implicit) expectations could provide a unified way to model a wide array of disparate ASD symptoms, such as (1) repetitive behaviors, (2) increased distress when expectations are being violated, and (3) reduced integration of new information—especially under large uncertainties typical of social interaction. By modeling Bayesian inference (currently implicit in SECONDS), we can model the emergent effects of such overly precise expectations on dyadic interaction.

For our study, the parameters of SECONDS were adjusted according to our expectations as outlined in section 2. Fitting parameters directly to many specific cases from a population would be more challenging numerically (and observationally!) but would provide more robust tests of SECONDS. Such model fitting allows for the development of diagnostic tools (e.g., questionnaires, short tasks) that estimate the parameter values for individual subjects (an approach called computational phenotyping; e.g., Friston et al., 2017). A dyad could then first be tested to measure these parameters, after which the outcomes of real interactions can be compared with simulated outcomes. Subsequently, such knowledge can be employed in the design of personalized behavioral strategies for parents of children with ASD. Measuring the parameter groups repeatedly at the end of each session would also allow for testing predictions concerning long-term changes in these parameters. Hypothesized mechanisms for such long-term changes can be directly implemented in future versions of SECONDS. For example, by taking the final values of the relatedness concern $c_{other,final}$, we can simulate changes in relatedness concern across the sessions. This has been done in a simulation of constructive dyadic play over 6 repeated sessions, thus modeling medium-term changes in constructive play parameters (see Steenbeek et al., 2014).

4.5. Conclusions

We demonstrated how SECONDS—a validated agent-based model of socio-emotional concern dynamics (Steenbeek and van Geert, 2005, 2008)—can be applied to real-time playful interactions between parent and child in the context of an idiosyncratic developmental disorder like ASD. Because SECONDS was originally derived from verbal psychological theories of behavior, our translational research increases the relevance of theory to empirical and clinical work in developmental psychology. SECONDS can help to disentangle conceptual degeneracies in the etiology of ASD. Within SECONDS, variations between simulated parents corresponded with expectations derived from previous literature (as discussed in section 2.4). The two simulated parent-child dyads showed better correspondence with the observed dyad than reference null distributions (as discussed in section 2.5). Based on these results, we conclude that the two simulated dyads are plausible representatives of parent-child dyads in the context of ASD. Given the strong correspondence, it is likely that remaining differences between these simulations and observations can be accounted for by direct fitting of parameters, increasing the number of observed dyads, and moving in future directions of SECONDS (outlined in section 4.4). Fitting more cases will allow us to further establish and improve the predictive value of SECONDS in characterizing the dynamics of such playful interactions. Although much exploration is left to be done, we conclude that our work provides a proof of principle that a dynamical model of play between typically developing children can indeed be adjusted to account realistically for another type of dyad, such as that of play between a parent and a child with ASD. Thanks to the virtual environment of SECONDS, our investigation opens the door toward the use of agent-based modeling as a cost-effective and ethical way to design and test new therapeutic interventions that stimulate the socio-emotional development of ASD children.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of Ethical Committee Psychology, University of Groningen, the Netherlands with written informed consent from the caregivers of the subject. The caregivers gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Ethical Committee Psychology, University of Groningen, the Netherlands.

AUTHOR CONTRIBUTIONS

CH rewrote the child-play model in Python in order to allow for flexibility, incorporated the changes in the model for the ASD parent-child dyad, ran the simulations, coded the observational data, supervised the inter-observer reliability measurements, compared and interpreted the correspondences between simulations and observation, produced the figures, and wrote the first draft. HS and PvG provided the source code and background to the original child-play model and worked to improve the first draft. HS provided supervision and theoretical background to the developmental aspects of ASD and set up the collaboration that collected the video material of the real ASD parent-child dyad. PvG provided theoretical background to the complexity approach and dynamical modeling.

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SYSTEMATIC REVIEW
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Twins' and Singletons' Linguistic Environment: A Systematic Review

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Background: Among twins, lower linguistic skills emerged when compared with singletons. Considering the association found between parental linguistic input and children's language development, exploring the differences between twins and singletons' linguistic environments could find variables that are potentially associated with the lower linguistic skills of twins.

Aim: The current systematic review aims to analyze and systematize the existing literature focused on the comparison of twins' and singletons' linguistic environments within their first 3 years of life. Methodological issues (i.e., the procedure used to assess the linguistic environment, the coding of the linguistic environment's features, the computational method employed to assess the parental linguistic input, and participant characteristics) and differences found among twins and singletons regarding their linguistic environment (i.e., linguistic input quantity, linguistic input complexity, linguistic features of child-directed speech, parental responsiveness, and directiveness, joint attention, and book reading) were highlighted.

Method: The Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement was followed. Eligible studies were searched through EBSCO, PubMed, and Web of Science. From this search, 1,347 study results emerged, and 8 studies were included.

Results: To our knowledge, this is the first systematic review focused on the comparison of twins' and singletons' linguistic environments. Differences between the groups were found in all of the included studies. Data against twins were generally identified regarding all the considered linguistic environment's features. However, conflicting results within and between the included studies emerged, mainly according to the computational method employed (i.e., *twin moms* value, *twin direct dyadic* value, *twin direct dyadic + both* value, and input directed toward both children simultaneously).

Conclusion: The disadvantaged linguistic environment of twins is likely due to limited parental resources and demands associated with the management of two children of the same age. However, the limited and conflicting data found did not allow for a firm conclusion to be drawn on the differences in the twins' and singletons' linguistic environments. Further studies on the topic are needed.

Keywords: twins, linguistic environment, linguistic input, systematic review, child-directed speech, joint attention, responsiveness, directiveness

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INTRODUCTION

Several studies found significant differences between twins and singletons regarding their linguistic development (Özçakar et al., 2003; Rutter et al., 2003; Olivennes et al., 2005; Nan et al., 2013; Rice et al., 2014; D'haeseleer et al., 2016). Controlling for potential confounding variables (i.e., age, gender, social background, prematurity), lower language scores among twins were identified. Controlling for social background and excluding children born before 33 weeks of gestation and with neurological or brain damages, a delay of 1.7 months at 20 months of age and a delay of 3.1 months at 36 months of age emerged among twins (Rutter et al., 2003). When comparing twins and singletons in groups matched for age, gender, and parental education, Olivennes et al. (2005) found differences against twins on several dimensions of communication. Similarly, Nan et al. (2013) identified lower scores on communication among twins at ages 3, 6, and 9 months, controlling for prematurity and gender. A recent study confirmed these findings, identifying lower receptive, and expressive linguistic skills among twins compared with singletons matched for age and gender. The results were replicated while even excluding infants born preterm (D'haeseleer et al., 2016). The prevalence of late language emergence found among twins was 38%, while 19.7% emerged within the general population (Rice et al., 2014). Linguistic impairments persisted at least until school age (Rutter et al., 2003; Gucuyener et al., 2011) and were highlighted as differences against twins at 12 years of age (D'haeseleer et al., 2016). However, controlling for birthweight, Dezoete and MacArthur (1996) did not find differences among twins and singletons regarding quality of language and intelligibility of speech. From their perspective, the lower scores that emerged in other studies could be influenced by the overrepresentation within twins' groups of children of low birthweight, a condition which represents about 60% of twin births (Martin et al., 2015). Furthermore, assessing linguistic differences within a triadic context in the home environment, Tremblay-Leveau et al. (1999) found a greater quantity and quality of communication among twins aged 23 months as compared with singletons. The results showed how a triadic setting could represent a favoring context for twins to express their communicative skills during their early life.

Linguistic impairment during the first 3 years of age was associated with concurrent lower social skills (Longobardi et al., 2016) and subsequent linguistic difficulties at 7 (Rice et al., 2008), 8 (Domsch et al., 2012), 13, and 17 years of age (Rescorla, 2005, 2009). Children with language impairment showed lower scores on measurements of school readiness (Justice et al., 2009) and academic achievement (van Noort-van der Spek et al., 2012), as well as higher rates of learning disabilities (Young et al., 2002). Behavioral and social problems at 12.5 years of age were found as well (Beitchman et al., 1996).

According to the social interactionist perspective (Snow, 1972), which emphasizes the environmental role and the value of daily interactions for language development, the linguistic environment's features were widely explored and were found to be predictors of children's linguistic skills (Mol et al., 2008; Farrant and Zubrick, 2012; Rowe, 2012; Weisleder and Fernald, 2013; Levickis et al., 2014; Tamis-LeMonda et al., 2014; Hudson et al., 2015; Sandbank and Yoder, 2016; Conway et al., 2018; Paavola-Ruotsalainen et al., 2018; Smith et al., 2019). Within the twin population, several characteristics of the linguistic environment were explored and compared with those of singletons to highlight variables potentially associated with the lower linguistic skills found among twins: input quantity, input complexity, child-directed speech (CDS) linguistic features, parental responsiveness and directiveness, joint attention (JA), and book reading. However, limited and conflicting results were found (Lytton et al., 1977; Conway et al., 1980; Bornstein and Ruddy, 1984; Tomasello et al., 1986; Stafford, 1987; Ostfeld et al., 2000; Butler et al., 2003; Thorpe et al., 2003). CDS refers to a specific linguistic pattern directed toward children, which is different in its features from the register used to communicate with adults (Golinkoff et al., 2015). CDS is characterized by the use of an exaggerated intonation, a simple structure, short and repetitive utterances, and a high frequency of questions and other forms of linguistic interaction (e.g., imitations, recasts, and expansions) that are useful to promote the flow of conversation. These features allow adults to attract the child's attention and make the language learning process easier (Ratner, 2013; Gonçalves Barbosa et al., 2016; Suttora et al., 2017).

In the general population, several characteristics of CDS were found to be associated with children's linguistic skills. First, the quantity of the input provided by parents emerged as a relevant factor (Hurtado et al., 2008; Rowe, 2012; Weisleder and Fernald, 2013). A positive association was found between the number of *word tokens* and utterances produced by mothers during the first 19 months and the children's vocabulary and efficiency in spoken language understanding at 24 months (Hurtado et al., 2008; Weisleder and Fernald, 2013) and 30 months (Rowe, 2012)

In addition to input quantity, the complexity of CDS influences language development as well (Hoff and Naigles, 2002; Sandbank and Yoder, 2016). A positive association was found between mean length of utterances (MLU) and the subsequent children's vocabulary production (Hoff and Naigles, 2002). However, a recent meta-analysis found only a weak positive association between length of parental input and language development in children with disabilities (Sandbank and Yoder, 2016). Longer utterances likely provide greater grammatical complexity and richer information regarding new words, which could be useful to children to better understand the input meaning and build a stronger vocabulary (Hoff and Naigles, 2002; Sandbank and Yoder, 2016). Nonetheless, the benefits of greater input complexity could vary on the basis of children's linguistic skills (Sandbank and Yoder, 2016).

In addition, parental responsiveness and directiveness were shown to be related, in opposite directions, with the children's linguistic skills (Murray and Hornbaker, 1997; Paavola et al., 2005; Levickis et al., 2014; Hudson et al., 2015; Conway et al., 2018; Paavola-Ruotsalainen et al., 2018; Smith et al., 2019). Parental responsiveness refers to parenting behaviors and communicative acts that follow linguistic input and actions produced by the child (Paavola et al., 2005; Tamis-LeMonda et al., 2014). By increasing the child's involvement, responsiveness promotes parent-child communication and the availability of

resources that are useful to learn new linguistic skills (Hudson et al., 2015). Accordingly, responsiveness was found to be associated with comprehensive skills at 12 months (Paavola et al., 2005; Paavola-Ruotsalainen et al., 2018) and with receptive and expressive skills at 24, 36 (Levickis et al., 2014), and 48 months (Hudson et al., 2015).

On the other hand, directiveness is characterized by the parental inclination to redirect the infant's attention to control the child's behavior (Murray and Hornbaker, 1997; Smith et al., 2019). Several studies identified a negative association between parental directiveness and children's receptive and expressive language skills at 24 (Murray and Hornbaker, 1997), 36, and 48 months (Conway et al., 2018; Smith et al., 2019).

Moreover, joint attention (JA) was identified as an influencing factor for children's linguistic skills. JA refers to interactions where the parent and child share their attentive focus toward the same object (Akhtar and Gernsbacher, 2007; Farrant and Zubrick, 2012). JA interactions allow the child to understand the reference of the parent's communication, increasing his or her opportunities to learn new words and improving their appropriate use (Scofield and Behrend, 2011). In line with these considerations, the quantity of time mother and child spent in JA interaction was found to be positively associated with receptive and expressive language skills during the first 3 years of life (Saxon, 1997; Markus et al., 2000; Farrant and Zubrick, 2012).

Lastly, parent-child book reading also represents a positive learning opportunity by providing occasions for learning new words within a stimulating context (Mol et al., 2008; Farrant and Zubrick, 2013; Salo et al., 2016). A meta-analysis conducted by Mol et al. (2008) identified an association of moderate effect size between dialogic book reading and expressive vocabulary, as well as an association of small effect size with receptive vocabulary.

Socioeconomic status (SES) is an important factor as well. Children at the lower levels of SES experience a lessened quantity and quality of linguistic input (Schwab and Lew-Williams, 2016; Inglebret et al., 2017). Specifically, Hoff (2003) highlighted the mediation role of the linguistic environment on the association between SES and the child's linguistic development. The author showed how SES impacts the quality of the linguistic environment experienced by the child, which in turn influences the child's linguistic development. Despite the limited evidence that twins are born in low SES families or contexts, it is possible that their birth influences the overall income of the family in comparison to a singleton birth. McKay (2010) showed that twins were commonly born in families with a low SES. Thus, it is important to explore further the association between SES and language development in twins, controlling for SES when assessing linguistic differences among twins and singletons.

In sum, CDS quantity and quality, maternal responsiveness and directiveness, JA interactions, and parent-child book reading emerged as relevant factors involved in the language development of children, particularly during the first 3 years of life. Despite these findings, limited studies have explored the association between language development and the linguistic environment's features within the twin population. To our knowledge, only five studies explored the association between parental linguistic input and twins' linguistic skills: a relation between the child's language development and the number of maternal words or utterances (Conway et al., 1980; Tomasello et al., 1986; Stafford, 1987; Ostfeld et al., 2000), CDS features (Tomasello et al., 1986; Stafford, 1987), joint attentional interactions (Tomasello et al., 1986), indicators of responsiveness and directiveness (Stafford, 1987) and the maternal engagement in dialogic book reading with the child (Thorpe et al., 2003) emerged. However, different computational methods were employed by these studies to assess twins' linguistic environment features, and potential confounding variables were not controlled for in most of the studies as well (e.g., SES, gender, birthweight. and prematurity). Considering the small number of data available and the methodological limitations identified, the findings emerged do not allow for a firm conclusion to be drawn and further studies are needed.

Considering these preliminary data, exploring the differences in the linguistic environment of twins and singletons could be particularly relevant in highlighting factors that are potentially associated with the lower linguistic skills emerging among twins.

AIM

The aim of our paper is to review the existing literature focused on the comparison of the linguistic environment of twins and singletons within the first 3 years of life, when environmental features emerged as critical factors for language development as discussed in the section Introduction. Moreover, we will systematize the methodological features of the studies included and the differences that have emerged between the groups to highlight factors potentially associated with the poorer linguistic skills found among twins.

Specifically, in the current systematic review, we aim to explore the following differences among twins and singletons regarding the linguistic environment's features, which, according to the results from the literature, are relevant for the child's linguistic development: number of words or utterances, linguistic features of CDS, parental responsiveness and directiveness, JA interaction, and parent-child book reading. Furthermore, we identify the differences between the studies included regarding the procedure used to assess the linguistic environment, the coded linguistic environment's features, the computational method employed to assess the parental linguistic input, and the characteristics of the groups included as participants.

METHOD

The current systematic review was conducted using the PRISMA guidelines (**Table 1**; Moher et al., 2009). We referred only to published data; therefore, the study did not require the approval of the Ethical Scientific Committee.

DATA SOURCE AND SEARCH STRATEGY

Two independent reviewers searched in titles, abstracts, and full texts through EBSCO (CINAHL Complete, eBook Collection

TABLE 1 | Studies included in the systematic review.

References	Title	Journal	Study design	Sample or participants	Procedure	Differences in linguistic environment
Lytton et al., 1977	The impact of twinship on parent-child interaction	Journal of Personality and Social Psychology	Observational study	46 pairs of same sex male twins, 44 male singletons (with sibiling), and respective parents. Mean age: 32,4 months	Home observation of unstructured interaction (coded with the Parent-Child Interaction Code PACIC). Parental language measures: rate of mother-child speech per minute and rate of father-child speech per minute	Mothers and fathers of singletons speak more to their children than parents of twins
Conway et al., 1980	Twin-singleton language differences	Canadian Journal of Behavioral Science	Observational study	12 set of twins, 24 singletons, and respective mothers. Age: 32–33 months	Home observation. Maternal speech measures: complexity (based on four measures: subject phrase, predicate phrase, verb complexity, and additional points), rate of speech per minute overall, and rate per minute of mother-to-child speech.	Significant differences against twins in Rate Mother-to-Child and in the complexity score.
Bornstein and Ruddy, 1984	Infant attention and maternal stimulation: predictor of cognitive development in singleton and twins	Attention and Performance X: Control of Language Processes. Editet by: Herman Bouma and Don G. Bouwhus	Observational and longitudinal study	20 singleton, 11 twin pairs and respective mothers. Age: 4 months (first assessment) and 12 months (second assessment)	Home observation of two maternal activities: encouraging the babie's attention to stimuli in the environment verbally and physically, and talking to the baby.	At 4 months mothers of twins encourage each baby's attention to the environment less than half as often on average as do mother of singletons, and talk to them less than mothers of singleton talk to their children. Maternal differences are stable. At 12 months twins' mothers encourage baby's attention 60% as often as mothers of singletons and vocalize 50% as often
Tomasello et al., 1986	Linguistic environment of 1- to 2- years old twins	Developmental Psychology	Observational and longitudinal study	6 sets of twins, 12 singletons, and respective mothers. Age: 15 (first assessment) and 21 months (second assessment)	Home observations. Parental language evaluated: (1) joint attention: For each interaction, it was established: the initiator; the following response (no response, a brief response, or a relatively extended period of joint attentional focus on some object or event); and who primarily maintained the state of joint attentional—the mother (mother lead), the child (child lead), or equally by both (equal lead). Joint attentional interaction with both twins and the mother was coded as a three-way joint interaction. (2) Child-directed speech: number and mean length (MLU) of child-directed utterances; their proportional distribution into comments, directives, and questions; proportion of utterances characterized by "motherese" intonation. For the twins, mother utterance was coded for its address, with utterances directed to both children simultaneously coded as both. Maternal use of an object word in an utterance directed to the child (or both twins) coded for whether it occurred in a directive or a non-directive form and if the mother used gestures to refers to the object. (3) Conversational responses (only at 21 months): conversation maintaining: imitation, recast, acknowledgment, and topic continuation. Conversational flow disruption: ignore, request for clarification and topic change.	Three computational method employed: (a) "twin moms" value; (b) "twin direct dyadic" value; (c) "twin direct dyadic + both" value. (1) Joint attention: employing the "twin moms" twins and their mothers initiated more social interactions than singletons; with the "twin direct dyadic" value initiated fewer interactions. Regardless the computational method used, twins spent less time in joint attention interactions, and twins and their mothers engaged in a much higher proportion of mother lead joint interactions, in a lower proportion of equal lead joint interactions and in no child lead joint interactions. There were no child age effects or Child Age X Birth Status interactions. (2) Child directed speech: with the individually based twin values, twins had fewer utterances directed to them, and these utterances were of shorter average length (MLU). Regardless the computational method used, twins received a higher proportion of directive utterances and a lower of comments and questions. The proportion of child-directed utterances referring to objects was higher than that of the singletons using the "twin direct dyadic" value. Regardless the computational method used twin mothers referred to objects almost exclusively in directive utterances and almost never in non-directive utterances. From T1 to T2 the proportion of utterances with a motherese intonation declined for all children (using all three values); The MLU of utterances stayed roughly the same for the twin children whereas it rose for the singleton children(using both individually based values); singletons showed a rise in the proportion of directives and a decline in the proportion of comments, while the proportion of questions rose over time for all children (using all three values). (3) Conversational responses: Twin mothers used imitation more often and topic continuation less often.

(Continued)

TABLE 1 | Continued

References	Title	Journal	Study design	Sample or participants	Procedure	Differences in linguistic environment
Stafford, 1987	Maternal input to twins and singleton children: implication for language acquisition	Human Communication Research	Observational study	22 mothers of twins and 22 mothers of singletons (with older sibling). Mean age of twins: 28 months and 16 days; mean age of singletons: 28 months and 15 days	Laboratory observation. The transcripts were divided into utterances, then coded for: (1) Discourse feature: imitations; expansions; extensions; items related to action; topic continuations; semantically unrelated utterances; yes-no answers; synergistic sequences; maternal self-answers; unintelligible remarks; fragments; unclassified utterances; each discourse feature was coded for its direction. Total frequency of utterances in each category regardless of direction was computed. (2) Illocutionary force (exploring two areas: responsiveness/eliciting and controlling/directing): commands (direct and indirect), repairs, questions, positive and negative acknowledgments, prompts, attention devices, spontaneous declaratives, and unclassified utterances. Each illocutionary force feature was coded for its direction. Total frequency of utterances in each category regardless of direction was computed. (3) Conversational style: number of utterances produced by the mother and children; total number of maternal utterances; number of utterances directed toward the target child individually and toward both children simultaneously; maternal self-utterances; number of utterances produced by the target child; number of utterances produced by both children; ratio of maternal utterances to the number of utterances produced by both children.	(1) Discourse features: (a) target child: more imitations, expansions, extensions, items related to actions, and maternal self- repetitions were produced by singletons' mothers. (b) Both children: twins' mothers used more imitations, extensions, utterances related to actions, topic continuations, semantically unrelated utterances, maternal self-repetitions, yes/no answers, and stock expressions. (c) Total environment: singletons' mothers produced more extensions, utterances related to actions, and stock expressions. (2) Illocutionary features: (a) target child: singletons' mothers produced more questions, positive acknowledgments attention devices, and spontaneous declaratives. (b) Both children: twins' mothers used significantly more commands, questions, positive acknowledgments, attention devices, and spontaneous declaratives. (c) Total environment: more commands, repairs and unclassified remarks were produced by twins' mothers. Singletons' mothers used more questions. (3) Style Parameters: singletons' mothers addressed more utterances toward the target children. Twins' mothers produced more utterances directed toward both children simultaneously and talked more to themselves. The ratio of maternal utterances to target child utterances was ∼3 to 1 in the singleton environment and 4.5 to 1 in the twin environment. The ratio of maternal utterances to the number of utterances produced by both children was about 1.5 to 1 in the singleton environment and 2.3 to 1 in the twin environment.
Ostfeld et al., 2000	Maternal behavior toward premature twins: implications for development	Twin Research	Observational and longitudinal study	8 premature twins, 22 premature singletons, and respective parents. Age: 1 (first assessment) and 8 months (second assessment)	Home observation (coded with the Modified Beckwith mother-Infant behavior checklist). Maternal behavior measured: positive verbalization (unprompted or responsive to)	Unprompted by and in response to the child, singletons' mothers more likely talk to their children; both groups maintained its performance (from T1 to T2).
Butler et al., 2003	Maternal speech style with prelinguistic twin infants	Infant and Child Development	Observational study	21 mothers of twins and 21 mothers of singletons. Age: 4 months	Videotaped Still-Face procedure. Maternal speech was coded for: (1) speech focus: Infant focus, Mother-Focus, and Other-Focus; (2) content/complexity subcategory: subcategories of Infant-Focus speech: Description, Responsive, Conversation, Simple Repetition, Semantic Repetition, Agency. Subcategories of Mother-Focus speech: Prompt, Game, Song, Description, Self-Reference; (3) syntax subcategory: Interrogative, Declarative, Imperative, Contentless; (4) Presence/Absence of negativity.	(1) Singletons' mothers produced a higher proportion of Infant-Focus utterances; (2) Sub-categories of Infant-Focus: singletons' mothers used a higher proportion of utterances that ascribed agency to the infant and more responsive utterances. (3) Syntax: singletons' mothers produced more Interrogatives; twins' mother used more declaratives.

(Continued)

TABLE 1 | Continued

References	Title	Journal	Study design	Sample or participants	Procedure	Differences in linguistic environment
Karen Thorpe, Michael Rutter and Rosemary Greenwood	Twins as a natural experiment to study the cause of mild language delay: II: Family interaction risk factors	Journal of Child Psychology and Psychiatry	Observational and longitudinal study	96 twin pairs, 98 pairs of singletons, and respective mothers. Age: 20 (first assessment) and 36 months (second assessment)	Home observations of an unstructured (at 20 months) and two structured (reading of a novel picture book and playing with a toy) interactions (at 20 and 36 months). The set of behaviors coded during the observation is not completely available.	At 20 months twins' mother more likely addressed the two children as a pair rather than individually. Toy observation: twins' mothers less likely provided strong motivation to the child. Book observation: twins' mothers less likely engaged the child in elaborations while looking at pictures, invited the child to say something, appeared familiar reading to the child, and reported regular book sharing (meaning getting the child to look at books and talk about the pictures or point to them). At 36 months, on the book interaction there was no longer a difference on mother motivating children, or in elaborating, or in inviting the child to talk.

[EBSCOhost], Education Source, ERIC, Family Studies Abstracts, Gender Studies Database, Historical Abstracts with Full Text, Mental Measurements Yearbook, PsycARTICLES, PsycINFO, Race Relations Abstracts, Social Sciences Abstracts [H. W. Wilson], Sociology Source Ultimate, and Violence & Abuse Abstracts), PubMed, and Web of Knowledge to find eligible studies. Considering the limited amount of data available, we did not impose a time limit for papers searching, and we searched for both papers and books published from the beginning to May 2019. The following keywords were used: ("twin*" or "multiple birth*") AND ("IDS," or "infant directed speech," or "CDS," or "child-directed speech," or "child addressed speech," or "infant addressed speech," or "motherese," or "baby talk," or "linguistic environment," or "maternal speech", or "paternal speech," or "parental speech", or "speech input," or "language input," or "linguistic input," or "maternal input," or "paternal input," or "parental input," or "JA," or "joint attention," or "responsive*," or "directive*," or "book reading", or "mother child* interact*," or "father child* interact*," or "parent child* interact*," or "mother infant interact*," or "father infant interact*," or "parent infant interact*").

INCLUSION AND EXCLUSION CRITERIA

The following criteria were used for the inclusion of studies in the systematic review: (a) the comparison of twins' and singletons' linguistic environments, (b) occurring within the children's first 3 years of life, and (c) the use of the English language in the papers. Studies that did not match these inclusion criteria were excluded. Furthermore, papers or book chapters that included triplets, quadruplets, or higher order multiples were excluded on grounds that they considered a different population that was not the focus of the current review. Research studies employing a composite measure of the parental environment that included an assessment of linguistic features but did not allow for the extraction of specific features from the parental linguistic input were excluded because they do not enable a comparison of the provided linguistic input.

STUDY SELECTION AND DATA EXTRACTION

From the 445 papers that resulted from a first search on EBSCO, 41 were selected for the full text review; from PubMed's 513 results, 28 were selected, and from Web of Knowledge's 756 results, 27 papers were selected. It is noteworthy that the majority of the studies found on the three databases focused on the use of twins as a study method rather than as a specific population, were oriented to the study of genetics, and involved several conditions in the shared and non-shared environmental factors. A large number of papers were excluded from the full text review primarily due to this reason. After removing duplicates, the full text review left only seven papers eligible, which were included in our systematic review. From examining references in the selected papers, one more book chapter was identified and added. Overall, seven papers and one book chapter were included

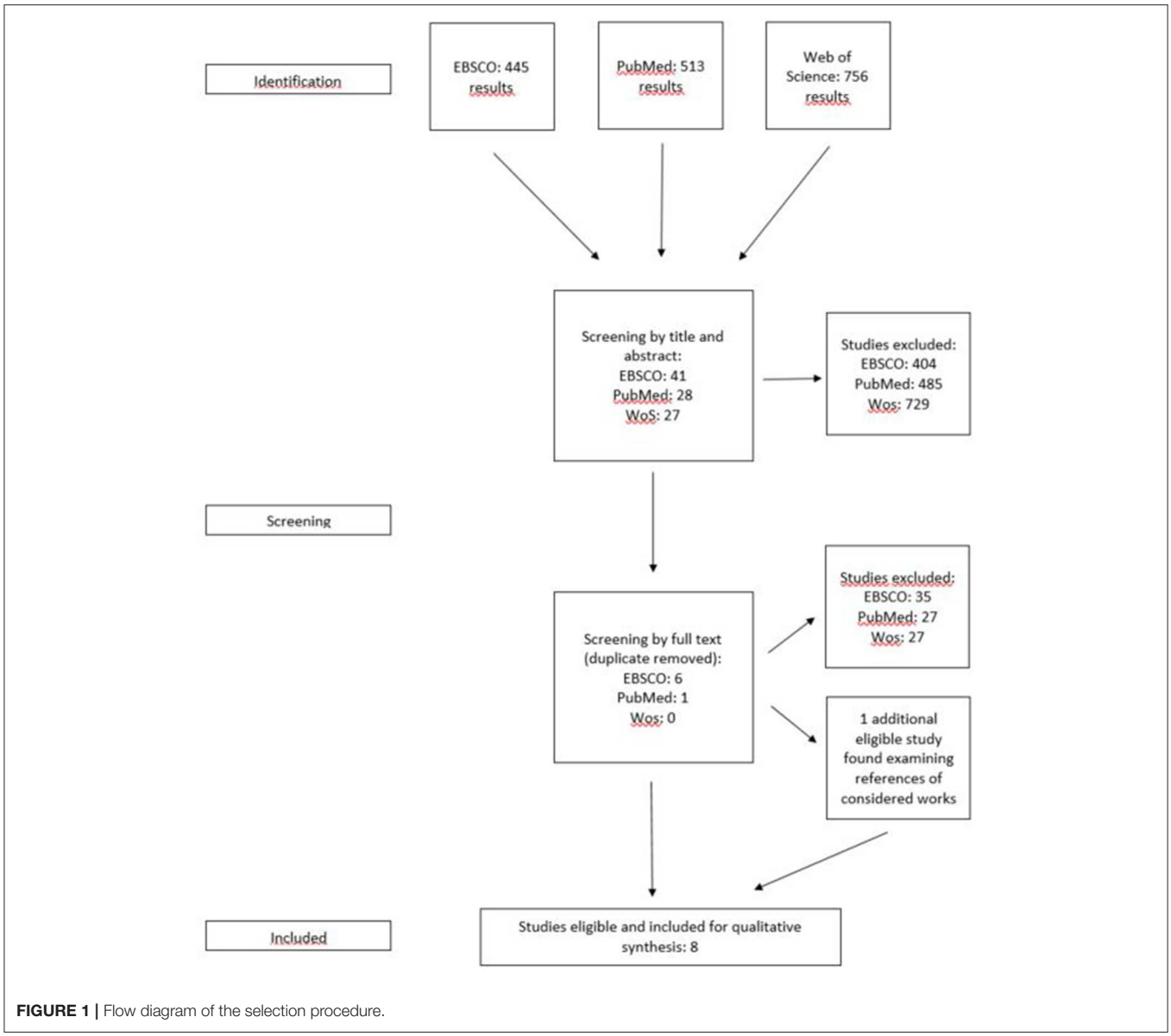

FIGURE 1 | Flow diagram of the selection procedure.

in the current paper (see **Figure 1**). Two independent reviewers conducted data extraction, and discrepancies were discussed to obtain a consensus.

RESULTS

In the next section, the methodological issues identified within the studies are explored to review the following: the procedure used to assess the linguistic environment, the coded linguistic environment's features, the computational method employed to assess the parental linguistic input, and the characteristics of the groups included as participants. Subsequently, the differences found within and between the reviewed research reviewed will be highlighted regarding the linguistic environment of twins and singletons, specifically focusing on the following: quantity of linguistic input, CDS linguistic features, parental responsiveness and directiveness, JA interaction, and parent-child book reading.

METHODOLOGICAL ISSUES

First, although all the papers adopted an observational approach, two papers used a laboratory setting to assess the linguistic environment of the subjects involved (Stafford, 1987; Butler et al., 2003), and six studies employed a naturalistic setting, conducting the observation in family homes (Lytton et al., 1977; Conway et al., 1980; Bornstein and Ruddy, 1984; Tomasello et al., 1986; Ostfeld et al., 2000; Thorpe et al., 2003). Note that the use of a laboratory setting to assess the linguistic features of the family imposes the presence of a camera and does not consider the common demands of

the home environment; both of these factors can influence parent-infant interactions (Stafford, 1987; Butler et al., 2003).

Regarding the linguistic environment's coded features, six studies assessed the number of words or utterances directed toward the children (Lytton et al., 1977; Conway et al., 1980; Bornstein and Ruddy, 1984; Tomasello et al., 1986; Stafford, 1987; Ostfeld et al., 2000). Two studies employed an assessment of the parental input complexity (Conway et al., 1980; Tomasello et al., 1986): one study assessed MLU (Tomasello et al., 1986), and one study employed a complexity composite measure based on the score obtained on four measures: subject phrase, predicate phrase, verb phrase complexity, and additional points (Conway et al., 1980). Three studies assessed linguistic features of CDS; however, the studies varied greatly on the variables coded (Tomasello et al., 1986; Stafford, 1987; Butler et al., 2003). Three studies evaluated characteristics of parental responsiveness and directiveness (Tomasello et al., 1986; Stafford, 1987; Butler et al., 2003). Moreover, three research studies assessed respective JA features, that is, the mother's propensity to encourage the infant's attention to the environment (Bornstein and Ruddy, 1984), JA interactions (Tomasello et al., 1986), and attention devices used (Stafford, 1987). Lastly, one study evaluated maternal input during unstructured activity and two structured activities (playing with toys and book reading) (Thorpe et al., 2003). Although observation of the family interaction was present in all the papers, differences emerged in the computational method used to assess the parental linguistic input. Tomasello et al. (1986) defined three different computational methods: the *twin moms* value, which counts the total communication produced by the mothers regardless of the direction and compares the input provided by twins' and singletons' mothers; the *twin direct dyadic* value, which considers the communication directed only toward the target twin; and the *twin direct dyadic + both* value, which instead codes the communication directed toward the twins pair contemporaneously as communication addressed to the twin target of the study; both the twin direct dyadic value and the twin direct dyadic + both value compared linguistic input toward twins with the communication directed toward the singleton individually. These values highlight different considerations about the input assumed as relevant for child development. The use of a twin direct dyadic value emphasizes the major role of the linguistic input directed exclusively to the child, whereas the adoption of the twin direct dyadic + both value implies the consideration of the communication directed toward both children as relevant for the infant's language development. With this classification as reference, we can affirm that one study in the current review employed the twin direct dyadic + both value (Lytton et al., 1977), while three papers adopted a mixed method (Conway et al., 1980; Tomasello et al., 1986; Stafford, 1987). Conway et al. (1980) used the twin direct dyadic value and the twin direct dyadic + both value; Stafford (1987) employed the twin moms value and the twin direct dyadic value, adding furthermore an assessment of the communication exclusively directed toward both children simultaneously (both for twins and singletons, including a singleton group with siblings). Only the study by Tomasello et al. (1986) used all three values mentioned above. Butler et al. (2003) were the only ones who adopted a process of observation that did not include both the twins in the interaction and coded only the communication directed toward the target child involved. Bornstein and Ruddy (1984), Ostfeld et al. (2000), and Thorpe et al. (2003) did not provide clear information; for this reason, we were not able to classify the computational method used.

Some differences can be identified regarding the groups included as participants: five papers used sets of twins that were compared with singletons with no siblings, that is, comparing a triadic situation with a dyadic situation (Conway et al., 1980; Bornstein and Ruddy, 1984; Tomasello et al., 1986; Ostfeld et al., 2000; Butler et al., 2003). Three studies compared twins and singletons with siblings in order to replicate the same family structure of twins' families (Lytton et al., 1977; Stafford, 1987; Thorpe et al., 2003). This methodological solution sought to understand if the differences found between the groups were actually due to factors exclusively related to the twin situation and not only to the demands associated with the presence of two children simultaneously. Three studies assessed children at the prelinguistic age of 4–8 months (Bornstein and Ruddy, 1984; Ostfeld et al., 2000; Butler et al., 2003), while five research studies considered children between 15 and 36 months of age (Lytton et al., 1977; Conway et al., 1980; Tomasello et al., 1986; Stafford, 1987; Thorpe et al., 2003), when infants are already starting to produce words (Taylor et al., 2018).

Furthermore, while most of the studies included controlled for age (Lytton et al., 1977; Bornstein and Ruddy, 1984; Tomasello et al., 1986; Stafford, 1987; Ostfeld et al., 2000; Butler et al., 2003; Thorpe et al., 2003) and gender (Conway et al., 1980; Tomasello et al., 1986; Stafford, 1987; Ostfeld et al., 2000; Butler et al., 2003) when assessing differences between the twins' and singletons' linguistic environments, only four studies controlled for prematurity (Bornstein and Ruddy, 1984; Stafford, 1987; Ostfeld et al., 2000; Butler et al., 2003) and three for birthweight (Tomasello et al., 1986; Stafford, 1987; Ostfeld et al., 2000), variables that emerged as potential confounding variables (Dezoete and MacArthur, 1996; Rutter et al., 2003; Olivennes et al., 2005; Nan et al., 2013; D'haeseleer et al., 2016). Moreover, it is noteworthy that only three studies controlled for SES (Conway et al., 1980; Tomasello et al., 1986; Butler et al., 2003). Considering the influence of SES on both the parental linguistic input and the children's linguistic skills found within the general population (Hoff, 2003; Schwab and Lew-Williams, 2016; Inglebret et al., 2017), as well as the preliminary data regarding the negative association between twin births and SES (McKay, 2010), further studies would need to control for this variable.

Lastly, four studies observed the characteristics of the linguistic environment at two time points (Bornstein and Ruddy, 1984; Tomasello et al., 1986; Ostfeld et al., 2000; Thorpe et al., 2003), while four research studies assessed parental input at only one time point (Lytton et al., 1977; Conway et al., 1980; Stafford, 1987; Butler et al., 2003).

LINGUISTIC ENVIRONMENT DIFFERENCES BETWEEN TWINS AND SINGLETONS

All the studies eligible for the current systematic review showed significant differences between twins' and singletons' linguistic environments (Lytton et al., 1977; Conway et al., 1980; Bornstein and Ruddy, 1984; Tomasello et al., 1986; Stafford, 1987; Ostfeld et al., 2000; Butler et al., 2003; Thorpe et al., 2003) and data against twins generally emerged. However, conflicting results within and between the studies mainly based on the computational method employed. For this reason, the results obtained do not allow for firm conclusions about the differences in the linguistic environments of twins and singletons.

LINGUISTIC INPUT

Linguistic Input Quantity

The six studies interested in the twins' and singletons' differences in the number of words or utterances expressed by parents showed results in favor of the singletons group (Lytton et al., 1977; Conway et al., 1980; Bornstein and Ruddy, 1984; Tomasello et al., 1986; Stafford, 1987; Ostfeld et al., 2000). However, differences emerged according to the computational method used. Employing the twin moms value, Tomasello et al. (1986) and Stafford (1987) did not find significant differences between groups. On the other hand, employing the twin direct dyadic value (Conway et al., 1980; Tomasello et al., 1986; Stafford, 1987) and the twin direct dyadic + both value (Lytton et al., 1977; Conway et al., 1980), significant results against twins emerged. The only study that computed the utterances directed toward both children simultaneously highlighted instead a larger number of words within the group of twins (Stafford, 1987). The results described showed no differences regarding the number of words or utterances computed with the twin moms value (Tomasello et al., 1986; Stafford, 1987). Otherwise, considering the number of words/utterances addressed to the child target of the study, computed both by considering exclusive input toward the target child or adding input directed to the pair simultaneously, significant differences against twins emerged in all the studies (Conway et al., 1980; Tomasello et al., 1986; Stafford, 1987). Twins' mothers do not speak less compared with singletons' mothers, although they talk less to the target child (also adding input addressed to the pair) in comparison with singletons' mothers (Conway et al., 1980; Tomasello et al., 1986; Stafford, 1987). The origin could be due to the nature of the twin situation and the limited attentive resources that they can direct toward two children of the same age (Conway et al., 1980; Tomasello et al., 1986).

Linguistic Input Complexity

Regarding the complexity of the linguistic environment provided by parents, results against twins generally emerged. Lower MLU among twins' mothers was shown by Tomasello et al. (1986). Significant differences were highlighted by exclusively employing the twin direct dyadic (results were not replicated controlling for birthweight) and the twin direct dyadic + both values, whereas no differences emerged using the twin moms value. In addition, Conway et al. (1980) found a reduced language complexity in the twins' linguistic environment, assessing a complexity composite measure based on the score obtained on four measures: subject phrase, predicate phrase, verb phrase complexity, and additional points (i.e., negative expressions, conjunctions, and questions).

Linguistic Features of Child-Directed Speech

Considering the results found in the studies that assessed the linguistic features of CDS, generally the disadvantaged condition of twins emerged (Tomasello et al., 1986; Stafford, 1987; Butler et al., 2003). However, conflicting findings surfaced according to the computational method used. All three studies showed a reduced number or proportion of questions among the twins' mothers, regardless of the computational method used [note that in the Tomasello et al. (1986) study, controlling for birthweight and child's language skills, the results were not replicated using the twin direct dyadic value] (Tomasello et al., 1986; Stafford, 1987; Butler et al., 2003). Only the Stafford (1987) study, computing the utterances toward both children, highlighted a higher number of questions among this group. The assessment of the proportion or number of utterances aimed at the topic continuation—parental linguistic features that ensure the flow of the conversation as questions (Tomasello et al., 1986)—showed diverging results. Tomasello et al. (1986) highlighted a reduced proportion among twins, whereas Stafford (1987) found differences only when considering input directed toward both children simultaneously, showing a higher number of topic continuation utterances among twins. Moreover, the author highlighted the lower participation of twins in the conversation compared with singletons, which is a condition that represents the mother's attempt to control and limit the conversation (Stafford, 1987). A higher number of declaratives—utterances with the function to assert or describe and which characterize the adult-directed speech (Butler et al., 2003)—were found among twins by Butler et al. (2003). On the other hand, conflicting results were found in the Stafford (1987) study according to the computational method used. Employing the twin direct dyadic value, the author found a lower number of spontaneous declaratives among twins, while a higher number was found considering the utterances directed toward both children simultaneously. Considering the remaining differences in kinds of utterances, which represent a facilitative/non-facilitative linguistic environment, the results highlighted the unfavorable condition of twins. Coding the linguistic input addressed toward both children simultaneously, Stafford (1987) found more semantically unrelated utterances and yes/no answers among twins, as well as more repairs and unclassified remarks adopting the twin moms value—all utterances representative of a non-facilitative linguistic environment. Computing input with the twin direct dyadic value, Stafford (1987) found a lower number of positive acknowledgments, while Tomasello et al. (1986) identified no differences. Positive acknowledgments are representative of an

adaptive linguistic environment; expressing approval for what the child says then increases the child's linguistic confidence (Stafford, 1987). Computing the utterances directed toward both children simultaneously, Stafford (1987) also identified a larger number of maternal self-utterances among twins' mothers. Lastly, Tomasello et al. (1986) found a larger use of object words among twins' mothers using the twin direct dyadic value, which provides a source of word learning during early development. No differences were found employing the twin direct dyadic + both and the twin moms values.

Parental Responsiveness and Directiveness

Considering the studies that assessed linguistic input by characterizing responsive and directive interactions, the results highlighted the disadvantaged linguistic environment of twins for several variables (Tomasello et al., 1986; Stafford, 1987; Butler et al., 2003). However, conflicting results emerged on the basis of the computational method used. Butler et al. (2003) identified a lower proportion of infant-focused utterances among the twins' mothers. Regarding the subcategory of infant-focused speech content, mothers of twins showed a lower proportion of utterances conveying agency and responsiveness to the child, which underlines the difficulty in understanding the meaning of the child's cues. This condition entails a non-optimal linguistic environment (Butler et al., 2003). Moreover, using the twin moms and the twin direct dyadic values, fewer extensions and items related to action (both considered responsive speech features) were found among twins' mothers in Stafford (1987). On the other hand, when coding input directed toward both children simultaneously, the opposite result emerged (Stafford, 1987). Tomasello et al. (1986) found a greater proportion of imitations among twins, while Stafford (1987) found the same results (considering the number and not the proportion) by only computing the verbal stimulations directed toward both children simultaneously. On the other hand, using the twin direct dyadic value, Stafford (1987) found a greater number of imitations among singletons and no differences employing the twin moms value. However, the role of imitation is controversial; from Stafford's (1987) perspective, imitations represented the mothers' responsiveness and ability to improve the language learning occasions. In contrast, Tomasello et al. (1986) categorized the imitations as utterances aimed at maintaining the conversation and stated that this linguistic form minimizes the stimulation and limits the speech escalation, highlighting its maladaptive role. It is noteworthy that the statistical analysis employed in these studies to evaluate the correlation between the linguistic environment's features and the children's linguistic development highlighted opposite results, supporting the conflicting theoretical perspective mentioned above (Tomasello et al., 1986; Stafford, 1987). Regarding the utterances that represent a lack of responsiveness, Stafford (1987) highlighted a reduced number of maternal self-answers among twins adopting the twin direct dyadic value, whereas a greater number was found when coding input directed toward both children simultaneously. Using this latter computational method, the results showed a higher number of stock expressions among twins, whereas when employing the twin moms value, the number of stock expressions was higher among singletons (Stafford, 1987).

On the other hand, regardless of the computational method used, Tomasello et al. (1986) highlighted a larger proportion of directive utterances among the twins' mothers, while Stafford (1987) found the same results (in terms of number of commands, not of proportion) only using the twin moms value and computing the input directed toward both children simultaneously. Butler et al. (2003) found no differences between groups (twin direct dyadic value). In the Tomasello et al. (1986) study, regardless of the computational solution adopted, mothers of twins referred to objects mainly with a directive form and almost never with non-directive utterances.

Joint Attention and Book Reading

Regarding JA interaction, although the results identified the disadvantaged condition of twins for most of the dimensions, the studies showed different results according to the computational method used (Bornstein and Ruddy, 1984; Tomasello et al., 1986; Stafford, 1987). The physical and verbal encouragement of the child's attention toward the environment was higher among singletons' mothers (Bornstein and Ruddy, 1984). In the Tomasello et al. (1986) study, employing the twin direct dyadic value, twins' mothers began fewer JA interactions (results were not replicated controlling for birthweight), whereas using the twin moms value showed opposite results; no differences were found with the dyadic + both value. Moreover, regardless of the computational method used, the authors highlighted a lower number and length of JA interactions, a reduced proportion of equal-led JA interactions, and a higher proportion of JA interactions maintained by the effort of the mother (results were not replicated controlling for birthweight, using the twin direct dyadic value) among twins. Within this group, no JA interaction maintained by the effort of the child (child-led joint interaction) were identified. The use of attention devices to attract the child's attention was higher among twins computing input toward both children simultaneously; the opposite results were found when employing the twin direct dyadic value (Stafford, 1987).

The Thorpe et al. (2003) study, which observed mothers and children involved in an unstructured interaction and two structured interactions (playing with toys and book reading), found that twins' mothers tended to approach the children simultaneously rather than individually (unstructured interaction), showing a reduced probability to motivate the children to action (toy observation) and to involve him or her in the elaboration of pictures and in linguistic production while reading a book. During this latter activity, twins' mothers also appeared less likely to be familiar with reading to the child.

LONGITUDINAL STUDIES

Ostfeld et al. (2000) highlighted the same performance and the same differences between groups in the number of verbalization both at T1 (1 month) and T2 (8 months); similarly, Bornstein and Ruddy (1984) found stable differences between T1 (4 months)

and T2 (12 months) regarding the encouragement of the child's attention. Tomasello et al. (1986) found no differences between T1 (15 months) and T2 (21 months) in JA interactions but identified a reduction in the proportion of utterances characterized by motherese intonation and an increase in the proportion of questions both in twins and singletons. Only singletons showed a decline in the proportion of comments and a rise in directives (using all three values employed by the respective authors). Furthermore, data identified an increase among singletons on the MLU, while twins showed stable results between T1 and T2: results were obtained, however, using the twin direct dyadic and dyadic + both values and not the twin moms value (Tomasello et al., 1986). Regarding the remaining CDS linguistic features coded, Tomasello et al. (1986) did not find differences between T1 and T2. Thorpe et al. (2003) did not provide clear information on the difference between the first and the second assessment. However, regarding maternal input during the book interaction, the authors did not find the differences between groups at the second assessment (36 months) that they found at the first time point (20 months). According to Thorpe et al. (2003), these data demonstrated how the results obtained at T1 (20 months) are not due to the lack of skills of twins' mothers but are likely related to the demands associated with the presence of twins during the first years postpartum, which affect the relationship and the linguistic environment qualities. From our perspective, these considerations are sustained by the absence of differences between T1 and T2 among twins on the majority of the measures assessed by the studies that considered the first 21 months of life (Tomasello et al., 1986; Ostfeld et al., 2000).

DISCUSSION

To our knowledge, this is the first systematic review focused on the comparison of twins' and singletons' linguistic environments. Limited data emerged from the literature, only seven papers and one book chapter matched the inclusion and exclusion criteria and were included (Lytton et al., 1977; Conway et al., 1980; Bornstein and Ruddy, 1984; Tomasello et al., 1986; Stafford, 1987; Ostfeld et al., 2000; Butler et al., 2003; Thorpe et al., 2003). Within all the studies included, differences were found between the groups. The results generally showed the disadvantaged condition of twins. Twins' mothers talked less to the target child and provided more non-facilitative input of lower complexity. Furthermore, twins' mothers were less responsive and more directive when interacting with their children, involved their children in fewer and shorter JA interactions, and stimulated their children less during book reading. As stated by several authors, the results against twins are likely due to the demands related to the twin situation, the limited attentive resources available, and the mothers' attempt to control the situation to manage two children of the same age (Tomasello et al., 1986; Stafford, 1987; Butler et al., 2003; Thorpe et al., 2003). The demands that entail the management of two children of the same age emerged from interviews conducted by Holditch-Davis et al. (1999). These findings are in line with the parental difficulties identified in families of twins in the first years of the toddlers' lives (Glazebrook et al., 2004; Olivennes et al., 2005; Sutcliffe and Derom, 2006; Lutz et al., 2012; Beer et al., 2013; Wenze et al., 2015; Anderson et al., 2017). Compared with singletons' parents, twins' parents experienced higher psychological symptoms and parenting stress (Glazebrook et al., 2004; Olivennes et al., 2005; Lutz et al., 2012; Beer et al., 2013; Wenze et al., 2015; Prino et al., 2016). Moreover, they needed greater resources and more involvement to rear twins (Prino et al., 2016). Less optimal interactions among twins and their parents were found in comparison with singletons' families (Glazebrook et al., 2004; Sutcliffe and Derom, 2006; Anderson et al., 2017). However, there were some conflicting results within and between the studies, and the results against twins were not replicated when employing different computational methods (i.e., twin moms value, twin direct dyadic value, twin direct dyadic + both value, and input directed toward both children simultaneously). A need remains to further confirm the results identified and understand the role of the differences found on the child's linguistic skills with specific computational methods to better understand the relevance of the findings against twins for language development. These findings could draw important theoretical and research conclusions about the linguistic environment's features and the input direction that impact twins' linguistic development (i.e., input addressed to the child individually, to the pair concurrently, or expressed by the mother regardless of direction).

On the other hand, it is noteworthy that the results obtained identified data favoring twins for some variables (i.e., use of extensions, items related to action, self-answers, stock expressions, spontaneous declaratives, questions, topic continuation, attention devices, object references, and number of JA interactions initiated by the mother). However, regarding the use of questions, topic continuation, extensions, items related to action, and attention devices, these results were obtained by comparing two triadic situations and coding input directed toward both children simultaneously (Stafford, 1987). These data showed a non-significant negative correlation with the twins' and singletons' linguistic skills (Stafford, 1987). Although the results showed the favoring condition of twins for these dimensions, input directed toward both children simultaneously did not contribute to the target child's language development. These preliminary findings assume theoretical and research relevance, which needs to be further confirmed.

It is also important to note that seven features of the linguistic environment (number of words/utterances, questions, declaratives, directives, topic continuation utterances, imitation, and acknowledgment) were assessed by more than one study. Of these, the results regarding quantity of words/utterances (with the twin direct dyadic value), questions (with the twin direct dyadic and the twin moms values), declaratives (with the twin direct dyadic value), and directives (with the twin moms value) were uniquely replicated by adopting the same computational method, confirming the disadvantaged condition of twins (Conway et al., 1980; Tomasello et al., 1986; Stafford, 1987; Butler et al., 2003).

It is noteworthy that the differences found among the twins' and singletons' linguistic environment are not exclusively due to the comparison of a triadic and a dyadic interaction. Compared with singletons with siblings, twins showed a disadvantaged linguistic environment (Lytton et al., 1977; Stafford, 1987; Thorpe et al., 2003), which could be due to the fact that two children of the same age have the same dependence degree and similar evolutionary needs that can emerge at different times. This entails great demands on the mothers, who cannot rely on the higher independence of one of the children, which would help to limit the double maternal commitment (Tomasello et al., 1986; Thorpe et al., 2003; Wenze et al., 2015). Moreover, twins' mothers were more likely to address the children as a pair, which is a condition that could limit individual stimulation and impact linguistic development (Thorpe et al., 2003). Lastly, as stated by Thorpe et al. (2003), the occurrence of an older sibling rather than a twin could guarantee more complex communication among siblings and a motivation for the mother to adopt a more sophisticated linguistic pattern to comply with the communicative competence of the older child.

Although the results obtained generally showed the disadvantaged condition of twins, conflicting results were identified within and between the studies, mainly according to the computational method employed. The limited data available and the conflicting and not replicated results do not allow the results to be confirmed nor clear conclusions to be drawn regarding the differences in the linguistic environment of twins and singletons.

LIMITATIONS

The current review presents several limitations: First, the results are limited by the reduced number of papers included due to the few studies that comply with the established selection criteria. Second, our review is not a meta-analysis, and this study design does not allow statistical conclusions to be drawn about the results found in the included studies. Lastly, limitations are related to the selection and exclusion criteria used: we excluded those studies that employed measures that—despite the evaluation of the linguistic environment's features—do not provide a clear understanding of the differences among twins and singletons, showing instead composite results of the total environment (Beer et al., 2013; Anderson et al., 2017). Moreover, we selected only studies that compared twins and singletons groups, excluding studies that considered only twins and found results that did not identify disadvantaged linguistic environment's features within the twin population (Barton and Strosberg, 1997; Rendle-Short et al., 2015). Finally, we included only studies published in English, not considering papers published in other languages concerned with the issue, which could provide additional information. The adoption of these selection criteria allowed for a clear identification of the studies concerned with the differences in linguistic environments of twins and singletons, but, on the other hand, did not allow the complexity of the issue to be considered. Other studies that draw conclusions about all the environmental variables involved in linguistic learning would be useful.

FUTURE DIRECTIONS

First, considering the limited and conflicting data that emerged, other studies with a comparative design would be useful to further explore the linguistic environment's features (i.e., quantity and complexity of linguistic input provided, linguistic features of CDS, maternal responsiveness and directiveness, JA interaction, and book reading) for which were found differences among twins and singletons in the studies included (Lytton et al., 1977; Conway et al., 1980; Bornstein and Ruddy, 1984; Tomasello et al., 1986; Stafford, 1987; Ostfeld et al., 2000; Butler et al., 2003; Thorpe et al., 2003) and that emerged as influencing factors for language development (Conway et al., 1980; Tomasello et al., 1986; Stafford, 1987; Ostfeld et al., 2000; Thorpe et al., 2003). This would allow for clearer conclusions about the preliminary differences within the studies included in the current systematic review and for further highlighting of factors potentially associated with the lower linguistic skills found among twins.

Furthermore, other studies are necessary to better understand the twins' and singletons' differences according to the computational method used, as well as the relation of these differences with the lower linguistic skills found among twins. Specifically, future studies focused on the comparison of the twins' and singletons' linguistic environments should employ the different computational methods highlighted by Tomasello et al. (1986) (i.e., input addressed to the child individually, to the pair concurrently, or expressed by the mother regardless of direction) to clarify the direction of parental input that entails differences in the twins' and singletons' linguistic environments. Moreover, further studies are necessary to explore the association between the linguistic environment's features against twins (emerged with the specific computational method) and the twins' language development, controlling for variables that could influence the results found (e.g., age, gender, birthweight, prematurity, and SES). These findings could assume a theoretical and research relevance to further confirm the results found in the studies included in the current review and to clarify the input and the input directions that influence twins' linguistic skills. It is noteworthy that only five studies included in the present review—which, to our knowledge, are the only ones in the literature—performed statistical analysis between the twins' linguistic environment and the twins' linguistic skills, finding results that confirm the influence of the linguistic environment's features (Conway et al., 1980; Tomasello et al., 1986; Stafford, 1987; Ostfeld et al., 2000; Thorpe et al., 2003).

Moreover, most of the studies compared a triadic and a dyadic situation (Conway et al., 1980; Bornstein and Ruddy, 1984; Tomasello et al., 1986; Ostfeld et al., 2000; Butler et al., 2003), while only three research studies compared twins and singletons with siblings (Lytton et al., 1977; Stafford, 1987; Thorpe et al., 2003). Further studies that adopt this latter

methodological solution are necessary to better understand whether the differences found are actually due to the demands associated with the twin situation—as emerged in the studies included in the current review that compared two triadic contexts (Lytton et al., 1977; Stafford, 1987; Thorpe et al., 2003)—and not only to the comparison of a triadic and a dyadic context and thus to the complexities related with triadic interactions.

Considering that the differences among twins and singletons emerged both at the prelinguistic age and until 21 months of age (Bornstein and Ruddy, 1984; Ostfeld et al., 2000; Butler et al., 2003), with no differences found at 36 months (Thorpe et al., 2003), other studies with a longitudinal design that assess the linguistic environment of twins and singletons until at least age 3 could be useful to understand whether the disadvantaged condition of twins are sustained or resolved as stated by Thorpe et al. (2003).

Lastly, future studies with a cross-cultural design that explore the association between SES and the linguistic environment of twins would improve the level of knowledge of the phenomenon.

AUTHOR CONTRIBUTIONS

TT and LR took overall responsibility for the creation of the framework used in this review and the selection of the papers. TT, LC, AC, and EG searched for the articles discussed in the review. LR and PB supervised the entire work. All authors were involved in the discussion, the writing, and the revision of the manuscript, and they gave the final approval of the version to be published.

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Observing Change Over Time in Strength-Based Parenting and Subjective Wellbeing for Pre-teens and Teens

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The focus of this study was on adolescent mental health. More specifically, the relationship between strength-based parenting (SBP) and subjective wellbeing (SWB) during adolescence was examined at three time points over 14 months (N = 202, M_{age} = 12.97, SD_{age} = 0.91, 48% female). SBP was positively related to life satisfaction and positive affect at each of the three time points, and was negatively related to negative affect. SBP and SWB both declined significantly over time. When examining the causal relationships between SBP and SWB, two different statistical models were applied: latent growth-curve models (LGM) and random-intercept cross-lagged panel models (RI-CLPM). The LGM revealed a strong positive relationship between changes in SBP and SWB. Specifically, this model showed that SBP at one time point predicted adolescent SWB at future time points. However, when the more stringent statistical test was completed through RI-CLPMs, no cross-lagged paths reached significance. Thus, while parenting is a significant predictor of wellbeing for pre-teens and teens in real time, it is not predictive of wellbeing at future time points. Parents, thus, cannot assume that their current levels of SBP are 'banked' by their children to support future wellbeing. Instead, SBP needs to be an ongoing, contemporary parenting practice. Furthermore, the fact that perceptions of SBP decline in this age bracket suggest that SBP interventions may be helpful in supporting adolescent mental health.

Keywords: wellbeing, parenting, strengths, adolescence, pre-teens, teens, positive psychology

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INTRODUCTION

"*A healthy family is necessary for a healthy society*"
(Shapiro, 2004, p. 27)

The teen, and now increasingly pre-teen, years are characterized by intense changes to a young person's physical development, identity, social life, family relationships, exposure to drugs and alcohol, academic requirements, employment and economic responsibilities (Larson et al., 1996; Singh, 1998; Levy-Warren, 1999; Brown, 2004; Sisk and Foster, 2004; Viner and Taylor, 2007; Andersen and Teicher, 2008; Hussain et al., 2008; Sodha and Margo, 2008; Lerner and Steinberg, 2009; Sodha, 2009). As such, the second decade of

life sees a young person needing to build up the psychological, emotional, and social capacities necessary to meet the demands of these changes and grow into adulthood. While these skills and dispositions develop continuously from childhood, adolescence has been recognized as a particularly sensitive developmental period for these skills to be gained (Pfeifer et al., 2011; Somerville, 2013) given the shift to more independence (Feldman and Elliott, 1990), greater life complexity (Crone and Dahl, 2012), the teen brains heightened neuroplasticity (Andersen and Teicher, 2008; Giedd, 2008), and the fact that this is the life phase immediately prior to adulthood/emerging adulthood (Steinberg, 2014). Indeed, Patton et al. (2016) state that adolescence is "a critical phase in life for achieving human potential" (p. 2324) as it is the life stage "in which an individual establishes the social, cultural, emotional, educational, and economic resources to maintain their health and wellbeing across the life course." (p. 2427).

Parents are critical in shaping an adolescent's health and wellbeing (Bruyn et al., 2003; Galambos et al., 2003; National Research Council, 2011; Bøe et al., 2018). Yet, in their review of adolescent health and wellbeing, Patton and his colleagues assert: "given that families and parents remain the most important figures in the lives of most adolescents, the paucity of rigorous research into family influences on adolescent health and wellbeing is a striking knowledge gap" (Patton et al., 2016, p. 2432). Adding to the critique of Patton et al., parenting research has been criticized for not adequately studying how parent–child dynamics change over time (Holden and Miller, 1999; Rimehaug et al., 2011) and for having a deficit focus that has concentrated on effects of negative parenting factors (e.g., parent addiction, violence, mental illness, or neglect) at the expense of understanding the effects of positive parenting factors (e.g., compassion, strengths, emotional atonement) (Sheridan and Burt, 2009; Conoley et al., 2015; Waters and Sun, 2016).

The current study focuses on mental health outcomes for adolescents and sits within the paradigm of positive psychology to explore the dynamic effect of strength-based parenting (SBP) on subjective wellbeing (SWB) in pre-teens and early-to-mid teens across a 3-wave longitudinal study.

Youth Wellbeing

Research shows that the greatest risk for developing mental illness occurs in the second decade of life (Costello et al., 2003; Slade et al., 2009; Kieling et al., 2011; De Girolamo et al., 2012; Schwartz et al., 2012; Eyre and Thapar, 2014; Patton et al., 2014). Costello et al. (2011) found that there is an increase in rates of panic disorder, agoraphobia, substance use disorders and depression from childhood to adolescence.[1] Kessler et al. (2001) epidemiological research revealed a rise from 1% depression in the population under age 12 to 17–25% of the population by the end of adolescence. In early adolescence, epidemiological research shows that mental disorders sit around 10% (10.9%, Anselmi et al., 2010; 9.8%, Frigerio et al., 2009) but rise to 13.4–21.8% in mid to late adolescence (Costello et al., 2011; Polanczyk et al., 2015).

Epidemiological data from Costello et al. (2003, 2011) revealed the most common diagnoses in adolescents to be substance abuse disorders (12.1%), anxiety disorders (10.7%), depressive disorders (6.1%) and behavioral/spectrum disorders (e.g., conduct disorder, oppositional defiant disorder, attention-deficit hyperactivity disorder; 3–4%). The World Health Organization (2014) lists depression as the number one cause of illness in adolescence and according to Andersen and Teicher (2008) "depression emerges with force and frequency in adolescence" (p.183). Tragically, suicide is a leading cause of death among teenagers worldwide (Hawton et al., 2012).

Naturally, the question has arisen as to whether the prevalence of mental illness has increased over the decades. The evidence is mixed, and while some researchers have found no evidence for change (Costello et al., 2006), the majority of studies find mental illness has increased (Rutter and Smith, 1995; Collishaw et al., 2004, 2010). For example, in the United States of America (USA), Twenge's research has been convincing in showing that mental illness in adolescents and early adults has increased over the generations. For example, Twenge et al. (2010) analyzed generational comparisons using the Minnesota Multiphasic Personality Inventory (MMPI) across college students from 1938 to 2007 (N = 63,706) and across high school students from 1951 to 2002 (N = 13,870) and found that fives time as many of the youth from the later cohorts scored above common cut-offs for psychopathology than compared to the earlier generations.

In another study of generational comparisons across high school and college cohorts from a 1980–1990 cohort to a 2000–2010 cohort (N = 6.9 million), Twenge et al. (2015) found that the 2010 cohort were twice as likely to report symptoms of mental illness than teens in 1980s. The more recent cohorts also reported greater trouble sleeping, more feelings of being overwhelmed and were twice as likely to have seen a professional for mental health issues. College students from the later decades were more likely to report feeling overwhelmed and to believe they were below average in mental health compared to earlier generations of college students. The suicide rate dropped from 1991 to 2011 but the researchers suggested "subtle symptoms of depression became more prevalent even as some overt indicators of depression became less prevalent" (p. 437).

Finally, Twenge et al. (2018) used two national data sets from 2010 to 2015 to study if there were any shifts in depression, suicidal-outcomes (e.g., making a plan, attempting suicide) and suicide for American adolescents (N = 506,820). The researchers found that depression increased by 33%, suicide-related outcomes rose by 15% and suicide rose by 31%. These increases in mental health issues were consistent across race/ethnicity, SES, region, and age/grade. However, there were gender effects with females showing greater increases than males.

These trends in the USA are similar those in the United Kingdom (UK) as shown by Collishaw and his colleagues who have conducted a number of independent cross-cohort comparisons of adolescent mental illness in the UK. In one study, Collishaw et al. (2004) compared levels of depressed mood, anxiety and fearfulness (as assessed by parents) in 15/16-year

[1]It is important to note that Costello et al. (2011) found a decrease in separation anxiety disorder and attention-deficit hyperactivity disorder from childhood into the teen years.

olds and found a substantial increase from 1986 to 1999. Indeed, the proportion of parents reporting mental health symptoms increased by 70% between 1986 and 1999. In a later study, Collishaw et al. (2010) found increases in symptoms of anxiety and depression from 1986 to 2006 based on youth self-report with twice as many adolescents reporting five or more symptoms of anxiety or depression in 2006 compared to 1986 (15% vs. 7%). Other UK researchers report similar findings and Sweeting et al. (2009) identified that the number of young people meeting established GHQ 'case criteria' almost doubled for Scottish boys and more than doubled for Scottish girls between 1987 and 2006.

In 2015, Collishaw broadened his research sample beyond the UK to look at international trends arising in UK, Finland, the Netherlands and other Nordic countries from 1977–2011. Data across 21 studies revealed that clinical diagnosis and treatment of adolescent psychiatric disorders, problems and antisocial behavior increased in recent decades. Another international study conducted by Bor et al. (2014) examined long-term time trends (>10 years) in mental health problems for adolescents across seven countries (Finland, Iceland, Sweden, Scotland, UK, USA, and China) and concluded that "The burden of externalizing problems appears to be stable... However, the findings for internalizing problems suggest an increasing symptom burden in recent cohorts of adolescents, especially girls" (p.614).

Strengths and Youth Wellbeing

It is evident from the data above, that efforts are needed to assist adolescents to build up their wellbeing. One factor that has been shown to be significantly, positively related to wellbeing in young people is that of strengths (Proctor et al., 2011; Suldo et al., 2014). Govindji and Linley (2007) define strengths as "the things you are able to do well or do best" (p. 146). Research into strengths builds upon earlier humanistic psychological research into personality, abilities, self-actualization, virtues and character (Kristjánsson, 2012).

Strengths are one's capacities for excellence and talent, together with one's positive personality traits that play out in persistent patterns of person-environment interaction including one's thoughts, actions and activities (Peterson and Seligman, 2004; Biswas-Diener et al., 2017; Waters, 2017). Strengths provide a person with a sense of energy and efficacy and are used to support one's goals, values and growth (Peterson and Seligman, 2004; Linley et al., 2010).

The scientific study of strengths is a growing body of research (Donaldson et al., 2015) and large-scale bibliometric analyses of the positive psychological literature by Rusk and Waters (2015) demonstrated that the study of strengths has grown considerably in scientific interest since 1992. Indeed, it is the highest growing topic within the field (other rising topics include life satisfaction, positive affect, self-determination and optimism) (Rusk and Waters, 2015).

To date there have been two broad approaches used in the study of strengths. The first approach, a content approach, focuses the types of strengths that people have. This approach has spawned the development of various strengths frameworks and assessments outlining a range of different strengths be they moral qualities (e.g., kindness, courage) (Peterson and Seligman, 2004; see the Values in Action Survey[2]), natural talents combined with knowledge and skills (e.g., maximizer, adaptable; Rath, 2007; see StrengthsFinder[3]) or qualities that are energizing and allow for optimal functioning (e.g., authenticity, narrator; Linley et al., 2010; see Realise2[4]).

The second approach, the process approach, moves away from categorizing types of strengths and instead considers the underlying processes that are used to develop strengths. Govindji and Linley (2007), for example, focus their research on developing strengths through two key processes: (1) strength knowledge which they define as a person's "awareness and recognition of their strengths" (p. 146), and (2); and strengths use, which is defined as the extent to which individuals "use their strengths in a variety of settings" (p. 147). Recently, Biswas-Diener et al. (2017) called for a third element beyond knowledge and use to be included in the process-approach to strengths, that of strengths development.

In adult samples (Park, 2004) and youth samples (Park and Peterson, 2006a), knowledge and use of certain character strengths (hope, love, gratitude, and zest) have been associated with greater life satisfaction and, furthermore, the same strengths in parents predict greater LS in their children (Park and Peterson, 2006b). In a meta-analysis of 14 articles (29 effect sizes) on character strength interventions in adult and adolescent samples, Schutte and Malouff (2018) identified significant relationships between knowing and using one's strengths with life satisfaction (weighted Hedges' g of 0.42) and positive affect (weighted Hedges' g of 0.32).

Youth samples show significant relationships between strengths and SWB. For example, in the United States, Suldo et al. (2014) studied the impact of a 10-week school-based wellness-intervention embedded with strengths in pre-teens (aged 10–12) and found significant improvements in life satisfaction after the program. In a sample of 12–14 year-olds in the UK, Proctor et al. (2011) found increases in life satisfaction following a 24-lessons 'Strengths Gym' program. Moving up to older teens and early adults, a study in China found that college students who undertook an 18-week elective course on strengths showed statistically higher levels of life satisfaction after the course than before, and compared to those who did not complete the course (Duan et al., 2014).

The meta-analysis and youth studies cited above show that strengths interventions increase SWB and life satisfaction and, thus, offer a promising route to mental health for teenagers. However, not every young person has the good fortune to participate in a strengths-intervention at school or college and, thus, other more naturally occurring opportunities that build strengths in young people need to be explored.

To this end, research shows that one powerful way to build strengths in a young person is through the strengths feedback they receive from others in their everyday life. For example, Spreitzer et al. (2009) found that when teenagers receive strengths

[2]www.viacharacter.org

[3]www.gallupstrengthscenter.com

[4]blog.cappeu.com/realise2/

feedback from teachers, coaches, bosses, friends and family it boosts their wellbeing. Importantly, this research showed that strengths feedback from both professional (teachers, coaches, bosses) *and* personal sources (family and friends) was more important than strengths feedback from professional sources alone, suggesting that parents play an important role in teens learning about their strengths.

The finding that other people can be even more accurate than the self at predicting certain trait-relevant behaviors and abilities (Vazire and Mehl, 2008; Vazire, 2010) suggests that others sometimes know us better than we know ourselves. In particular, few experiences in life rival the extensive insight gained about another human being than that of a parent raising their child. As parents have a myriad of daily opportunities to notice which situations and activities their child enjoys, is energized by and performs well in, they are uniquely placed to provide feedback to their teenager about his or her strengths.

Parenting and Youth Wellbeing: Strength-Based Parenting

Parenting has been a topic of empirical psychological inquiry since the 1960's and over the past 50+ years researchers have examined a range of ways in which parenting affects a child's mental health, adjustment, brain development, and trajectory into adulthood (for reviews see Steinberg, 2001; Mejia et al., 2012).

Historically, the research has focused on the effects of harmful parenting with studies investigating the impact of parental control, punishment, coldness, neglect, violence, conflict, addiction and mental illness on child and teen outcomes (Steinberg, 1987; Erel and Burman, 1995; Lovejoy et al., 2000; Caprara et al., 2002; Barnard and McKeganey, 2004; Dubowitz and Bennet, 2007; Ma et al., 2012). The impact of such parenting has been shown to lead to increased risk of psychopathology, suicidal ideation, substance abuse, delinquency, aggression, externalizing disorders, teen pregnancy and criminal behavior as well as deficits in social and emotional functioning (Kinard and Klerman, 1980; Baumrind, 1991a; McCloskey et al., 1995; Kaplan et al., 1999; Mejia et al., 2012). Beyond the focus on negative parental states (e.g., addiction, mental illness) and negative parenting practices (e.g., punishment, discipline, violence, neglect), environmental adversities and family level adversities such as poverty, poor education levels of parents and family stress have also been shown to be related to negative outcomes for adolescents including peer problems, emotional and conduct problems, inattention, mental health problems and psychiatric disorder (Bøe et al., 2012, 2018).

Prospective and retrospective studies have shown that negative parenting during adolescence leads to a raft of harmful outcomes not only in one's youth but also through into adult life including poorer adjustment to college, marriage, and to becoming parents themselves, as well as greater risk of heart attack, alcoholism, and obesity (Holmes and Robins, 1988; Mullen et al., 1999; Vaillant and Mukamal, 2001; Willinger et al., 2005; Schnuck and Handal, 2011; Bentley and Widom, 2012). Sadly, longitudinal research shows that adults with a history of parental maltreatment in their childhood are three times more likely to have depression and suicidality (Brown et al., 1999).

The research above has motivated an early intervention approach through the design of parenting programs used with at-risk families. One such example is the Family Strengthening Program, a strength-based program for families in crisis and for whom child safety concerns have been identified. This program involves therapists working with parents to teach them solution-focused strategies and unearth the assets within the family that can be used to create safer, healthier patterns. The Family Strengthening Program been shown to improve family safety, family health, family interaction, and child wellbeing (Katsikitis et al., 2013).

In addition to working with families at risk of harm, programs have also been designed to assist parents who may have high levels of parental stressors due to raising children who have challenges such as autism, developmental disabilities, intellectual disabilities, anxiety disorders and conduct disorders (Feldman, 1994; McConachie and Diggle, 2007; Plant and Sanders, 2007; Cartwright-Hatton et al., 2011). The Positive Parenting Program (Triple P) is one successful example that has been utilized in families with children who have behavioral, emotional, and/or developmental problems (Sanders et al., 2000). This program teaches parents how to praise pro-social behavior, minimize coercion and reduce opportunities for problem behavior (e.g., by providing ground rules). The meta-analysis of de Graaf et al. (2008) found the Triple P parenting program successfully reduces disruptive behaviors in children.

Other strength-based movements in family therapy include 'family centered services' (Dunst and Deal, 1994) and 'resilient families' (McCubbin et al., 1999; Shortt et al., 2007) both of which employ positive processes to reduce negative outcomes for families undergoing adversity and/or crisis.

Looking at the above research, it is no surprise to learn that the parenting literature has been criticized for its bias toward studying negative factors in terms of the type of families studied (families in distress/dysfunction/crisis; families at-risk, low SES families) and in terms the outcomes investigated (e.g., mental illness, substance abuse, conduct disorders, behavioral disorders). The programs used, while positively oriented, are designed to focus upon family problems (e.g., behavioral disorders) and are measured in terms of the ability to reduce *negative outcomes* (e.g., conduct disorders). Indeed, according to Shapiro (2004), much of the existing research in parenting is characterized by "one-sided and negative views of family process" (p. 33). In line with this, Sheridan and Burt (2009) assert that "Most research in children and families maintains a deficit focus; it concentrates more on the role of risk factors than assets." (p.552). Similarly, Katsikitis et al. (2014) argue that "Much of the focus of mother-daughter relationships in the literature has been on strategies to manage and deal with negative adolescent behavior" (p. 1).

While a great deal is now known about the adverse impacts of being raised with parental abuse, neglect, mental illness, conflict and the like; and while we have learnt about the impact that positive parenting approaches can have on *ameliorating negative outcomes*, such as harm in at-risk families and conduct issues in certain sub-samples of children, surprisingly little is known

about how to support parenting approaches that create positive outcomes for mainstream families who are not at risk and are not dealing with adversities such as poverty or children with challenging behaviors. Yet, when considering Seligman's (1999) call, that psychology should be able to help document the factors that promote flourishing families (not just support struggling families), it is time for parenting research to study the ways in which we can enhance positive outcomes in everyday families. Given that mainstream families (i.e., families who do not meet the clinical levels for dysfunction or pathology) represent the biggest proportion of families in society, Seligman's call motivates us to apply parenting research to the whole community and not just those with difficulties.

One pioneer in the application of positive parenting in non-clinical families is Steinberg who, together with his colleagues, has been studying the effect of autonomy-granting parenting since the 1970's in everyday families across multiple cultures[5] (Steinberg et al., 1992; Gray and Steinberg, 1999; Steinberg, 2001; Steinberg and Morris, 2001; Steinberg, 2014). Autonomy-granting parenting refers to the extent to which parents allow teens to develop their own opinions and beliefs and is characterized by three parental elements: warmth, boundaries/firmness, and autonomy granting (Steinberg, 2000). Autonomy-granting parenting has been related a host of beneficial outcomes for children and teens including higher self-esteem, social-confidence, subjective wellbeing, self-reliance, achievement motivation and school grades (for a review see Steinberg, 2001). Steinberg's work has long shown us the benefits of positive parenting.

Other positively oriented research can be found in the USA with Baumrind's work on authoritative parenting, defined as warm and firm (Baumrind, 1991b) and the research by Conger et al. (1992) who showed that positive behavior in mothers (e.g., nurturing and involvement) predicted school performance, self-confidence and peer relationships. In Australia, Havighurst and her colleagues have found that when parents are taught how to emotionally tune into their children they are more skilled at discussing causes and consequences of emotions and this leads to fewer internalizing issues with their children (Havighurst et al., 2010; Kehoe et al., 2013). In another Australian study, a longitudinal prospective study that tested the relationship between parent communication and brain development showed that positive parent communication (defined as a pattern of communication where the parent is approving, validating, affectionate, humorous, happy, pleasant, and caring) was associated with beneficial brain growth that enhances capacity for learning, decision-making, social skills, and emotional functioning (Whittle et al., 2014). As part of the Bergen Child Study in Norway, Bøe et al. (2014) found that affirmative parenting practices such as love, affection, praise, rewarding and respect as well as giving help and support when the adolescent is stressed (Last et al., 2012) were inversely related to externalizing problems, such as conduct problems and hyperactivity-inattention, together with internalizing problems, such as peer problems and emotional problems, in 11–13 years olds. Moreover, these positive parenting practices together with the parent's own emotional wellbeing, mediated the relationship between the family's socio-economic status and the degree to which the early adolescents were reporting symptoms of externalizing and internalizing disorders. Finally, a two-wave retrospective study in the UK on well-being in midlife women showed that the effects of positive parenting from childhood persisted into adulthood, with higher levels of parental care being associated with higher psychological well-being in mid-life (Huppert et al., 2010).

Although the last five decades have tipped more to the deficit end of parenting research, there have been pockets of positively oriented research as identified above. More recently, the advent of positive psychology, through its umbrella effect of gathering together positively oriented science into an aligned movement (Rusk and Waters, 2013, 2015) has provided the impetus and platform for a larger group of researchers to study factors that create thriving families (Shapiro, 2004; Sheridan et al., 2004; Katsikitis et al., 2013; Waters, 2017). Indeed, positive psychology, with its appreciative outlook on human virtue, resilience and potential, provides parenting researchers with a broad canvas upon which to explore the positive and pro-social side of family life. Several new strands of positive psychology research are being applied in parenting and family research both in clinical/at risk families and mainstream families. These strands of research include mindful parenting (Dumas, 2005; Geurtzen et al., 2015; Waters, 2016), family centered positive psychology (Sheridan et al., 2004; Sheridan and Burt, 2009), positive family therapy (Shapiro, 2004; Conoley et al., 2015), empathy (Farrant et al., 2011), compassion-focused parenting (Neff and McGehee, 2010; Kirby, 2017; Kirby and Baldwin, 2018) and SBP (Waters, 2015a,b, 2017; Waters and Sun, 2016; Jach et al., 2017; Loton and Waters, 2017; Waters et al., 2019).

Some of these strands of inquiry are still in the conceptual phase (e.g., family centered positive psychology, positive family therapy) and most are in the early stages of empirical research, which is to be expected given that positive psychology is still a relatively new field. At this stage in time, SBP has the highest number of peer reviewed empirical publications of the positive psychology parenting topics outlined above and is the focus of the current three-wave field study.

Waters (2015a) defined SBP as an approach to parenting that "deliberately identifies and cultivate positive states, positive processes and positive qualities in children" (p. 690). Rather than take a content approach to strengths, SBP follows the process approach in that it focuses on how parents can help their children develop and improve their strengths, regardless of what the type of strength is (Waters, 2017). The 'cultivate' element of the SBP definition includes both the 'use and develop' aspects of a process model of strengths and, thus aligns with both Govindji and Linley's (2007) process model (knowledge and use) as well as the model of Biswas-Diener et al. (2017; identify-use-development). SBP has been found to be a distinct parenting construct to autonomy-granting parenting (Waters, 2015b; Loton and Waters, 2017).

[5]Note: autonomy granting parenting has also been studied in at risk and troubled youth.

The effects of SBP on children, teenagers and parents have been examined using a range of different methods including survey research, vignette studies, dyadic studies, intervention studies, longitudinal studies, and panel designs in sample sizes ranging from 100 to over 11,300 (Waters, 2015a,b; Jach et al., 2017; Loton and Waters, 2017; Sağkal and Özdemir, 2019). Research on SBP has identified two overarching findings: (1) SBP is a *protective factor* that is inversely related to anxiety, depression, stress, and negative emotions; and (2) SBP is an *enhancing factor* that is positively related to life satisfaction, self-confidence, subjective wellbeing, positive emotions, and academic grades. The relationship between SBP and youth mental health is mediated by engagement, self-efficacy, persistence and mental toughness (Loton and Waters, 2017; Sağkal and Özdemir, 2019; Waters et al., 2019). Mindset has been found moderate the relationship between SBP and strength use in teens (Jach et al., 2017). Research in the effects of SBP on the mental health of parents shows that SBP boosts parental self-efficacy and positive emotions in the parents (Waters and Sun, 2016). Research in the effects of SBP on the family level happiness shows that SBP interventions raise happiness in families (Waters, in press).

Parental Stability Over Time

Given the significant influence a parent has on their pre-teen and teen's wellbeing, the question of the degree to which a parent displays consistent parenting over time is an important one.

Currently, there are two competing viewpoints held as to the temporal stability of parenting. The invariant viewpoint has historically been the most dominant in the literature and holds that parenting is trait-like and, thus, stable over time. As an advocate of the invariant approach, Maccoby (1984) argued that "We can assume that the family system, like any system, has self-stabilizing properties [horizontal ellipsis]. Families stabilize around habitual patterns of interaction; thus, there is continuity over time in the familial forces" (p. 326). The assumption of temporal consistency in parenting allows researchers to assume that child-rearing approaches assessed at one point in time are a stable reflection of future parenting and can, thus, be used to predict child outcomes over time (e.g., Baumrind, 1991a; Maccoby, 1992; Steinberg et al., 1994; Holden, 1997).

An alternate school of thought characterizes parenting as consistent *and* mutable, arguing that parental behavior is influenced not only by parent traits but also by the changes in needs and behaviors of the child over time[6] (Bornstein et al., 2008). While recognizing that a certain proportion of parenting is constant over time, this approach also explores the adjustments and changes that parents make in their approaches as their children grow. To this end, Madigan et al. (2016) assert that "It is necessary for the field to move beyond an exclusive focus on stability" (p. 122).

Holden and Miller (1999) conducted a meta-analysis on studies that had assessed parenting invariance-stability in infancy and childhood (babies: 0 months to 11 months/infants: 1–2 years/children: 3–11)[7], and found that maternal behavior was moderately enduring over time ($r = 0.45$) but was also "a moving picture of parent-child interaction" (p. 243). In other words, parenting is both stable *and* changeable. In another test of variance-invariance in maternal patterns during in infancy and early childhood, Madigan et al. (2016) conducted a three-wave study over 36 months and concluded that stability and variability co-exist in parenting during the young years.

When it comes to the pre-teen and early-teen years, research shows the same pattern of variance-invariance and a notable trend toward more negative parenting styles as compared to earlier childhood years (Collins, 1990; Rimehaug et al., 2011). A particular pattern identified in the research is that the decline in parenting is most prominent during early adolescence where control, conflict, power, prohibition, and secrecy rise, while support, knowledge about the child, and closeness decrease (Stattin and Klackenberg, 1992; McGue et al., 2005; De Goede et al., 2009; Keijsers et al., 2010; Keijsers and Poulin, 2013). According to Levy-Warren (1999), this dip in early adolescence is likely to be due to the teen's drive for autonomy and individuation which leads to increases in conflict and parent–child distance (Levy-Warren, 1999).

The pattern of negative changes in the parent-teen relationship alters as the teen becomes older and the parent-child relationship has been re-negotiated to one of power symmetry, where research shows closeness, respect, and trust between teen and parent rises while conflict and control diminish in the last teen years (Smollar and Youniss, 1985; Steinberg, 2001; De Goede et al., 2009).

A quick glance over the parenting variables examined above such as control, prohibition, and power, reveal a prevalence of negatively oriented constructs being tested in temporal teen-parent studies. But what of the stability of more positively oriented constructs of parenting? Does positive parenting stand the test of time or does it also take a 'nose dive' in the teenage years? Here, it is fair to say, the answer is still unclear as there have been few studies exploring the changes to positive aspects of parenting over time. The small amount of research that has been done, however, suggests that positive aspects of parenting decline during the pre-teen and early teen years. This has been found for parental warmth (McGue et al., 2005; Rodríguez et al., 2014[8]; Walkner and Rueter, 2014), parental closeness (Walkner and Rueter, 2014), parental support (Hafen and Laursen, 2009), as well as parental involvement, closeness and regard (McGue et al., 2005) – all of which decrease in pre-teen and teen years.

No studies have yet examined naturalistic change in SBP across time. While SBP has been treated as a trait-like construct in past studies (Waters, 2015b; Waters et al., 2019) it is also possible that SBP, like many other aspects of parenting, changes across the

[6]The current study focuses on variance-invariance over time but it is also important to note that the stability of parenting has also been examined across contexts, tasks and siblings (see Holden and Miller, 1999; Madigan et al., 2016).

[7]Note: The large majority of the studies included in Holden and Miller's meta-analysis were of parenting in the first year of a baby's life (45%), followed by studies of parenting from ages 1–3 (32%). This meta-analysis included only four studies that contained teenage sample (7%).

[8]Rodríguez et al. (2014) found gender differences in parenting. Modest declines in *paternal* warmth were evident from early to late adolescence, but *maternal* warmth was high and stable across this time period.

pre-teen and teen years. The reduced knowledge of parents about their teens, together with reduced teen-parent closeness may provide parents with fewer opportunities to see and acknowledge their teen's strengths. Increased conflict between parents and their teens may make it more challenging for parents to see the strengths in their child, and/or may make the teen feel the conflict is occurring because the parents is only seeing their problem behaviors and is not acknowledging their positive qualities. This could result in SBP declining in the pre-teen and early-to-mid teen years. Increased self-doubt in teenagers may also mean that, even if the parent remains constant in their strength-based approach, the teen is not able to consistently absorb and integrate the positive feedback. For these reasons, and in-line with the research on parenting invariance during the pre-teen and teen years, especially the finding that other positive aspects of parenting decline, it is reasonable to assume that SBP will decline through the pre-teen and into the early teen years.

The Current Study

Prior studies of SBP have relied on single-time-point or two-time-point designs (Waters and Sun, 2016; Sağkal and Özdemir, 2019; Waters et al., 2019). While these studies have usefully identified measurement characteristics, mediating and moderating factors, and wellbeing outcomes of SBP, more research is required to test if SBP naturalistically changes over time and, additionally, how the relationship between SBP and wellbeing changes over time. One means by which researchers can empirically investigate the dynamic causal relationship between SBP and SWB is by observing factors over multiple time points and establishing temporal precedence (McArdle, 2009; Hamaker et al., 2015). That is, whether a change in one variable tends to precede a change in another, which supports separable causal directionality and is one criterion for understanding causality. This study primarily aims to extend research on SBP by examining change in SBP and SWB at three time points over a period of 14 months in a sample of pre-teens and teens. The study is guided by four hypotheses.

Hypothesis One: Consistent with prior studies showing reductions in life satisfaction in teen samples, adolescent SWB is predicted to show a decline over time.

Hypothesis Two: Consistent with past research showing a reduction in positive parenting during the teen years, it is hypothesized that SBP will decline over time.

Hypothesis Three: Over time, adolescents who experience decreases in SBP will also tend to experience decreases in SWB, meaning these factors are likely to change together.

Hypothesis Four: After accounting for within-person stability and auto-regressive effects, changes in SBP will cause concomitant changes in SWB in the form of past SBP predicting future SWB.

MATERIALS AND METHODS

Sample

The sample for this study comprised students across years 7–9 from a public secondary school in Victoria, Australia. The sample formed part of a three-wave study and two previously published cross-sectional studies have been published from this data set (Jach et al., 2017; Waters et al., 2019). The current paper investigates the causal and longitudinal effect of SBP on SWB, in the sample of students who successfully completed all three waves of the survey.

The school from which the sample was drawn has a socio-economic index equal to the Australian average, indicating it is representative in terms of socio-educational advantage. Two hundred and two adolescents between the ages of 12–15 completed all three waves of data collection and formed the current sample (M_{age} = 12.97, SD_{age} = 0.91, 48% female, 49.5% male, 2% preferred not to say and 1 selected 'other' gender). Unequal numbers of participants participated across the year levels (N = 113 or 55.9% Year 7s, N = 39 or 19.3% Year 8s, and N = 50 or 24.8% Year 9s; χ^2 = 47.36, $p < 0.001$). It is unclear why response rates were lower in years 8 and 9 but it could be due to timetabling issues when the survey was completed in class time. Potential sample bias was analyzed (see Sample Bias Due to Attrition) below with tests comparing participants who completed all three waves, to those only completing one or two. Of the four variables across three points in time, only one variable (PA at time two) was significantly different between responders and non-responders indicating that response bias was not an issue in this sample.

Procedure

Students completed a 30-min online survey during school hours across the three time points and their surveys were matched based on a unique ID number. Applying listwise deletion, 15 cases were removed due to missing data. Data collection took place in May, 2016, November, 2016, and July 2017. The average number of days elapsed between data collection waves from baseline to wave 2 was M_{days} = 184.77 (SD_{days} = 9.89) and number of days between wave 2 to wave 3 was M_{days} = 241.1 (SD_{days} = 3.66). The average total time elapsed from baseline to the third wave of measurement was (M_{days} = 426.49, SD_{days} = 8.46, M_{months} = 13.50, SD_{months} = 0.50).

All procedures in this study complied with the National Statement on Ethical Conduct in Human Research and were approved by the University of Melbourne's Human Research Ethics Committee, and school Principal. Standing informed consent was provided by parents, through a process of advertising the study in the school newsletter and website prior to data collection, with an option to for their child opt-out. Participating students were also given active 'assent' to withdraw from the study and were advised by the classroom teacher and school Wellbeing Coordinator immediately preceding in-class data collection that the study was voluntary.

Measures

Strength-Based Parenting Knowledge

The 7-item SBP-knowledge scale (Jach et al., 2017) asks teens to rate the degree to which their parents see and understand their strengths. 'Strengths' here are defined broadly to include "personality, ability, talents and skills." They are non-specific and subjective, that is, particular strengths listed in some strengths taxonomies (e.g., love of learning, kindness,

empathy, perseverance) are not included in the scale. Participants responded to items (e.g., "My parents see the things I do best") on a 7-point scale ranging from 1 (*strongly disagree*) to 7 (*strongly disagree*). Scores ranged from 7 to 49.

The SBP knowledge scale has demonstrated strong internal consistency across several studies, with a current omega reliability coefficient of $\omega = 0.95$, 95% CI [0.94,0.96]. The scale has shown discriminant validity from autonomy-granting and responsiveness parental styles, and incremental validity in predicting life satisfaction in teens over and above authoritative parenting (Waters, 2015b). The scale also shows moderate convergence between teen ratings of their parents' strength knowledge and parents' self-reported strength knowledge (Waters, 2015a).

Subjective Wellbeing

Following Diener (1984) model of subjective wellbeing, we assessed the three elements of positive affect (PA), negative affect (NA), and life satisfaction (LS). Positive and negative affect were measured using the 10-item shortened Positive and Negative Affect Schedule for Children (Ebesutani et al., 2012). Students rated the extent to which they felt positive affect (e.g., joyful, happy) and negative affect (e.g., miserable, afraid) on a 5-point scale ranging from 1 (*very slightly or not at all*) to 5 (*extremely*). Scores ranged from 5 to 50.

Life satisfaction was measured using the 5-item Satisfaction with Life Scale for Children (Gadermann et al., 2010). Participants responded to items (e.g., "In most ways my life is close to the way I would want it to be") on a 5-point scale ranging from 1 (*disagree a lot*) to 5 (*agree a lot*). Convergent and discriminant validity has been demonstrated for these three components of subjective wellbeing in several other studies (Gadermann et al., 2010; Ebesutani et al., 2012). Scores ranged from 5 to 25.

Data Analysis

Two statistical approaches to model longitudinal data were applied. Both use a structural-equation modeling (SEM) approach with latent variables indicated by survey items, thereby accounting for measurement error in scales. Latent factors also model change that occurs over time by fitting a curve to each participant's scores, in what are commonly termed latent growth curve models (LGM; Duncan and Duncan, 2009), in order to examine univariate change in all study variables (hypothesis One and Two); and relationships between rates of growth between variables over the study period (hypothesis three). A random-intercept cross-lagged panel model (RI-CLPM; Hamaker et al., 2015) was also applied to test for possible within-person causal effects of SBP on PA, NA and LS (hypothesis Four) while controlling for and assessing the degree of between-person stability in the variables over time. As scale ranges vary across SBP and the other measures, we rely on reporting standardized (SD units) effects where suitable.

Latent Growth Models

An LGM investigated intra-individual change over time by modeling a latent trajectory for each participant's three repeated measures. Scores at each time point were used as indicators of the trajectory (Raudenbush, 2001; Muthén and Muthén, 2015). With three data points, an LGM is limited to linear trajectories, but this technique can still be a useful way to examine within-person change and the correlation among change across multiple variables. In the present case, we investigated correlated change in SBP and LS, NA and PA simultaneously. The linear time factor included an additional 50% for the second lag, as the time difference between T2-T3 was approximately 50% longer (9 months vs. 6 months).

Random Intercept Cross-Lagged Panel Model

RI-CLPM was to analyze causality between SBP and SWB. According to Hamaker et al. (2015) these models are suitable to non-experimental settings with datasets comprising three repeated measures or more. Like traditional cross-lagged panel models, the RI-CLPM construe causality similar to Granger (1988). However, the approach also apportions variance to a latent factor capturing a time-invariant average around which people's levels on a given measure tend to regress over time. This approach facilitates examination of causal change (i.e., cross-lagged effects) separately to change associated with mean reversion (i.e., autoregression).

Longitudinal studies of life events and SWB highlight the importance of capturing stable within-person predispositions, which form early and are resistant to change in all but drastic events (Diener et al., 2018). The ability of the RI-CLPM to achieve this decomposition has been described by some as arising from separating within- and between-person variability (for an example with adolescent parental-related data see Keijsers, 2016). However, LGMs also undertake a similar 'multi-level' treatment of change over time by first modeling trajectories for individuals, then considering population distribution characteristics in the sample of these individual trajectories (Raudenbush, 2001). The autoregressive and cross-lagged paths in the RI-CLPM are reflective solely of within-person change, without the influence of between-person variance.

Initially, maximum-likelihood (ML) was the chosen estimator, but due to problems with convergence under ML, a Bayesian estimator with uninformative or diffuse prior probabilities was adopted – these priors allow Bayesian and ML results to converge in the long run (Muthén and Asparouhov, 2012). Specifically, under ML the RI-CLPM failed to converge in some cases due to very high latent correlations among between-person factors, indicative of strong correlations among stable traits driving stability in the variables. Bayesian estimators are known to perform better than ML under conditions where values are near the edges of their parameter spaces, as is the case here with highly correlated latent factors. For similar issues, Bayesian estimators are also becoming more widely applied in longitudinal analyses (Asparouhov et al., 2018). ML estimation was utilized for nested model tests of measurement and invariance properties. To investigate the

influence of sample size on the key parameters of interest, a *post hoc* power analysis was undertaken by imputing the Bayesian-derived estimates into Monte Carlo simulations of varied sample sizes.

RESULTS

Data Cleaning and Preparation

Data cleaning and preparation was undertaken in SPSS and Excel, with MPlus used for all substantive analyses. Data were examined for out-of-range values, survey completion times, open-ended comments that suggest spurious responses, duplicate I.P. addresses and/or participants, and missingness. One participant was cut due to a completion time of less than 2 min and many items in neutral. Fifteen cases had almost no items completed and were excluded. Only four other cases demonstrated some missingness, with approximately half the survey items missing in each case. These cases were retained as full-information- ML was utilized. Items were reverse-scored where necessary to consistently measure their underlying factor, and simple scale means calculated.

TABLE 1 | Distribution characteristics for observed variables.

Variable	Observed						
	M	*SD*	Median	Mode	Skew	Kurt	*n* univariate outlier (± 2 *SD*)
SBP T1	39.02	9.14	42	49	−0.83	0.06	9 (all −)
SBP T2	38.27	9.87	40	49	−1.05	0.75	8 (all −)
SBP T3	37.02	8.52	38	42	−0.58	−0.21	8 (all −)
LS T1	18.37	4.65	19	19*	−0.49	−0.52	8 (all −)
LS T2	18.09	4.43	18	17	−0.47	−0.29	8 (all −)
LS T3	17.06	4.23	17	20	−0.55	0.10	7 (all −)
PA T1	19.22	4.00	20	22	−0.78	0.41	10 (all −)
PS T2	18.44	3.84	19	19	−0.58	0.47	6 (all −)
PS T3	17.61	4.07	18	19*	−0.71	0.42	2 + 8 −
NA T1	9.78	3.81	9	8	1.06	1.17	9 (all +)
NA T2	10.04	4.08	9	5	0.68	−0.28	6 (all +)
NA T3	10.69	4.07	10	10	0.67	−0.06	6 (all +)

Multivariate outliers $n = 3$ (Mahalanobis' Distance, χ^2, $p < 0.001$, $df = 12$)

*SBP, Strength-based parenting knowledge. LS, life satisfaction. PA, positive affect. NA, negative affect. Skew, skewness. Kurt, kurtosis. Standard error of skewness = 0.17, standard error of kurtosis = 0.34. * = smallest mode is shown. T denotes the wave of data collection. Total range for SBP is 7–49; NA, PA, and LS from 5 to 25.*

Outliers

Data were screened for outliers. As shown in **Table 1**, univariate (±2 SD of the mean) and multivariate (Mahalanobis Distance, with probability from the Chi-Squared distribution greater than $p < 0.001$ with $df = 12$) outliers were identified in distributions of observed scores of the final matched sample (Tabachnick et al., 2001). Relatively few cases were identified as outliers, and a theoretical rationale for excluding univariate and multivariate outliers was not apparent. As such, all were retained.

Descriptive Statistics

Distributional characteristics for all variables are reported in **Table 1** and correlations are presented in **Table 2**. Observed score distributions indicate acceptable levels of skewness and kurtosis, with SBP knowledge, LS, and PA somewhat negatively skewed (mean falling on the higher end of the scale), and NA positively skewed (mean falling on the lower end of the scale). A slight decrease in SBP simple scale mean scores was evident as time progressed, probabilistically indistinguishable from zero in T1-T2 ($M = -0.11$, $SD = 1.23$, $t = -1.24$, $p = 0.22$); a slightly larger and significant decrease from T2-T3 ($M = -0.18$, $SD = 1.20$, $t = -2.12$, $p = 0.03$); and a significant decline over the full study period ($M = -0.29$, $SD = 1.34$, $t = -3.02$, $p = 0.01$). Significant correlations were evident between SBP and SWB at all three time points. SBP was positively correlated with LS and PA, and inversely correlated with NA.

TABLE 2 | Zero-order correlation matrix of all variables (observed, simple scale means).

Variable		1	2	3	4	5	6	7	8	9	10	11	12
1	SBP T1												
2	SBP T2	0.59**											
3	SBP T3	0.44**	0.59**										
4	LS T1	0.45**	0.38**	0.33**									
5	LS T2	0.32**	0.49**	0.39**	0.66**								
6	LS T3	0.32**	0.36**	0.46**	0.54**	0.59**							
7	PA T1	0.40**	0.26**	0.21**	0.62**	0.48**	0.36**						
8	PA T2	0.23**	0.35**	0.20**	0.39**	0.60**	0.39**	0.51**					
9	PA T3	0.12	0.06	0.24**	0.21**	0.27**	0.40**	0.36**	0.34**				
10	NA T1	−0.28**	−0.22**	−0.17*	−0.46**	−0.38**	−0.32**	−0.39**	−0.31**	−0.16*			
11	NA T2	−0.21**	−0.21**	−0.20**	−0.49**	−0.61**	−0.40**	−0.41**	−0.42**	−0.13	0.59**		
12	NA T3	−0.15*	−0.08	0.01	−0.28**	−0.23**	−0.22**	−0.22**	−0.14*	0.19**	0.36**	0.50**	

*SBP, Strength-based parenting knowledge. LS, life satisfaction. PA, positive affect. NA, negative affect. N = 202. T denotes the wave, with T1 being the first measurement interval/baseline. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.*

Sample Bias Due to Attrition

Returners for all three waves (N = 202) were compared to non-returners of either time 2 or 3 (N = 380–504 depending on measure). As mental health is known to decline over the teen years, baseline year level was included as a control variable. To retain the benefit of accounting for measurement error, a structural equation model tested the effect of attrition status (a dichotomous predictor) on the continuous latent outcome variables. In this instance, the effect of attrition reflects a probit regression estimate using weighted least squares, while all other estimates reflect linear regression of continuous, latent variables, utilizing full information maximum likelihood to handle missing data.

Results of the attrition analysis are presented in **Table 3**. Students in later year levels had significantly lower cross-sectional SBP, LS, PA and higher NA at T1. In addition, higher baseline year level was associated with lower PA at T2. Only one of the outcomes variables was significantly predicted by attrition status, with students reporting higher life satisfaction at T2 more likely to complete all three waves. Given that this was the only significant difference, across 4 variables across 3 points in time, between responders and non-responders we are confident that the results of the final sample are reflective of the fuller sample at baseline.

Measurement and Invariance Testing

Before proceeding to the RI-CLPM, invariance testing was undertaken to ensure measurement properties of the scale were comparable over time. Measurement invariance testing consisted of modeling a latent factor at each wave for each measure, freely covaried and using ML estimation, with measurement properties evaluated against Hu and Bentler's (1999) simulation-based fit indices, with Cheung and Rensvold's (2002) recommendation of a <0.01 change in CFI was used as the key basis for proceeding. **Table 4** presents results of the measurement invariance testing, which was then applied in the RI-CLPM models.

Strength-based parenting had good measurement qualities and retained good fit under scalar invariance. SWL had good model fit indices under metric invariance, but fit declined under a scalar invariance, and a partial intercept invariance model was adopted, with LS items 3 and 2 intercepts being freely estimated. Possibly consistent with the more temporally variable nature of emotion, which is itself an indicator of healthy emotional function (Koval et al., 2016), PA and NA both demonstrated poorer invariance properties; and NA also had poorer single-factor measurement properties. PA had acceptable fit indices but required one factor loading to be freely estimated to retain good fit, and all but one intercept to be freely estimated. NA had poor measurement qualities, but without any very low loading items, or a theoretical rationale for modeling anything but a one-factor solution to the scale, invariance testing was not undertaken. Results of the RI-CLPM including NA should therefore be interpreted with caution. The final measurement models identified in **Table 4** were utilized in the subsequent latent growth and random intercept cross-lagged panel models.

TABLE 3 | Tests of sample bias due to attrition.

Variable	*N* non returners	Baseline Year level		Returner status	
		β	*SE*	β	*SE*
SBP T1	499	−0.171***	0.049	0.154	0.132
SBP T2	382	−0.085	0.058	0.242	0.145
LS T1	504	−0.170***	0.033	0.045	0.087
LS T2	381	−0.033	0.036	0.206*	0.091
PA T1	504	−0.178***	0.028	0.063	0.075
PA T2	381	−0.122***	0.033	0.058	0.083
NA T1	504	0.137***	0.029	−0.007	0.078
NA T2	380	0.087	0.036	−0.076	0.088

SBP, Strength-based parenting knowledge. LS, life satisfaction. PA, positive affect. NA, negative affect. T denotes the time point. Returners to all three waves of data were dummy coded as '1' and non-returners as '0.' N = 202 participants returned for all three waves.

Hypotheses One and Two: Latent Growth Curve Model

The LGM provides a robust test of intra-individual change across the sample in SBP and SWB and forms the tests of hypotheses 1–3. As the LGM controls for measurement error by design, simple scale mean scores were used, and to account for the unequal data collection waves an additional 50% of time was included in the time factor in the second lag. A single LGM simultaneously estimated univariate and correlated change in SBP, LS, PA, and NA.

This LGM was initially modeled with ML estimation, which provided good fit ($\chi^2(34) = 119.934$, $p < 0.001$; RMSEA.112 [0.091.134]; CFI.922; TLI.849), suggesting a linear curve fit the sample well. However, a non-positive definite matrix made the solution unreliable. As such, a Bayesian estimator with 10000 iterations and diffuse/uninformative priors was adopted, which converged according to acceptable criteria (a posterior scale reduction or PSR < 1.05 for the latter half of iterations). Posterior SD is reported as Standard Error (SE) for Bayesian-derived estimates.

Hypothesis One

Latent growth-curve models results demonstrate a significant univariate decline in within-person SBP across the time period (unstandardized mean slope factor $\mu_{SBP-S} = -0.12$. [−0.19 −0.04], SE/PSD (posterior SD) = 0.04, $p < 0.001$), thus hypothesis one was supported. Participants starting values also influenced their change over time. Covariances between the intercept and slope factors in the LGM indicate participants who began with initially higher scores tended to decline at a greater rate in SBP (unstandardized $\psi_{SBP-I\ SBP-S} = -0.26$ [−0.43 −0.16], $SE = 0.07$, $p < 0.001$).

Hypothesis Two

In relation to wellbeing, a significant within-person decline in all components of SWB over the time period was found, thus supporting hypothesis two. A negative and significant mean latent trajectory was evident for LS (unstandardized

TABLE 4 | Measurement and invariance testing.

Model	χ^2	*df*	CFI	TLI	ΔCFI	M.I. EPC (stdyx)	λ (std) range	Decision
SBP								
M	359.884	168	0.961	0.951			0.414–0.922	Accept
FL	382.988	180	0.959	0.952	−0.002			Accept
FL&FI	**406.569**	**194**	**0.957**	**0.953**	**−0.004**			**Final**
LS								
M	144.508	75	0.961	0.945			0.603–0.884	Accept
FL	153.290	83	0.960	0.950	−0.001			Accept
FL&FI	192.457	93	0.944	0.937	−0.017^{+}	I: −0.110:*LS2t3*		Reject
FL&PI: *LS2t3*	181.504	92	0.950	0.942	−0.011^{+}	I: −0.106:*LS3t3*		Reject
FL&PI: *LS2t3, LS3t3*	**172.238**	**91**	**0.954**	**0.947**	**−0.007**			**Final**
PA								
M	156.909	75	0.958	0.941			0.578–0.964	Accept
FL	181.678	83	0.949	0.935	−0.009	L: −0.124:*PA3t1*		Accept
PL: *PA3t3*			0.951		−0.007	L: −0.133:*PA5t3*		Reject
PL: *PA3t3*, *PA5t3*	167.779	81	0.955		−0.003			Reject
PL&FI	214.041	91	0.936	0.927	−0.022^{+}	I: −0.093:*PA4t3*		Reject
PL&PI: *PA4t3*	203.826	90	0.941	0.931	−0.017^{+}	I: −0.090:*PA3t3*		Reject
PL&PI: *PA4t3*, *PA3t3*	195.667	89	0.945	0.935	−0.013^{+}	I: −0.075:*PA1t3*		Reject
PL: *PA3t1, PA5t3*&PI: *PA4t3, PA3t3, PA1t3*	**186.543**	**88**	**0.949**	**0.939**	**−0.009**			**Final**
NA								
M	391.952	75	0.782	0.694			0.583–0.875	Accept
FL	404.596	83	0.779	0.720	−0.003			Accept
FL&FI	473.101	93	0.738	0.705	−0.044	I: 0.241:*NA2t3*		Reject
FL&PI: *NA2t3*	440.005	92	0.760	0.727	−0.022	I: −0.178:*NA5t3*		Reject
FL&PI: *NA2t3, NA5t3*	**418.063**	**91**	**0.775**	**0.740**	**−0.007**			**Final**

SBP, strength-based parenting knowledge. LS, life satisfaction. PA, positive affect. NA, negative affect. df, degrees of freedom. CFI, comparative fit index. TLI, Tucker Lewis index. M.I. EPC (stdyx), minimum expected parameter change, standardized. Model conventions: M, measurement. FL, full loading. FI, full intercept. PL, partial loading: freed loading survey item(s). PI, partial invariance: freed intercept survey item(s). t1-3 denotes survey wave. $^{+}$ a change in CFI of 0.01 or greater from the measurement model was adopted as the guideline for invariance acceptability. ΔCFI, change in CFI from the measurement model to the present model. Maximum likelihood estimator was utilized for measurement and invariance testing. For PA, while partial loading invariance held, the decrement in fit was close to 0.01 (ΔCFI = −0.007), and as such loadings were freed before proceeding to tests of intercept invariance. Final model adopted and utilized in all LGM and RI-CLPM models for each factor is in bold.

μ_{LS-S} = −0.11 [−0.16 −0.06, *SE* = 0.03, $p < 0.001$), and PA (unstandardized μ_{PA-S} = −0.13 [−0.18 −0.08], *SE* = 0.03, $p < 0.01$), and a positive trend for NA (unstandardized μ_{NA-S} = 0.074 [0.03.22], *SE* = 0.03, $p < 0.01$). As with SBP, participants starting values influenced their change over time. Covariances between the intercept and slope factors in the LGM indicate participants who began with initially higher scores tended to decline at a greater rate in PA (unstandardized $\psi_{PA-IPA-S}$ = −0.09 [−0.15 −0.04], *SE* = 0.03, $p < 0.001$) and increase more for NA (unstandardized $\psi_{NA-I\ NA-S}$ = −0.05 [−0.11, −0.01], *SE* = 0.03, $p < 0.01$).

Hypothesis Three

The LGM also tested whether rates of change in SBP and aspects of SWB were related. A significant slope correlation between SBP and wellbeing variables was evident. Increases in SBP during the study period was associated with growth in LS (unstandardized $B_{SBP-SLS-S}$ = 0.05 [0.02,0.079], *SE* = 0.02, $p < 0.001$) and PA (unstandardized $B_{SBP-SPA-S}$ = 0.06 [0.03,0.09], *SE* = 0.02, $p < 0.001$); but not NA (standardized $B_{SBP-SNA-S}$ = 0.01 [−0.03,0.03], *SE* = 0.02, $p < 0.430$); partially confirming hypothesis three.

Hypothesis Four

Three RI-CLPMs each tested the potential causal and reciprocal relationships between SBP and LS, PA and NA. Non-positive definite matrices were encountered using the ML estimator, and, as such, a Bayesian estimator with 10,000 iterations was utilized with default diffuse uninformative priors, as in the LGM. The final measurement models adopted were per invariance testing. Results of the RI-CLPMs are presented in **Figures 1–3**.

As with the LGM testing, the RI-CLPMs found significant positive contemporaneous effects between SBP with LS, PA and NA at time 1 and then again between SBP with LS and PA at time three. These results, described by some as "correlated change" (Keijsers, 2016), are in line with the LGM and also with past findings of the beneficial effects of SBP on teen wellbeing and suggest that SBP is important factor for teenager wellbeing in their immediate time frames (Loton and Waters, 2017).

In relation to the test of time-variant stability/instability, the random intercept was significant in each model for each variable, although smaller in the case of NA: SBP-U (in the LS model) = 0.29 [0.01 – 2.4], *SE* = 0.64, $p < 0.001$; LS-U = 0.26 [0.01 – 1.13], *SE* = 0.32, $p < 0.001$; PA-U = 0.24 [0.03 −0.69], *SE* = 0.54, $p < 0.001$; NA-U = 0.06 [0.01 −0.53], *SE* = 0.14,

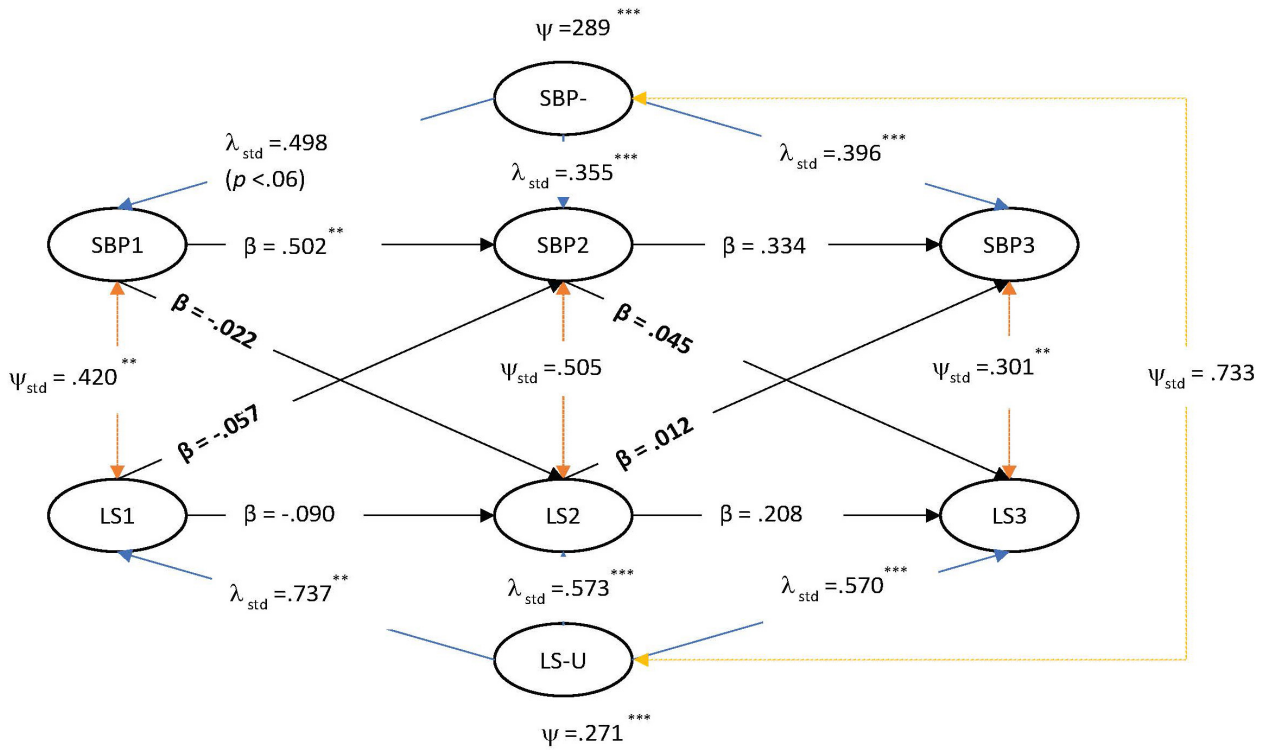

FIGURE 1 | RI-CLPM of strength-based parenting and life satisfaction.

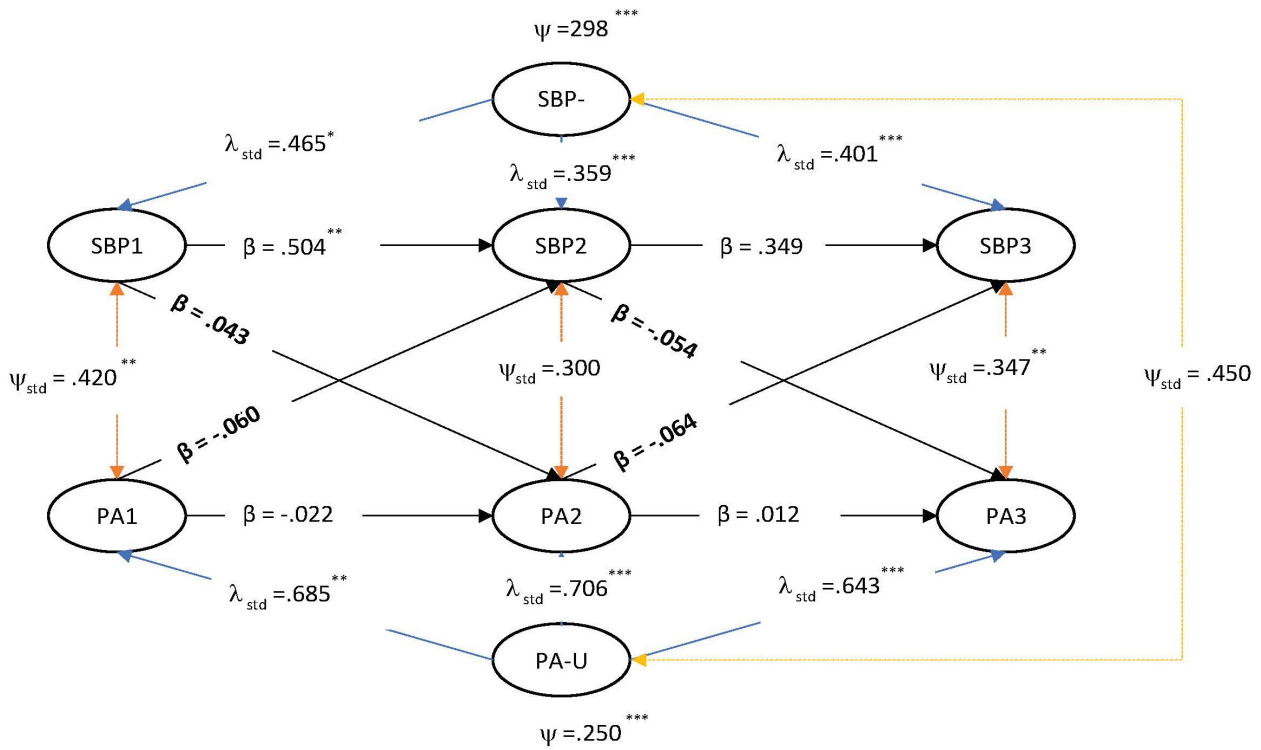

FIGURE 2 | RI-CLPM of strength-based parenting and positive affect.

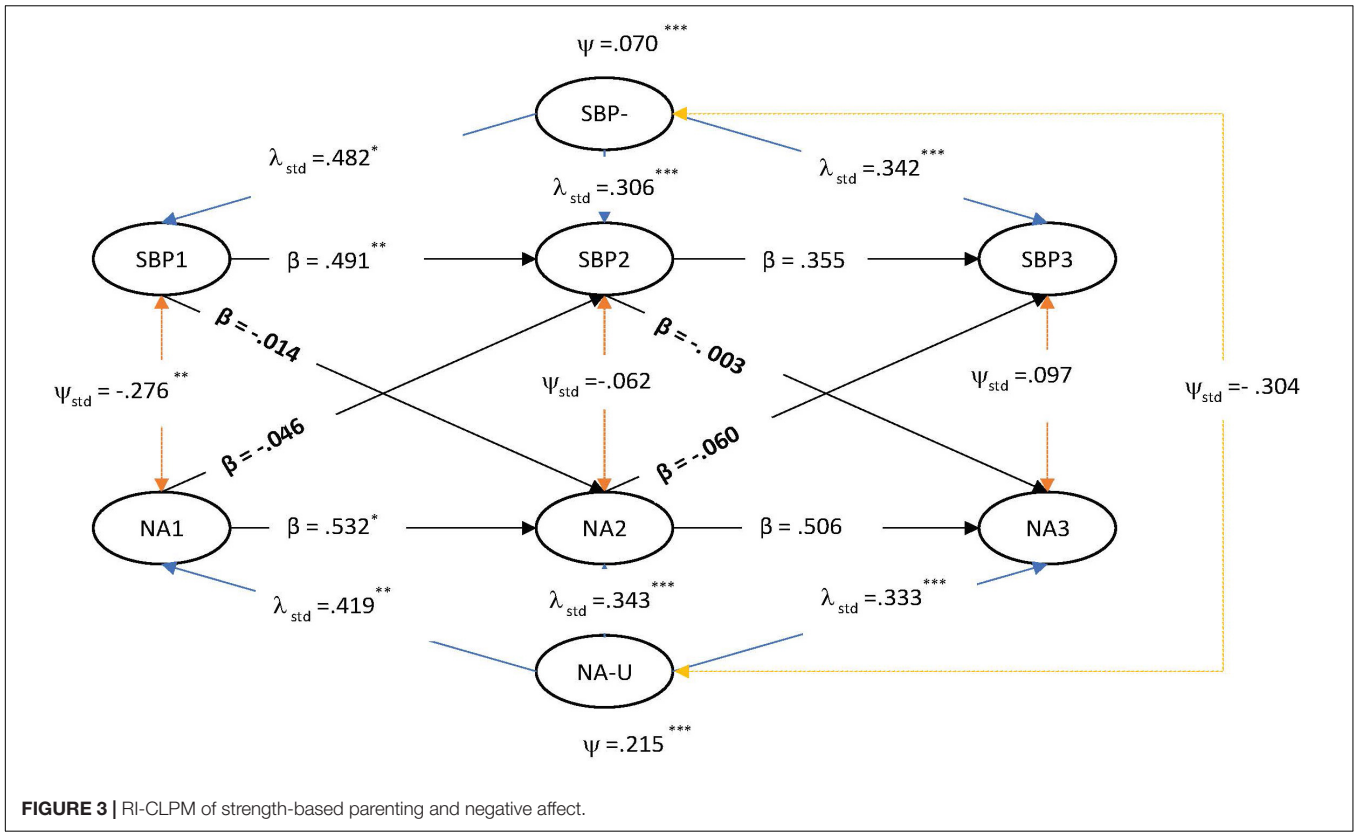

FIGURE 3 | RI-CLPM of strength-based parenting and negative affect.

$p < 0.001$. The ICC for each between-variable (i.e., 'random intercept' latent trait variance/total average variance for each latent factor from times 1–3) indicate most variance was time-specific/within-person. The between-person proportions for SBP were 13.0%, LS = 24.7%, PA = 33.8%, and NA = 34.7%. In the present case, a participant's level of SBP at time one did predict SBP at time two (∼6 months) but this effect was not retained over the second lag (∼9 months). These results are consistent with past research showing that parenting is characterized by stability *and* change (Holden and Miller, 1999).

The substantive parameters of interest in the RI-CLPM are the cross-lagged paths, which represent an indication of causal predominance, and are interpreted as '*predicting change*' at the within-person level (Hamaker et al., 2015, p. 104). In our models, all cross-lagged paths were not significant, pointing instead to possible 'third factors' that may explain the strong positive contemporaneous effects evident between SBP and SWB.

Power Analysis

With a sample of $N = 202$ and 82 parameters freely estimated in the RI-CLPMs, the sample size to parameter ratio exceeds common guidelines (Bentler and Chou, 1987). However, the indicators to latent factor ratio is relatively high, which is sometimes thought to compensate for the detrimental effect of small samples on power in SEM (Marsh et al., 1998). As such, a *post hoc* power analysis was undertaken using Monte Carlo simulation (see Muthén and Muthén, 2002) of the Bayesian-derived estimates, to determine the increase in sample size required for CL effects to reach a significance level of $p < 0.05$. Results are presented in **Table 5**. Based on these simulation specifications, the CL path results held even in simulated samples up to $N = 5002$.

DISCUSSION

Early adolescence is a pivotal period of development and parents play a key role in the mental health of young people during this life stage (Bruyn et al., 2003; Galambos et al., 2003; Bøe et al., 2014; Steinberg, 2014). Understanding the role of positive parenting on teen SWB motivated the present study. With past evidence for the concurrent and two-wave repeated measures beneficial effects of SBP on teen wellbeing (Waters, 2015b; Loton and Waters, 2017; Waters et al., 2019), we extended the time frames to a three-wave, fourteen-month study. Based on findings in past studies in the field of parenting research, we hypothesized a decline in SWB (hypothesis one) and SBP (hypothesis two) together with a relationship and causal impact of SBP on SWB over time (hypotheses three and four respectively).

Three of the four hypotheses were supported. Firstly, as predicted, SWB diminished significantly over time, confirming hypothesis one. Specifically, LS and PA declined while NA increased over time. Secondly, within-person SBP significantly declined over the study period, supporting hypothesis two. Thirdly, teens who reported a decrease in SBP over the study period also tended to experience declines in LS and PA, but no

TABLE 5 | *Post hoc* power analysis: Monte Carlo simulations of larger samples using Bayesian-derived estimates.

N	Percentage of draws in which the cross-lagged path is significant at $p < 0.05$			
	SBP to LS lag 1	**SBP to LS lag 2**	**LS to SBP lag 1**	**LS to SBP lag 2**
402	0.00%	0.01%	0.00%	0.00%
1002	0.00%	0.00%	0.00%	0.00%
5002	0.03%	0.00%	0.03%	0.01%
	SBP to PA lag 1	**SBP to PA lag 2**	**PA to SBP lag 1**	**PA to SBP lag 2**
402	0.00%	0.00%	0.00%	0.00%
1002	0.00%	0.04%	0.00%	0.00%
5002	0.03%	0.03%	0.03%	0.03%
	SBP to NA lag 1	**SBP to NA lag 2**	**NA to SBP lag 1**	**NA to SBP lag 2**
402	0.02%	0.00%	0.00%	0.00%
1002	0.00%	0.00%	0.02%	0.00%
5002	0.08%	0.03%	0.01%	0.03%

SBP, strength-based parenting knowledge. LS, life satisfaction. PA, positive affect. NA, negative affect. Initial sample N = 202, repetitions = 500, seed = 45355, population and coverage both defined by the Bayesian RI-CLPM outputs.

change to the trajectory of NA, as revealed through the LGM analysis. The same beneficial contemporaneous effects of SBP on LS and PA, but not NA, were evident in correlated change at T1 and T3 through the RI-CLPM analyses, thus providing partial support hypothesis three. In regards to hypothesis four, we examined these dynamic relationships by applying a causal panel modeling framework that partitions variance into stable/time-invariant components and links within-person fluctuations across each wave for each variable (Hamaker et al., 2015). In these models, results were partially supportive of the SBP-SWB link but did not support direct causal effects. The cross-lagged paths indicated that within-person changes in SBP did not predict increases in SWB over time, or vice-versa, thus failing to support hypothesis four.

When the causal analysis framework was applied, the degree of stability across factors ranged from 13% to 34.7% of variance apportioned to between-person stability which highlights the importance of modeling change in a multi-level framework. In addition, rank-order stability in SBP held only in the first 6 but not over the ensuing 9 months, showing a pattern of variance-invariance in parenting, and supporting past research that positive parenting changes through the adolescent years.

The decline in wellbeing during early adolescence is highly consistent with past research (Ullman and Tatar, 2001; Suldo and Huebner, 2004; Park, 2005) and is likely to be a function of the significant life changes young people go through when stepping into the second decade of their lives. Developmental psychologists have long identified that the shift from childhood into adolescence marks a time of intense social, physical, identity and economic changes (Larson and Wilson, 2004; Sodha, 2009; Dorn and Biro, 2011). Together with increases in responsibilities and academic pressures, these changes put early adolescents at risk of mental ill-health (Frigerio et al., 2009; Anselmi et al., 2010).

Neuroscientists have also now added to our understanding of why mental health declines in this age bracket by showing that adolescence is a time where the brain is particularly vulnerable to stress and depression (Andersen and Teicher, 2008) because it is undergoing rapid change (Giedd, 2008), including the process of synaptic pruning of gray matter coupled with new production of white matter (Giedd, 2008). The 'back to front' development of brain structures in the teen years from the amygdala, through to the hippocampus and on to the prefrontal cortex lead to the situation where the emotional systems of the brain develop faster than the cognitive systems of the brain (Sowell et al., 2001) which has been posited as a reason for greater emotional sensitivity and vulnerability in the teen years. Ernst et al. (2006) hypothesized that adolescent depression may emerge because the limbic structures that drive negative emotions mature more quickly than the pre frontal cortext which assists teens to regulate their mood. Toward the end of adolescence and in early adulthood the brain becomes more integrated and connected (Paus et al., 2008), and the cognitive systems catch up with emotional systems which scientists suggest is a reason why the risk for psychopathology diminishes in early adulthood (Giedd, 2008).

Importantly, neuroscientists have also shown that the type of parenting that occurs in the life of a young person transitioning into early adolescence has a significant impact on mental health. For example, early teens whose parents had displayed contemptuous, angry, impatient, belligerent, disapproving, threatening, or argumentative behaviors during a lab experiment in their late childhood were more likely to experience the onset of depressive symptoms and major depression in adolescents (Yap et al., 2008; Schwartz et al., 2011). Conversely, early teens whose parents related to them in approving, validating, affectionate, humorous, happy, pleasant, and/or caring ways, showed beneficial brain growth in regions that supports a teenager's capacity for social-emotional functioning as well as declines in areas that make an early adolescent vulnerable to mental illness[9] (Whittle et al., 2014).

[9]In this neuroscientific study, positive maternal behavior was linked to accelerated cortical thinning in left and right orbitofrontal cortices, between baseline and follow up. Thinning of the orbitofrontal cortices is associated with superior cognitive functioning. For boys there was also a thinning in the right anterior cingulate. Thinning of the orbitofrontal cortices is associated with superior cognitive functioning. Thinning of the orbitofrontal cortices and anterior cingulate

In line with the above research that highlights the importance of positive parenting for youth wellbeing, both the LGM and RI-CLPM analyses revealed a pattern of positive contemporaneous effects between SBP and SWB. When pre-teens and early teens are asked to reflect on the parenting they receive and, at the same time, report on their wellbeing, a significant relationship is present. These results are consistent with those found across multiple samples of teens where SBP has been related to a range of wellbeing indicators such as SWB (Jach et al., 2017), life satisfaction (Waters, 2015b), happiness and self-efficacy (Loton and Waters, 2017), subjective happiness (Sağkal and Özdemir, 2019), and family happiness (Waters, in press).

Waters has argued that having strength-based parents provides teens with an interpersonal context that supports the development and reinforcement of strengths (Waters, 2015b). In support of this, Jach et al. (2017) found that SBP increased teen's use of their strengths. Other studies have shown that strengths-use and development is a significant factor in youth well-being (Proctor et al., 2011; Suldo et al., 2014). Adding to the interpersonal context triggered by SBP, Waters (2015a) proposed that SBP creates an intrapersonal trigger for positive self-identity because having knowledge of one's strengths creates a lens through which teens engage with the world and, thus, a positive filter for teen identity. Related to this, past research has shown that SBP predicts positive aspects of teen identity such as self-efficacy (Loton and Waters, 2017) and mental toughness (Sağkal and Özdemir, 2019).

An important finding in the current study was the non-significant relationship between SBP and SWB over time. While the degree of SBP teens reported that they were receiving was linked to their levels of LS and PA in 'real time'[10] this real time relationship did not transfer to longer time frames. That is, SBP at time one was not predictive of SWB at time two or three (6 and 14 months later). Likewise, SBP at time two was not predictive of SWB at time three (9 months later). This finding differs to past studies that have found SBP significantly predicts life satisfaction 12 months later (Waters, 2015b) and academic performance 3 months later (Waters et al., 2019). However, these past studies did not employ the stringent statistical analysis of RI-CLPM.

One reasons why SBP may not predict future SWB for early adolescents could be the reduction in the parent–child closeness that occurs during this particular life stage. Certainly, it is well recognized that increased distance and separation between parent and child are characteristic of the age bracket targeted for the current study due to the psychological need for 'individuation' (Levy-Warren, 1999). Larson and Richards' (1991) study of differences in time spent with parents between 5th and 9th graders found that early teens spent 40% less time with their parents than those in their late childhood. This life stage also marks a period of emotional distance and research shows that reductions in parent-child closeness together with increases in child secrecy are especially prominent in the early adolescent years (Larson and Richards', 1991; Keijsers et al., 2010). Steinberg and Silverberg (1986) assert that young teens no longer allow their parents to know everything about their lives. The process of separation and distance that unfolds during early adolescence may explain why parenting approaches that are present in the beginning of this study (e.g., pre-teens) are not having an impact on the wellbeing of the young person 14 months later because the relationship is become more distant. Future researchers could include measures of teen-parents closeness and conflict to test for the potential mediating or moderating effects of these two variables on changes to teen ratings of SBP over time. It might also be fruitful for future researcher to collect data about SBP from teen-parent dyads or triads (see Waters, 2015b) to examine the way parent-teen perceptions of SBP interact and change over time. The degree to which parent-teen perceptions of SBP get more aligned or more discrepant over time might influences psychological outcomes such as subjective wellbeing.

Whatever the cause, the results of this study indicate that parents cannot assume that their prior, or current, levels of SBP are 'banked' by their children to support future wellbeing. Instead, SBP needs to be a frequent, ongoing approach. Indeed, the fact that SBP was related to LS and PA in real time in our sample suggests that parents can contribute to the wellbeing of their sons and daughters at each step along the way by committing to regularly helping their pre-teens and teens cultivate their strengths.

Despite the importance of SBP, it was not consistent over time in current study with the youth samples' ratings of SBP declining. The current findings are similar to past research showing a decline in a range of positive aspects of parenting such as parental warmth, support, involvement, and regard (McGue et al., 2005; Hafen and Laursen, 2009). Therefore, the decline in SBP that we observed may be related to this particular life stage, and the changes in the parent–child relationship that occur during this time. Waters (2015b) argues that SBP provides interpersonal benefits but it may be that in the early adolescent phase, a phase marked by increased parent-teen conflict, being strength-based is more difficult to achieve. The negative emotions that arise through conflict may heighten certain cognitive biases, such as the negativity bias in either the parent or the teen (Baumeister et al., 2001; Robin and Foster, 2002), making them focus more on problems and challenges rather than strengths and opportunities.

The reduction in SBP may also be to do with intrapersonal changes that occur for teens during this stage, especially the identity changes and increases in self-doubt. Klimstra et al. (2010) found that identity uncertainty increased in early to-middle adolescence. Increased self-doubt in the teen may mean that, even if the parent remains constant in their strength-based approach, the teen is not able to consistently absorb and integrate the positive feedback, thus accounting for reports of declines in SBP.

Study Limitations and Future Research

This study has a number of positive features. It provides an example of a thorough analysis of observational panel data examining the relationship between parenting and wellbeing

cortices is associated with higher temperamental effortful control (i.e., self-regulation and impulse control) and lower levels of internalizing behaviors (e.g., depression and anxiety). This research also found reduced growth of the right amygdala. Reduced growth in the amygdala is associated with a lower fear response, lower emotional reactivity and higher emotional regulation abilities.

[10]The significant relationship was found at the baseline and 14 month re-tests.

in an important life phase - early adolescence. The rigorous statistical modeling using both LGM and RI-CLPM are a strength of this study and encourage future researchers to ensure that the nuanced changes in phenomena over time are adequately tested. The measures were psychometrically sound and had been used in prior research. The sample was drawn from a socio-economically typical school rather than a focus on at-risk students allowing us to examine an under-explored strata of families. The study took an asset-based approach and adds to the small, but growing, literature on positive parenting, thus responding to the criticism of the parenting literature being overly deficit-oriented.

Alongside the above assets of the paper, we must also recognize several weaknesses. Firstly, the study was only able to provide a view of how SBP and SWB changed over 14 months. Given that early adolescence stretches over 3 years the study may have found different results had we extended the time lines. Perhaps SBP may have been causally linked with SWB had we followed the sample for longer into the next stage of adolescence where parents and their teens become closer again.

Secondly, the time points of data collection within the 14-month timeframe may have been too long to meaningfully examine causality. Six months and nine months are a long time in the life of a teen whose minds track time differently to adults (Steinberg, 2008). The current study suggested that temporal dynamics between SBP and SWB could instead operate in short timeframes, and future research may choose to use methods that tap more into the 'real time' dynamics such as daily diary methods (Fisher and Gershuny, 2013) or experiential sampling methods (Hektner et al., 2006) in order to better explore the mechanisms that are underpinning the SBP-SWB link.

Thirdly, the small sample size relative to the large number of estimated factors is another limitation, although a Monte-Carlo analysis simulating larger samples sizes with identical parameter solutions supported no change on that basis to the results. The use of Bayesian rather than ML estimators in the present study, increasingly used in dynamic examinations (Asparouhov et al., 2018), provides an example for social scientists wanting to model complex factors in small samples over time. Future similarly designed studies with larger samples are required to confirm the present results.

CONCLUSION

Seligman and Csikszentmihalyi (2000) assert that "promoting competence in children is more than fixing what is wrong with them. It is about identifying and nurturing their strongest qualities, what they own and are best at, and helping them find niches in which they can best live out these strengths" (p. 6). The current study is relevant for professionals working with parents and prompts them to encourage parents to maintain a strength-based approach over time, so as to avoid the more typical patterns of parent-child decline in early adolescence. The study offers several opportunities for future research on this topic and we hope to be part of an ever-growing movement toward the study and practice of positive parenting.

ETHICS STATEMENT

This study was approved by The University of Melbourne Human Research Ethics Committee, application number 1748708.

AUTHOR CONTRIBUTIONS

LW drafted and substantially edited the literature and discussion. DL and MZ undertook the analysis and wrote the "Materials and Methods" and "Results" section. DL assisted in drafting the introduction and substantially drafted the first draft of the discussion. DG reviewed the literature and drafted most of the first draft of the introduction. RJ-H assisted with critical feedback and data preparation.

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Father Involvement and Cognitive Development in Early and Middle Childhood: A Systematic Review

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This systematic review aims to examine the existing literature concerning the association between father involvement and the development children's cognitive skills during early and middle childhood. Specifically, it analyzes: (1) how the number of researches developed across years; (2) which are the main socio-demographic characteristics of the samples; (3) which are the main focuses examined; and (4) which operational definitions were used to assess father involvement and children cognitive skills. Following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, the articles were searched through PubMed and EBSCO (PsycInfo, PsycArticles, Education Source, Social Sciences Abstract, Family Studies Abstracts, Gender Studies Database and CINAHL complete). The findings suggest that, although each research used a different operational definition of the father involvement construct, in recent years there was a wide and constant interest increase about this issue. Most of the empirical studies utilized quantitative methods, whereas relatively few used qualitative and only one mixed methods. As regards the analysis of socio-demographic characteristics of the samples there is a great evidence that most of them included biological and residential fathers: it may reflect that this type of sample is easier to recruit than non-residential and non-biological fathers. Regarding the socio-economic status and the ethnicity of families, the data highlighted how in recent years the literature on father involvement is starting to look at differences in ethnic and cultural backgrounds, in contrast to past researches. The findings revealed that the main focus is the impact of father involvement on children's cognitive skills and the most of the studies highlighted that it is positive and statistically significant. Regarding to the assessment of father involvement and children's cognitive skills, the literature is quite heterogeneous

Keywords: fathers, fathers involvement, cognitive skills, learning, parenting

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INTRODUCTION

Cognitive skills development is a broad concept that involves the maturing of a variety of abilities and is defined by the American Psychological Association (VandenBos, 2015) as "the skills involved in performing the tasks associated with perception, learning, memory, understanding, awareness, reasoning, judgment, intuition, and language" (p. 202). In this process, as Bandura highlighted in 1993, parents can play a crucial role, contributing to stimulating and supporting children's self-regulatory and cognitive development (Bandura, 1993). Indeed, parents who undertake verbal interactions

and structure activities and games with their children allow them to live the rich linguistic communication and contexts of shared attention and meanings. These experiences encourage children's active exploration and engagement with their environments, improving children's academic skill and their success in school (Grossmann et al., 2002). Paternal involvement has been also situated within Bronfenbrenner's bioecological theory (1979) which highlighted that both proximal (e.g., paternal involvement) and distal (e.g., socioeconomic status, race/ethnicity, school context) factors must be considered to fully understand paternal influences on children's cognitive skills development. In line with these findings, various meta-analyses and reviews investigated the link between parental involvement during early and middle childhood and student achievement (e.g., Fan and Chen, 2001; Jeynes, 2007) and proximal and distal factors influence levels of fathers' involvement in literacy activities (e.g., Varghese and Wachen's, 2016). Even though various proximal and distal factors (e.g., fathers' education, income level, residencial status, relationship with the child's mother) are indirectly associated with children's language development and literacy activities (Varghese and Wachen, 2016), research confirmed a direct, positive and relatively strong association between paternal involvement and children's cognitive skills development (Fan and Chen, 2001; Jeynes, 2007). For instance, Varghese and Wachen (2016) found that fathers made unique and direct contributions to their children's literacy outcomes through their engagement in reading and writing activities and the use of complex language and responsive parenting behaviors.

However, notwithstanding the extensive literature on the topic, there is a great difficulty in finding an agreed definition of the construct of parental involvement, as it is conceptualized in a variety of ways (Harris and Goodall, 2007). For example, some authors distinguish between school- and home-based involvement: the first refers to the communications between parents and school personnel and to the parental engagement in activities children must perform at school (Grolnick and Slowiaczek, 1994; e.g., Hill, 2001), while the second (home-based) includes all the school activities that both mothers and fathers perform with their children at home (Hill, 2001). Other researchers investigated a further form of parental involvement not directly related to school (e.g., playing sports and other games, going to the cinema or a museum) that can influence school achievement (Nord et al., 1997).

Furthermore, while the first studies on the influence of parenting on children's outcomes focused mostly on mother–child dyadic interaction, nowadays, given the increasing number of working mothers and the changing social climate regarding male and female gender roles, the assumption that mothers were the gatekeepers and that father–child relationships had little impact on children's development is diminished. Consequently, various current studies are focused on the construct of coparenting as "the ways that parents work together in their roles as parents" (Feinberg, 2003, p. 1499) and to explore the determinants of fathers' involvement with their children's education (Lamb et al., 1985; Volling and Belsky, 1991). One of the most widespread and accredited models of the construct of father involvement was developed by Lamb et al. (1985). It includes: (a) engagement, the amount of time fathers spends in direct contact with their children (e.g., verbal stimulation, caregiving, and physical play); (b) accessibility, fathers' attendance and availability; and (c) responsibility, the ability to plan activities specifically adapted to the age and needs of the child (Lamb et al., 1987). Although this model allowed an increase in the understanding of the ways in which fathers are involved in their children's lives, it showed various gaps (Fagan et al., 2014). First, given the lack of systematic development regarding the different heuristic categories, there are only a few validated and reliable tools. Second, of the three types of involvement suggested by Lamb et al. (1985), researches have generally focused more on paternal engagement than on accessibility and responsibility, resulting in an overfocus on the amount of time fathers spend with their children (Pleck, 2012). As a consequence, Pleck (2010) widens the definition of "engagement," identifying two distinctive elements: (a) positive engagement activities, the amount of time fathers and children are involved in interactive activities, such as reading books and teaching, that may promote learning and development; and (b) the dimensions of parenting, how fathers engage with their children, including the dimensions of Baumrind's (1967) parenting style model (*responsiveness and demandingness*). This contribution showed that the originally engagement construct may be not well-defined for studying the effects of fathers' parenting on children. However, many gaps related to the original tripartite model remained (Fagan et al., 2014). One of these gaps is that positive engagement was still largely focused on the amount of time fathers are involved with their children; another is related to the lack of a valid theory that guided the selection of the different dimensions of positive father engagement. In addition, the multidimensional construct has not been integrated into a comprehensive conceptual framework that could enable an understanding of what fathering is, why fathers parent in the manner they do, and how paternal actions directly and indirectly help determine children's development (Palkovitz, 2002; Pleck, 2007, 2010). To overcome this research gap, Cabrera and Volling (2019) proposed a "Developmental Ecological Systems Framework for understanding fathering and children's development." This approach considers fathers as part of dynamic systems characterized by interconnected relationships between and among caregivers and children and explains how these relationships evolve and change through time and social and contextual factors (Cabrera et al., 2014, 2018). Previously, based on this ecological approach, Cabrera et al. (2014) developed a model to acknowledge the flow and actions affecting the quality (and quantity) of fathering on child functioning. According to this model, the father–child relationship results are influenced by the personality, personal characteristics, and behaviors of the father and other family members (e.g., mother, child, siblings) and the overall context of the family system by the family relationship (e.g., coparenting), the different family households, socioeconomic statuses (SES), and cultures, and the child's and family's development (Volling and Belsky, 1991; Cabrera et al., 2014; Cabrera and Volling, 2019). The strengths of this model are the inclusion of interpersonal and contextual variables in

determining the level of father involvement (Volling and Belsky, 1991) and, also, the consideration of the transactional and reciprocal relationships between fathers and children (Sameroff, 2010). In line with complexity put in light by this model, the literature about father involvement is still very heterogeneous. As a consequence, in order to design innovative and rigorous research, it becomes necessary to increase knowledge about what has been previously investigated, particularly in relation to the following issues: how should father involvement, especially in early and middle childhood, be conceptualized and measured? What is the relationship between the different components of father involvement and children's cognitive skills? Which are the main focuses investigated? Are non-residential, step-, low-income, and minority fathers included in the research samples? How is it possible to increase father involvement in children's education?

Although some attempts of synthesis have already been produced, many are prior to 2010 (Saracho, 2007a,b; Downer et al., 2008), while the more recent are focused on specific themes, such as educational achievement (Lipscomb, 2011; Jeynes, 2015; Kim and Hill, 2015), and none were published after 2016. Consequently, the previously presented questions call for a systematic examination of the existing research concerning the association between father involvement and children's cognitive skills during early and middle childhood, to widen our knowledge about the definition and measurement of father involvement, the pathways of its influence on children's cognitive skills development, and the differences from/similarities to mother involvement.

AIMS

The aims of the present review are to systematically examine the literature about father involvement in the development of children's cognitive skills and, in particular, to analyze: (1) how the number of researches and the design/methods developed across years; (2) if non-residential, step-, low-income, and minority fathers are included in the research samples; (3) which are the main focuses of the examined literature; (4) which operational definitions of the construct and measures were used to assess father involvement and children's cognitive skills.

METHODS

Data Source and Search Strategy

We followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2009). Articles were searched through PubMed and EBSCO (PsycInfo, PsycArticles, Education Source, Social Sciences Abstract, Family Studies Abstracts, Gender Studies Database, and CINAHL Complete).

We examined titles and abstracts to find eligible studies published in English, from the first publication in 1964 to November 2018. The keywords used for the query were "Father*" and "learning" or "cognitive skills" and "children." Of the 2,215 papers resulting from this first search, after duplicates removal, 777 met the criteria of being published in English in peer-reviewed journals. We selected, by titles and abstracts, 178 papers. As a second step, we selected the papers to be included in the data synthesis by reading the full-text. A total of 40 papers was finally retained (see **Figure 1**).

Study Inclusion and Exclusion Criteria

The inclusion criteria for the papers were: (a) the presence of the father involvement construct and a specific reference to cognitive skills; (b) age of children not above thirteen; (c) written in English; and (d) published in academic journals. Both qualitative and quantitative articles were selected as well as reviews, with the aim of looking at the different approaches and methodologies used in this field.

The exclusion criteria were: (a) clinical samples to avoid bias in focusing more on father involvement as related to the outcomes associated with disease (e.g., ADHD, autism); (b) studies that were not specifically focused on the father involvement construct; (c) adolescent samples (2 studies with 10-year-old children were excluded because they were part of samples aged between 10 and 16 years); and (d) studies focused on other children's outcomes (e.g., physical, diet). Two independent reviewers selected the articles by title and abstract. Afterwards, they compared the results to determine a common list of selected papers; each choice that was different between the two reviewers was discussed in order to find an agreement.

Strategy for Data Synthesis

The selected articles were independently entered by each reviewer into two classification tables: one dedicated to analyzing the reviews and meta-analyses, and the other to analyzing the qualitative, quantitative, and mixed-methods studies. The papers that, when reading the full text, did not match our selection criteria were further excluded. Each reviewer independently completed the tables, and discussed each discrepancy in the selection in order to find an agreement.

We subsequentely developed a dataset of the selected papers and conducted a thematic analysis (TA) with the purpose of defining the main focuses of the reviewed articles, using a semantic approach, according to the guidelines provided by Braun and Clarke (2006). The reviewers discussed the TA results as well.

To avoid a thematic overlap, each article was linked to a single topic, in particular, the main focus of each study.

RESULTS

Table 1 shows the frequency of the different types of papers. Quantitative methods were mostly used, whereas there were few qualitative and only one utilized mixed methods.

Table 2 (meta-analyses and reviews) and **Table 3** (empirical studies, case reports, and theoretical articles) describe the researches' primary characteristics—authors and year, study design, objective, content focus, determinants, and key findings—in relation to general information and our review question. Other features of the reviewed literature will be discussed in detail in the following four paragraphs: growing interest with

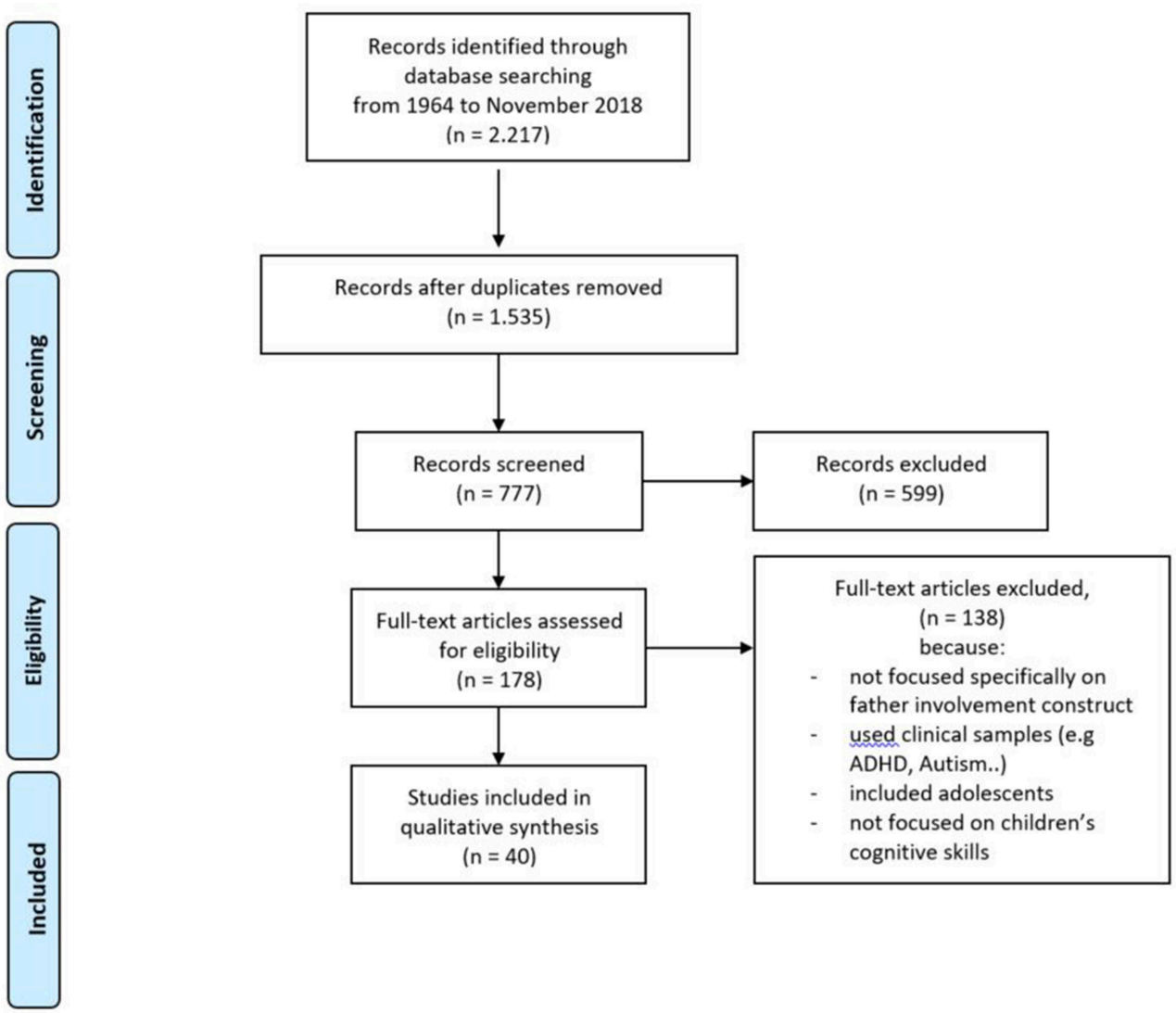

FIGURE 1 | PRISMA flow diagram of study selction.

the role of father involvement in children's education, and the samples' sociodemographic characteristics, main focuses, and measurement methods.

Growing Interest in the Role of Father Involvement in Children's Education

This paragraph's main objective is to expand on the state of the literature about father involvement in children's cognitive skills development. One of the more widespread problems was that, in the literature on caregiving and children, fathers' parenting has been studied less than mothers' (Downer et al., 2008).

However, in the 70s and 80s the scholarly interest in fatherhood grew (Lamb, 2004) and, during the 90s, there was an increase in the researches on various fatherhood aspects, developing a large and heterogeneous body of studies that emphasized the unique role of fathers in children's development. For example, Marsiglio et al. (2000), in their review about fatherhood, examined the relationships between the dimensions of the father–child relationship (e.g., time spent with children, emotional support, everyday encouragement, and overseeing children's behaviors) and children outcomes. The increasing trend of the number of articles specifically focused on the construct of "father involvement" in children's education is shown in **Figure 2**. In the next paragraphs, we will focus on the main sociodemographic characteristics and measurement methods used in this growing literature.

Samples' Demographic Characteristics

Regarding age, father involvement research was mostly conducted on groups of children aged 0–6 (27.5%), preschoolers

TABLE 1 | Type of document.

Study design	Frequency	Percentage %
Quantitative	16	40
Qualitative	9	22.5
Meta-analysis	3	7.5
Review	4	10
Case report	5	12.5
Theoretical article	1	2.5
Mixed methods	2	5
	40	100

(3–5) (22.5%), and infants/toddlers (0–3) (20%); mixed age (7.5%) and middle childhood samples (15%) were less frequent. However, reviews and meta-analyses focused on a wider age range, from early years to 20 years old.

Concerning fathers' characteristics, it is possible to see a predominance of biological and residential fathers: 35% of the reviewed studies collected samples of only biological fathers and more than 35% of only residential fathers. This trend may reflect that this sample type is easier to recruit. Indeed, only two studies used samples mostly comprised of non-residential fathers (Black et al., 1999; Baker, 2018). In the first quantitative study Baker (2018) investigated, in a sample of 74% non-resident fathers, father–school involvement was a predictor of improving academic achievement and social-emotional skills.

The results showed that, although mothers were always more engaged in their children's education, father–school involvement was positively associated with children's math and reading skills and with teacher-related approaches to learning during early childhood. In the second study with a sample composed of non-residential biological and non-biological African American fathers (who were involved at least monthly). Black et al. (1999) assessed the relationship between paternal roles (e.g., nurturance, emotional and economic support) and children's well-being.

The results showed that children whose fathers are satisfied with their parenting and economically supportive of their families have better language competences and cognitive skills, proving the unique fathers' contributions.

Nevertheless, regarding the families' SESs and ethnicities, we found a great heterogeneity across all the studies. Between the studies that distinguished minority, non-minority, and mixed ethnicity samples, 12.5% of the selected articles recruited only minority fathers, 30% exclusively focused on non-minority men, and 40% had a mixed ethnicity sample. More specifically, most of the studies that focused on minority or mixed ethnicity included African American (Black et al., 1999; Cabrera et al., 2011) and Hispanic fathers (Ortiz, 2000; Saracho, 2007a, 2008).

Despite the well-established relevance of household income for children's academic success, the research and knowledge about father involvement and children's cognitive skills in low-income families were lacking. Among the reviewed articles that studied the SESs of the families with children in early and middle childhood, 20% centered on low-income fathers while 42% included a mixed sample with family income ranging from low to high.

Main Research Focuses

As shown in **Figure 3**, half the empirical studies and all the reviews and meta-analyses focused on the relationship between father involvement and children's outcomes; a good number also focused on the effectiveness of interventions to increase fathers' engagement with their children's education and on the comparison between mother and father involvement, while a few articles examined the determinants, and only one study addressed the issue of assessment. In the following subparagraphs, we will synthetize the literature for each research focus, except the assessment, which we will discuss in the next paragraph.

Extent of the Association Between Father Involvement and Children's Cognitive Skills

The findings of the reviewed articles (including reviews and meta-analyses), focusing in particular on the association between father involvement and children's cognitive skills, showed a positive and statistically significant association during early childhood (Flouri and Buchanan, 2004; McBride et al., 2005, 2009; Roopnarine et al., 2006; Saracho, 2007b; Downer et al., 2008; Coley et al., 2011; Fagan and Lee, 2012; McWayne et al., 2013; Duursma, 2014; Jeynes, 2015; Kim and Hill, 2015; Baker, 2017, 2018) beyond mothers' parenting (Roopnarine et al., 2006). More specifically, Fagan and Lee (2012) argued that this relationship was significantly strengthened for children living in single-mother households, whereas Coley et al. (2011) found that family characteristics were trifling.

However, it is important to underline that several studies highlighted that this pattern generally remains significant across ethnicity and SES (Downer et al., 2008; Jeynes, 2015; Baker, 2017).

For example, Cabrera et al. (2011) examined father engagement—verbal stimulation, caregiving, and physical play—across race, monitoring marital status, parental conflict, parental education, and depressive symptoms. The findings showed that while Caucasian fathers demonstrate a lower involvement in care and physical play than African American and Latino fathers, there were no differences in verbal stimulation across ethnicity. Furthermore, fathers' education (i.e., college level) was linked with more verbal activities, whereas couple conflict was associated with less engagement in care and physical activities. In conclusion, the authors argued that, although the level of involvement differed across ethnicity, the general model did not change.

Conversely, some scholars found that the relationship between father involvement and children's cognitive skills diverges across children's and parents' gender (Tan and Goldberg, 2009; Eng et al., 2014), race, and SES (McBride et al., 2013).

For example, Baker et al. (2018) found that, although poverty negatively influences more fathers' than mothers' parenting, fathers' engagement was a stronger moderator between poverty and children's cognitive skills than mothers' involvement.

Comparison Between Maternal and Paternal Involvement

In addition to the studies that specifically focused on the relationship between father involvement and children's outcomes, another great part of research aimed at comparing

TABLE 2 | Reviewes and meta-analysies included in the study.

Study and year	Study design	Objects	Variables		Focus	Key findings
			Determinant	Outcomes		
Saracho (2007a)	Review	Hispanic father involvement in children's literacy development	Ethnicity minority	Literacy skills	FI and children's outcomes	Hispanic father support their children's literacy skills by (a) reading books (b) books discussion (c) recording book already read and (d) stimulating children to enhance their reading
Jeynes (2015)	Meta-anlysis	Relationship between father involvement and children's educational outcomes	Mix ethnicity Biological fathers Ages 3–20	Academic skills Psychological Welfare Positive behaviors Other healthy results	FI and children's outcomes	Relationship between father involvement and child educational outecomes is significant statistically both for white and minority children
Downer et al. (2008)	Meta-analysis	Father involvement and children's early learning	Mixed Ethnicity Mixed SES Mixed biological status Mixed residential status Ages 0–6	Academic and socio-emotional competence	FI and children's outcomes	The consistent of the association between father involvement and children's academic achievement is manteined across etnicity and SES
McWayne et al. (2013)	Meta-analysis	Father involvement and children's early learning	Mixed ethnicity Mixed SES Mixed biological status Mixed residential status Ages 3–8	Social and cognitive domains	FI and children's outcomes	Father involvement showed a consistent association with early childhood competencies, differing based on father's characteristic
Saracho (2007b)	Review	The role of father in supporting their children's literacy learning		Literacy skills	FI and children's outcomes	Fathers' contribution improve their children's literacy and academic skills
Kim and Hill (2015)	Meta-anlysis	The association between parental involvement and children's acedemic achievement	Mixed Ethnicity Mixed SES Mixed Residential status Ages 5–18		FI and children's outcomes	Parental involvement and student achievemente are positively, althought mothers' involvement is higher than fathers'
Lipscomb (2011)	Review	The effects of FI on their children's educational achievement and programs to increase it			FI and children's outcomes and intervention	There are several programs, particularly aimed to specific population or more general, that can increase father involvement in children education

maternal and paternal involvement in children's education. Most studies on this topic highlighted that, although the mean level of mothers' involvement was higher than fathers' (Duursma, 2014; Kim and Hill, 2015; Baker, 2018), fathers' involvement and children's academic skills had a positive association.

For example, Keown and Palmer (2014) collected a sample of 94 two-parent families, with the aim of comparing father and mother involvement with their young son. The findings revealed that, although the mothers were more available to their sons on workdays, and fathers were more involved in activities with their children on weekend days, both mother– and father–child conversations were rich resources for children during their school ages.

Another study, specifically focused on the comparison between maternal and paternal involvement, was conducted by Foster et al. (2016). The authors investigated the home learning environment (HLE) during early childhood and how mothers' and fathers' parenting practices predict children's academic outcomes. The findings showed that mothers provided HLE activities more frequently than fathers although, in families in which mothers had at most a high school diploma, fathers' contributions were a significant predicator of children's early academic skills. However, other studies indicate that also fathers' education levels were often associated with mother engagement and that parental education indirectly influences children's language development through multiple pathways (Pancsofar et al., 2010).

Furthermore, Duursma (2014) examined the association between book-reading frequency of low-income fathers and mothers and children's cognitive and literacy skills and found

TABLE 3 | Studies included in the meta-analysis listed by author, year of study, type of document, objects, and other.

References	Study design	Objective	Methods		Variables		Focus	Key findings
			Participants	Measures	Determinant	Outcomes		
Potter et al. (2013)	Case report	Evaluete the benefits of Father Transition Project (FTP)	5 fathers and 2 grandfathers Children Ages 5–6	Interview Focus Group	Low SES	Enjoyment Achievement Learning	Intervention	Key benefits: a closer relationships with children and an improved involvement both in educational activities
Potter et al. (2012)	Case report	Assess thestrategies most successful in engaging fathers of FTP	5 fathers and 2 grandfathers Children Ages 5–6	Interview Focus Group	Low SES	Enjoyment Achievement Learning	Intervention	The most effective strategies were a personalized, strengths-based within a cooperation context and utilizing an empowerment approach.
Eng et al. (2014)	Quantitative	The role of social capital as a predictor of parental involvement in children's education	273 parents Children Ages 6–10	FI at school: P-TIQ (Parent Version) Walters (2001) FI at Home: Self-report	Minoriy Ethnicity		Determinant	Parents' social networks, academic ambition, trust, gender attitudes and fatalistic convinction can be considered as a predictor of parental involvement
Keown and Palmer (2014)	Qualitative	Compare father-son and mother-son involvement	94 families Children Age 4 (T1) Age 7 (T2)	Interview Questionnire Observation	Resident Fathers Mixed Ethnicity Mixed SES		Comparison	Mothers are more accessible to their son on the working days than fathers, while fathers spend more time with their children on weekend days
Flouri and Buchanan (2004)	Quantitative	Early father and mother involvement and child's later educational outcomes	3,303 parents and childrn Time 1 (age 7) Time 2 (age 20)	Self-report		Accademic Motivation General Ability	FI and children's outcomes	Father involvement indipendently and significantly predicted educational attainment by 20 years
Fagan and Lee (2012)	Quantitative	Effects of fathers and mothers cognitive stimulation and household income on single mother e two parents household on young childrend	8,400 children and parents 9 months (T1) 24 months (T2)	Mother Interview Fathers SelfReport Observation	Mixed SES Biological Fathers Mixed Residential Status	Cognitive skills (BSF)	FI and children's outcomes	Positive association between fathers' cognitive stimulation and children cognitive skills is stronger for children living in single mother household than for children living in 2 parents families
Coley et al. (2011)	Quantitative	Relationship between fathers early parenting and cognitive skills	261 biological Fathers Children Ages 2–4	Self-report	Mixed Ethnicity Low-SES Mixed Residential Status	Math reading (WJ-R)	FI and children's outcomes	Fathers' support and warm predicted higher accademic skills, over and beyond the charateristics of the family
Baker (2018)	Quantitative	Father–school involvement and children's academic and social-emotional skills	3,570 children in kindergarten	Self-report	Mixed Ethncity Mid to high SES Mostly non residential fathers (74%)	Reading math and approch to leaning	FI and children's outcomes	Although mothers are more engaged in school involvement, father-school involvement is positively associated with children's academic skills
Chawla-Duggan (2006)	Qualitative	How father development workers supported fathers to increase paternal involvement in children's learning	4 fathers and their early years sons	Interview Focus Group		Children's learning	Intervention	Father development workers support fathers within the group, raising confidence and responsibility, and with the child, improving children's learning

(Continued)

TABLE 3 | Continued

References	Study design	Objective	Methods		Variables		Focus	Key findings
			Participants	Measures	Determinant	Outcomes		
Black et al. (1999)	Mix methods	Low income fathers and competences, behaviors and home environment (HE) of preschool children	175 3-years African American Children	Self report "Who Does What" (Cowan and Cowan, 1988, 1990) Observation	Low-income Minority Ethnicity Mixed biological and residential status	Children's well-being: cognition, receptive language, behavior HE	FI & children's outcomes	There is a significant relationships between paternal role and each index of children's well-being.
McBride et al. (2013)	Quantitative	Examine the relationship between father involvement in school and children's achievement	596 children Ages 5–12 (T1)	Self-report	Mixed biological status Resident fathers Mixed ethnicity Mixed SES	Reading math (WJ)	FI and children's outcomes	It can be see a variation based on children gender, ethnicty and SES in the relationship between father involvement and children's achievement
Ball (2009)	Qualitative	To develop a theoretical framework about the experiences of Indigenous fathers in various needs and goals.	80 fathers Children Age under 7	Self-report Interview	Biological fathers (84%)		Determinant	Six ecological and psychological factors: personal well-being, learning, socio-economic inclusion, social, legislative and policy support and cultural continuity
Baker (2017)	Quantitative	The role of ethnicity and poverty status as a moderators of the association between father involvement and sons' cognitive and socio-emotional skills	4,240 young boys Ages 0–5	Self-report	Mixed Ethnicity Mid to high SES Mostly residential fathers (82%)	Math and reading	FI and children's outcomes	Paternal warmth and home learning stimulation (HLS) at T1 positively predicted cognitive and social emotional skills at T2, across raical groups.
Baker et al. (2018)	Quantitative	Relationship between family poverty, warmth and home learning stimulation (HLS) and children's preschool achivement	7,700 children Ages 0–5	Self-report	Mixed SES Mixed Ethnicity Biological and residential fathers	Reading and math	FI and children's outcomes	Although poverty negatively influences more fathers' parenting than mothers', fathers involvement turned out as stronger moderator between poverty and children's cognitive skills than mothers'
Tan and Goldberg (2009)	Qualitative	Parents involvement in children's education at school and at home	91 families and children Ages 6–10	Self-report (API) (Tan and Goldberg, 2009)	Biological (87%) Residential (92%) Non minority (74%) Mid to high SES	School Attitudes (SAS)	Comparion	Mothers' and fathers' school involvement show a different association with their sons' and daughters' sacademic achievement.
Giallo et al. (2013)	Quantitative	Fathers vs. mothers in the relationship between child, parents, family factors, parental involvement, and self-efficacy	851 mothers 131 fathers of children Ages 0–4	Self-report (PIS)	Non minority Mixed SES		Comparison	There are few differences between mothers 'and fathers' involvement. Parenal self efficacy plays a mediating role both for mothers and fathers
Bradley and Corwyn (2000)	Qualitative	Personal and contextual factors correlate with socioemotional investment in children.	65 fathers children Ages 0–2	PIC	Non minority Ethnicity Mid to high SES Biological and resident	Cognitive skills (MDI) (Bayley, 1993)	Determinant	Paternal involvement is multi-determined. There is no single factor that has a mastery role.

(Continued)

TABLE 3 | Continued

References	Study design	Objective	Methods		Variables		Focus	Key findings
			Participants	Measures	Determinant	Outcomes		
Foster et al. (2016)	Quantitative	Relationship between home learning environment (HLE) and children's academic skills	767 parents and children Ages 2–6	PQ (Morrison and Cooney, 2002)	Mid to high SES Ethnicity (80.4%) Biological fathers (99%)	Decoding non-minority (WJ-III) Letter Knowledge Math skills (TEMA-3)	FI and children's outcomes	Fathers involvement increase children's academic achievement only whether mothers have at most a high school diploma
Saracho (2008)	Case Report	Effects of Literacy Program, assisting fathers to support children's literacy skills	25 fathers and children Age 5	Interview Observation Documentary Analysis		Literacy skills	Intervention	In the program fathers learn literacy strategies to support and increase their children's literacy development
Kelly (2018)	Theoretical article	Conceptual model on the relationship between fathers engagement and children's prosocial skills				Cognition Emotional Regulation and social behaviors	FI and children's outcomes	Fathers engagement with their children is directly related to the childrend's cognitive skills, self-regulation and social behaviors, influencing civic readiness development
Anderson et al. (2015)	Qualitative	How the experience on Early Childhood Program (ECP) impact the father-role construction and support the engagement	7 fathers Ages 0–4	Focus Group	Low-income Biological resident (86%) Mixed ethnicity	Learning Enjoyment	Intervention	ECP supports fathers to develop parenting skills. These competences can improve father engagement and create a positive father–child relationships, changing the father-role construction.
Roopnarine et al. (2006)	Quantitative	The association between parenting styles and parent involvement and children's academic achievement and social behaviors	70 parents and children Ages 3–6	Interview Self-report	Minority ethnicity Mixed SES	Academic skills (K-SEALS) (Kaufman and Kaufman, 1993)	FI and children's outcomes	Father-school involvement is positively associated with children's academic competences but it is negatively associated with authoritarian parenting style
Hernandez and Coley (2007)	Quantitative	Psychometric properties of father and mother reports of father involvement	227 parents and children Ages 2–4	Self-report Mother-report	Low-income Minority ethnicity Mixed residential status Biological fathers	Cognitive skills (WJ-R)	Assessment	The reliability is similar between father and mother reports and among residential status and race.
Jeong et al. (2016)	Quantitative	Paternal stimulation and Early Child Development (ECD) in low- and midlle-income countries (LMICs)	87,286 children Ages 3–4	Mother-report	Residential Biological Mixed ethnicity and SES	Physical growth child development (ECDI)	FI & children's outcomes	When fathers are unengaged children have a lower ECD scores than children whose fathers highly engaged
Nordhal et al. (2016)	Qualitative	Predictors of fathers positive involvement and negative reinforcement	726 fathers Children Ages 0–1	Interview Observation NICHD (Cox and Crnic, 2003)	Mixed SES		Determinant	Positive involvement and negative reinforcement can be considered two different parenting dimensions
Sun et al. (2018)	Quantitative	Fathers engagement in early learning activities ss a protective factor in LMICs	7,583 children Ages 3–5	Mother-report	Ethnic majority Mixed SES	Early child development (EAP-ECDS)	FI and children's outcomes	Parenatal engagement moderates the relationship between SES and early learning

(Continued)

TABLE 3 | Continued

References	Study design	Objective	Methods		Variables		Focus	Key findings
			Participants	Measures	Determinant	Outcomes		
McBride et al. (2009)	Quantitative	Direct and indirect effects of early parenting on later parental school involvement and children academic achievement	390 children Ages 2–5 (T1)	Self-report	Resident Mixed biological status Non minority Mixed SES	Academic achievement (WJ)	FI and children's outcomes	Early parenting is significantly linked to later parental school involvement for both parents but it is not directly associated to academic achievement for both of them.
McBride et al. (2005)	Quantitative	Fathers school involvement as a mediator in the relationship between school, neighborhood family and children's academic skills	1,334 families Children Ages 5–12	Self-report	Resident Mixed biological status Non minority Mixed SES	Math Reading (WJ)	FI and children's outcoms	Father involvement result a mediator of the relationship between contextual factors and children's academic achievement.
Duursma (2014)	Qualitative	Paternal and maternal bookreading frequency and young children's language and cognitive development	430 families Children Ages 2–5	Interview	Low-income Mixed biological and residential status Mixed ethnicity	Cognitive skills (MDI) (Bayley, 1993) Language Development Literacy skills	FI and children's outcomes	Paternal bookreading significantly related to children's language and cognitive skills, although mothers read more than fathers.
Ortiz (2000)	Qualitative	Mexican American fathers bookreading frequency	25 father Children Ages 5–7	Questionnaire interviews Participant observation	Minority ethnicity Mixed SES	Literacy skills	FI and children's outcomes	Fathers involvement in early reading activities with their children, although the time varied by different area.
Cabrera et al. (2011)	Mix methods	Father engagement across race, monitoring the following variables: fathers' education, personal wellness, marital status and couple conflict	5,089 families Children Ages 0–1	Mothers Interview Fathers Self-report	Biological and resident fathers Mixed ethnicity and SES		Determinant	Fathers' education, marital status, couple conflict, depressive symptoms and type of involvemen do not differ by race, while physical pla and the levels of engagement change.
Baskwill (2008)	Case study	Program for increase fathers' perseptions of their role and their responsability in children's literacy development	15 fathers Children Ages 3–5		Mixed biological status Mixes SES Non minority Ethnicity	Litaracy skills	Intervention	During the program fathers can learn the importance of FI, devolop a repertoire of strategies as well as raise a confidence in their ability to engage in children education.

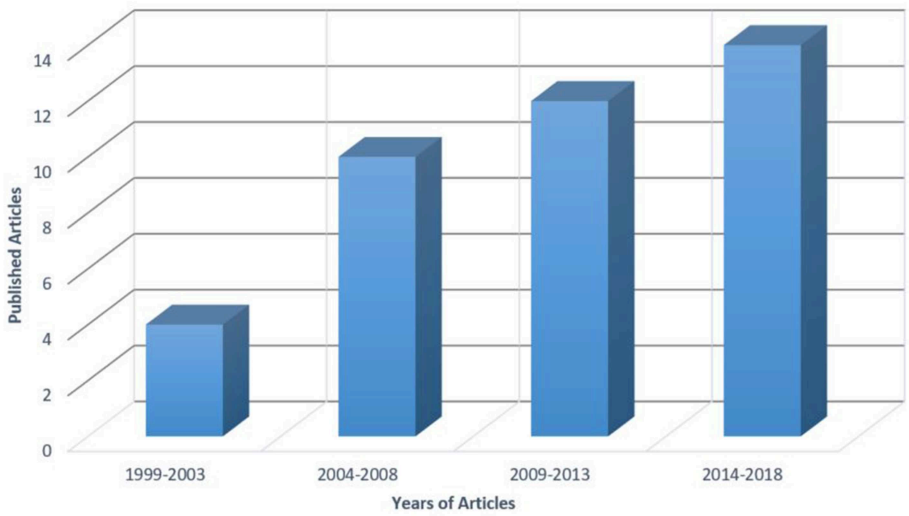

FIGURE 2 | Published articles (included in this review) across years.

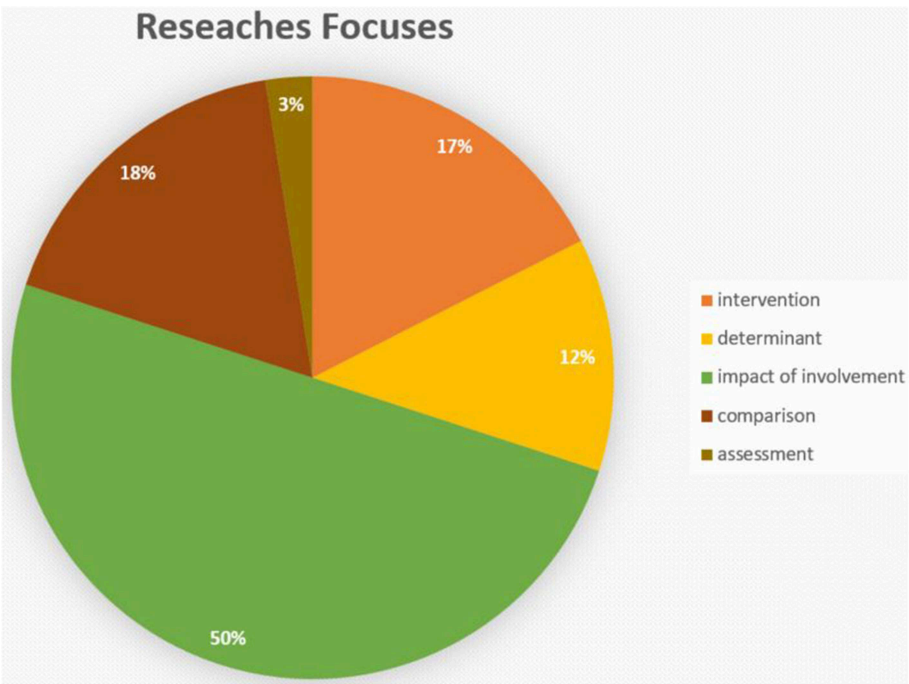

FIGURE 3 | Main researches focuses.

that, although mothers read to their children more frequently than fathers, approximately 55% of fathers reported that they read to their children weekly. Moreover, this study highlighted that fathers' book reading significantly predicted children's language competences, book knowledge, and cognitive skills.

In line with mentioned studies, Giallo et al. (2013) found quite a few differences between mothers' and fathers' involvement, despite both of them were influenced by parenatal self-efficacy (PSE), considering it one of the determinants of father involvement.

Determinants of Father Involvement

Another group of articles specifically focused on the determinants of father involvement, examining both contextual, and personal factors.

Ball (2009), in a qualitative study about the involvement of 80 Canadian Indigenous fathers, introduced a conceptual model that identified six key ecological and psychological factors of fathers' involvement in circles of care for children. The six found factors are: (a) individual health, (b) learning fathering (direct father–child interaction, role models, and direct instructions), (c) socioeconomic inclusion, (d) social support for positive involvement, (e) legislative and policy support for involvement, and (f) cultural continuity.

In the same direction, Bradley and Corwyn (2000) investigated the influence of factors related to context (e.g., income), child characteristics (e.g., temperament), marital quality, and mother's and father's occupation on paternal socioemotional investment toward their children. The results highlighted that paternal investment is a multidetermined construct: it was not possible to identify one single factor that played a predominant role.

In recent years, Nordhal et al. (2016) suggested a conceptual model based on the "social interaction learning model" (SIL; Patterson, 1982), regarding the protective and risk factors of father involvement. Given that the interactions between children and parents can be considered a two-way process (Patterson, 1982; Patterson and Fisher, 2002). Nordhal et al. (2016) distinguished protective factors for fathers, including mental functioning and contextual and personal resources, and protective factors for children, including typical development, male gender, and easy behavior. While the negative factors related to fathers were mental dysfunction and personal and contextual strains, and the negative factors for children were development difficulties, female gender, and difficult behaviors. According to the findings, given that protective and negative factors were positively associated to fathers' positive involvement and to negative reinforcement, respectively, these last two dimensions could be considered different parenting components.

Another study that focused on the determinants of father involvement in Cambodian American families showed that parents' social networks, academic ambitions, trust, gender attitudes, and fatalistic convictions can be considered predictors of parental involvement (Eng et al., 2014). As a consequence, the authors highlighted the need for educators who work with Cambodian American parents to consider mothers' and fathers' beliefs systems and to identify personal and contextual resources to increase parents' involvement in children's education.

To sum up, the examined studies make reference to the following factors as determinants of father involvement: fathers' and mothers' education, families' income level, residencial status, race-ethnicity, characteristics of fathers and children, mother-father relation and social support for positive involvement. Indeed, although the studies in this field are characterized by a great heterogeneity, there is a general agreement in the literature about the necessity to consider how personal (e.g., mental health, child temperament, personality), interpersonal (e.g., marital quality, coparenting), and contextual factors (e.g., social support, culture) influence one another on their impact on father involvement.

Programs to Increase Father Involvement

As seen, although many studies highlighted that mothers were engaged in their children's education more frequently than fathers (Duursma, 2014; Kim and Hill, 2015; Baker, 2018), at the same time, there is strong evidence that fathers can play a unique role in children's cognitive skills development (Flouri and Buchanan, 2004; McBride et al., 2005, 2009; Roopnarine et al., 2006; Saracho, 2007b; Downer et al., 2008; Fagan and Lee, 2012; McWayne et al., 2013; Duursma, 2014; Jeynes, 2015; Kim and Hill, 2015; Baker, 2017, 2018).

Consequently, in recent years, there was an increase in studies focused on the efficacy of father involvement interventions. Indeed, among the 40 selected articles, the focus most investigated, after the relationship between father involvement and children's outcomes, was the benefits and strategies that can improve father involvement in children's education.

For example, Lipscomb (2011) reviewed various intervention types and found that different programs exist, each designed for specific population groups (programs related to incarcerated fathers, minority ethnic groups, and fathers with low income or literacy skills). The following are some examples: The My Baby's Father (MBF) Involvement Model; Dads at School; the Alliance of Concerned Men (Abridging); 100 Black Men; Long Distance Dads; and the Incarcerated Fathers Program. The study of Saracho (2008) can be considered an example of research on the evaluation of an intervention specifically related to fathers with low literacy. The results demonstrated that, when fathers improve literacy strategies, this can help and support their children's literacy skills development.

There are other important contributions in the same direction. Baskwill (2008) identified three main benefits after participating in the Picture It, Dads! (PID) literacy initiative: (1) fathers improved their literacy skills; (2) participants increased their knowledge about the relevance of father involvement in children's well-being; and (3) men acquired a wide range of dad-friendly strategies and increased their ability to engage with their children in learning and intellectual activities.

Chawla-Duggan (2006) identified two ways in which father development workers (FDWs) can help improve men's involvement with their children's education: (a) by encouraging fathers within the group to increase their self-confidence and (b) by helping fathers use both indirect and direct learning approaches to improve their children's intellectual abilities. Potter et al. (2012) examined the findings of fathers' participation in the Father's Transition Project (FTP), which aims to increase the involvement of fathers who live in deprivation areas in children's education during their transition to school. The more successful strategies in engaging fathers were: the focus on strengths rather than weakness, cooperation within the group, constant follow-up, the use of male activities, and mothers' engagement. Moreover, the main program participation benefits can be identified as follows: closer relationships with their children and a higher level of father involvement in playing and in learning activities.

Definition and Measurement of Father Involvement and Children's Cognitive Skills

Definition and Measurement of Children's Cognitive Skills

Most of the reviewed studies examined children's academic/student achievement, cognitive skills, and literacy skills. Regarding the studies that focused on cognitive skills, on one hand, some that assessed memory, vocabulary, problem-solving, enumeration, and the competence to form generalizations and classifications used the Bayley Short Form (BSF) or the Bayley Mental Development Index (MDI)[1]. On the other hand, other studies about cognitive skills investigated particular math and reading skills with the Woodcock-Johnson Psycho-Educational Battery (WJ): this measure is used in the studies that focused on academic achievement as well. Moreover, the studies that focused on father involvement and children's literacy skills assessed the relationship between the amount of time fathers spend reading books to their children and developing reading skills (Ortiz, 2000; Saracho, 2008). For instance, in his review, Saracho (2007a) found that fathers support and increase their children literacy skills by reading books, involving children in book discussions, recording which books have already been read, and stimulating children to enhance their reading (Saracho, 2007b).

Definition and Measurement of Father Involvement

To address the way father involvement is studied in the different researches, it is necessary to deepen the construct's characteristics: **Table 4** shows that there are many types of father involvement and, for each, there is no single definition or component. Father involvement is a multidimensional construct that has been conceptualized and measured in various ways. For example, 40% of the articles focused on "father involvement" in general, defining and measuring the construct differently, without any other specification (e.g., related to school, home, etc.). Most of the studies used self-reports (40%), and only a few utilized interviews and observations (30%) or mothers' reports (10%); however, each self-report focused on different aspects of father involvement. For instance, Baker (2017) used a self-report questionnaire to investigate the frequency (1 = "never" to 5 = "always") of fathers' participation in warm interactions and in three home learning activities with their children. Furthermore, the kind of control/discipline that fathers used with their children was assessed with a 5-point Likert scale, where 1 = "not at all like me" and 5 = "exactly like me."

In another study, Tan and Goldberg (2009) investigated parental school involvement using a 26-item scale adapted from Tan and Goldberg (2009) About Parental Involvement.

It aimed to assess how frequently mothers and fathers are engaged in four different kinds of school/educational-related activities: direct school involvement, homework involvement, interpersonal involvement, and extracurricular activity involvement.

[1]The MDI is the most used measure to assess toddlers' cognitive development, in which high scores reveal high levels of cognitive development.

TABLE 4 | Type of construct.

	Construct *n.*	Frequency %
Father involvement	15	47.5
Father involvement at school	4	10
Father involvement at home	1	2.5
Father involvement in education	4	10
Early father involvement	5	12.5
Engagement	11	27.5
	40	100

Each item was evaluated using a 5-point scale, where 1 = "never" and 5 = "always."

These two studies are useful for understanding the great difference in the way in which the construct of father involvement is defined and measured.

DISCUSSION

Growing Interest in the Role of Father Involvement in Children's Education

The first aim was related to the progression of the amount and nature of the researches on this theme over the years. The findings suggest that, although each research used a different operational definition of the father involvement construct, in recent years there has been a wide and constant interest increase about this issue. Moreover, most of the examined articles were empirical studies and, in particular, a sizable number had a quantitative design.

Fathers' Living Conditions

Regarding our second aim, the analysis of fathers' research samples revealed that most included biological and residential fathers: this trend may reflect that this sample type is easier to recruit than one comprised of non-residential and non-biological fathers.

Regarding the SES and the ethnicity of the families, the data highlighted how, in comparison with past researches, in recent years the literature on father involvement is starting to consider cultural differences and different educational and economic levels.

Indeed, while the most of past researches collected samples of Caucasian and middle-class men, failing to grasp the families' diversity, more and more articles, recently, include minority populations or diversified samples both in terms of the cultural level and the SES of the family (Black et al., 1999; Ortiz, 2000; Saracho, 2007a, 2008; Cabrera et al., 2011; Sun et al., 2018).

Main Research Focuses

The third objective was to analyze the main focuses of the examined literature. The findings revealed that the main focus is the impact of father involvement on children's cognitive skills. The studies highlighted a positive association between father

involvement and children's cognitive skills[2] in early and middle childhood (Flouri and Buchanan, 2004; McBride et al., 2005, 2009; Roopnarine et al., 2006; Saracho, 2007b; Downer et al., 2008; Fagan and Lee, 2012; McWayne et al., 2013; Duursma, 2014; Jeynes, 2015; Kim and Hill, 2015; Baker, 2017, 2018). Moreover, it is important to underline that several studies highlighted that this positive association between father involvement and children's cognitive skills remains significant across ethnicity and SES (Downer et al., 2008; Jeynes, 2015; Baker, 2017). Instead, regarding the family household, some authors argued that this association is lower for children living in two-parent families than for children living with a single mother (Fagan and Lee, 2012), whereas others supported the strength of this association, regardless of the family characteristics (Coley et al., 2011). In line with these findings, Volling and Belsky (1991), in their study of multiple determinants of father involvement in dual- and single-earner families, found that even the fathers' personality characteristics had a significant impact on their responsibility for child care in single-earner but not in dual-earner families; contextual factors (e.g., marital quality and work) were potential influents in both dual and single families.

The study of father involvement in different families' households allowed a wider understanding of the direct and indirect pathways of the fathers' influence on their children's development. Regarding the direct patterns of influence, many studies found that father–school involvement was positively and directly associated with children's reading, math, and approach to learning (Baker, 2018). Moreover, fathers' SES (including education level and income) is uniquely and directly associated with children's cognitive skills (Cabrera et al., 2007; Malin et al., 2012). Finally, depending on the level of involvement, fathers can positively affect children's development even when they do not live with them (Cabrera et al., 2000) while, according to the well-known contribution of Amato and Gilbreth (1999) about non-residential fathers, the complete absence of a father is associated with less success in school and impaired cognitive function. Moreover, with respect to indirect effects, fathers impact their children through their financial responsibilities by influencing the quality of children's home experiences (Cabrera et al., 2009; Kolak and Volling, 2013). Another indirect effect may be largely attributable to harmonious family contexts: there is empirical support for the hypothesis that a positive marital quality is associated with positive parent–child relationships and child adjustment (Gable et al., 1994), whereas marital conflict is associated with maladjustment (Emery, 1994; Cummings et al., 2004).

However, although these findings highlight the various pathways of fathers' involvement in influencing their children's development, they do not explain how fathers and mothers are similarly and differently involved in their children's development, and how this could similarly or differentially affect child outcomes. On one hand, some authors, in stressing the differences between parents, noted that fathers give a unique contribution to their children's development—one that is different from the mothers'. Most of the articles highlighted that, although mothers showed higher levels of involvement compared to fathers (Duursma, 2014; Kim and Hill, 2015; Baker, 2018), there is great evidence that fathers' involvement had a positive association with their children's academic skills, demonstrating a unique influence provided by the paternal contribution. In line with these results, several researches showed that fathers are more likely than mothers to engage their children, especially sons, in rough-and-tumble play (Hossain and Roopnarine, 1994; Panksepp et al., 2003; Paquette et al., 2003), to encourage them in risk taking (Hagan and Kuebli, 2007) and dealing with scary experiences (Sandseter and Kennair, 2011).

On the other hand, other researches have focused on the similarities between mothers and fathers and found that children may benefit from parental support regardless of which parent provides it, as long as it is frequent and of high quality (Ryan et al., 2006; Cabrera et al., 2007). To conclude, given the evidence of both the similarities and differences in father– and mother–child relationships, Cabrera et al. (2014) suggested considering fathers and mothers as a complements to each other, where each person's behavior can help strengthen or weaken the bond between them. Consequently, sometimes fathers will enact roles played by mothers, and vice versa, in response to environmental conditions that require adaptation (e.g., both parents working, single-parent fathers). Given these findings, a model that attempts to capture the complexities of father involvement must consider contextual and individual factors that may move fathers to being more similar to or different from mothers. For this reason, the examined articles that focused on the determinants of father involvement tried to identify which possible risk and protective factors are related to fathering.

Although these studies are characterized by a great heterogeneity, there is a general agreement in the literature about the necessity to consider how personal (e.g., mental health, child temperament, personality), interpersonal (e.g., marital quality, coparenting), and contextual factors (e.g., social support, culture) influence one another on their impact on father engagement. A current model that tried to compile these factors, overcoming linear and static approaches considering the transactional and reciprocal nature of the father–child relationship, is the *Ecology of Father–Child Relationships: An Expanded Model,* developed by Cabrera et al. (2014). It considers fathers as part of dynamic systems characterized by interconnected relationships between and among caregivers and children and explains how these relationships evolve and change through time and social and contextual factors. This model also considers the personal, interpersonal, and contextual variables in determining the level of father involvement (Volling and Belsky, 1991) and the transactional and reciprocal nature of the relationship between fathers and children (Sameroff, 2010).

As a consequence, if future studies enable the achievement of a shared knowledge and understanding of such factors, then researchers and professionals will be able to enhance father involvement through specific programs based on such protective and risk factors. Indeed, a sizable number of articles focused on the effectiveness of programs to improve

[2]Further ahead, we will discuss the construct of the operational definition of "cognitive skills" which, in some articles, is also referred to as academic/student achievement.

paternal engagement. It is possible to discriminate two kinds of programs: one aimed toward samples with specific characteristics (e.g., Dads at School, 100 Black Men, Long Distance Dads, Incarcerated Fathers Program, programs for fathers with low-literacy skills); the other concerns programs that can be applied to a more generic sample (e.g., Father-to-Father Mentoring Program, Father in Training (FIT): Empowering Men to Become Better Fathers).

In the end, it is possible to summarize that, although the literature about father involvement is characterized by a great heterogeneity, there is a general agreement about the necessity to consider how personal (e.g., mental health, child temperament, father's personality, father and mother level of education,), interpersonal (e.g., marital quality, coparenting), and contextual factors (e.g., social support, culture) influence one another on their impact on father involvement.

Definition and Measurement of Father Involvement and Children's Cognitive Skills

The last aim of the present review concerns the operational definition of the construct and the measurement instruments used to assess father involvement and their children's cognitive skills. Regarding the assessment of cognitive skills, the literature is quite heterogeneous: on one hand, some studies examined cognitive skills by evaluating problem-solving, memory, math ability, vocabulary, and competence to create generalization and categorization (Fagan and Lee, 2012); on the other hand, other studies investigated, in particular, math and reading skills as well as the studies focused on "academic/student achievement" (Baker, 2017, 2018). For this reason, it is clear that the most investigated children's outcomes are math and reading skills, also referred to as "cognitive skills" and "academic achievement." As for father involvement, the selected researches used different types of constructs and tools to understand the father–child relationship, focusing on some aspects of father involvement and neglecting others.

Most of the selected researches used quantitative methods, in particular self-report questionnaires, usually developed or specifically adapted to assess mother–child relationships. In contrast, the use of interviews, observations, or diaries in qualitative studies to explore father–child relationships allow the assessment of more specific aspects. For instance, Keown and Palmer (2014), in their qualitative study, used semistructured interviews, which evaluated both the frequency and nature of parents' involvement with their children. Such heterogeneity related to the measuring instruments reduces the possibilities of comparing the results of each study: this remains one of the main limits in most empirical studies. Moreover, the use of only self-reported data does not make it possible to understand how the ecology of children's lives changes, how fathers interact with their children, how they engage in different activities, and what circumstances bring fathers into and remove them from their children's lives (Cabrera and Volling, 2019).

In conclusion, it could be argued that parental involvement assessment requires overcoming the traditional developmental models focused on dyadic interactions, usually mother–child, by using a broader multidimensional perspective, and thus a comprehensive methodological approach based on a developmental ecological system framework (Cabrera and Volling, 2019), to evaluate the father–child relationship in their family system, including a multidimensional, multi-informant assessment.

LIMITATIONS

The main limitation across studies is related to generalizability. This aspect could reflect the recruitment process and the configuration of the samples: confined to residential, American and middle-class fathers. For example, in their study Fagan and Lee (2012) identified a limitation in the low response rate of non-resident fathers. Furthermore, given the increase of non-residential fathers in the general population, their involvement in study designs becomes more necessary.

The second limitation is related to measurement. Indeed, the ways in which father involvement is measured are criticized for more than one reason: (a) the simplicity of the construct's measurement (e.g., assessing the extent rather than the quality of interaction); (b) the wide variability of instruments; (c) instruments validation testing of the mothers; (d) the use of mothers' reports about fathers' involvement; and (e) the overuse of self-report questionnaires. In particular, the self-report measure of father involvement is not considered the best way to assess paternal engagement because it may reflect fathers' aspirations to look better than they might be (because of a social desirability bias), and they cannot grasp the dynamic and transactional nature of father–child interactions, which is a complex phenomenon that could be investigated across several dimensions (Cabrera et al., 2018; Cabrera and Volling, 2019). Thus, the integration of self-reported data with qualitative tools (e.g., observations) in father–child interactions should be preferred.

Further developments in evaluation procedures are needed for broader comprehension of fathers' involvement and their impact on their children's well-being: in fact this limitation on the source of information (e.g., parent report) could have and effect on the estimation of children's enjoyment of school and cognitive skills. The use of the same data source for both the independent and dependent variables may lead to overestimate the correlation between the variables, which, in turn, compromise the possibility of making causal inferences starting from parental involvement to understand the children's outcomes. For this reason, researches that utilize a multi-informant approach can be more informative compared to studies based on a single data source.

We must also take into consideration that, to avoid bias, we excluded the articles involving clinical samples, which would need to be addressed with a specific literature review.

A further limitation is about the design of the reviewed studies, since the majority of them used a cross-sectional design, which limits the inferences of causality.

Finally, in many studies, the reported interaction effects and sample sizes were quite small. However, although the great

heterogeneity of the examined studies represented a limiting condition also for conducting the present review, it was possible to outline many important points in relation to the examined literature and to draw on future research directions.

IMPLICATION FOR FUTURE RESEARCHES

Given the previously discussed limits, the first implication for future researches is related to the need to expand the research samples, including more ethnic groups and different geographical contexts (e.g., suburban, urban, or rural areas)and low-income, non-resident, social, and step-fathers in the studies that are addressed to deepen the knowledge about father involvement. This is necessary because it could enhance both the internal and external validity of the existing studies about father involvement in the literature. Indeed, parenting occurs in a social context (Bronfenbrenner, 1979) and, for this reason, fathering patterns may vary by race or social context.

Another implication for future researches is related to the necessity of extending and deepening the conceptualizations of father involvement in children's cognitive skills development, not focusing exclusively on fathers engagement. Currently, there is vast evidence in the literature that father involvement is a multidimensional construct influenced by personality, family history, child characteristics, marital quality, and the father's sociocultural context (Volling and Belsky, 1991). For this reason, the use of one single source of information and one method of measurement of father involvement is reductive, and there is a necessity for studies to incorporate multiple informants and methods (e.g., observations, surveys carried out by both fathers and mothers, diaries) in the assessment of paternal involvement (Cabrera et al., 2018; Cabrera and Volling, 2019). Furthermore, future research should create and validate measures of parenting practices for both low-income and minority families and use longitudinal designs to better understand the association between father involvement and children's outcomes.

In conclusion, the consideration of the above indications in future research designs could make it possible to increase the knowledge about mothers' and fathers' involvement in their children's cognitive skills development.

AUTHOR CONTRIBUTIONS

LR, GG, and AC took overall responsibility for the creation of the frame used in this review and the selection of the papers. TT, LC, EG, and PB searched for the articles discussed in the review. LR and AC supervised the entire work. All authors were involved in the discussion, the write and the revision of the manuscript and they gave the final approval of the version to be published.

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