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Linking early maternal input during shared reading to later theory of mind through receptive language and executive function: A within- and between-family design

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ABSTRACT

This study explored whether early maternal input during shared reading predicted later theory of mind (ToM) understanding through children's receptive language and executive function (EF). Maternal input plays a prominent role in the development of children's language skills, which are crucial for both EF and ToM development. There is also an abundance of behavioral evidence suggesting a directional link from EF to ToM. This relation raises the possibility of a cognitive cascade in which maternal input during shared reading promotes ToM development sequentially through receptive language and EF. The sample included 656 children clustered within 328 ethnically and sociodemographically diverse families. The shared reading sessions occurred when the younger and older siblings were 1.5 and 4 years old, respectively. Receptive language, EF, and ToM were measured when the siblings were approximately 5 years old to account for age differences. Multilevel modeling using Bayesian estimation was used to account for the effect of family-wide confounds (i.e., shared between the siblings in the family) while isolating child-specific processes (i.e., unique to each child within the family). The results supported two indirect paths from shared reading to children's ToM: one through receptive language alone and another that operated sequentially through receptive language and EF. These paths were observed only at the family level. These findings emphasize the importance of maternal input during early shared reading for

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cognitive development and suggest a cascade from maternal input to ToM via language and EF during the preschool period.

Introduction

Research has demonstrated that linguistic input during early shared reading is associated with the development of children's literacy skills (Bus, van IJzendoorn, & Pellegrini, 1995; Demir-Lira, Applebaum, Goldin-Meadow, & Levine, 2019; Dowdall et al., 2020; Mol, Bus, de Jong, & Smeets, 2008), and some research has even found benefits regarding children's academic outcomes (Sénéchal & LeFevre, 2002; Wade, Jenkins, Venkadasalam, Binnoon-Erez, & Ganea, 2018). Research has also demonstrated that linguistic input during shared reading aids children's social-emotional and social-cognitive awareness (Ziv, Smadja, & Aram, 2013). One such social-cognitive proficiency is theory of mind (ToM), which is the ability to infer others' mental states such as desires, beliefs, intentions, and emotions. ToM has been associated with book reading (Mar, 2018), language abilities (Farrar, Benigno, Tompkins, & Gage, 2017), and executive functioning (EF; Wade, Prime, et al., 2018). However, the mechanisms underlying the association between shared reading and ToM development are still unknown. Tying together research from several domains of cognitive development, the current study tested the theoretically derived hypothesis that maternal input during shared reading during early childhood is associated with children's later ToM through their receptive language and EF skill development. We expanded on previous research by using a powerful sibling-comparison design in which we can separate child-specific factors from family-wide factors to determine whether these processes operate at the child or family level. Specifically, by examining two children per family, we can determine whether maternal input during shared reading to individual children scaffolds ToM through individual improvements in language and EF or whether family-wide shared reading improves ToM of all children in the home via general improvements in language and EF among all siblings.

Language and theory of mind

Language is one of the strongest correlates of ToM (Farrar et al., 2017; Milligan, Astington, & Dack, 2007; Slade & Ruffman, 2005). The finding that children with language impairments have significant difficulties on ToM tasks (Baird & Astington, 2012; Miller, 2006; Nilsson & de López, 2016) supports the essential role of language in ToM understanding. Evidence from longitudinal studies shows that children's early language competence predicts later ToM even after accounting for prior ToM; however, early ToM is less strongly associated with later language ability after controlling for prior language skills (Astington & Jenkins, 1999; De Villiers & Pyers, 2002; Slade & Ruffman, 2005). Similarly, a meta-analysis synthesizing 104 studies found that earlier language was a better predictor of later ToM rather than the reverse, providing support for the directional nature of this effect (Milligan et al., 2007).

Although research strongly supports the idea that language facilitates ToM development, the nature of this relation is multifaceted (Nilsson & de López, 2016). A recent meta-analysis suggests that there are multiple linguistic pathways to ToM understanding, with general language ability serving as one putative pathway for typically developing children (Farrar et al., 2017). In the current study, we considered the *pragmatic enrichment perspective,* wherein basic language ability promotes conversational exchanges that expose children to alternative perspectives that are vital for ToM development (Harris, De Rosnay, & Pons, 2005). Through linguistically rich interactions with others, children come to understand that their social partners can have perspectives that differ from their own, and this understanding helps them to understand the underlying mental states of others. Diverse and sophisticated vocabulary with toddlers and decontextualized language such as narratives in preschoolers aid in developing receptive language (Rowe, 2012). In the current study, which included mothers' language input to two siblings during shared reading as well as the language abilities of an individual child and the sibling, we operationalized the pragmatic enrichment perspective as exposure to language and book reading that went beyond those that were specifically related to the child. We hypothesized that general receptive language abilities would play an essential role in mediating the relation between shared reading and ToM ability.

Executive function, language, and theory of mind

EF describes a collection of cognitive processes such as working memory, cognitive flexibility, and inhibitory control that facilitate planning, goal-directed behavior, and problem solving (Anderson, 2002; Carlson, 2005). A large body of research indicates that early EF skills predict later ToM ability after controlling for variables such as age, gender, verbal ability, and socioeconomic status (SES) (Benson, Sabbagh, Carlson, & Zelazo, 2013; Carlson, Claxton, & Moses, 2015; Carlson, Mandell, & Williams, 2004; Devine & Hughes, 2014; Flynn, 2007; Hughes, 1998; Marcovitch et al., 2015; Müller, Liebermann-Finestone, Carpendale, Hammond, & Bibok, 2012). In addition to the preponderance of behavioral evidence pointing to a directional link from early EF to later ToM, researchers have been interested in understanding how precisely EF and ToM are associated. A recent review by Wade, Prime, and colleagues (2018) surmised that separate neurobiological mechanisms underlie ToM and EF functions, but there is also a shared neural mechanism for domain-general processing that supports both abilities. One such shared system is language ability. Language may scaffold children's ability to control thoughts and regulate behavior through the internalization of words, gestures, and semiotic cues, in turn facilitating verbal representation and reasoning about mental states (Wade, Prime, et al., 2018). In line with the pragmatic enrichment perspective, therefore, language and EF may form a cognitive cascade in which early language is associated with later EF, which in turn is related to children's ToM.

Indeed, the association between language and EF has been well established (Müller, Jacques, Brocki, & Zelazo, 2009; Wade, Prime, et al., 2018). Zelazo (2015) proposed that language creates mental representations of the target actions, thereby supporting EF performance. Studies have demonstrated that linguistic cues indeed facilitate success in EF tasks (Jacques, 2001; Kirkham, Cruess, & Diamond, 2003; Müller, Zelazo, Hood, Leone, & Rohrer, 2004). Research also indicates that there are strong correlations between receptive language and children's performance on the Dimensional Change Card Sort task (ranging from.40 to.70; Lang & Perner, 2002; Müller, Zelazo, & Imrisek, 2005; Müller et al., 2009). Beyond these cross-sectional studies, longitudinal studies show that language is a significant predictor of later EF (Kuhn, Willoughby, Vernon-Feagans, & Blair, 2016; Kuhn, Willoughby, Wilbourn, Vernon-Feagans, & Blair, 2014). In particular, children's language and EF skills at 2 years of age independently predicted language at 3 years, but only language at 2 and 3 years of age, and not EF at 2 years, predicted EF at 4 years (Kuhn et al., 2014). Thus, EF skills from 2 to 4 years of age were entirely mediated by language at 3 years. Together, these findings suggest that both language ability and EF skills are precursors to ToM and that language may precede and predict later EF. Thus, in the current study we explicitly tested a cognitive cascade in which maternal linguistic input was hypothesized to be associated with later ToM through children's receptive language and EF.

Shared reading as an antecedent to language, executive function, and theory of mind

In the current study, shared reading was operationalized as a measure of maternal input while reading a wordless picture book. Research has indicated that although the frequency of shared reading is important, the quality of the interaction is paramount in predicting later literacy (Marjanovič-Umek, Hacin, & Fekonja, 2017). As a result, a global measure of shared reading that considered both quality and quantity was used in this study (Pentimonti et al., 2012). This section discusses research showing that parental input during shared reading is important for developing language, EF, and ToM abilities.

Maternal input during shared reading is vital for promoting language development. During the first 3 years of life, linguistic input during shared reading at home is more influential in language development than verbal input during free play (Fletcher & Reese, 2005) because parents provide greater vocabulary diversity and syntactic complexity than during non-shared reading interactions (Demir-Lira et al., 2019). Parental input during shared reading is a reliable predictor of children's language skills (Bracken & Fischel, 2008; Bus et al., 1995; Demir-Lira et al., 2019; Dowdall et al., 2020; Raikes et al., 2006; Saracho, 2017; Sénéchal & LeFevre, 2002; Sénéchal, LeFevre, Hudson, & Lawson, 1996). For instance, shared reading at 18 months of age significantly predicts receptive and expressive vocabulary development at 42 months (Deckner, Adamson, & Bakeman, 2006). Thus, shared reading is a strong antecedent to language development.

Although there is also research to suggest that certain aspects of early parenting behavior (e.g., mindfulness, autonomy support) are associated with EF development (Bernier, Carlson, & Whipple, 2010; Cheng, Lu, Archer, & Wang, 2018), not many studies have directly tested the relation between maternal input during shared reading and later EF (Daneri et al., 2019). One recent study examined how maternal linguistic input derived from reading wordless picture books at 15, 24, and 36 months of age mediated the relation between socioeconomic risk at 6 months and EF at 48 months (Daneri et al., 2019). Maternal vocabulary diversity (number of words) at 24 months of age and maternal mean length utterances at 36 months mediated the relation between socioeconomic risk and EF independent of parental sensitivity. Moreover, children's receptive language at 36 months of age partially mediated the association between vocabulary diversity at 24 months and EF at 48 months, and it fully mediated the association between vocabulary diversity and mean length utterances at 36 months and EF at 48 months. This study provides strong longitudinal support for the notion that maternal linguistic input during shared reading is associated with later EF through children's receptive language.

In the current study, we extended this idea by further positing a downstream effect of EF on children's ToM. Indeed, research on the role of shared reading in ToM understanding has examined the direct relation between parental mental state production during book reading and children's ToM (Adrián, Clemente, & Villanueva, 2007; Adrian, Clemente, Villanueva, & Rieffe, 2005; Slaughter, Peterson, & MacKintosh, 2007; Symons, Peterson, Slaughter, Roche, & Doyle, 2005; Tompkins, 2015). These findings cohere with the pragmatic enrichment perspective and indicate that maternal input during shared reading is valuable for ToM development. In a training study, children improved on ToM tasks after being taught labels and being made aware of dual perspectives (Sellabona et al., 2013). The positive effect of storybook exposure on ToM performance in 4- to 6-year-olds (Mar, Tackett, & Moore, 2010) has been attributed to children's books containing a high frequency of mental state verbs (Dyer-Seymour, Shatz, Wellman, & Saito, 2004), which are believed to foster ToM ability in young children. Nevertheless, the cognitive mechanisms linking shared reading to children's ToM remain elusive. Thus, consistent with the above literature, we examined whether children's receptive language and EF skills provide an intermediary link between shared reading and later ToM ability.

Sharing of wordless picture books can promote children's oral language, vocabulary, reading comprehension, and inferential thinking (Arizpe, 2013). Few studies have compared shared reading with wordless and text picture books. Some research suggests that toddlers and parents have more verbal interactions when reading wordless picture books compared with text picture books (Sénéchal, Cornell, & Broda, 1995). Children and teachers have also been shown to produce more diverse words during shared reading with wordless picture books, whereas teachers produced longer sentences with text-based picture books (Chaparro-Moreno, Reali, & Maldonado-Carreño, 2017). This finding suggests that wordless picture books during shared reading may foster vocabulary skills to a greater degree than picture books with text (Grolig, Cohrdes, Tiffin-Richards, & Schroeder, 2020). In the current study, using wordless picture books during shared reading allowed us to examine the entire conversation during the reading session and ruled out the possibility of parents solely reading the text.

The current study

The research summarized above suggests that: (a) shared reading is associated with language development, EF, and ToM; (b) language precedes and predicts later EF and ToM; and (c) EF is directionally related to later ToM. Together, this wide body of literature invokes a theoretically driven developmental cascade in which maternal input during shared reading is indirectly and sequentially associated with children's ToM via their receptive language and EF. Although research reveals multiple linguistic pathways to ToM understanding (Farrar et al., 2017), including general pragmatic development, the precise mechanisms through which this occurs are unclear. This study differentiated between maternal and child-level factors to uncover support for the pragmatic enrichment perspective.

Most prior studies examining the relation between parent–child reading and cognitive development have used between-family designs that test only a single child per family. This design cannot differentiate between shared family-level influences and child-specific influences. Specifically, between-family designs, although common and informative, cannot disentangle family-level factors that are shared between all children in a given family from those that are specific to each child. This limitation is important because conclusions regarding the effect of parenting on a given child outcome often presume that this effect is child specific, yet family-level factors may explain such an association.

Thus, the current study used a within-family sibling comparison design to examine how variation in maternal input during shared reading between siblings is associated with within-family differences in ToM via within-family differences in receptive language and EF. This design necessitated data from multiple children per family on all the constructs of interest. This design allowed us to examine whether maternal input at the family level (averaged across both siblings) or maternal input unique to each child is a stronger predictor of children's ToM. If we found that maternal input matters more at the family level than at the individual child level, this would suggest that maternal talk directed to the child's sibling adds to the prediction of the child's ToM over and above direct talk to the child. Similarly, we could examine whether the mediation processes involved in the cognitive cascade (maternal input → language → EF → ToM) operates at the family level (the average of both siblings' EF and language) or at the child level. If the mediation is stronger at the family level, this would suggest that the siblings' language and EF add to the prediction of the child's ToM over and above the child's own language and EF. This finding would also support the pragmatic enrichment perspective, which argues that it is not just the child's own abilities that predict ToM development but rather the variety of perspectives and inputs that the child receives from other people.

Hypotheses

1. We hypothesized that general receptive language abilities and executive function would play an essential role in mediating the relation between maternal input during shared reading and ToM ability during the preschool period.
2. We expected to see this pattern of mediation at the child and family levels, in accord with the pragmatic enrichment perspective.

Method

The sample came from the Kids, Families and Places (KFP) study. Families were recruited through the Healthy Babies Healthy Children public health program in Toronto and Hamilton, Ontario, Canada, between April 2006 and September 2007. The inclusion criteria were that families had an English-speaking mother who agreed to be videotaped, a newborn who weighed more than 1500 g, and at least one older child under 4 years old. A total of 501 families were enrolled in the longitudinal KFP study. The goal of the KFP study was to examine biological and contextual influences on children's cognitive, social-emotional, and academic development using a within-family procedure.

There were four visits throughout early childhood. The newborn sibling was approximately 2 months old at Time 1. The three follow-up sessions occurred when the newborns were approximately 1.5 (Time 2), 3 (Time 3) and 4.5 (Time 4) years old. Observational and direct testing was conducted with the newborn and the next-in-age older sibling at all time points on the same day. Questionnaire data were also collected from parents. This study used a subsample of the KPF participants at Times 2, 3, and 4 for the two siblings (hereafter, the newborn is referred to as the "younger sibling" and the next oldest is referred to as the "older sibling"). The inclusion criterion for the current study was that a shared reading measure was required for both siblings at the Time 2 assessment.

Participants

The final sample consisted of 656 children nested within 328 families (52.30% male). Mothers' mean age for the subsample at Time 2 was 34.66 years (*SD* = 4.40, range = 22–49), and 65.85% of mothers identified as White, 22.26% as Asian, 5.49% as Black, and 6.40% did not disclose this information. At home, 60.21% of children in this sample spoke English, 32.47% were bilingual, 0.76% predominantly spoke another language, and 6.55% did not disclose this information. We compared the KFP subsample with the 2006 Canadian Census data limited to women aged 20 to 50 years with at least one child in the Toronto and Hamilton area. The subset of the KFP families had fewer children compared with the census sample (*M* = 2.29, *SD* = 0.56 vs. *M* = 4.13, *SD* = 1.22), fewer non-intact families than the census sample (12.60% vs. 27.10%), and more Canadian-born mothers (63.10% vs. 47.60%). The KFP sample also had more mothers who earned a bachelor's degree or higher (57.60% vs. 30.60%), but maternal income was slightly lower for the subsample of KFP mothers (*Mdn* = C$20,000–29,999 vs. *M* = C$30, 504.16, *SD* = C$37,808.12).

Attrition in longitudinal studies related to sociodemographic characteristics is common (Fitzgerald, Gottschalk, & Moffitt, 1998; Wolke et al., 2009). In this particular sample, attrition analysis indicated that lower SES, $t(273.56) = -3.23$, $p < .01$, lower maternal education, $t(318.79) = -2.06$, $p < .05$, and younger maternal age of first pregnancy, $t(838) = -2.21$, $p < .05$, were related to family dropout from Time 2 to Time 4.

Procedure

Shared reading was evaluated at Time 2 for both siblings. The approximate mean age of the younger sibling was 1.5 years (*M* = 1.58 years, *SD* = 0.13), and that of the older sibling was 4 years (*M* = 3.99 years, *SD* = 0.71). Given the developmental sensitivity of measures of cognitive functioning, we assessed receptive language, EF, and ToM using an age-snapshot technique (Wichman, Rodgers, & MacCallum, 2006), in which these constructs were measured at two different time points for each sibling in a given pair to match them as closely as possible on chronological age, with each sibling being 4 to 7 years old at the assessment point. Specifically, the older sibling was tested on ToM, EF, and receptive language at Time 3 (*M* = 5.52, *SD* = 0.74) and the younger sibling at Time 4 (*M* = 4.80, *SD* = 0.27), such that their ages more closely approximated one another at the time of assessment (Fig. 1). This technique reduced age-related confounds for abilities that show strong maturational change such as language, EF, and ToM. In addition, it resulted in all siblings being tested at approximately the age when children begin to pass ToM tasks (Wellman & Liu, 2004).

Measures

Maternal input during shared reading

Mothers were videotaped reading a wordless picture book with each child individually for approximately 5 min at Time 2. Wordless picture books were selected so that the entire session would consist of input derived by and unique to the mothers. Before the session began, mothers were given time to go through the book to understand and build a story that would correspond to the pictures, negating the difficulty that readers could experience when using a wordless picture book. The picture books were age appropriate. Mothers read *Hug* by Jez Alborough for the younger sibling and read *Jack and the Missing Piece* by Pat Schories for the older sibling. Both books were the same length (32 pages) and were similar in context because they involved animals with concealed negatively valenced emotions (i.e., being sad and lonely). The use of two different books allowed for a more organic measure of maternal input during shared reading because each child heard the story read to them for the first time, preventing the mothers from repeating similar phrases during the second reading. Mothers of non-monolingual children read using their preferred language, and fully fluent research assistants transcribed (and, when needed, translated) maternal linguistic input from the sessions.

The Systematic Assessment of Book Reading (SABR; Pentimonti et al., 2012) was adapted to code the transcripts by a different pair of research assistants. The SABR focuses exclusively on adults' extra-textual talk and creates a comprehensive measure of shared-reading quality and quantity during the shared-reading session (i.e., *what* is being done and *how* it is being done). Mothers were rated on their ability to both *provide* and *ask for* information on different linguistic aspects: language development (e.g., labeling or definitions), abstract thinking (e.g., making inferences), and elaborations (e.g., making connections to real life or imitations) (see online supplementary material for examples). A global code was used for the shared reading task instead of an interval-based assessment that codes the

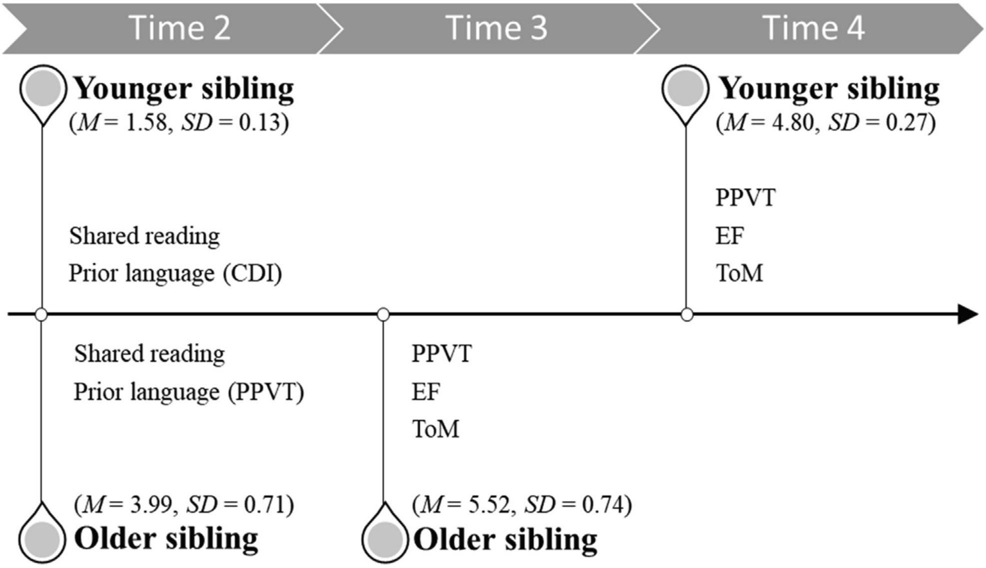

Fig. 1. Schematic of the age-snapshot technique and measures collected. Mean age in years and standard deviation are shown in parentheses. To control for chronological age between siblings, theory of mind (ToM) was measured when each sibling was approximately 5 years old; the older and younger siblings' scores were taken at Time 3 and Time 4, respectively. As seen here, this technique resulted in approximately similar ages between older and younger siblings, on average, for the cognitive assessments. PPVT, Peabody Picture Vocabulary Test; EF, executive function; CDI, MacArthur Communicative Developmental Inventories–Short Form.

frequency of verbalizations in a given interval (Aspland & Gardner, 2003; Morawska, Basha, Adamson, & Winter, 2015). Two coders were trained on the SABR scheme, and inter-rater reliability was tested throughout the coding process to reduce coder drift. In the end, 10% of all transcripts were double-coded, resulting in good inter-rater reliability on all dimensions, ranging from α =.75 to.86 (Cronbach, Rajaratnam, & Gleser, 1963).

We created standardized *z*-scores of shared reading by residualizing for age of the younger and older siblings separately. This method was meant to partial any differences in reading that were due to age differences across siblings. A family-level variable was created by averaging the scores of both children in a given family. Child-specific predictors were created as a given sibling's deviation from the family average (Krull & MacKinnon, 2001; Tofighi & Thoemmes, 2014; Zhang, Zyphur, & Preacher, 2009). Child-specific scores were group-mean-centered by subtracting the family mean from the child's score. In this approach, a positive score indicated that a child received *more* maternal input for that family, and a negative score indicated that the sibling received *less* input during shared reading for that family. The family means and child-specific deviation scores were entered into the models.

Language

Children's language ability at Time 3 (older sibling) and Time 4 (younger sibling) was assessed using the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 1997). The PPVT is a standardized measure of receptive vocabulary that is widely used for children aged 2.5 years and older. Children were shown four pictures and were required to select the one corresponding to the word they heard. The age-standardized scores were *z*-scored for the younger and older siblings separately to account for age differences. The *z*-scores were then used to create receptive language family means and child-specific deviations.

Executive function

EF was measured using the Dimensional Change Card Sort (DCCS; Zelazo, 2006) at Time 3 (older sibling) or Time 4 (younger sibling). Children were told that they were going to play a sorting game.

They completed two practice trials. During the first five rounds, children sorted the cards by color. For the next five rounds, children were instructed to sort the cards by shape. Post-switch scores ranged from 0 to 5 and were z-scored for the younger and older siblings separately. We created standardized z-scores for EF by residualizing for the age of the younger and older siblings separately and then created EF family means and child-specific deviations.

Theory of mind

Children's ToM was measured using an adaptation of the Wellman and Liu (2004) tasks at Time 3 (older sibling) or Time 4 (younger sibling). This scale presents seven tasks in a sequential format that increases in complexity. The first three ToM tasks assessed children's understanding of diverse desires, diverse beliefs and knowledge access, followed by four tasks that assessed more sophisticated ToM understanding such as content and explicit false belief, belief-based emotion, and real–apparent emotion. We added a second-order belief question at the end of the scale (Astington, Pelletier, & Homer, 2002). All tasks were acted out using props and puppets. The session ended when children failed two consecutive tasks. Internal consistency was high (α =.85; Cronbach et al., 1963). Scores ranged from 0 to 8, with higher scores representing better ToM ability.

Child-specific and family-wide covariates

Early language ability at Time 2 was controlled for in the models. Early language was measured by the PPVT for the older siblings and by the MacArthur Communicative Developmental Inventories–Short Form (CDI; Fenson et al., 2000) for the younger siblings (the PPVT was not collected for younger siblings at Time 2 because they were under 2 years old). The CDI is a parental questionnaire that measures children's expressive language, which has been shown to predict children's receptive language 4 years later (Can, Ginsburg-Block, Golinkoff, & Hirsh-Pasek, 2013). Mothers selected words that children produced from a list of 100 options. Because both the PPVT and CDI were assessed at Time 2, both measures were z-scored residualizing for age for the younger and older siblings separately. The z-scores were used to create family means and child-specific deviations.

Moreover, parents answered questions about household income and assets (e.g., house size, ownership status, cars), which were highly correlated (r =.70, p <.001). These items were standardized and combined into a composite, with higher means signifying greater income and assets. Covariates at the child level included child sex (0 = male, 1 = female), age at Time 3 or 4 (in years), and child-specific early language scores at Time 2 (as above). Family-level covariates were siblingship size (0 = 2 children in family, 1 = three or more children in family), family mean early language scores (as above), and the composite family SES score.

Analysis plan

The two-level multilevel model partitions variance in ToM scores into between- and within-family levels. The family-level score was created by averaging the two siblings' ToM scores for each family in the dataset. The child-specific score was computed as the deviation from the family average for each child. Predictor variables are constructed in the same way with a family average (e.g., the average of child and sibling PPVT) and a child-specific score, which is the child's deviation from the family average. We tested a multilevel, indirect mediation model to examine the effect of maternal input during shared reading on children's ToM through their language and EF (see Fig. 2). Mplus 7.0 was used to analyze the data where children (Level 1) were nested within families (Level 2). Significant paths at the family level highlight the importance of broad maternal language input to both children and, in the case of the cognitive cascade, the value of the siblings' language and EF in addition to the child's own language and EF. In contrast, paths at the child level suggest that maternal input specific to the individual child, or EF and language of the individual child, is most central in ToM development. To account for variance at both levels, multilevel modeling using Bayesian estimation with uninformative priors was conducted. When samples are large enough, both Bayesian and maximum likelihood approaches account for non-normal or asymmetrical distributions of indirect effects (Enders, Fairchild, & MacKinnon, 2013; Falk & Biesanz, 2016; Yuan & MacKinnon, 2009) and offer procedures

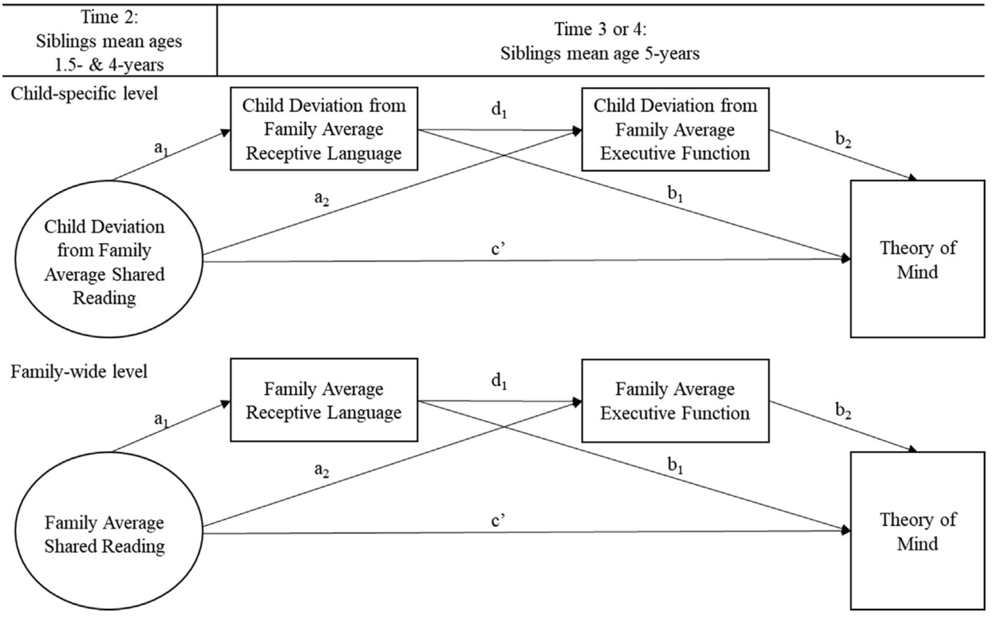

Fig. 2. Structure of the theoretically derived indirect mediation model. The indirect mediation model shows the association among maternal input during shared reading, receptive language, executive function, and theory of mind scores at the child-specific and family-wide levels. At Time 2, the younger and older siblings had mean agea of 1.5 and 4 years, respectively. Shared reading was a latent variable and thus is represented with a circle, although the individual loadings are not presented to reduce clutter. Shared reading and receptive language and executive function were group-mean-centered variables.

for handling missing data that are superior to other methods like listwise deletion (Buhi, Goodson, & Neilands, 2008; Schafer & Graham, 2002).

Results

Descriptive statistics for the raw scores are presented in Table 1, and bivariate correlations between study variables used in the models are presented in Table 2. ToM scores were positively correlated with age, SES, maternal input during shared reading, and EF at the family level as well as early and receptive language scores at the child and family levels. In the following sections, we fit a series of models with increasing complexity to the data (see Table 3 for results). *Fixed effects* represent the average effect of a variable in the sample population (for the appropriate level of measurement), denoted by the estimated regression coefficient (listed at the top of Table 3 for child-specific and family-wide levels). *Random parameters* are the variance components for each level (listed at the bottom of Table 3). The null model showed the partitioning of variance within and between families. Model 1 controlled for child-specific covariates (age, sex, and early language) and family-wide covariates (siblingship, family early language scores, and SES). Model 2 tested the direct effect of shared reading on ToM (path *c*). Model 3 examined the indirect effect of shared reading on ToM sequentially through the cognitive cascade from receptive language to EF (*a1*d1*b2*) and independently via receptive language and EF (*a*b* paths).

Models

The null model (not shown) revealed that 50% of the variance in ToM was at the child level and 50% was at the family level, resulting in an intraclass correlation of.50. Thus, siblings show substantial

Table 1
Descriptive statistics for raw scores for the younger and older siblings.

	Shared reading (0–7)		Receptive language (40–146)		Executive function (0–5)		Theory of mind (0–8)	
	Younger sibling	Older sibling	Younger sibling	Older sibling	Younger sibling	Older sibling	Younger sibling	Older sibling
n	328	328	237	260	234	234	229	236
M	2.68	3.16	105.49	109.30	4.23	4.58	3.80	4.48
SD	0.88	0.79	13.96	13.59	1.21	1.06	1.57	2.14

Note. N = 656. Shared reading was measured at Time 2. Receptive language, executive function, and theory of mind were measured at Time 3 for the older siblings and Time 4 for the younger siblings.

similarity to one another in their ToM scores. This result necessitates the use of multilevel modeling to deal with the non-independence of the data.

In Model 1, age, sex, SES, and early language were significant predictors of ToM. These covariates explained 25% [(1.00–0.75)/1.00] of the variance in ToM within families and 45% [(1.00–0.55)/1.00] of the variance in ToM between families compared with the null model.

Model 2 examined the direct effect of shared reading on ToM for siblings in the same family after controlling for child-specific and family-wide covariates. Family shared reading, but not child-specific reading, significantly predicted ToM. This model explained an additional 1.33% [(0.75–0.74)/0.75] of variance in ToM within families and 12.73% [(0.55–0.48)/0.55] of variance between-families compared to Model 1.

Model 3 examined the indirect effect of shared reading on ToM through receptive language and EF. After controlling for child and family covariates, child-specific shared reading did not predict later receptive language, EF, or ToM. However, family shared reading significantly predicted receptive language (*a1*), which significantly predicted ToM (*b1*). Although family shared reading did not predict EF (*a2*), receptive language predicted EF (*d1*), which in turn predicted ToM (*b2*). This model explained an additional 1.35% [(0.74–0.73)/.74] of variance in ToM within families and 47.92% [(0.48–0.25)/0.48] of variance in ToM between families compared with Model 2. Table 4 shows the specific indirect effects of shared reading on ToM through receptive language and EF in Model 3. At the child level, the direct, total, and indirect effects were not significant. At the family level, only the total effect and indirect effects via language (*a1*b1*) and sequentially via language and EF (*a1*d1*b2*) were significant. After controlling for child and family influences, the findings suggest that there is a significant indirect effect of shared reading on later ToM through family-level receptive language alone and sequentially through receptive language and EF. Although the proposed cascade model is theoretically supported, determining the directionality of effects is challenging because constructs of PPVT, EF, and ToM were measured concurrently, which is further considered in the Discussion.[1] It is also worth noting from Table 3 that EF is a significant predictor of ToM only at the family level, whereas language is significant at both the child-specific and family-wide levels. This finding suggests that the child's own language, not just the two siblings' average language, contributes to ToM understanding, even though the mediation cascade is significant only at the family level.

[1] Inverse models with ToM as a mediator between shared reading and PPVT (see Tables S2 and S3 in supplementary material) and between shared reading and EF (Tables S4 and S5) were conducted. For language, only the direct (and total) effect between shared reading and PPVT at the family level was significant, suggesting that neither ToM nor EF was a significant mediator of this relation. For EF, the indirect effects through PPVT only, and sequentially through PPVT and ToM, were significant, similar to what was observed for ToM in the main text. Although we cannot rule out the direction of the relation between EF and ToM given the similar pattern of direct and indirect effects, the indirect effect with EF as the primary outcome was slightly smaller compared with the proposed model with ToM as the outcome.

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Table 2
Bivariate correlations with means and standard deviations.

	1	2	3	4	5	6	7	8	9	10	11	12	13
Covariates													
1. Gender	–												
2. Age[a]	−.04	–											
3. Siblingship	−.05	−.08†	–										
4. SES[b]	−.02	.04	−.07	–									
Child-specific variables													
5. Early language[b]	.003	.15**	.00	.00	–								
6. Shared reading[b]	.08†	.05	.00	.00	.09*	–							
7. Receptive language[a]	−.02	−.10*	.00	.00	.22***	.06	–						
8. Executive function[a]	.03	.01	.00	.00	.17**	.10*	.25***	–					
Family-wide variables													
9. Early language[b]	.01	−.05	.05	.19***	.00	.00	.00	.00	–				
10. Shared reading[b]	−.05	−.03	.02	.29***	.00	.00	.00	.00	.13**	–			
11. Receptive language[a]	.02	.05	−.07†	.42***	.00	.00	.00	.00	.38***	.36***	–		
12. Executive function[a]	.05	−.02	−.04	.24***	.00	.00	.00	.00	.06	.15***	.41***	–	
Outcome													
13. Theory of mind[a]	.07	.43***	.04	.20***	.18***	.03	.07	.04	.17***	.16**	.33***	.21***	–
M	–	5.18	0.24	0.08	0.00	0.00	0.00	0.00	0.10	0.00	0.003	0.01	4.15
SD	–	0.68	0.43	0.77	0.61	0.65	0.46	0.62	0.81	0.76	0.91	0.80	1.91

Note. M and *SD* were the *z*-scored variables used in the models.

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[a] Measure collected for the younger siblings at Time 4 and the older siblings at Time 3.

[b] Measure collected at Time 2.

† $p < .10$.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 3
Multilevel model predicting theory of mind at the child and family levels (N = 656).

	Model 1	Model 2	Model 3
Fixed effects			
Intercept	−**2.86 (0.95)**[***]	−**2.74 (0.94)**[***]	−**2.75 (0.85)**[**]
Child-specific			
Female	**0.10 (0.05)**[*]	**0.11 (0.05)**[*]	**0.11 (0.05)**[*]
Age[a]	**0.45 (0.04)**[***]	**0.45 (0.04)**[***]	**0.47 (0.04)**[***]
Early language[b]	**0.13 (0.05)**[**]	**0.13 (0.05)**[**]	**0.10 (0.05)**[*]
Direct paths			
Shared reading[b] (*c* path)		0.01 (0.05)	
Shared reading[b] (*c*' path)			0.003 (0.05)
Mediator			
Receptive language (*b1*)			**0.10 (0.05)**[*]
Shared reading[b] (*a1*)			0.05 (0.05)
Female			−0.01 (0.05)
Age[a]			−0.10 (0.05)[†]
Early language[b]			**0.23 (0.05)**[***]
EF (*b2*)			0.01 (0.05)
Shared reading[b] (*a2*)			**0.10 (0.05)**[*]
Female			0.05 (0.05)
Age[a]			0.04 (0.05)
Early language[b]			0.08 (0.05)[†]
PPVT (*d1*)			**0.21 (0.05)**[***]
Family-wide			
Siblingship	0.17 (0.12)[†]	0.14 (0.11)	0.16 (0.11)[†]
Early language[b]	**0.47 (0.12)**[***]	**0.42 (0.12)**[***]	**0.28 (0.11)**[**]
SES[b]	**0.32 (0.12)**[**]	**0.25 (0.12)**[*]	0.11 (0.11)
Direct paths			
Shared reading[b] (*c* path)		**0.30 (0.11)**[**]	
Shared reading[b] (*c*' path)			0.19 (0.10)[†]
Mediator			
Receptive language (*b1*)			**0.29 (0.14)**[*]
Shared reading[b] (*a1*)			**0.22 (0.05)**[***]
Siblingship			−0.07 (0.05)
Early language[b]			**0.29 (0.05)**[***]
SES[b]			**0.27 (0.05)**[***]
EF (*b2*)			**0.37 (0.12)**[***]
Shared reading[b] (*a2*)			0.02 (0.06)
Siblingship			0.01 (0.06)
Early language[b]			−**0.13 (0.06)**[*]
SES[b]			0.08 (0.06)[†]
PPVT (*d1*)			**0.46 (0.06)**[***]
Random parameters			
Within families	**0.75 (0.04)**[***]	**0.74 (0.04)**[***]	**0.73 (0.04)**[***]
Between families	**0.55 (0.17)**[***]	**0.48 (0.16)**[***]	**0.25 (0.14)**[***]

Note. Fixed effect estimates are shown with posterior standard deviation in parentheses. Parameters that are significant are bolded. EF, executive function; PPVT, Peabody Picture Vocabulary Test; SES, socioeconomic status.
[a] Measure collected for the younger siblings at Time 4 and the older siblings at Time 3.
[b] Measure collected at Time 2.
[†] p <.10.
[*] p <.05.
[**] p <.01.
[***] p <.001.

Discussion

This study examined the relation between maternal input during sharing of wordless picture books and ToM in young children and the mediational role of receptive language and EF in this association. Using a sibling comparison design within a multilevel modeling framework, we analyzed children nested within families to capture differences between siblings after accounting for family-level vari-

Table 4
Total, direct, and indirect effects of shared reading on theory of mind for Model 3.

Effect	Child-specific *SE (P.SD)* [95% CI]	Family-wide *SE (P.SD)* [95% CI]
Direct (*c*' path)	0.01 (0.12) [−0.24, 0.25]	0.21 (0.12) [−0.02, 0.43][†]
Indirect		
Receptive language (*a1*b1*)	0.01 (0.02) [−0.01, 0.05]	**0.07 (0.04) [0.004, 0.16]**[*]
EF (*a2*b2*)	0.001 (0.02) [−0.03, 0.03]	0.01 (0.03) [−0.04, 0.06]
Receptive language to EF (*a1*d1*b2*)	0.00 (0.002) [−0.004, 0.01]	**0.04 (0.02) [0.01, 0.09]**[***]
Total (*a1*b1* + *a2*b2* + *a1*d1*b2* + *c*' path)	0.02 (0.12) [−0.22, 0.26]	**0.33 (0.12) [0.09, 0.56]**[**]

Note. Standardized estimates (*SE*s) are shown with posterior standard deviations (*P.SD*s) in parentheses and 95% confidence intervals (CIs) in brackets. Parameters that are significant are bolded.
[†] $p < .10$.
[*] $p < .05$.
[**] $p < .01$.
[***] $p < .001$.

ables. We hypothesized a theoretical cognitive cascade model in which receptive language and EF served as indirect paths between maternal input during shared reading and ToM during the preschool period. A crucial implication of this work is that it bridged several established findings in the literature. First, maternal input during shared reading is a strong predictor of language (Deckner et al., 2006; Demir-Lira et al., 2019; Saracho, 2017; Sénéchal & LeFevre, 2002; Sénéchal et al., 1996). Second, language is associated with EF (Jacques, 2001; Kirkham et al., 2003; Kuhn et al., 2014, 2016; Müller et al., 2004, 2009; Zelazo, 2015). Third, language is associated with ToM (Farrar et al., 2017; Milligan et al., 2007; Slade & Ruffman, 2005). Fourth, EF is reciprocally associated with ToM (Benson et al., 2013; Carlson et al., 2004, 2015; Devine & Hughes, 2014; Flynn, 2007; Hughes, 1998; Marcovitch et al., 2015; Müller et al., 2012; Wade, Prime, et al., 2018). We found that maternal input during shared reading early in development was associated with later ToM indirectly via language alone and sequentially through language and EF, suggesting two distinct paths (one EF mediated and one not). This effect was observed only at the between-family level, which aligns with the pragmatic enrichment perspective in that it suggests that multiple and varied language exposures are important for ToM development. Therefore, this study suggests that observed associations between maternal linguistic input during shared reading and ToM via language and EF might not be child specific but instead may reflect a more global phenomenon that differs between families rather than between siblings in the same family.

One of the central findings of this study is the difference with respect to between-family versus within-family effects. Specifically, between-family indirect mediation effects through receptive language and EF were stronger than the within-family effects after controlling for family and child covariates, including prior language ability. Indirect effects in the absence of direct effects are still meaningful (Hayes, 2009; Rucker, Preacher, Tormala, & Petty, 2011) and can emerge when multiple indirect effects or more complicated relations are present. Indirect effects are often the case for a complex dynamic system. The indirect effects observed in the current study support the viewpoint that ToM development is multifaceted (Farrar et al., 2017; Nilsson & de López, 2016), that receptive language is an important cognitive pathway from shared reading to later ToM, and that EF may further participate in this cascade by partially mediating the effects of language on later ToM. However, the findings support the importance of family-level variables for the development of language, EF, and ToM and the presence of a cognitive cascade in which language and EF support the development of ToM, ostensibly through pragmatic enrichment during conversations.

Our results showed that 50% of the variance in children's ToM is attributable to factors at the family level. Close to half of this between-family variance is explained by measured predictors in our model (maternal input, PPVT, and EF). Thus, we need to consider that other between-family influences operate to explain the reamining variance. Indeed, evidence from twin studies indicates that genetics and shared environmental factors are important in the development of language (Stromswold, 2001), EF (Fujisawa, Todo, & Ando, 2017), and ToM (Hughes et al., 2005). The strong family-level effect observed in the current study is an affirmation of why family characteristics such as SES and maternal factors (e.g., education, mindedness, attachment) are prominent predictors of cognitive development in single-child, between-family studies. Such family effects have been reported in studies investigating shared reading (Aram, Deitcher, Shoshan, & Ziv, 2017), language outcomes (Fernald, Marchman, & Weisleder, 2013; Hughes, Devine, & Wang, 2018; Raikes et al., 2006; Vernon-Feagans et al., 2008), EF (Daneri et al., 2019; Kao, Nayak, Doan, & Tarullo, 2018; Lawson, Hook, & Farah, 2018; Raver, Blair, & Willoughby, 2013), and ToM (Devine & Hughes, 2018; Ebert, Peterson, Slaughter, & Weinert, 2017). Our results cohere with the notion that family factors shared between siblings, such as parental hereditary traits, behaviors, and experiences (e.g., vocabulary, education), SES, and neighborhood factors, collectively play a vital role in early cognitive development.

Another implication of these findings is that early maternal linguistic input might not be specific to each child, but instead may operate across the entire family. When mothers engage in activities that foster language growth with siblings who are close in age, they potentially influence all children in the vicinity, not only the target child in the interaction. In a case study with six families, many parents mentioned that the older siblings often brought reading activities home from school, which the parents then shared with the younger siblings (Taylor, 1981). Research using typical picture books (i.e., with text) has shown that conversations during shared reading have more diverse vocabulary and more complex syntax than conversations during non-shared reading interactions (Demir-Lira et al., 2019). Interestingly, children and adults had more verbal interactions (Sénéchal et al., 1995) with diverse words (Chaparro-Moreno et al., 2017) during shared reading with wordless picture books compared with text-based picture books. These syntactically and linguistically rich extra-textual conversations are significant precursors of receptive language performance (Rowe, 2012). Thus, in addition to hereditary and environmental factors, shared reading can also have direct implications for language development.

Early enriched linguistic environments appear to have a positive impact on children's EF and ToM, with children's own language skills providing a fundamental pathway in this cascade. In the current study, receptive language and EF indirectly and sequentially mediated the association between shared reading and ToM at the family level. This finding parallels recent work showing that maternal input during shared reading and child language are equally important in the complex relation between socioeconomic risk and EF (Daneri et al., 2019). Furthermore, the pragmatic enrichment perspective posits that children's language ability facilitates conversations, eventually allowing children to understand perspective taking, which is fundamental in ToM (Harris et al., 2005). Studies have typically shown greater ToM reasoning among children when mothers provide higher-quality input such as connecting the content in picture books to real-life events or knowledge (Slaughter et al., 2007; Tompkins, 2015). Furthermore, children with lower vocabulary show improved ToM after mothers have been trained to be more elaborative in their style of talk while reminiscing about shared past events compared with mothers who conversed about past events as they normally would (Taumoepeau & Reese, 2013). Therefore, high-quality contingent parental input afforded by early shared reading and conversations can improve children's language skills, with positive downstream consequences for EF and ToM.

There are some limitations to this work. One drawback of the current study is the inability to draw conclusions about the directionality of effects due to concurrent measurement of receptive language, EF, and ToM. Nevertheless, prior research has found that early language competence predicts later ToM while accounting for prior ToM ability, whereas the inverse relation is not significant (Astington & Jenkins, 1999; De Villiers & Pyers, 2002; Slade & Ruffman, 2005). Similarly, research has demonstrated that language is a precursor to EF (Kuhn et al., 2014; Müller et al., 2009). Although some evidence demonstrates that early ToM predicts later EF, a greater body of evidence suggests the converse—that early EF predicts later ToM (see Wade, Prime, et al., 2018). In the current study, a rearrangement of cognitive variables demonstrated that although EF and ToM did not offer much in the way of mediation when receptive language was treated as the outcome, both language and ToM provided a mediational link between shared reading and EF. This pattern of effects was generally weaker but similar to when ToM was treated as the outcome (main results). Our design also did not allow us to examine the role of child effects in the maternal input that children received. Longitudinal reciprocal effects models have shown that siblings differentially elicit parental behaviors and that this differential elicitation may relate to endogenous differences between siblings (Browne et al., 2018). Future research that measures all our constructs longitudinally and examines cross-lagged paths (controlling for prior levels) is warranted to better elucidate the direction of effects between parents and children as well as different aspects of developing cognition.

Given that age and prior language explained significant variance in ToM scores, more tightly controlled studies are needed to test this proposed relation among shared reading, language, EF, and ToM, especially at the child level. In the current study, measuring shared reading when siblings were similar in age (e.g., all at 3 years) may have reduced confounds with age and possibly even language ability. However, this may have also constrained our ability to detect child-level effects. Another related area of concern in this study is construct validity. Measurement of constructs can vary considerably across time points, which may have affected the pathways in reciprocal effects models with cross-lagged designs. There are alternative behavioral measures of language ability that can be used at 18 months of age (e.g., the Computerized Comprehension Task [CCT]; see Friend & Keplinger, 2003; Friend, Schmitt, & Simpson, 2012) in place of parental reports such as the CDI, and replication with such measures is encouraged. Moreover, there were issues surrounding how EF and ToM were measured from early infancy to preschool. Hendry, Jones, and Charman (2016) conceptualized a model in which early core foundational abilities (i.e., control of attention, self-regulation, and processing speed) begin to develop during infancy, leading to emergent and dissociable EFs (i.e., cognitive flexibility, impulse control, and conflict resolution) during toddlerhood, which then predicts EF around the preschool age. Thus, EF cannot be reliably measured in the same way (with the same tools) across ages, complicating our understanding of its development and its influence on other cognitive skills. For ToM, implicit preverbal measures in infants and toddlers have raised issues regarding reliability and validity and the nature of what is being measured throughout development (Beaudoin, Leblanc, Gagner, & Beauchamp, 2020). Thus, although there is developmental continuity and progression in ToM and EF, there remain considerable methodological challenges in assessing these over time. The current results should be considered in light of these nuances. Future studies with developmentally sensitive, valid, and reliable tasks are important to confirm the robustness of the current results while taking account of earlier developmental competencies.

Another potential limitation is that maternal input was measured only through a 5-min shared reading session at a single time point in this study. This small snapshot into reading interactions raises two issues—(a) the stability of this measure over time and (b) the type of input considered—because shared reading is not the only way home environments contribute to vocabulary development (Raikes et al., 2006). Having multiple instances of maternal input over a longer period of time (e.g., reading with both siblings, training mothers on dialogic reading strategies that promote greater external talk, measuring maternal input across different contexts such as mother–child dyads engaged in play) would provide a more comprehensive picture of mother–child interactions over the course of childhood. Because parents commonly engage in shared reading with siblings (Taylor, 1981), reading with both siblings might simulate a more natural environment. Similarly, other figures in the family (e.g., father, grandparent, older siblings) may read to children, such that measuring only maternal input underestimates the effect of reading on development. Finally, because a global measure was used to measure maternal input during shared reading, it is possible that the SABR might not have been as precise a measure as frequency-based coding schemes.

Although the PPVT is widely used in research, studies have shown that receptive vocabulary has a weaker association with false belief understanding than other language measures (Farrar et al., 2017; Milligan et al., 2007). Researchers suggest that the weaker association may be because the PPVT is a simple task with a 25% success rate on any given trial and because receptive language may overlap with other linguistic skills (Milligan et al., 2007). Thus, it is conceivable that other language tasks that tap into more specific competencies (e.g., syntactical knowledge) may yield a different (perhaps stronger) pattern of results than those reported here. Correspondingly, the extent to which various aspects of language are related to EF is virtually unknown (Müller et al., 2009). Thus, testing different language competencies as a mechanism linking maternal input during shared reading to later EF and ToM is a ripe area for future research.

Finally, due to the study design, these findings cannot be generalized to families with only one child or older children. There is also variation in the way shared reading takes place with the different types of books (e.g., text vs. wordless picture books: see Chaparro-Moreno et al., 2017, and Sénéchal et al., 1995; different genres: see Anderson, Anderson, Lynch, & Shapiro, 2004). Thus, the pattern of results observed in the current study may differ if the reading stimuli are changed or include other features such as text. This requires explicit testing in future studies. Moreover, future studies should consider controlling for potentially relevant factors such as the child's age, interest, motivation to read, and general indices such as children's attachment security that may moderate the likelihood of engaging in book reading (Fletcher, Cross, Tanney, Schneider, & Finch, 2008; Fletcher & Reese, 2005; Raikes et al., 2006). As children's reading ability evolves, the roles of the parent and child in a shared reading context will change dynamically over time, and understanding these dynamics requires attention in future research. Finally, other factors that were not accounted for in the current study, such as the use of mental state verbs (Adrian et al., 2005; Devine & Hughes, 2018; Ruffman, Slade, Devitt, & Crowe, 2006), maternal mind-mindedness (Devine & Hughes, 2018; Hughes et al., 2018; Kirk et al., 2015), and maternal reminiscing (Taumoepeau & Reese, 2013), are well-known contributors to ToM and also require greater attention in determining the dimensions of parenting that most strongly scaffold ToM development during and outside reading contexts.

Conclusion

This study found empirical support for a theoretically driven cognitive cascade model in which the relation between early shared reading and later ToM operated sequentially through children's language and EF skills during the preschool period. A similar but less strong pathway was observed for EF as the outcome with language and ToM as sequential mediators. The use of a sibling comparison design provided clear evidence that early maternal input during shared reading predicts children's vocabulary skills, which in turn support emerging EF and ToM abilities. This study underscores the benefits of early shared reading in fostering foundational cognitive skills known to support children's later academic, social, and emotional development, and it pinpoints language as a fundamental mechanism through which these effects operate for EF and ToM.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jecp.2022.105469.

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