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# The role of maternal responsiveness and linguistic input in pre-academic skill development: A longitudinal analysis of pathways

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ABSTRACT

This prospective, longitudinal study examined the association between maternal responsiveness and linguistic input and children's pre-academic skill development. Further, we assessed the extent to which nascent cognitive and literacy abilities mediated the association between parenting dimensions and pre-academic skills. The sample consisted of 501 mother-child dyads recruited at birth. Maternal responsiveness and linguistic input were coded at 18 months during a shared picturebook reading task. Pre-academic skills were measured at age 4.5 using standardized tests of letter-word identification, reading comprehension, math applied problems, and receptive vocabulary. At age 3, cognitive and literacy mediators included inhibitory control, theory of mind, receptive language, and print recognition. Longitudinal path analyses revealed that both responsiveness and linguistic input made unique contributions to pre-academic outcomes, with linguistic input operating indirectly through cognitive and literacy abilities to a greater extent than responsiveness. Results suggest disparate mechanisms for these parenting dimensions in the facilitation of pre-academic skills.

## 1. Introduction

Academic achievement is a powerful predictor of psychosocial health and development across the lifespan. Underachievement in school not only has negative consequences for later economic and occupational attainment, but is also linked to a host of other problems such as higher rates of psychopathology, substance use, and teenage pregnancy (Fergusson, Woodward, & Horwood, 2000; Henry, Knight, & Thornberry, 2012; Masten et al., 2005). The roots of academic success are established early in life. Using six longitudinal data sets, Duncan et al. (2007) showed that academic skills at school entry (i.e., reading, verbal ability, and math) were stronger predictors of later academic outcomes compared to socio-emotional competence and attention skills. Thus, promoting early academic skill development is critical to foster positive outcomes and attenuate the risk of difficulties in many domains of functioning. The purpose of the current study was to examine the extent to which mothers' responsive behavior and linguistic input at 18 months independently predicted children's pre-academic skills in language (receptive vocabulary), reading (word reading and comprehension) and mathematics (problem solving) at age 4.5. Further, we investigated how emerging cognitive and literacy abilities at age 3–inhibitory control, theory of mind, print recognition, and receptive language – provided a mechanism linking mothers' responsiveness and linguistic input to children's pre-academic skills.

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### 1.1. Parenting and pre-academic skill development

From a Vygotskyian perspective, children's progression toward autonomous and self-directed learning and problem-solving relies on early parental scaffolding that is both responsive and cognitively stimulating (Vygotsky, 1978). The cognitive dimension involves the provision of concrete strategies, alternative perspectives, suggestions for stepwise task completion, and basic information relevant to the given activity. This dimension is strongly linguistically-mediated, and has been shown to promote both verbal and non-verbal cognitive skills in the preschool period (Hubbs-Tait, Culp, Culp, & Miller, 2002; Landry, Smith, Swank, & Miller-Loncar, 2000; Smith, Landry, & Swank, 2000). The responsiveness dimension (frequently termed 'sensitivity' in the extant literature) involves cultivating a warm interactional style, offering praise and encouragement, promoting autonomy, and being attuned to the needs of the child. For instance, Pianta and Harbers (1996) showed that mothers who provide encouragement, warmth, emotional support, and respect for their child's autonomy at school entry have children with better academic achievement over the first few years of school. Similarly, Connell and Prinz (2002) showed that responsive parenting (goal-corrected behavior, parental control, and affective mutuality) predicts teacher-reported readiness skills, social skills, and receptive communication (also see Hirsh-Pasek & Burchinal, 2006; Molfese, Modglin, & Molfese, 2003; Poe, Burchinal, & Roberts, 2004; Tamis LeMonda, Bornstein, & Baumwell, 2001). Thus, while maternal responsiveness and linguistic input underscore distinct behaviors, both have been linked to pre-academic skill development.

Less is known about the relative influence of responsiveness and linguistic input on pre-academic skill development. Indeed, there is reason to suspect that these parental behaviors may act on child outcomes in different ways, or via disparate mechanisms. This is consistent with growing evidence which suggests that socialization is not a general process, but a collection of distinct processes that bear upon specific domains of functioning (Smetana, 2017). In this "domains" approach, parenting can be differentiated on the basis of discrete sets of behaviors that demonstrate specificity with respect to child outcomes (Davidov, 2013; Grusec & Davidov, 2010). For instance, while some studies have shown independent contributions of both cognitive stimulation and parental responsiveness to early academic functioning (Bradley, Corwyn, Burchinal, McAdoo, & Garcia Coll, 2001), others have shown stronger links for certain dimensions, such as parental nurturance (Merlo, Bowman, & Barnett, 2007). Leerkes, Blankson, O'Brien, Calkins, and Marcovitch (2011) showed that maternal emotional support (interest, encouragement, and praise), but not cognitive support, during problem-solving tasks predicted gains in pre-academic skills from age 3 to 4. The quality of the home learning environment, including availability and engagement with learning materials, also predicted pre-academic skill development.

More recently, Merz et al. (2015) demonstrated that parental responsiveness was positively associated with concurrent language ability at 2–4 years, as well as growth in literacy, math, and emotion knowledge over a one-year period. In addition, while the *quantity* of parental language input was not related to any child outcome, inferential language *quality* was positively associated with concurrent emotion knowledge, and marginally associated with concurrent language ability. Merz et al. (2015) suggested that, while literal discourse plays an important role in language and literacy development, inferential discourse may additionally encourage the development of higher-level reasoning skills, such as understanding hypotheticals, decontextualized knowledge, and abstract concepts (see Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010; Rowe, 2012; van Kleeck, 2008). To this end, complex linguistic input that entails both literal and inferential discourse may support both core literacy abilities and higher-level cognitive skills. However, given the lack of direct effect of parental inferential language on math and literacy skills observed by Merz and colleagues, it was suggested that such effects may operate indirectly through intermediary cognitive and linguistic abilities. In line with this proposal, the current study examined a subset of interceding cognitive and literacy skills that may be couriers of these maternal inputs.

In the current study, we assessed maternal responsiveness and linguistic input at 18 months. We focused on this period since the first two years of life are a period of rapid postnatal brain maturation – not only does the brain grow to approximately 80% of the adult size within the first two years of life (Lenroot & Giedd, 2006), but brain volume doubles in the first year, with 15% additional growth in the second year (Knickmeyer et al., 2008). During this period, the brain is particularly sensitive to environmental influence, including linguistic input from caregivers, maternal responsiveness, and other factors such as early adversity (see Bick & Nelson, 2016; Curley & Champagne, 2016; Werker & Hensch, 2015; Zeanah, Gunnar, McCall, Kreppner, & Fox, 2011). Moreover, we examined the relation between both maternal responsiveness and linguistic input on pre-academic skills *simultaneously*, statistically controlling for the covariance between these parenting dimensions. This enabled us to test the independent contribution of each dimension to children's pre-academic skills, as well as unique pathways through emerging cognitive and literacy abilities.

### 1.2. Cognitive and literacy abilities as predictors of pre-academic skill development

Developmental psychobiological models posit that children's cognitive abilities provide a proximal mechanism through which social-contextual influences support early learning, including the acquisition and maturation of specific academic skills (Blair & Raver, 2015). A host of cognitive abilities have been identified in the extant literature that may be relevant for children's achievement. In selecting abilities that link early maternal behaviors with later pre-academic functioning, we focused on four cognitive/literacy abilities that have garnered significant support as predictors of a wide range of learning outcomes. The first ability is *inhibitory control* (IC), which is a facet of executive functioning that reflects the ability to inhibit prepotent thoughts or actions in favor of less salient responses, usually during goal-directed activities. Theoretically, children with higher IC should be able to more effectively attend to relevant information and inhibit irrelevant information whilst undertaking academic tasks, especially those with superfluous or distracting details. IC may also aid in behavioral regulation that enables successful engagement with academic material. Consistent with this proposal, IC has repeatedly been found to predict early academic skills using an array of assessment methods (Allan & Lonigan, 2011; Bull & Scerif, 2001; Espy et al., 2004; Swanson, Jerman, & Zheng, 2008; Valiente, Lemery-Chalfant,

& Swanson, 2010; Welsh, Nix, Blair, Bierman, & Nelson, 2010).

The second potential mediator of pre-academic skill development that we evaluated is *theory of mind* (ToM), which is the ability to attribute mental states (e.g. beliefs, desires, intentions, and emotions) to oneself and others in order to predict and make sense of behavior. For children, ToM is considered a higher-order conceptual skill that portends later metacognition ("thinking about thinking"), which enables a reflective awareness and deliberation about strategies that may be useful in solving a given task or navigating complex social interactions (see Lecce, Demicheli, Zocchi, & Palladino, 2015). ToM is considered a sophisticated type of social cognition that matures alongside IC (Devine & Hughes, 2014). For this reason, we refer to both ToM and IC as 'cognitive' abilities, even though they are distinct capacities. ToM may support pre-academic skills by facilitating the ability to generate new knowledge or meaning by representing concepts in unique ways or from different perspectives. Behaviorally, ToM may foster children's ability to communicate their thoughts and beliefs, understand the intentions of others (e.g. teachers, peers), and engage in activities such as collaborative learning (Astington & Pelletier, 2005). Indeed, ToM in the preschool period has been shown to significantly predict an array of academic outcomes at school age, including letter knowledge, mathematics, reading, and text comprehension (Atkinson, Slade, Powell, & Levy, 2017; Blair & Razza, 2007; Lecce, Caputi, & Hughes, 2011). Studies that examine ToM and IC contemporaneously suggest that both cognitive processes at age 3 make unique contributions to pre-academic skills at age 4 (Blankson et al., 2017). Thus, both IC and ToM appear to be plausible intercedents supporting the development of pre-academic skills, and may serve as conduits between early parenting behaviors and later academic competencies.

The next two mediators we examined – receptive vocabulary and print recognition – are early literacy competencies that have been shown to promote development of more complex language-based tasks, such as reading and writing (Cutting & Scarborough, 2006; Protopapas, Mouzaki, Sideridis, Kotsolakou, & Simos, 2013). With regard to *receptive vocabulary*, Agostin and Bain (1997) found that receptive language in kindergarten was predictive of early math and reading success in grade 1, while Pagani, Fitzpatrick, Belleau, and Janosz (2011) reported that kindergarteners' receptive language was significantly predictive of mathematics, reading, writing, science, and overall ability in grade 4. Similarly, *print recognition* (letter/word identification, phonological awareness) has been shown to support later literacy skills (Justice & Ezell, 2000, 2002; Levy, Gong, Hessels, Evans, & Jared, 2006) and arithmetic problem solving (Fuchs et al., 2006). Importantly, most previous studies examining ToM and IC as mediators of academic outcomes have not adequately accounted for concurrent language/literacy skills. By including both cognitive (IC/ToM) and literacy (print recognition/receptive vocabulary) abilities in the same model, we statistically control for their shared variance, which enables us to uncover their unique mediational effect on pre-academic skills.

### 1.3. Do cognitive and literacy abilities mediate the effect of early parental inputs?

The above research underscores IC, ToM, receptive vocabulary, and print recognition as four abilities that may support pre-academic skill development. These abilities may also serve as intermediaries that link early parental inputs to pre-academic functioning. Several previous studies have examined mediation models of this sort. For instance, with regard to the meditational role of early literacy skills, Forget-Dubois et al. (2009) demonstrated that exposure to reading material at 19 months was indirectly predictive of school readiness (knowledge of colors and shapes, spatial recognition, numbers, and letters) at 63 months through expressive vocabulary at 19–32 months. Similarly, among economically disadvantaged children, Cristofaro and Tamis-LeMonda (2011) showed that mothers' oral language ('wh'-questions and lexical diversity) at 36 months predicted school readiness at 60 months via their receptive vocabulary.

Regarding the meditational role of other cognitive skills, attentional control (which relates to our metric of IC; Nigg, 2017) has been shown to mediate the relationship between home environment quality and achievement outcomes at 54 months (NICHD Early Child Care Research Network, 2003). Comparable findings have been found in low-income children, with focused attention linking maternal hostility to later receptive language ability (Razza, Martin, & Brooks-Gunn, 2010). Kopystynska, Spinrad, Seay, and Eisenberg (2016) recently demonstrated that parental control, including verbal control/guidance, affectionate interaction, encouragement to follow rules, and offering alternative suggestions, operated through IC in predicting academic functioning in early childhood. It has also been suggested that early language skills and IC coalesce in a developmental cascade that connects early maternal behavior to later pre-academic skills (Bernier, McMahon, & Perrier, 2017). Together, these findings suggest that several early cognitive and literacy abilities may annex the influence of parenting behaviors on later academic outcomes. However, no previous study has examined multiple cognitive and literacy abilities simultaneously – that is, as competing mechanisms – through which distinct dimensions of parenting differentially predict children's pre-academic skills.

### 1.4. Differential mechanisms for maternal responsiveness and linguistic input

As suggested above, both maternal responsiveness and linguistic input are related to better cognitive and literacy outcomes. Indeed, there is overlap between these parenting behaviors, as parents who are more sensitive tend to be more stimulating (Holden & Miller, 1999). These dimensions of parenting have likely co-evolved because they confer an adaptive advantage and promote, for instance, shared intentionality and cooperative interactions that build a cognitive architecture for thinking, learning, and problem-solving, which assists in transmitting culture and knowledge across generations (Tomasello & Carpenter, 2007). This dovetails with Vygotsky's conception that children progressively internalize semiotically (primarily linguistically) mediated interactions with others (especially caregivers), ultimately facilitating internal thought and private speech that encourages growth in language, ToM, IC, and other abilities that support learning (Fernyhough, 2008; Perrone-Bertolotti, Rapin, Lachaux, Baciu, & Loevenbruck, 2014). Yet, from an individual differences perspective, parents may be more effective in one domain than another, and variability in distinct parenting dimensions seems critical to enable successful adaptation to environmental variation. In other words, there may be a co-evolution of flexible parenting behaviors that serve different but complementary roles in children's development dependent upon myriad ecological conditions, as well as parents' own goals, their children's needs, and the types of behaviors being targeted (Feldman, 2015; Royle, Russell, & Wilson, 2014; Smetana, 2017).

Despite the possibility that distinct dimensions of parenting have different roles and/or pathways to various child outcomes, most broad metrics of parenting do not effectively parse the more linguistically-mediated dimensions from the responsiveness-oriented dimensions. With few exceptions (e.g. Devine, Bignardi, & Hughes, 2016; Bernier, Carlson, & Whipple, 2010), most previous studies have either examined single dimensions of parenting as predictors of pre-academic outcomes, or aggregated several dimensions into a global composite. Likewise, the presence of one parenting dimension often implies the other, possibly conflating these effects and obfuscating their routes to child outcomes (de Rosnay & Hughes, 2006; Jessee, McElwain, & Booth-LaForce, 2016). In our proposed model, the shared variance between responsiveness and linguistic input is statistically partialled out. For instance, mothers may show sensitivity, warmth, facilitation, or reinforcement both verbally and non-verbally. Although these are components of maternal responsiveness, whatever is shared between the verbal aspects of responsiveness and linguistic input is statistically controlled. Thus, only the unique components of these dimensions are used to predict pre-academic skills and cognitive/literacy mediators, enabling a more stringent test of differentiated pathways for these dimensions of parenting. By untangling the differential pathways of responsiveness and linguistic input to pre-academic outcomes, this study has implications for intervention science by pinpointing the specific cognitive/literacy-facilitating aspects of parenting that may foster later pre-academic skills (Hirsh-Pasek et al., 2015).

Empirically, there is evidence that distinct parenting dimensions may operate on early cognitive and literacy via disparate mechanisms. For instance, Devine et al. (2016) recently showed that child executive functioning mediated the relationship between observed maternal scaffolding and academic ability at age 5, whereas self-reported provision of learning opportunities was directly associated with academic ability. Moreover, Neitzel and Stright (2003) have shown that, compared to emotional support, mothers' cognitive support more strongly predicted outcomes related to cognitive awareness, such as metacognitive talk, self-monitoring, and help-seeking, which may support early learning. Specific maternal behaviors, such as verbal expansions, may be particularly powerful predictors of early expressive and receptive language ability (Levickis, Reilly, Girolametto, Ukoumunne, & Wake, 2014). Finally, Vallotton, Mastergeorge, Foster, Decker, & Ayoub, 2017 recently demonstrated that, while mothers' sensitivity remained constant from 14 to 36 months, their cognitive stimulation grew over this period, and both dimensions significantly predicted children's vocabulary development. Together, these results suggest that several dimensions of parenting may encourage children's early cognitive and literacy abilities, yet the manner in which they do so may be different. In the current study, we test for the first time the independent contribution of maternal responsiveness and linguistic input to pre-academic skill development, and whether these pathways can be differentiated on the basis of their connection with intermediary cognitive/literacy abilities.

### 1.5. Goals of the current study

The goals of the current study are to: (1) examine whether maternal linguistic input and responsive behavior each uniquely predict children's pre-academic skills at age 4.5; (2) examine whether maternal linguistic input and responsive behavior each uniquely predict child IC, ToM, receptive vocabulary, and print recognition at age 3; (3) determine whether child cognitive/literacy abilities at age 3 are associated with their pre-academic skills at age 4.5; and (4) examine whether specific child cognitive/literacy abilities provide an intermediary link connecting maternal responsive behavior and linguistic input to child pre-academic skills. Moreover, most previous studies have used smaller, low-income samples when assessing the relationship between parenting or cognitive abilities and academic outcomes. The current study extends past work by using a large and socio-demographically diverse community sample of 501 mother-child dyads followed longitudinally from birth. This is the first study to examine the simultaneous effects of maternal responsiveness and linguistic input on pre-academic skills through multiple competing cognitive and literacy mediators. By specifying a path model in which all parameters are estimated simultaneously, we are able draw conclusions around the specificity of these effects over developmental time.

## 2. Method

### 2.1. Participants

Multiparous women giving birth to infants in two large southeastern cities in Ontario, Canada, between 2006 and 2008 were contacted by the *Healthy Babies, Healthy Children* (HBHC) public health program and considered for participation. Inclusion criteria included: (1) an English-speaking mother; (2) a newborn weighing > 1500 g; (3) one or more children less than 4 years old in the home; and (4) agreement to be videotaped and to have biological data collected. Thirty-four percent of mothers whose information was passed by HBHC consented to participate in the study. Reasons for non-enlistment included inability to contact families, ineligibility once contacted, and refusals. The current sample was part of this ongoing longitudinal study, the goals of which were to examine contextual and biological influences on children's social-emotional, cognitive, and academic skill development using within-family methodology. This required at least two children per family. However, as we were interested in pre-academic skills at discrete periods of development, only the target newborns were included in the current analysis.

A total of 501 mothers and their children were enlisted at Time 1 (T1; target child was a newborn, $M_{age}$ = 2.0 months; SD = 1.06). Families were followed up at three subsequent waves: due to sample attrition, 397 (79.2%) families were followed up at Time 2 (T2; $M_{age}$ = 1 year, 7 months; SD = .16 years), 385 (76.8%) were followed up at Time 3 (T3; $M_{age}$ = 3 years, 2 months; SD = .27 years),

**Table 1**
Demographics of sample at study entry ($N$ = 501).

| Measure | $N$ | % of sample |
|---|---|---|
| Ethnicity of mothers | 501 | 100.0 |
| European/Caucasian | 283 | 56.5 |
| South Asian | 73 | 14.6 |
| East Asian | 60 | 12.0 |
| Black | 46 | 9.2 |
| Other | 39 | 7.7 |
| Teen mom | 31 | 6.2 |
| Single parent family | 32 | 6.4 |
| New-immigrant family (< 10 years) | 146 | 29.1 |
| Low income family (< $20,000) | 45 | 9.5 |
| Mother's years of education (< high school) | 34 | 6.2 |
| Mothers scoring in depressed range on CES-D | 71 | 14.4 |

CES-D – Center for Epidemiological Studies Depression Scale.

and 323 (64.5%) were followed up at Time 4 (T4; $M_{age}$ = 4 years, 8 months; SD = .28 years). The current study drew on data from all time points. Attrition analysis showed that family dropout was related to lower maternal age at first pregnancy, $t(494) = -5.10$, $p < .001$, lower socioeconomic status, $t(498) = -5.07$, $p < .001$, and lower maternal education, $t(498) = -2.99$, $p < .005$. Dropout related to these sociodemographic characteristics is common in longitudinal studies (Fitzgerald, Gottschalk, & Moffitt, 1998; Wolke et al., 2009), and best practice missing-data techniques were used to reduce the effects of attrition bias (see below). Mothers averaged 32.7 years of age ($SD$ = 4.9; range = 18–48) and 15.3 ($SD$ = 2.7) years of education (4.6% < high school; 14.8% high school only; 25.6% non-university diploma or certificate; 3.0% university certificate or diploma below Bachelor level; 32.8% Bachelor's degree; 2.4% university certificate or diploma above Bachelor's level; 16.8% Master's degree or above). Ninety-four percent of the sample reported that they were married or cohabitating, 2% were divorced, and 4% were single. Mean family income, reported on a scale from 1 ('no income') to 16 ('$105,000 or more'), was between C$55,000–64,999. Additional sample demographics are presented in Table 1.

At study entry, the sample was compared to the general population using 2006 Census Data, limiting the census to women between 20 and 50 years and having at least one child. The study sample was similar to the general population on family size ($M$ = 4.52, $SD$ = 1.01 vs. $M$ = 4.13, $SD$ = 1.22) and personal income (C$30,000–39,999 vs. C$30,504.16). Since our sample was recruited shortly after childbirth, there were unsurprisingly fewer non-intact families than in the general population (5% vs. 16.8% lone-parent families; 4.3% vs. 10.3% stepfamilies). The ratio of Canadian-born to immigrants was slightly higher in the study sample (53.5% vs. 47.6%), likely due to the language requirement for participation. English was the main language spoken in the home for 397/501 families (79.2%) and only a small percentage of families spoke only in their heritage language (9.0%). Finally, more study mothers had earned a Bachelor's degree or higher (53.3% vs. 30.6%).

## 2.2. Procedure

At each time point, a home visit of approximately two hours involved questionnaires relating to demographics, family life, and child behavior. Direct measurement of parent-child interactions and child cognitive and academic functioning was assessed using age-appropriate observational and/or standardized tasks and administered in English. Home interviewers were trained in interview administration, standardized test administration, and observational data collection. Below, measures are listed in the order in which they were administered.

## 2.3. Measures

### 2.3.1. Maternal responsiveness and linguistic input (18 months old)

Children and their mothers jointly read a wordless picture book (*Hug* by Alborough, 2001) for 5 minutes. Mother-child interactions were videotaped and coded for both mothers' responsive behavior and linguistic input separately, as outlined below.

*2.3.1.1. Responsive behavior*. Trained coders watched videotaped interactions and coded mothers on three dimensions of responsiveness using the Coding of Attachment-Related Parenting (CARP; Matias, Scott, & O'Connor, 2006), and the Parent-Child Interaction System (PARCHISY; Deater-Deckard, Pylas, & Petrill, 1997): (i) *Sensitivity* (from the CARP) measured the degree to which the parent responded to the child's verbal and non-verbal signals, supported the child's autonomy, showed warmth, and demonstrated an ability to see things from the child's perspective; (ii) *Mutuality* (CARP) is a dyadic code and is compatible with the concept of the 'goal-corrected partnership' (Bowlby, 1982). Mutuality was indexed by reciprocity in conversation (e.g., a conversation that "goes somewhere" and is a genuine dialogue), affect sharing, joint engagement in task, and open body posture; and (iii) *Positive control* (PARCHISY) captures the parents' positive means of getting the child to do something that she wanted him or her to do through the use of praise, explanations, and open ended questions. Each of these three domains – sensitivity, mutuality, and positive control – was globally rated on a 7-point scale across the whole 5-min interaction, with higher values indicating higher levels of responsive parenting. Observational coders, who were independent from home visitors, were blind to all participant information. Internal consistency across three scales was good ($\alpha = .80$), and a composite was created by taking the average. Coders were trained to criterion and calibration continued through the coding period to reduce rater drift. Inter-rater reliability was assessed on 44 mothers and ranged from $\alpha = .81$ to $\alpha = .94$ on the individual scales, and was $\alpha = .94$ on the composite. Also, this measure during book reading was significantly correlated with the same construct during both a 5-min free play task ($r = .45$, $p < .001$) and a 5-min cooperative building task ($r = .49$, $p < .001$), as well as assessments of the same constructs between 1 and 3 years later (correlations between $r = .16$ to .40, $p = .02$ to .001).[1]

*2.3.1.2. Linguistic input.* The videotaped interactions during book reading were transcribed by different individuals than those who collected the data (i.e., home interviewers) and those who coded the interactions for responsive behavior to reduce measurement bias. The transcripts were coded based on an adaptation of the Systematic Assessment of Book Reading (SABR; Pentimonti et al., 2012). Rather than interval-based assessment that codes the frequency of verbalizations in a given interval, a global code was utilized for the duration of the book reading task (Aspland & Gardner, 2003; Morawska, Basha, Adamson, & Winter, 2015).[2] Three dimensions were coded: (i) *Language development (LD)* includes maternal inputs such as describing actions/events/objects, providing labels or definitions of words, and recasting child utterances (e.g. "What is the boy doing here?"; "That is a big bear"; "What does 'explore' mean?"); (ii) *Abstract thinking (AT)* includes maternal inputs that are 'cognitively challenging' because they get the child to think at a level that goes beyond what is perceptually available in the book. Verbalizations that encourage children to compare/contrast, evaluate, predict/hypothesize, and make judgments fell within this category (e.g., "Do you think the monkey is happy or sad?"; "What does this remind you of?"; "He is upset because no one wants to play with him"); and (iii) *Elaborations (E)*, which include verbalizations such as linking the text to real-world experiences of the child, elaborating on concepts in text with discussion, and encouraging imitation or dramatization of what is observed/read in the text. Mothers may also elaborate on the feelings of characters in the text, or verbally respond to child overtures by elaborating on topics of interest to them ("Which animal lives in a nest?"; "When did we see an elephant?"; "Doctors use this word sometimes").

In addition, we divided these codes according to whether mothers *provided* (P) these inputs or *asked for* (A) these from their children. For instance, a mother could provide a noun label or ask their child for one; they could provide an inference (e.g. "this monkey feels sad") or ask for one (e.g. "how do you think the monkey feels?"); or they could provide an elaboration (e.g. "we saw this at the zoo last week") or ask for one (e.g. "When did we see an elephant?"). Thus, there were six scores in total, two (P & A) for each of the language development, abstract thinking, and elaboration categories. There were four items for each of the six scores (24 total items), each rated from 1 ('Rarely') to 7 ('Always'). Internal consistency for the six scales ranged from $\alpha = .79$ to .94. Coders were trained to criterion. Calibration continued through the coding period to reduce rater drift. Inter-rater reliability ($N = 48$) on the six scales was: LDP ($\alpha = .84$); LDA ($\alpha = .88$); ATP ($\alpha = .70$); ATA ($\alpha = .82$); EP ($\alpha = .72$); EA ($\alpha = .68$).

*2.3.2. Cognitive/literacy mediators (3 years old)*

*2.3.2.1. Print recognition.* The Get Ready to Read (GRTR) screening tool was used to assess early print recognition. GRTR was designed to predict future reading success among preschool children (Whitehurst, 2003). GRTR consists of 20 items assessing book, letter, and word identification abilities, as well as early phonological skills.

*2.3.2.2. Receptive language.* The *Peabody Picture Vocabulary Test* (PPVT-III; Dunn & Dunn, 1997) is a widely used and well-validated measure of receptive vocabulary skills for children aged 2 years and older. Children point to a picture which corresponds to the stimulus word among plates of four pictures. The PPVT-III has been shown to be reliable and valid for use in preschool populations (Dunn & Dunn, 1997). We used standardized, age-normed scores.

*2.3.2.3. Theory of mind.* This was measured using the scale described by Wellman and Liu (2004). This scale presents various tasks in a sequential format that map closely onto the development of children's ToM. As children move through the scale, tasks become conceptually more difficult. Thus, progression further along the scale reflects more sophisticated ToM. The first three tasks assessed children's understanding of diverse desires and beliefs, and knowledge and ignorance. This is followed by tasks that assessed more sophisticated ToM understanding such as belief-based emotion, and real-apparent emotion. If children failed two consecutive tasks on the scale, testing was stopped. For all ToM tasks, stories were enacted for children with the use of puppets and props. For each of the tasks, the child is given a score of 0 (fail) or 1 (pass). A total score across all tasks was computed, with higher scores representing higher ToM ability. Internal consistency was high ($\alpha = .85$).

*2.3.2.4. Inhibitory control.* This was assessed using two previously developed and widely used tasks that were appropriate to the age of the child: Grass/Snow (Carlson & Moses, 2001) and Bear/Dragon (Reed, Pien, & Rothbart 1984). The *Grass/Snow* task is a Stroop-like task in which the children were instructed to point to a green color chip when the experimenter said the word "snow" and to a white color chip when the experimenter said "grass." The score was a total of correct responses on 16 total trials. For the *Bear/Dragon* task, children were instructed to do what they were told by the nice bear (e.g., "touch your nose"), but not to do what they were told

[1] We also examined the results using a composite measure of maternal responsiveness across all three tasks (shared reading, free play, and cooperative building), and the substantive results were not different.

[2] A copy of the coding manual is available at the request of the reader to the corresponding author.

by the mean dragon. Children were scored for total number of compliance (0–10) on five dragon and five bear trails. In the present study, Grass/Snow and Bear/Dragon were significantly correlated, $r(309) = .28$, $p < .001$. Thus, the two tasks were $z$-scored and combined into a composite IC variable. Higher scores represented better IC ability.

#### 2.3.3. Pre-academic outcomes (4.5 years old)

Children's pre-academic skills were assessed at age 4.5 using selected subtests from the Woodcock-Johnson Third Edition – Tests of Educational Achievement (WJ-III-ACH; Woodcock, McGrew, & Mather, 2001). Print and sight-word recognition was assessed using the *Letter-Word Identification* subtest, which required children to name letters and words aloud from a list. *Reading comprehension* was assessed with the Passage Comprehension subtest, which required children to read a partially incomplete passage and identify the missing word. Numeracy and mathematical ability was assessed using the *Applied Problems* subtest. Children had to respond to math problems that were read to them aloud, and some items have accompanying visual stimuli. The WJ-III-ACH is widely used in research and clinical settings, as it provides reliable and valid yet brief assessment of early academic functioning. The WJ-III-ACH has been normed on a large, representative sample of the population. Raw scores were used, but age and gender were partialled out in the regression analysis. There was no evidence of floor or ceiling effects on these tasks. Scores on all tasks were normally distributed, with the exception of Reading Comprehension, which was slightly positively skewed. As noted below, the estimator chosen for the path model is robust to non-normality. However, as a validity check, we log-transformed this variable and re-examined the model. The substantive results were unchanged. Finally, we included *Receptive Vocabulary* at age 4.5 as an outcome, also assessed using the PPVT-III.

#### 2.3.4. Covariates

All analyses controlled for the following covariates: child age (years and months converted to year decimals), gender (0 = male, 1 = female) and maternal education (number of years of formal education excluding kindergarten; $M = 15.3$, $SD = 2.7$). We also controlled for mothers' mean length of utterances (MLU), which is a measure of general language complexity. MLU was computed as the total number of morphemes divided by the total number of utterances produced during the book reading task. By controlling for mothers' MLU, we ensure that the effects are not driven simply by mothers who have overall better language skills, but rather by the quality of linguistic input in interactions with their child. Finally, given that early language is a key predictor of later cognitive and academic functioning (and may also confound the relationship between maternal input and these abilities), all analyses also controlled for children's expressive language at 18 months. This was measured using the MacArthur CDI (Fenson et al., 1994), a mother-reported measure of children's expressive vocabulary that can be used with children under the age of 2. Children were coded on 'words and sentences'. Words spoken ranged from 0 to 100 ($M = 26.5$, $SD = 20.1$). Scores were residualized for age and gender (i.e., residual scores that were adjusted for age and gender were saved and used in all subsequent analyses).

### 2.4. Analysis plan

All analyses were conducted using Mplus 7.2 (Muthén & Muthén, 2012). To handle missing data, full information maximum likelihood estimation (FIML) was utilized for all analyses. This method offers improvements over traditional approaches for handling missing data such as listwise deletion, pairwise deletion, and imputation in terms of parameter bias, model convergence, and model fit (Acock, 2005; Enders & Bandalos, 2001). FIML can handle up to 50% missing data without biasing the estimates (Graham & Schafer, 1999). The estimator used was a maximum-likelihood with robust standard errors (MLR) estimator, which produces parameter estimates with standard errors and a chi-square that are robust to non-normality when missing data are present (Yuan & Bentler, 2000). We fit a single, full path model that tested all direct and meditational effects simultaneously, controlling for all other effects in the model. For model fit, we report the root-mean-square-error of approximation (RMSEA), comparative fit index (CFI), and standardized root-mean-square residual (SRMR).

## 3. Results

### 3.1. Descriptive analyses

Descriptive statistics and bivariate correlations between study variables are presented in Table 2. Notable associations include the relationship between both maternal linguistic input and responsiveness (T2) and virtually all pre-academic outcomes (T4) and child mediators (T3). Child expressive language at T2 was also associated with all T4 pre-academic outcomes and T3 child mediators. Mothers' MLU was concurrently associated with responsive behavior and linguistic input. Finally, all child mediators were associated with all pre-academic outcomes.

### 3.2. Measurement model for linguistic input

Under the assumption that each of the six behaviors used to index maternal linguistic input were represented by a common underlying factor, we subjected the manifest variables to a confirmatory factor analysis (CFA; Cole & Maxwell, 2003). The measurement model fit the data well: CFI = .99, SRMR = .032, and RMSEA = .042 [.00, .11]. Hu and Bentler (1999) recommend goodness of fit cut-offs of .95 for CFI, .08 for SRMR, and .06 for RMSEA. All fit indices were equal to or better than these recommended cut-offs. Also, all of the model-estimated loadings onto the latent factor were positive and significant at the $p < .001$

**Table 2**
Means, standard deviations, and bivariate correlations among study variables.

| | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | M | *SD* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Child gender (T1) | – | | | | | | | | | | | | | – | – |
| 2. Maternal education (T1) | −.04 | – | | | | | | | | | | | | 15.27 | 2.68 |
| 3. Child language (T2) | −.00 | .02 | – | | | | | | | | | | | .00 [a] | 1.00 |
| 4. Maternal responsive behavior (T2) | .13* | .15** | .20*** | – | | | | | | | | | | 3.22 | 1.01 |
| 5. Maternal linguistic input (T2) | .08 | .16** | .17** | .47*** | – | | | | | | | | | 2.70 | .89 |
| 6. MLU (T2) | −.05 | .19*** | .07 | .13* | .22*** | – | | | | | | | | 3.62 | .87 |
| 7. Theory of mind (T3) | .06 | .17*** | .21*** | .11 | .16** | .05 | – | | | | | | | 1.38 | .90 |
| 8. Inhibitory control (T3) | .05 | .21*** | .28*** | .24*** | .25*** | .22*** | .25*** | – | | | | | | −.01 | .81 |
| 9. Print recognition (T3) | .08 | .08 | .21*** | .20*** | .20*** | .10 | .21*** | .34*** | – | | | | | 8.92 | 3.56 |
| 10. Receptive vocabulary (T3) | .10 | .15** | .25*** | .37*** | .35*** | .11 | .25*** | .23*** | .45*** | – | | | | 94.78 | 15.45 |
| 11. Receptive vocabulary (T4) | −.01 | .25*** | .32*** | .31*** | .33*** | .24*** | .27*** | .29*** | .31*** | .54*** | – | | | 104.01 | 14.22 |
| 12. Word identification (T4) | .03 | .05 | .20** | .23*** | .13* | .06 | .15* | .17** | .35*** | .18** | .16** | – | | 12.87 | 8.23 |
| 13. Reading comprehension (T4) | −.01 | −.02 | .21*** | .18** | .08 | .05 | .13* | .13* | .29*** | .17* | .07 | .73*** | – | 5.40 | 3.36 |
| 14. Math applied problems (T4) | −.03 | .21*** | .20** | .28*** | .24*** | .09 | .20*** | .27*** | .33*** | .37*** | .47*** | .41*** | .24*** | 14.65 | 4.65 |

MLU – mean length of utterances.

level.[3]

### 3.3. Path model linking parenting dimensions to pre-academic skills

Model fit for the overall path model was good: CFI = .94, SRMR = .047, and RMSEA = .053 [.045, .062]. Fig. 1 presents all of the significant links between maternal linguistic input and responsive behavior at T2 to the mediators at T3, and the mediators at T3 to the pre-academic outcomes at T4. Only significant paths are presented for simplicity. In this model, maternal linguistic input and responsiveness were highly related, as were several within-time pre-academic skills, and most within-time T3 mediators (results not shown for clarity).

### 3.4. Goal #1: unique effect of linguistic input and responsiveness on pre-academic skills

First, to determine the unique influence of linguistic input and responsiveness at 18 months on pre-academic skill outcomes at age 4.5, we examined the *total effects*, which measure the effect of each dimension of parenting on pre-academic outcomes without any age 3 mediators in the model. Importantly, we entered linguistic input and responsiveness into the model simultaneously and controlled for within-time covariance terms, which enabled us to determine the independent contribution of these dimensions to the pre-academic outcomes. Table 3 reports the *total effects* for each of maternal linguistic input and responsive behavior on all four pre-academic skills.[4] For linguistic input, the only total effect to emerge as significant was the effect on receptive vocabulary at T4, with higher linguistic input related to more advanced vocabulary.

For maternal responsive behavior, there were significant total effects for all four pre-academic outcomes: letter-word identification, reading comprehension, math applied problems, and receptive vocabulary. In all cases, higher responsiveness was related to more advanced pre-academic skills. On the basis of these findings, maternal responsiveness was significantly related to more pre-academic outcomes than linguistic input when no mediators were accounted for in the model.

### 3.5. Goal #2: effect of linguistic input and responsiveness on cognitive/literacy mediators

Second, we tested whether each dimension of parenting was related to children's cognitive/literacy skills at age 3 by examining each of these relationships simultaneously, controlling for all other effects and covariates. Fig. 1 shows the significant and marginal associations between both linguistic input and responsiveness on each of the mediators at T3.

Maternal linguistic input was significantly associated with all T3 mediators (ToM, IC, print recognition, and receptive vocabulary) after controlling for every other path and covariates. On the other hand, maternal responsiveness was only significantly associated with receptive vocabulary at T3. Again, these effects were unique, suggesting that linguistic input was significantly related to more cognitive/literacy mediators than maternal responsiveness.

[3] Loadings ranged from .62 to .92, suggesting highly significant but somewhat variable contributions to the latent factor. Thus, using a latent factor took account of the extent to which each indicator contributed to the scaling of this variable.

[4] Results were re-examined with letter-word identification and reading comprehension combined into a single 'reading' score. This manipulation neither improved nor worsened model fit: RMSEA = .053, CFI = .94, SRMR = .047. The results mirrored those of each construct its own, which showed a similar pattern, as outlined in the text.

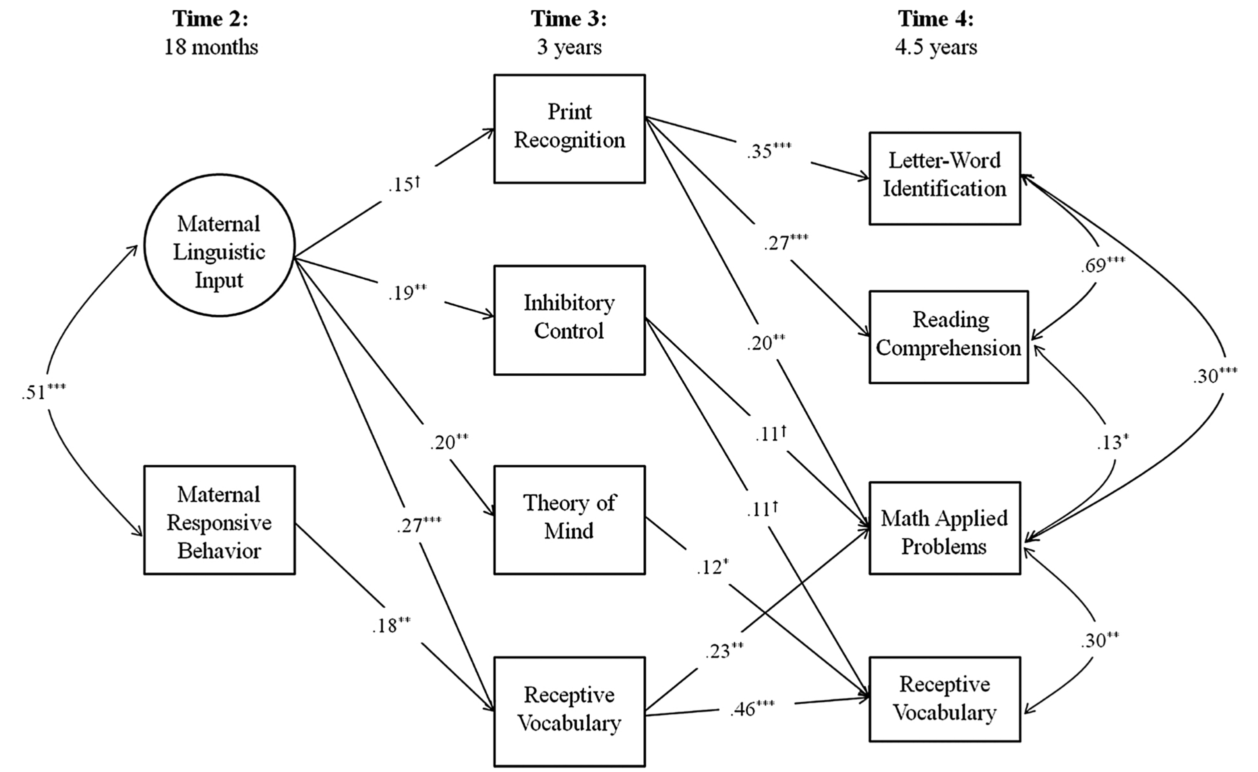


**Fig. 1.** Path model showing the links between maternal linguistic input and responsive behavior with pre-academic outcomes at age 4.5 through age 3 mediators. Parameters are standardized coefficients. Only significant paths are shown for simplicity. Linguistic input is a latent variable and thus represented with a circle, although the individual loadings are not presented (to reduce clutter). Total, direct, and indirect effects are presented in Table 3. All parameters are unique estimates (i.e., controlling for all other paths in the model) and also control for child age, gender, maternal education, child expressive language at 18 months, and maternal MLU at 18 months. † $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

### 3.6. Goal #3: cognitive/literacy abilities as predictors of pre-academic outcomes

Next, we examined the relationship between each specific cognitive/literacy ability and each school readiness outcome, with all parameters controlling for all other paths in the model and covariates. Fig. 1 shows the significant links between each cognitive/literacy ability at T3 and each pre-academic outcome at T4. Print recognition at T3 proved to be associated with the highest number of pre-academic outcomes, predicting letter-word identification skills, reading comprehension, and math applied problems (but not receptive vocabulary). IC at T3 predicted both math applied problems ability and receptive vocabulary, while ToM only predicted receptive vocabulary. Finally, receptive vocabulary at T3 predicted both math applied problems at T4 and receptive vocabulary at T4. Again, these effects are over-and-above all other effects and covariates. This is why in the correlation matrix all T3 mediators were associated with all T4 pre-academic skills, whereas in the path model some of these effects are non-significant (i.e., other variables were stronger predictors of outcome variance).

### 3.7. Goal #4: indirect effects linguistic input and responsiveness on pre-academic skills

Finally, to examine whether the effect of maternal linguistic input and responsiveness on pre-academic skills at age 4.5 operated through children's cognitive/literacy abilities at age 3, we examined the *indirect effects*. This is a statistical test of whether each parenting dimension (linguistic input and responsiveness) is associated with each pre-academic outcome through the cognitive/literacy mediators. Indirect effects were estimated using the delta method (Sobel, 1982), which calculates the standard error of the product of two variables that can then be used to determine the significance of the indirect path. Table 3 reports the *total indirect effects*, which can be interpreted as the sum of all indirect effects. For linguistic input, there was a significant total indirect effect on math applied problems and receptive vocabulary at T4 through T3 cognitive/literacy abilities (overall). There was also a marginally significant total indirect effect on reading comprehension at T4. For maternal responsiveness, there was a significant total indirect effect on receptive vocabulary at T4, and a marginally significant total indirect effect on math applied problems at T4. Neither total indirect effect from linguistic input or responsiveness on letter-word identification at T4 was significant.

Table 3 also shows the *specific indirect effects* of linguistic input and responsiveness on all pre-academic skills through each of the mediators, controlling for all other paths and covariates. For linguistic input, there was a significant indirect effect on both receptive vocabulary and math applied problems at T4 through receptive vocabulary at T3. In addition, there were marginally significant

**Table 3**
Total, direct, and indirect effects of maternal linguistic input and responsive behavior on pre-academic outcomes.

| Predictor | Effect | Letter-Word Identification | STD ES 95% CI | Reading Comprehension | STD ES 95% CI | Math Applied Problems | STD ES 95% CI | Receptive Vocabulary | STD ES 95% CI |
|---|---|---|---|---|---|---|---|---|---|
| | | □(SE) | 95% CI | □(SE) | 95% CI | □(SE) | 95% CI | □(SE) | 95% CI |
| Maternal Linguistic Input | Total | .01 (.10) | [-.19, .21] | -.05 (.11) | [-.27, .17] | .12 (.09) | [-.06, .29] | **.18*** (.08) | [.02, .34] |
| | Direct | -.033 (.11) | [-.24, .18] | -.11 (.12) | [-.34, .12] | -.01 (.09) | [-.19, .17] | .001 (.09) | [-.17, .18] |
| | | *z* | STD ES 95% CI | *z* | STD ES 95% CI | *z* | STD ES 95% CI | *z* | STD ES 95% CI |
| | Indirect | 1.29 | .04 [-.02, .11] | **1.83**† | .06 [-.01, .13] | **3.17**** | .13 [.05, .21] | **3.70***** | .18 [.08, .27] |
| | ToM | 1.24 | .01 [-.01, .04] | 1.24 | .02 [-.01, .04] | 1.38 | .02 [-.01, .04] | **1.79**† | .02 [-.01, .05] |
| | IC | .44 | .01 [-.02, .03] | .19 | .00 [-.02, .03] | 1.54 | .02 [-.01, .05] | **1.64**† | .02 [-.01, .05] |
| | GRTR | **1.95**† | .05 [.00, .10] | **1.90**† | .04 [-.01, .08] | 1.63 | .03 [-.01, .06] | .54 | .01 [-.02, .03] |
| | PPVT | -1.24 | -.03 [-.07, .02] | .18 | .00 [-.04, .05] | **2.46*** | .06 [.01, .11] | **3.19**** | .13 [.05, .20] |
| | | □(SE) | 95% CI | □(SE) | 95% CI | □(SE) | 95% CI | □(SE) | 95% CI |
| Maternal Responsive Behavior | Total | **.19*** (.09) | [.02, .35] | **.19*** (.09) | [.01, .37] | **.16*** (.08) | [.00, .33] | **.13*** (.06) | [.00, .25] |
| | Direct | **.18*** (.08) | [.02, .034] | **.17**† (.09) | [-.01, .33] | .11 (.08) | [-.05, .26] | .04 (.06) | [-.08, .16] |
| | | *z* | STD ES 95% CI | *z* | STD ES 95% CI | *z* | STD ES 95% CI | *z* | STD ES 95% CI |
| | Indirect | .24 | .01 [-.05, .06] | .02 | .02 [-.03, .08] | **1.83**† | .06 [-.01, .12] | **2.25*** | .09 [.01, .16] |
| | ToM | -.66 | .00 [-.01, .01] | -.67 | .00 [-.01, .01] | -.71 | .00 [-.01, .01] | -.74 | -.01 [-.02, .01] |
| | IC | .39 | .00 [-.01, .01] | .19 | .00 [-.01, .01] | .78 | .01 [-.01, .02] | .81 | .01 [-.01, .02] |
| | GRTR | 1.16 | .03 [-.02, .07] | 1.13 | .02 [-.02, .06] | 1.13 | .02 [-.01, .04] | .56 | .00 [-.01, .02] |
| | PPVT | -1.24 | -.02 [-.05, .01] | .18 | .00 [-.03, .03] | **2.00*** | .04 [.00, .08] | **2.55*** | .08 [.02, .15] |

***$p < .001$.
**$p < .01$.
*$p < .05$.
†$p < .10$.
SE – standard error; STD ES – standardized effect size (a*b) for the indirect effect; CI – Confidence interval, standardized.
*z* = standardized estimate/SE(estimate).
ToM – Theory of Mind; IC – Inhibitory Control; GRTR – Get Ready to Read; PPVT – Peabody Picture Vocabulary Test.

indirect effects on receptive vocabulary through ToM and IC at T3. Finally, there were marginally significant indirect effects of linguistic input on letter-word identification and reading comprehension through children's print recognition at T3. For maternal responsiveness, there were significant specific indirect effects on receptive vocabulary and math applied problems at T4, both of which operated through receptive vocabulary at T3. Thus, there were more significant indirect effects of linguistic input on pre-academic skills through the cognitive/literacy mediators than for maternal responsiveness. Although there were few indirect effects involving responsiveness – which was mainly a function of the non-significant associations with T3 mediators – there were significant total and direct effects. This means that responsiveness is predictive of pre-academic skills, but after controlling for the effect of linguistic input, these effects were not operating through T3 cognitive/literacy mediators.

## 4. Discussion

The current study aimed to determine whether maternal responsiveness and linguistic input at 18 months was associated with children's pre-academic skills at age 4.5. We then examined competing pathways from responsiveness and linguistic input to pre-academic skills through four emerging cognitive/literacy abilities believed to support pre-academic skill development: IC, ToM, print recognition, and receptive vocabulary. Key findings were that: (i) both maternal responsiveness and linguistic input were significantly and independently associated with pre-academic skill development in reading, math, and vocabulary; (ii) linguistic input was a stronger predictor of intermediary cognitive/literacy skills than responsiveness; (iii) literacy abilities (print recognition and receptive vocabulary) tended to be stronger mediators of pre-academic skills compared to cognitive mediators (IC and ToM); and (iv) there were disparate pathways connecting linguistic input and responsiveness to pre-academic skills, with the former operating through intermediary cognitive/literacy abilities to a greater extent than the latter.

### *4.1. The contribution of linguistic input and responsiveness to pre-academic skills*

The analysis of total effects suggested that maternal responsive behavior, but not linguistic input, significantly predicted all pre-academic skills at age 4.5. In particular, maternal responsiveness was significantly associated with each of letter-word identification, reading comprehension, math applied problems, and receptive vocabulary at age 4.5, while linguistic input was only significantly associated with receptive vocabulary. The maternal responsiveness effect, however, did not account for age 3 mediators. When age 3 cognitive/literacy abilities (IC, ToM, print recognition, and receptive vocabulary) were included in the model, linguistic input was shown to predict all of these mediators, whereas responsiveness only predicted receptive language. Consequently, and consistent with study hypotheses, linguistic input was shown to be associated with pre-academic outcomes indirectly through age 3 cognitive/literacy abilities more so than responsiveness. Thus, while responsiveness was directly associated with children's pre-academic skill development at age 4.5, linguistic input was primarily related to these outcomes indirectly through intermediary cognitive/literacy abilities.

### 4.2. Unique pathways for different parenting dimensions on pre-academic skills

For linguistic input, the pattern of indirect effects appears to vary depending on the pre-academic outcome assessed. For instance, in terms of reading-based competencies (letter-word identification skills and reading comprehension), early print recognition was the key mediator. Alternatively, for math applied problems, children's receptive vocabulary was the key mediator. Finally, for receptive language at age 4.5, both ToM and IC made small but unique mediational contributions, whereas earlier receptive vocabulary was the strongest mediator. Importantly, all of these effects controlled for all other effects in the model. This is crucial, as many previous studies have suggested that each of these mediators is consequential for children's academic readiness. This is the first study to explicitly test each of these paths as a competing mechanism linking early maternal inputs to pre-academic outcomes. Our findings do not suggest equally significant contributions from all domains of early cognition/literacy to pre-academic functioning, and instead highlight specific pathways through which linguistic input in the first two years of life relate to children's early academic competencies.

It might appear that linguistic input plays a more prominent role for pre-academic skill development than responsiveness owing to the more salient indirect effects through children's nascent cognitive/literacy abilities. However, responsiveness was significantly associated with pre-academic skills in a manner that was largely independent of these intermediary skills, suggesting that the mechanism carrying these social inputs may be different. Thus, not only are different pre-academic outcomes supported by specific cognitive/literacy mediators, but different dimensions of parenting may be connected to these outcomes via disparate mechanisms. For linguistic input, the mediators tested in the current model appear to be plausible candidates in this intricate mechanism. This seems sensible since parental discourse that promotes language, abstract thinking, and expands on children's existing knowledge may scaffold not only vocabulary, but also executive, symbolic, and representational abilities that have carry-forward effects for pre-academic skill development. These results are consistent with those of Merz et al. (2015), who showed a minimal direct effect of inferential discourse on children's pre-academic skills. Moreover, these findings support their untested hypothesis that linguistic input operates on pre-academic outcomes indirectly through nascent cognitive and literacy skills.

Alternatively, for maternal responsiveness, modest effects on math and receptive language at age 4.5 through receptive vocabulary at age 3 were observed. The link between responsiveness and child language is consistent with previous observational and intervention studies (Landry, Smith, Swank, & Guttentag, 2008; Madigan, Wade, Plamondon, Browne, & Jenkins 2015), while the link to later math skills is relatively novel (but see Assel, Landry, Swank, Smith, & Steelman, 2003; Aunola & Nurmi, 2004). In either case, a lack of mediation by other cognitive and literacy abilities suggests that the pathway from responsiveness to pre-academic skills may differ from those of linguistic input. Here, it is important to consider that maternal responsiveness tapped behaviors such as attunement, praise, emotional support, mutuality, and autonomy promotion. The observation of significant direct effects of maternal responsiveness on pre-academic outcomes, with few indirect effects, raises the possibility that responsiveness operates through other competencies not measured in the current study. In other words, while it is plausible that responsiveness bears directly upon children's pre-academic skills, it is more likely that its effects are channeled through another proximal, but presently unidentified, mechanism.

One such mechanism is self-regulation, which may facilitate academic learning by increasing children's capacity to access and retain key skills being taught (Blair & Diamond, 2008). In the current study, after controlling for linguistic input, maternal responsiveness was unrelated to IC, which reflects children's ability to intentionally or effortfully suppress a triggered response. While IC may partially contribute to more elaborate forms of self-regulation, it may not be sufficient. Thus, it may be the case that responsiveness scaffolds dimensions or subcomponents of self-regulation that are independent of IC. For instance, maternal responsiveness/sensitivity has recently been shown to predict higher levels of reward-related control in the preschool period (Pauli-Pott, Schloß, & Becker, 2017), as well as better emotion regulation and distress tolerance skills among young children (Frick et al., 2017). Maternal sensitivity may operate on self-regulation by fostering increased child engagement (Ispa, Su-Russell, Palermo, & Carlo, 2017). In turn, more engaged and regulated children may be better positioned to uptake new concepts or skills during structured or informal learning episodes. Moreover, maternal emotional support has been shown to mediate the link between mothers' own executive functions and her child's behavioral regulation, such as attentional control, discipline, persistence, and work habits (Zeytinoglu, Calkins, Swingler, & Leerkes, 2017). Supportive parenting is also linked to higher levels of interest and persistence in toddlerhood, which in turn predicts academic skills at age 5 (Martin, Ryan, & Brooks-Gunn, 2013). Finally, responsiveness promotes child cooperation, positive affect, and joint engagement (Landry, Smith, & Swank, 2006).

In sum, building children's capacity to regulate the expression of their needs and emotions, cooperate and respond compliantly with others, act prosocially and follow rules, and tolerate frustration may facilitate on-task behavior, persistence, interest, and intrinsic motivation that begets early academic success (Farkas & Grolnick, 2010). Thus, it is conceivable that the association between responsiveness and pre-academic skills operates through various social-emotional aptitudes rather than the emergent cognitive and literacy abilities measured in the current study. Although future studies are required to test these hypotheses, such results would speak to the importance of different dimensions of parenting in supporting the parallel but complementary cognitive, self-regulatory, and social-emotional skills that are required for early academic success.

### 4.3. Not all cognitive and literacy mediators are equally relevant for pre-academic skills

We tested multiple competing pathways from maternal responsiveness and linguistic input to academic readiness through children's emergent cognitive and literacy skills. For language-based outcomes at age 4.5 (letter-word identification and reading comprehension), print recognition at age 3 was the only significant mediator of linguistic input. This variable assessed letter and word recognition, as well as phonological skills and letter-sound correspondence. These results are consistent with meta-analytic findings by the National Early Literacy Panel, which found a number of variables that had a medium to large predictive relationship with measures of literacy in kindergarten after controlling for IQ and SES. Among the strongest predictors of later literacy were alphabet knowledge, phonological awareness, rapid naming, and phonological memory (Lonigan & Shanahan, 2009). Other notable variables included concepts of print and print knowledge. These predictive relationships were shown to be strongest near the end of kindergarten or at the beginning of grade one compared to later achievements, suggesting a prominent role of early print and phonological skills in the acquisition of more sophisticated literacy. Building on these findings, the current results suggest that mothers' rich linguistic input in the second year of life is an important social factor that may augment these early competencies, which in turn fosters more advanced pre-academic skills.

For math applied problems at age 4.5, both maternal linguistic input and responsive behavior operated through receptive vocabulary at age 3. Given that this task requires problem solving and mental reasoning, it makes sense that vocabulary skills should help in this endeavor. Numerous studies have previously documented the link between linguistic skill and mathematic competence in early childhood (Durand, Hulme, Larkin, & Snowling, 2005; Hecht, Torgesen, Wagner, & Rashotte, 2001; Krajewski & Schneider, 2009). Receptive vocabulary may be a specific capacity for acquiring vocabulary around math concepts and number systems, and may also augment core mathematical knowledge that does not strictly involve reading or verbal comprehension (LeFevre et al., 2010). In sum, parents who provide linguistic input that is literal (e.g. defining and describing), abstract, and elaborative may encourage the development of language skills that support pre-mathematic skills.

Finally, it is interesting that children's receptive language ability at age 4.5 was predicted by linguistic input at 18 months through ToM, IC, and prior levels of vocabulary at age 3. The latter effect is not surprising given that we would expect early skills to predict later skills of the same kind, especially for a stable cognitive ability like language. The mediational role of ToM and IC, on the other hand, is more notable, as it has long been presumed that language is important for the development of ToM (Fernyhough, 2008) and IC (Müller, Jacques, Brocki, & Zelazo, 2009). The current results suggest that these two cognitive abilities may reciprocally support language development in so far as they are couriers of early linguistic stimulation from parents. It is important to mention, however, that when all mediators were considered simultaneously, the effects of ToM and IC were relatively weak. Nonetheless, it appears that aspects of maternal linguistic input in the second year of life provide at least some of the "cognitive material" that fosters children's aptitude to represent, reason, and control thoughts and behavior which support early linguistic development. Future studies that examine other competencies such as on-task behavior, frustration tolerance, and social responsiveness may further enhance our understanding of how these discrete cognitive skills give way to more advanced early vocabularies.

### 4.4. Implications

To date, progress in understanding the mechanisms by which distinct dimensions of parenting relate to pre-academic skills has been limited by few explicit attempts to disentangle these pathways. However, some conceptual models support a differentiated approach to understanding parenting effects on child outcomes (Davidov & Grusec, 2006; Carr & Pike, 2012), and the current study is congruent with the notion that maternal responsiveness and linguistic input are independently associated with pre-academic skills. Our conclusion is that these pathways are, at a minimum, not completely overlapping, with linguistic input operating through emergent cognitive and literacy abilities more so than responsiveness. This does not mean, however, that responsiveness is less important to pre-academic skill development (evidenced by significant direct effects), but that it is likely functioning through another mechanism. In other words, both *what mothers* say and *what mothers do* are important contributors to pre-academic skill development. Thus, efforts to enhance these skills through parent-child enrichment activities such as joint reading or structured learning activities should include components of responsiveness *and* linguistic input rather than narrowly focusing on a single dimension. This may be especially true for vulnerable or disadvantaged families who experience increased stress and a lack of access to learning resources (Huttenlocher et al., 2010).

In addition to additive effects of parenting on pre-academic skills, we should not discount the possible interaction between these dimensions. In this regard, parenting that is sensitive and responsive may have the effect of recruiting children into social exchanges and keeping them engaged in activities such as book reading through recursive and socially-reinforced interactions. In turn, this may enable children to access the rich material afforded to them during these interactions, including exposure to valuable linguistic input that advances early cognition and literacy (Zauche, Thul, Mahoney, & Stapel-Wax, 2016). Yet, we know there is variability in the extent to which mothers engage in particular parenting behaviors. Currently it is unclear how these parenting dimensions operate in tandem to support early skill development, and whether one dimension potentiates the other, resulting in a multiplicative advantage over either dimension on its own. Future work that details the independent and joint effects of these and other dimensions of parenting are encouraged to further disentangle these complex mechanisms.

### 4.5. Strengths, limitations, and future directions

The current findings should be considered in light of several strengths and limitations. Strengths included the large and sociodemographically diverse sample – which complements and builds on prior studies by improving issues related to power (e.g. small samples) and generalizability (e.g. focus on low-SES samples) – as well as the longitudinal follow-up, detailed observational/ standardized measurement across time points, and rigorous statistical and confound controls. The relatively low proportion of families considered low-income in the current study may limit generalizability of these results to all individuals, and replication in other stratified samples is encouraged based on these findings. Moreover, sample attrition over time should be considered a potential source of bias, although we attempted to reduce this by using best-practice methods for handling missing data (Graham, 2009). Also, despite the longitudinal design, the current study is limited in its capacity to make causal inferences on the influence of parenting dimensions and on pre-academic skills. Future studies that apply sophisticated cross-lagged or experimental designs will help to elucidate the causal nature of these social inputs on children's outcomes. Further, we used a short 5-min interaction between mothers and their children to measure their linguistic input and responsive behavior. Although the latter measure was shown to correlate across other tasks not included in the current study, follow-up studies that assess these effects over longer durations (and at different ages) will be useful in determining the generalizability of these effects. Likewise, our coding of the interactions was based on global aspects of linguistic input and responsiveness within a familiar environment. Whether the effects documented herein extend to other social partners (e.g. fathers, teachers, siblings), and whether the positive effects of linguistic input and responsiveness are maintained over the school-age years, is currently unclear. Future research would also benefit from examining models that include alternative parenting dimensions such as social modeling, direct instruction, and overall quality of the home environment as additional sources of variability in pre-academic skill development. With a greater understanding of how these dimensions of parenting build children's pre-academic skills and the distinct cognitive, social-emotional, and behavioral skills that carry these social inputs, effective early prevention and intervention programs may be crafted for parents and their children in order to ensure positive health and development throughout childhood and beyond.

## 5. Conclusion

The current study shows that two separate but related dimensions of parenting behavior, responsiveness and linguistic input, make independent contributions to pre-academic skill development at age 4.5. For linguistic input, these effects operate through children's burgeoning cognitive and literacy abilities at age 3, while for maternal responsiveness there appears to be another, currently unspecified mechanism. Future research should focus on ascertaining the unique pathways by which different facets of parenting foster early academic competencies.

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