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Associations among Mothers' Depression, Emotional and Learning Material Support to Their Child, and Children's Cognitive Functioning: A 16-year Longitudinal Study

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Abstract

This study examined the associations among maternal depression, mothers' emotional and material investment in their child, and children's cognitive functioning. Middle-class Chilean mothers and children (N = 875; 52% males) were studied when children were 1, 5, 10, and 16 years (1991-2007). Results indicated that highly depressed mothers provided less emotional and material support to their child across all ages, which related to children's lower IQ. Children with lower mental abilities at age 1 received less learning-material support at age 5, which led to mothers' higher depression at child age 10. Mothers' low support was more strongly linked to maternal depression as children got older. Findings elucidate the dynamic and enduring effects of depression on mothers' parenting and children's development.

Keywords: child cognition, maternal depression, maternal responsiveness, parental investment

Associations among Mothers' Depression, Emotional and Learning Material Support to Their Child, and Children's Cognitive Functioning: A 16-year Longitudinal Study

Maternal depression has been consistently linked with children's poor cognitive outcomes (Kurstjens & Wolke, 2001; Yan & Dix, 2016). Although chronic maternal depression is more consistently associated with children's delayed cognitive and language development, low levels of acute depression also can have harmful effects (Campbell, Matestic, von Stauffenberg, Mohan, & Kirchner, 2007; Conners-Burrow et al., 2014). Different mechanisms have been put forth to explain the association between mothers' depression and children's cognition. Foremost

among them is a maternal socialization explanation, which posits that the emotional withdrawal and detachment stemming from depression lead mothers to be less interactive and responsive toward their children which, in turn, contribute to children's lower cognitive abilities (Chien & Mistry, 2013; Milgrom, Westley, & Gemmill, 2004; Mistry, Biesanz, Taylor, Burchinal, & Cox, 2004). Indeed, depression has been widely linked to mothers' disengaged parenting, or less sensitive and playful interactions and lower levels of verbal responsivity and engagement (Field, 2010; Goodman, 2007). Mothers' low sensitivity and responsivity have also been widely related to children's poorer cognitive skills (Landry, Smith & Swank, 2006; Malmberg et al., 2016), particularly children's language and verbal skills (Stein, Malmberg, Sylva, Barnes, & Leach, 2008; Tamis-LeMonda, Bornstein, & Baumwell, 2001).

Another mechanism used to explain the link between maternal depression and children's lower cognitive functioning is mothers' reduced learning-material investment in their child. This explanation posits that depression and its associated pessimism lead mothers to make fewer investments in their children's growth and development, such as providing few cognitively stimulating learning materials, which ultimately has a negative effect on children's cognitive skills (Sohr-Preston & Scaramella, 2006; Yeung, Linver, & Brooks-Gunn, 2002). Indeed, several studies have shown that maternal depression is associated with mothers' lower investment in their child's learning environment (i.e., providing fewer age-appropriate toys or materials), which in turn, links to children's lower academic achievement and language scores (Baydar et al., 2014; Conners-Burrow et al., 2014; Yeung et al., 2002).

Both mediating mechanisms can be understood within a parental investment framework, with one emphasizing mothers' reduced emotional investment in their child, and the other emphasizing mothers' limited learning-material investment in their child (Foster, 2002; Kalil & DeLeire, 2004). The present study examined both the emotional and learning-material forms of parental investment as mediating the effect of mothers' depression onto their children's cognitive functioning. A repeated-measures longitudinal design was used, involving 875 Chilean mothers and children who were studied when children were 1, 5, 10, and 16 years old. This allowed us to examine the within-time, across-time and possible bidirectional effects among mothers' depression, their investment in their child, and children's cognitive skills across children's development (Figure 1).

The Current Study

This study addressed five issues. First, we examined the extent to which mothers' investment in their child (both emotional investment and learning-material investment) mediates the association between mothers' depressive symptoms and children's cognitive skills. Based on the parental investment model, we hypothesized that mothers' more frequent depressive symptoms will contribute to both mothers' lower emotional and lower learning-material investment, which in turn, will contribute to children's poorer cognitive skills. We emphasize here the distinction between a depressed mother's *feelings* of emotional investment and the extent to which she demonstrates that investment toward her child. A depressed mother may certainly be emotionally invested in her child, but the manifestations of depression may prevent her from demonstrating that investment in a productive manner toward her child's development (Goodman, 2007). Thus, poor investment secondary to depressive symptoms does not necessarily imply a lack of love or devotion. Rather, it may mean a lesser allocation of resources extended to that child in the form of attentiveness, affection, and nurturing play materials.

Second, we examined the inverse of these associations, or how children's cognitive abilities are associated with mothers' subsequent investment, which in turn, might relate to mothers' depression. This inverse mediated pathway is informed by an expected benefit explanation, such that parents are more likely to invest in better-endowed children (Behrman, 1997). This pattern has been largely confirmed in previous research, with children's higher cognitive ability eliciting greater parental investment (Gershoff, Aber, & Clements, 2009), and more child stimulating learning materials in the home predicting lower depressed affect in mothers (Yeung et al., 2002). However, some studies also point to a compensatory effect, wherein parents invest more in low-performing children to maximize their children's potential, however limited (Datar, Kilburn, & Loughran, 2010). The current study addressed both expected benefit and compensatory effects over time.

Third, we examined whether the strength of the aforementioned processes vary as children grow older. For example, we addressed whether the influence of mothers' depression on their provision of support changes across time and whether the influence of mothers' support on children's cognitive ability changes as children get older. These analyses will reveal whether mothers' emotional, and separately, learning-material support influence children's cognitive skills at all points in development, or whether one form of support wanes or strengthens in its influence on children's cognitive ability over time. There is some evidence that mothers'

emotional-verbal responsiveness and learning-material supports have stronger effects for reading abilities and vocabulary skills in younger (3-5 years) versus older (10-13 years) children (Bradley, Corwyn, Burchinal, McAdoo, & Garcia Coll, 2001a). However, other research shows that parental investment inputs affect children's cognitive abilities uniformly from birth to age 7 (Hernandez-Alava & Popli, 2017). Given these findings, no specific hypotheses are put forth regarding varying effects as a function of child age.

Fourth, we tested for the presence of transactional (simultaneous bidirectional) effects and reciprocal feedback processes. Transactional models of development have become increasingly important in documenting how simultaneous bidirectional effects between person and context influence and shape the other over time (Kuczynski, Pitman, & Mitchell, 2009; Sameroff, 2009). Findings consistent with a transactional effect would show that mothers' high investment enhances children's cognitive skills, while children's high cognitive skills simultaneously boost mothers' investment (Gershoff et al., 2009; Lugo-Gil & Tamis-LeMonda, 2008). Reciprocal feedback processes are evident when two factors have an ongoing association across time (Bronfenbrenner, 1999). Given evidence of reciprocal feedback between mothers' academic socialization and children's reading achievement (Sy, Gottfried, & Gottfried, 2013), we hypothesized that mothers' lower investment in their child will contribute to children's subsequent lower cognitive scores, which will feed back to sustain mothers' lower investment. Similarly, other work has shown reciprocal and sustaining effects between maternal depression and mothers' low nurturance (Campbell et al., 2007; Goodman, 2007). Thus, we also hypothesized that high levels of maternal depression will lead to mothers' lower investment in their child, which will feed back to support continued maternal depression. Because mothers and children were studied in infancy and followed into adolescence, results can reveal how patterns of bidirectionality and reciprocity develop and are maintained across time.

Finally, we compared the two mediating models to discern which component of maternal investment might serve as a more salient process linking maternal depression to children's cognitive skills. Although a few studies show that maternal depression is associated with both less interaction with their child and less provision of stimulating learning materials (Albright & Tamis-LeMonda, 2002; Conners-Burrow et al., 2014), we are unaware of any study that has analyzed how these different investment components might differentially mediate the link between mothers' depression and children's cognitive skills.

The current study expands earlier research in several ways. For instance, we analyze the two components of maternal investment within the context of one study to clarify the contribution of each for children's cognitive skills. We also adopt a stringent approach to operationalizing mothers' emotional and learning-material investment in their children. Earlier studies have combined mothers' language stimulation, involvement with child, and stimulating learning materials to index parenting quality or parental investment generally (Gershoff, Aber, Raver, & Lennon, 2007; Lugo-Gil & Tamis-LeMonda, 2008; Stein et al., 2008). Such an approach precludes an understanding of how each investment component (emotional versus learning-material) mediates the effects of maternal depression onto children's cognitive skills. Additionally, most studies have examined mediating mechanisms within a cross-sectional design and analyzed child outcomes only to age 5. The current study includes repeated, longitudinal assessments starting at the child's infancy and extends across 16 years. Furthermore, the current sample was relatively homogenous in socioeconomic class, such that no more than five percent of the sample fell outside the middle- or lower-middle class at any study time point. Social class homogeneity is important when examining maternal depression and family supportive resources as exogenous variables. Furthermore, mothers within the current sample reported relatively frequent depressive symptoms, as is often the case among mothers, particularly those with low income and little education (Ertel, Rich-Edwards, & Koenen, 2011). Thus, findings will be useful for understanding the effects of depressive symptoms as experienced by many mothers.

Method

Participants and Study Design

Participants were 875 Chilean mothers and their children (52% male) who were part of a randomized-controlled infancy iron-deficiency anemia preventive trial or neuromaturation study (Lozoff et al., 2003). Mothers and infants were recruited from community clinics in Santiago, Chile between 1991 and 1996, with a total of 1,790 infants enrolled. All infants were healthy, singleton, born at term and weighed $\geq$ 3.0 kg at birth. Most mothers had a 9th-grade education (9 years of education was compulsory in Chile at the time of study), and almost all children's families were middle- or lower-middle class. Mothers and children were studied when children were 1, 5, 10, and 16 years old. At 5 and 10 years, all children were attending school, and at age 16, all but 2% were attending school. Chile has a literate population and a comprehensive health care system where infant health is generally excellent and generalized undernutrition is virtually

absent. Table 1 shows descriptive information about the study sample.

At 5½ years of age, a drastic budget cut necessitated a smaller sample. Only those children who received either high iron or no iron supplementation at infancy as part of the preventive trial or who were part of a neuromaturation study (iron-deficient anemic infants and nonanemic controls who received more intensive laboratory tests) were contacted for follow up. This involved 1,353 mother-child pairs, of whom 888 families participated at 5½ years. At the 10- and 16-year follow ups, we sought to contact the total original sample (those studied at infancy, N=1,790) to participate.

In order to focus on participants with the most complete longitudinal data, the current analyses included those who were studied at 5½ years (n=888). Thirteen of these families had missing data on most study variables and were eliminated from all analyses, leaving 875 for the current analytic sample. All 875 5-year old participants had data at infancy, 838 had data at age 5, 860 at age 10, and 823 at age 16. The full information maximum likelihood function was applied to replace missing data within the above parameters, and we assessed sample representativeness by testing the robustness of model parameters (described below, in **Analytic Strategy**).

There were no differences between those who were or were not studied at 5½ years in terms of background characteristics (child sex, infant iron status, maternal age, mother IQ, number of children in the household, number of adults in the home, family stress, father presence, mothers' marital status, or parental education) or any of the model variables (children's cognitive scores, mothers' emotional-verbal or learning material support, etc.). However, children in the current analytic sample were less likely to have been breastfed as the sole source of milk at 6 months, less likely to have received iron supplementation in infancy, and were from lower socioeconomic families ($p < .05$). These factors were controlled in all analyses.

Procedure

The infant study and all follow-ups were approved by the relevant institutional review boards in the U.S. and in Chile. Signed informed consent was obtained from parents for their and their child's participation at each time point, and assent was obtained from children at 10 and 16 years.

Measures

At each study time point, Spanish versions of the study measures were used, which have

good reliability and high equivalence to the English-language measures. All measures were extensively pilot-tested with the population under investigation prior to conducting the study, and measures were back-translated to verify comparability with the English version. The Cronbach coefficient alphas reported were obtained using the current sample.

Mothers' depressive symptoms. The Center for Epidemiologic Studies-Depression Scale (CES-D; Radloff, 1977) was completed by mothers at all four study time points. Research-trained psychologists administered the scale to mothers via private interview at the Institute of Nutrition and Food Technology (INTA), a research center at the University of Chile. This 20-item scale asks about the frequency of depressed mood within the past week (e.g., "I could not get going"), with response options ranging from *rarely or none of the time* (0) to *most or all the time* (3). Items were summed so that scores ranged from 0 to 60, with scores $\geq$ 16 commonly used as a threshold for potential depressive symptomatology (Radloff, 1977). Approximately half of mothers had CES-D scores > 16 at any one of the various study time points. Throughout, we use the phrase 'more frequent depressive symptoms' to indicate relatively higher CES-D scores and do not intend this to indicate a clinical diagnosis of depression. In our sample, Cronbach alphas of the CES-D items ranged from 0.83 to 0.91 across the four study time points.

Mothers' emotional-verbal and learning-material support. To assess mothers' emotional-verbal and, separately, learning-material support to their child, mothers were observed in spontaneous interaction with their 1-year old child in their homes using the Home Observation for Measurement of the Environment Inventory (HOME; Caldwell & Bradley, 2003). The HOME observation was conducted by research staff specifically trained in the HOME assessment. When children were 5½ and 10 years of age, mothers were interviewed on the HOME items by a trained researcher at the INTA research center. The HOME is a well-established evaluation of the quality of stimulation and support made available to a child in his or her home, including in Latin American countries (Bradley & Corwyn, 2005). We used the Infant/Toddler HOME (HOME-IT) version at infancy, the Early Childhood HOME (HOME-EC) version at 5½ years, and the Middle Childhood HOME (HOME-MC) version at 10 years. Similar but age-appropriate items were used at the various age assessments. For emotional-verbal support, we used only those items that reflected mothers' warmth/affection and responsivity directed toward their child. This involved nine items from the emotional and verbal responsivity scale at infancy, nine items from the warmth/affection and language stimulation scales at 5 years,

and six items from the emotional and verbal responsivity scale at 10 years (e.g., "mother praises child," "when speaking of the child, mothers' voice conveys positive feelings," "mother hugs child"). Mothers' learning-material support was assessed by the play materials scale at infancy (nine items, "child has toys for literature or music"), 12 items from the learning stimulation scale at age 5 ("child has toys or games that teach color, size, shape), and six items from the growth-fostering materials scale at 10 years (e.g., "child has at least 10 age-appropriate books"). We did not include items that assessed mothers' direct encouragement of or involvement with their child's learning because of their potential conceptual overlap with items indexing mothers' emotional-verbal responsiveness and because the parental investment literature has largely conceptualized parental enrichment as material support and, separately, emotional support.

Items were coded as present (1) or absent (0) and summed across items. Because the number of items at each developmental period varied, scores were standardized, which allowed us to treat the scale as equivalent across age groups. The original mean scores are shown in Table 1 to better indicate the level of maternal support at each time point.

Children's cognitive functioning. Children completed cognitive assessments at 1, 5½, 10, and 16 years as administered by psychologists trained in the administration of such tests at the INTA research center. At 1 year, children were assessed on the Mental Development Index (MDI) portion of the Bayley Scales of Infant Development (BSID; Bayley, 1969). The MDI assesses developmental functioning in language, comprehension, and problem-solving. The test has well-documented reliability and validity (Gagnon & Nagle, 2000), and yields scores with a mean of 100 and standard deviation of 15. At 5½ years, children completed the similarities subtest of the Wechsler Preschool and Primary Scale of Intelligence – Revised test (WPPSI-R; Wechsler, 1989), which consists of 19 items measuring verbal concept formation and verbal reasoning. The standardized subtest has a mean of 10 and standard deviation of 3 (Wechsler, 1989). The similarities subtest of the Wechsler Intelligence Scale for Children – Third Edition (WISC-III; Wechsler, 1991) was used at 10 and 16 years to measure verbal cognition and concept formation abilities. The standardized subtest has a mean of 10 and standard deviation of 3 (Wechsler, 1991).

Covariates. Family socioeconomic status was assessed by parent responses on the 13-item Graffar Social Classification instrument (Graffar, 1956), which is widely used to measure disadvantage in developing countries. Items ask about the family's housing conditions, material

belongings, and parental occupations. Scores range from 13 to 65, with higher scores indicating greater disadvantage. Number of children in the household younger than 15 years, number of adults in the household, mother's marital status, father presence, and mothers' educational level were assessed by maternal interview. Mothers' IQ was assessed at the infant assessment by mothers' completion of an abbreviated Wechsler Adult Intelligence Scale (WAIS-III; Wechsler, 1955), which yields a full-scale IQ score (Mean = 100, SD = 15). Family stress was assessed at all four time points by mothers' completion of a modified Social Readjustment Rating Scale questionnaire (Holmes & Rahe, 1967), which asks about the presence of 30 stressors. (Cronbach coefficient α's ranged from .85 to .91). Infants' iron status was assessed by finger stick hemoglobin level at 6 months and venipuncture with multiple iron measures at 12 and 18 months, and classified as iron sufficient, iron deficient, or iron-deficient anemic. Whether children received iron supplementation as part of the preventive trial was another covariate (coded as no supplementation = 0, some form of supplementation = 1). Child sex and age at each assessment were also included as covariates.

Analytic Strategy

Cross-lagged path analysis using Mplus 6.0 (Muthén & Muthén, 1998-2007) was used to evaluate our conceptual model (Figure 1). We tested two models: one with mothers' emotional-verbal support as the mediator between mothers' depression and children's cognitive scores, the other with mothers' learning-material support as the mediator. As shown in Figure 1, the model includes autoregressive paths, cross-lagged paths, and within-time correlations. Because the autoregressive paths function as a type of control for the cross-lagged paths, the variance that remains is change from the earlier wave. Thus, the parameters for all time points from age 5 to age 16 represent change from the previous time point. Model fit was determined by reviewing indices of good model fit (Kline, 2011), including a nonsignificant chi-square, comparative fit index (CFI) > .90, root mean square error of approximation (RMSEA) < .06, and the standardized root mean square residual (SRMR) < .08. Mediation was tested using the INDIRECT command within Mplus, which estimates indirect effects with the delta method standard errors (Muthén, 2011). Mplus utilizes the full information maximum likelihood (FIML) feature, which incorporates measures that support missing completely at random to impute missing data. Analyses were conducted using the maximum likelihood estimator (MLR), which is robust to non-normality. We tested across-time differences in cross-lagged parameter estimates

using the Wald test of parameter constraints, and we compared the two mediating models using information criteria indices of each model. To test for sample representativeness, we re-estimated the two mediating models using the full sample of those eligible to participate at 5½ years (N = 1353) to discern if these results were consistent with results found using the current analytic sample of 875 mother-child pairs.

Inclusion of covariates. Both mediating models included an identical set of covariates. Correlational results and a review of the literature determined which covariates to control. Mothers' age, educational level, number of adults in the household, family SES and stress were included as covariates on mothers' depressive symptoms. Mothers' age, educational level, family SES, number of children in the home, father presence, and child age and sex were included as covariates on both maternal support variables. Child sex, age, infant iron status, iron supplementation assignment, mothers' educational level and IQ, number of adults in the home, and family SES were used as covariates on children's cognitive scores. The covariates were temporally adjusted where applicable. For example, family stress and family SES at each time point were included as covariates on the corresponding time point of mothers' depression scores. Modification indices did not indicate any additional covariates for any of the models, and all covariates were retained regardless of statistical significance level.

Results

The pattern of correlations among the model variables shows strong stability of all within-domain variables across time, as well as strong predictive relations across time (Table 2). For example, mothers' more frequent depressive symptoms at infancy were significantly related to children's lower cognitive scores at ages 5, 10, and 16, and both mothers' emotional-verbal support and learning-material support at infancy were strongly related to children's cognitive scores at ages 5, 10, and 16. The significant but moderate associations between the emotional-verbal responsiveness and learning-material support scales indicate that they are measuring distinct yet related aspects of maternal support.

Model Results

We first examined whether sample selection at 5½ years yielded unbiased estimates. We did this by analyzing the two mediating models using the sample of those eligible for study at 5½ years (n = 1,353, described above in **Participants and Study Design**). There were no differences in the fit indices and only minimal differences in parameter estimates (e.g., all

significant and nonsignificant findings held). Thus, the results obtained using the analytic sample are robust and not biased by participation at 5½ years. In addition, missingness was ≤ 20% for all variables (Table 1), except for mothers' depressive symptoms at infancy (which had 72% coverage). Little's missing completely at random (MCAR) test for all 14 model variables within the subsample of 875 was not significant (χ^2 [160] = 10.01, p = 1.0), indicating that missing was completely at random. Missingness of mothers' depressive symptoms at infancy correlated with two background variables (mothers' education and family socioeconomic status), which were included as controls.

Next, we tested whether the strength of relations within the two models differed by child sex. The omnibus chi-square difference test was nonsignificant for the multiple group analyses comparing model paths for males and females for both the emotional-verbal model (χ^2 [64] = 60.52, *ns*) and the learning-material model (χ^2 [64] = 57.25, *ns*), suggesting that sex did not moderate the associations in the model.

In addressing this study's main hypothesis, the results of the model analyzing mothers' emotional-verbal support as a mediator indicated that the model had good fit (Figure 2). Results of the within-time paths indicated that, at child ages 5 and 10, mothers' more frequent depressive symptoms were related to lower levels of mothers' emotional-verbal support, and mothers' low emotional-verbal support at the child's infancy and 5 years were related to children's lower cognitive scores. The cross-lagged paths were consistent with mediation, such that mothers' more frequent depressive symptoms at infancy were related to lower emotional-verbal support at child age 5, which related to lower child cognitive scores at age 10. The crossed-lagged paths from mothers' depression at child age 5 to mothers' emotional-verbal support at child age 10 to child's cognitive scores at age 16 were also significant. The significant indirect effects of this model are shown in Table 3 (top) and indicate that both pathways showed significant or marginally significant mediation by mothers' emotional-verbal support.

Regarding the inverse mediated pathways, children's lower cognitive ability at age 5 related to mothers' lower emotional-verbal responsiveness at child age 10, which in turn, predicted mothers' more frequent depressive symptoms at child age 16. This mediated pathway approached statistical significance (Table 3). A significant reciprocal feedback effect was also found, such that mothers' more frequent depressive symptoms at child age 5 predicted decreases in mothers' emotional-verbal support at child age 10, which fed back to increases in maternal

depressive symptoms at child age 16.

The results of the model analyzing mothers' learning-material support as a mediator indicated that the model had good fit (Figure 3). Results of the within-time paths show that mothers' more frequent depressive symptoms at child age 5 were related to mothers' provision of fewer learning materials, and mothers' learning-material support at the child's infancy and age 10 were positively related to children's cognitive scores. The cross-lagged paths were consistent with the hypothesized mediation, such that mothers' frequent depressive symptoms at infancy predicted fewer learning-material supports at child age 5, which related to child's lower cognitive scores at age 10. Mothers' depressive symptoms at child age 5 also related to lower learning-material supports at child age 10, which related to children's lower cognitive scores at age 16. The former indirect effect showed significant mediation and the latter indirect effect was marginally statistically significant (Table 3, bottom).

Several individual inverse paths were also significant (i.e., children's lower cognitive scores at infancy related to fewer learning-material supports at age 5, which related to mothers' more frequent depressive symptoms at child age 10) but did not achieve statistically significant mediation. Two reciprocal feedback pathways are of note (Table 3, bottom). Children's lower cognitive scores at infancy were related to fewer learning-material supports at age 5, which fed back to lower cognitive scores at age 10. Additionally, mothers' more frequent depressive symptoms at child age 5 were related to mothers' lower learning-material investment at child age 10, which fed back to higher levels of maternal depression at child age 16.

Comparisons of Transactional Effects

The results showed three instances of transactional (simultaneous cross-lagged) effects (Figures 2 and 3). Using Wald tests, the paths within one cross-lagged effect were statistically different (Figure 3): the relation between learning materials at infancy and children's cognitive scores at age 5 (β = .17) was stronger than the relation between children's cognitive scores at infancy and learning materials provided at age 5 (β = .09; Wald test = 9.38, p = .002).

Across-Time Differences in Cross-Lagged Effects

The cross-lagged effects were compared across age (Table 4). Two significant differences were found. The effect of mothers' emotional-verbal support at child age 10 on maternal depressive symptoms at child age 16 (β = -.11) was stronger than the effect of mothers' emotional-verbal support at child age 5 on mothers' depressive symptoms at child age 10 (β =

.02; Wald test = 5.71, $p < .02$). Additionally, the effect mothers' learning-material support at child age 10 on maternal depression at child age 16 ($\beta = -.10$) was stronger than the effect of mothers' learning-material supports at infancy on maternal depression at child age 5 ($\beta = .01$, Wald test = 4.04, $p < .05$).

Comparing the Two Mediating Models

We compared the two mediated models using each model's Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), which provide penalizing information reflecting a preference for more parsimonious models. The model with smaller AIC and BIC values is the preferred model (Burnham & Anderson, 2004). The difference in the AICs and BICs was 1515.30, favoring the learning-materials mediated model which was associated with the smaller index value. In terms of evaluating the relative strength of the two models for predicting the endogenous (outcome) variables, both models yielded equivalent R^2 values, apart from predicting maternal support at 5 years. The model variables accounted for 20% of the variance in mothers' learning-material support at 5 years and 9% of the variance in mothers' emotional-verbal support at 5 years.

Discussion

This study utilized a parental investment framework to understand the association between maternal depression and children's cognitive abilities. The study results suggest several general conclusions. First, mediation results indicated that mothers' more frequent depressive symptoms appear to dampen mothers' ability to invest emotionally and materially in their child, which undermined their child's cognitive growth and development. This indirect pathway was significant from the child's infancy to age 10 and held marginally from child age 5 through age 16. The consistency and longevity of this result speaks to the enduring effect of depression on mothers' parenting and their children's development. Indeed, mothers' depression is known to interfere with their sensitive and responsive caregiving during their child's early formative years (Kurstjens & Wolke, 2001; Yan & Dix, 2016), but the effect of mothers' depression on their parenting up until their children reach adolescence has been less studied. The current findings show consistent negative effects of maternal depression on mothers' investment in their children which, in turn, had long-term detrimental effects on children's cognitive abilities.

Second, there was some evidence for an inverse mediated pathway, such that children's lower cognitive abilities inhibited mothers' emotional and learning-material investment, which

subsequently led to higher levels of mothers' depression. This finding supports a transactional and dynamic view of development, with mothers reacting to the individual characteristics of their child, which precipitate changes in the mother (Sameroff, 2009). The current findings indicate that children's lower developmental functioning as early as 1 year can be disruptive for mothers' later responsivity. It may be that mothers emotionally and verbally disengage with less cognitively advanced children which, in turn, contributes to mothers' depressive symptoms. Studies show that mothers of children with a cognitive delay report lower responsiveness (Guralnick, Neville, Hammond, & Connor, 2007), as well as high levels of depression, stress and difficulties coping and managing such children (Cheng, Palta, Poehlmann-Tynan, & Witt, 2015). The children in the current study tested broadly in the normal intelligence range. Thus, study findings indicate similar effects when children score in the lower normal range.

A third finding of this study is that the magnitude of some cross-lagged effects increased significantly across children's development. Specifically, mothers' low provision of support (both emotional-verbal and learning-material) was more strongly linked with maternal depression as children got older. The increase in this link across age might reflect a distancing between mother and child and is consistent with studies showing increases in maternal distress as children age into adolescence (Luthar & Ciciolla, 2016). Children might also be seeking independence from their mothers, with less need for maternal support, which could also be distressing for mothers (Steinberg & Silk, 2002).

Results also revealed several reciprocal-feedback processes, some of which achieved statistical significance. For instance, mothers' experiences of depression during their child's early childhood appeared to dampen mothers' warmth and affection toward their child during middle childhood, which fed back to sustain mothers' depression when their children reached adolescence. This reflects an unfortunately typical feedback cycle, with depressive symptoms negatively affecting social relationships, which serve only to increase feelings of loneliness and isolation (Goodman, 2007; McCue Horwitz, Briggs-Gowan, Storfer-Isser, & Carter, 2007). This cyclical process might also be occurring due to children's behavior problems. That is, low child cognitive functioning is often accompanied by externalizing behaviors (Baker et al., 2003). Thus, children's behavior problems might be triggering mothers' depression in addition to a child's low cognitive abilities. In either case, the current findings demonstrate the sustaining effects maternal depression can have on long-term mother-child relations and mothers' future mental

health.

We also found that mothers invested less in learning materials for children who had lower cognitive abilities at infancy, and fewer learning materials contributed to further declines in children's cognitive scores between ages 5 to 10. In this case, mothers appear to be reacting to the expected benefit and 'endowments' of their child, with mothers investing less in lower-ability children (Behrman, 1997). Some literature points to compensatory effects, wherein parents invest more in low-performing children (Datar et al., 2010). Evidence for this effect was not found in this sample.

In one of this study's few transactional effects, findings showed that mothers' learning-material support at infancy had a stronger effect on children's cognitive scores at age 5 than the reverse. Thus, although both processes seem to be at work (children's cognitive skills influence mothers' learning-material investment and mothers' learning-material investment contributes to children's cognitive skills), mothers' initial material supportiveness appears to have a stronger impact on children's subsequent cognitive abilities. In fact, both mothers' emotional and learning-material supportiveness had significant effects on children's subsequent cognitive scores from infancy to adolescence, suggesting the consistent and long-term importance of such inputs.

Comparisons between the two mediating models indicated that the learning-material support model was a slightly better fitting model. Additionally, the model variables accounted for slightly more variability in mothers' learning-material supports than mothers' emotional-responsiveness. However, the models were highly comparable in the other fit indices and accounted for similar proportions of the variance in the other endogenous variables. Thus, neither mediating mechanism was found to be vastly superior over the other in terms of understanding how maternal depression affects children's cognitive skills.

Limitations and Strengths

Study limitations should be considered when interpreting the findings. For instance, the HOME instrument was completed in different formats at different study periods (by in-home observation at infancy and by interview with mothers at 5½ and 10 years). Several large-scale studies that have implemented the HOME by in-home observational visits supplemented by phone or in-person interview show good equivalence between formats (e.g., Han, Leventhal, & Linver, 2004). However, there remains the issue of reporter bias between the HOME scores

derived by maternal interview and mothers' self-report on the depression inventory. In addition, the HOME items that assessed mothers' emotional-verbal and learning-material support across the three age periods were age-appropriate but not identical. This is due in part to variations in the HOME instruments for various developmental periods. Bradley and others provide evidence that the scores on the various factors of the HOME instrument represent the same constructs across different age periods, despite some variation in actual item content (Bradley et al., 2001a, 2001b).

Our sample was lower-middle and middle-income. The results may not generalize to families of other socioeconomic levels. It should be noted, however, that the reduced variability of social class within the current sample allowed for better control of potential confounding due to socioeconomic factors. Although we statistically controlled for family, home, mother, and child characteristics in attempts to adjust for extraneous factors, unmeasured features in the environments of mothers and children within this sample could have contributed to the observed relations.

It is also possible that this Chilean sample may not be representative of mothers or children of other cultural backgrounds or nationalities. In the past 30 years, parenting socialization patterns in Chile have readjusted in response to a re-establishment of democracy after nearly two decades of military government (Darling, Cumsille, & Peña-Alampay, 2005). Parenting is now more consistent with broader social convictions emphasizing age-appropriate child autonomy and independence as opposed to strict conformity and obedience (Bush & Peterson, 2014). Additionally, traditional patriarchal gender roles were present during much of the course of this study, with significantly fewer Chilean women attending college or university than men (Martinez, Cumsille, & Thibaut, 2006). Most study mothers, while literate, had only 9 years of education, were not employed outside the home, and often lived with extended family in small crowded homes, factors that may have contributed to their depressive symptoms.

Although family characteristics, such as father presence, number of children and number of adults in the household were considered as covariates, each of these factors likely plays a role in the mechanisms examined. For example, it is plausible that a mother with several other young children to care for might lack the resources (both emotional and economic) to optimize her child's cognitive development. Also important is the role of fathers. The child of a depressed mother who is a single parent or with an absentee father may be more affected by their mothers'

depression compared to a child with an emotionally and physically present father. Extended family might also compensate for a depressed mothers' emotional withdrawal. These issues represent areas for further study.

Finally, while the current findings show that maternal depressive symptoms at a particular point in time were associated with both mothers' investment in their children and children's cognitive scores, it is important to recognize the stability of mothers' depression across time. Children's exposure to chronic maternal depression seems to be associated with more problematic child outcomes than intermittent depressive bouts (Sohr-Preston & Scaramella, 2006). Studies examining the longitudinal and possible accumulating effects of mothers' continued depressive symptomatology on mothers' parenting and children's development are needed.

The study is strengthened by a four-wave longitudinal design encompassing important developmental periods from infancy to adolescence. Very few studies have addressed mediated and transactional pathways across such an extended timeframe and, thus, most cannot assess the strength of relations across children's development. Other strengths include the use of tester-, observer-, and mother-reports in the assessment of study variables and a relatively large sample. It is also noteworthy that study children were healthy as newborns. Thus, there were no neonatal health problems confounding children's cognitive abilities. Additionally, the mothers in this study reported relatively frequent depressive symptoms. High rates of depression have often been found among mothers with young children and in mothers from developing countries (Ertel, et al., 2011; McCue Horwitz et al., 2007; Wolf, De Andraca, & Lozoff, 2002). Thus, the current findings are relevant to many mothers around the world.

Conclusions

Findings reveal long-term adverse effects of mothers' depression for their parenting and their children's development. Findings highlight the importance of early identification and treatment of maternal depression, particularly given research citing its wide prevalence. Home-based interventions that foster appropriately responsive and stimulating parenting with depressed mothers would likely be helpful to both mother and child (Van Doesum, Riksen-Walraven, Hosman, & Hoefnagels, 2008). Interventions that help mothers appropriately respond and stimulate less cognitively able children would also likely be mutually beneficial (Landry et al., 2006). In addition, enrichment programs that provide supplemental learning resources to children

affected by maternal depression would help ensure that such children reach their full cognitive potential. Recognition of the value to mothers to remain emotionally connected with their children, particularly as they transition into adolescence, is also important. In all, study findings provide an understanding of the dynamic and enduring relations among mothers' depression, their investment in their children, and children's cognitive functioning across development.

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Table 1. *Descriptive Statistics of Sample and Study Measures (N = 875)*

Variable	N	Min	Max	Mean or %	Standard deviation
Child characteristics					
Sex (1=male)	875	0	1	52.0%	
Child age					
Infancy (months)	875	12	18	13.80	2.74
5 years	875	5.4	6.0	5.51	0.05
10 years	875	10	11	10.01	0.08
16 years	875	15.3	17.4	16.19	0.20
Breastfeeding at 6 months	864	0	1	61.0%	
Iron status at infancy	875				
Iron sufficient	499	0	1	57%	
Iron deficient/ID-anemic	376	0	1	43%	
Iron supplementation	875				
Iron supplemented	518	0	1	59.2%	
Not iron supplemented	357	0	1	40.8%	
Mother characteristics					
Mothers' age (years)[a]	868	15	44	26.63	6.03
Mothers' education (years)					
At child age 1 year	875	1	17	9.47	2.70
At child age 10 years	857	1	19	9.78	2.02
Mothers' IQ[a]	846	58	115	85.6	9.90
Marital status[a]	837				
Married	611	0	1	73%	
Separated	100	0	1	12%	

Never married	126	0	1	15%	
Family characteristics					
Socioeconomic status[b]					
At child age 1 year	873	19	65	39.75	8.14
At child age 5 years	838	19	59	35.97	7.82
At child age 10 years	838	19	63	34.12	7.39
At child age 16 years	823	18	58	33.10	6.74
Family stressors					
At child age 1 year	859	0	14	4.66	2.62
At child age 5 years	838	0	15	5.05	2.62
At child age 10 years	854	0	15	4.96	2.62
At child age 16 years	800	0	13	4.51	2.65
No. children < 15 yrs in family[a]	814	1	8	2.14	1.20
No. adults in household[a]	837	1	11	3.23	1.68
Father present[a]	837	0	1	85%	

Table continues

Mothers' depressive symptoms					
At child age 1 year	627	0	51	15.97	12.04
At child age 5 years	839	0	59	19.66	13.68
At child age 10 years	856	0	57	18.02	12.93
At child age 16 years	705	0	60	19.03	13.98
Mothers' support					
Emotional-verbal support					
At child age 1 year	702	0	9	6.45	1.74
At child age 5 years	700	0	9	7.53	1.60
At child age 10 years	854	0	6	4.11	1.47

Learning-material support					
At child age 1 year	702	0	9	3.99	1.79
At child age 5 years	700	0	12	5.24	2.36
At child age 10 years	857	0	6	3.18	1.27
Child cognitive functioning					
Bayley Mental Development Index, 1 year	875	58	140	105.08	12.07
WPPSI-R[c], 5 years	805	2	16	7.73	1.94
WISC-R[c], 10 years	860	1	19	8.41	3.43
WISC-R[c], 16 years	776	2	17	8.17	1.99

[a]Assessed at child's infancy. [b]Higher scores indicate greater poverty, or lower socioeconomic status. [c]The similarities subtest was given, which measures verbal abilities.

Table 2

Correlations among Mothers' Depressive Symptoms, Emotional-Verbal and Learning-Material Support, and Child Cognitive Functioning

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Mat depress – 1	--												
2. Mat depress – 5	.37***	--											
3. Mat depress – 10	.39***	.48***	--										
4. Mat depress - 16	.34***	.38***	.45***	--									
5. Emotional-verbal – 1	- .01	-.01	-.04	-.03	--								
6. Emotional-verbal – 5	-.16**	-.26***	-.11**	-.18***	.12*	--							
7. Emotional-verbal – 10	-.09*	-13***	-.19***	-.16***	.15***	.26***	--						
8. Learning-material – 1	-.07	-.04	-.04	-.11*	.24***	.03	.05	--					
9. Learning-material – 5	-.10*	-.18***	-.19***	-.15**	.17**	.29***	.19***	.22***	--				
10. Learn-material – 10	-.12**	-.18***	-.15***	-.16***	.17***	.20***	.23***	.14**	.41***	--			
11. Child cognitive – 1	-.01	-.03	-.01	-.01	.09*	.05	-.01	.20***	.10**	.01	--		
12. Child cognitive - 5	-.11*	-.05	-.04	-.05	.11*	.12**	.12**	.17**	.13**	.08*	.14***	--	
13. Child cognitive – 10	-.14**	-.09*	-.12***	-.09*	.13**	.11**	.14***	.11*	.22***	.19***	.05	.26***	--

14. Child cognitive – 16	-.09*	-.14***	-.14***	-.12**	.14**	.14**	.11**	.18***	.26***	.21***	.09*	.18***	.51***

*$p < .05$. **$p < .01$. ***$p < .001$. Mat depress = mothers' depressive symptoms. Emotional-verbal = mothers' emotional-verbal support. Learning-material = mothers' learning-material support. Child cognitive = children's cognitive functioning.

Table 3

Summary of Significant Indirect Effects Derived from a Cross-lagged Path Analysis of Mothers' Depressive Symptoms, Emotional-Verbal and Learning-Material Support, and Children's Cognitive Functioning

	B	*(SE)*	Type of effect
Emotional-verbal model			
Mat depress 1 → emo-verb support 5 → child cog 10	-.005*	.002	mediated
Mat depress 1 → child cog 5 → emo-verb support 10	-.002^{+}	.001	direct-inverse
Mat depress 5 → emo-verb support 10 → child cog 16	-.001^{+}	.001	mediated
Child cog 5 → emo-verb support 10 → mat depress 16	-.054^{+}	.030	inverse mediated
Mat depress 5 → emo-verb support 10 → mat depress 16	.012*	.006	reciprocal feedback

Learning-material model

Child cog 1 → learn-material support 5 → child cog 10	.003*	.002	reciprocal feedback
Child cog 1 → learn-material support 5 → mat depress 10	-.007^{+}	.004	inverse mediated
Mat depress 1 → learn-material support 5 → child cog 10	-.004*	.002	mediated
Mat depress 5 → learn-material support 10 → child cog16	-.007^{+}	.004	mediated
Mat depress 5 → learn-material support 10 → mat depress 16	.009^{+}	.005	reciprocal feedback

Note. Mat depress 1 = mothers' depressive symptoms at 1 year. Emo-verb support 5 = mothers' emotional-verbal support at 5 years. Learn-material support 10 = mothers' learning-material support at 10 years. Child cog 16 = children's cognitive functioning at 16 years.

$+p < .09$. $*p < .05$.

Table 4. *Across-Age Cross-Lagged Effects Derived from a Cross-lagged Path Analysis of Mothers' Depressive Symptoms, Emotional-Verbal and Learning-Material Support, and Child Cognitive Functioning*

Pathways	B	SE	β	Inverse Pathways	B	SE	β

Mat depression 1 → emo-verbal 5	-.020	.008	-.12*	Emo-verbal 1 → Mat depression 5	-.237	.198	-.05
Mat depression 5 → emo-verbal 10	-.021	.007	-.11**	Emo-verbal 5 → Mat depression 10†	.108	.213	.02
				Emo-verbal 10 → Mat depression 16†	-.533	.174	-.11**
Emo-verbal 1 → child cog 5	.087	.037	.12*	Child cog 1 → emo-verbal 5	.010	.006	.06
Emo-verbal 5 → child cog 10	.198	.060	.12**	Child cog 5 → emo-verbal 10	.101	.046	.07*
Emo-verbal 10 → child cog 16	.060	.025	.08*				
Mat depression 1 → learn-material 5	-.018	.008	-.10*	Learn-material 1 → Mat depression 5††	.090	.331	.01
Mat depression 5 → learn-material 10	-.010	.004	-.09**	Learn-material 5 → Mat depression 10	-.417	.205	-.07*
				Learn-material 10 → Mat depression 16††	-.871	.336	-.10**

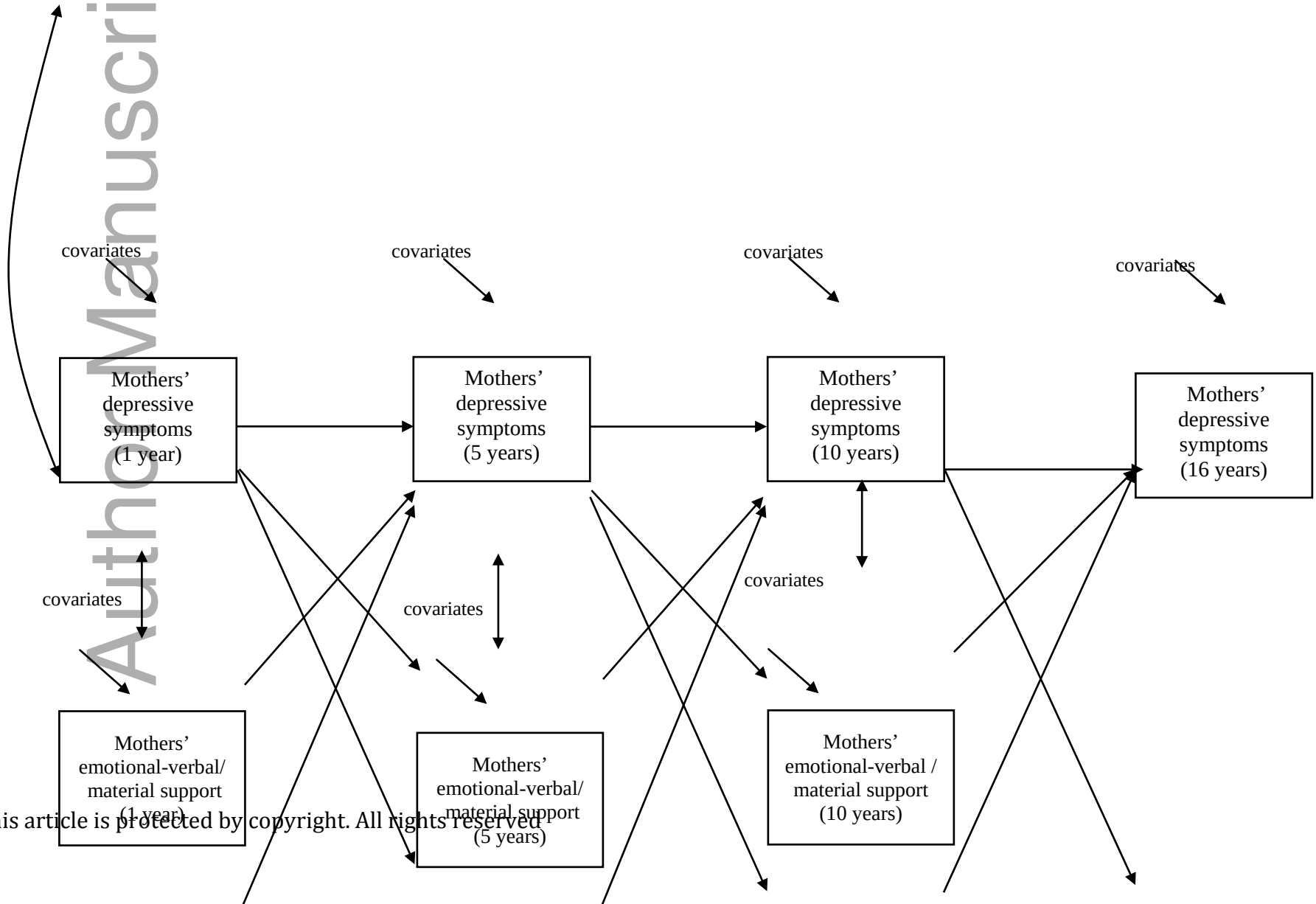
Learn-material 1 → child cog 5	.192	.057	.17**	Child cog 1 → learn-material 5	.017	.006	.09*
Learn-material 5 → child cog 10	.207	.065	.13**	Child cog 5 → learn-material 10	.022	.028	.03
Learn-material 10 → child cog 16	.098	.047	.07*				

Table continues.

Table 4 continued.

Pathways[a]	B	SE	β	Inverse Pathways[a]	B	SE	β
Mat depression 1 → child cog 5	-.019	.007	-.13**	Child cog 1 → Mat depression 5	-.053	.039	-.05
Mat depression 5 → child cog 10	-.002	.009	-.01	Child cog 5 → Mat depression 10	-.035	.224	-.01
Mat depression 10 → child cog 16	-.009	.005	-.05	Child cog 10 → Mat depression 16	.036	.139	.01

*$p < .05$. **$p < .01$. † Beta coefficients are significantly different. [a]Coefficients were nearly identical for both models.



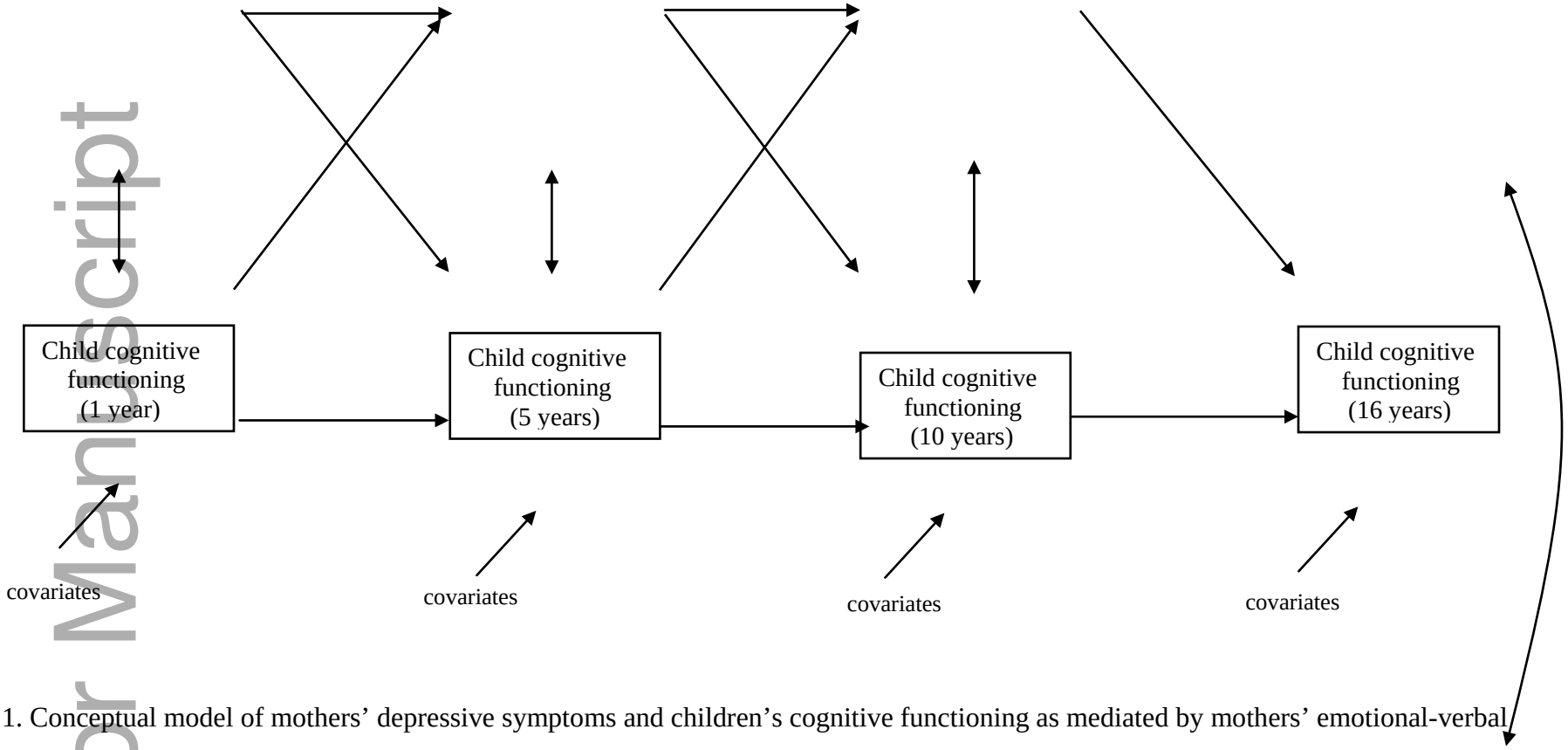
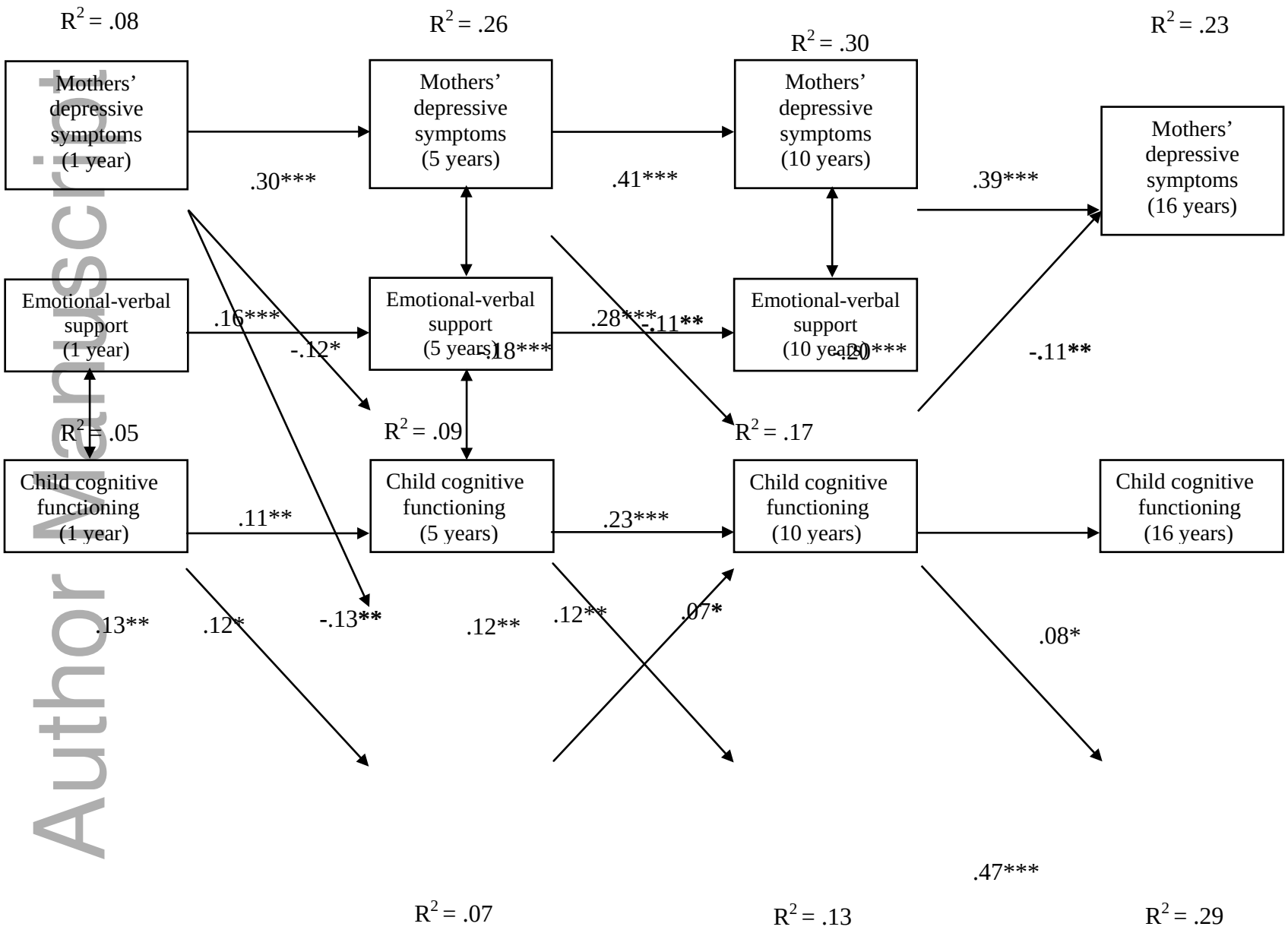


Figure 1. Conceptual model of mothers' depressive symptoms and children's cognitive functioning as mediated by mothers' emotional-verbal and learning-material support to child. (5- and 10-year maternal depressive symptoms and child cognitive functioning were allowed to correlate, but these paths are not shown for ease of presentation.)



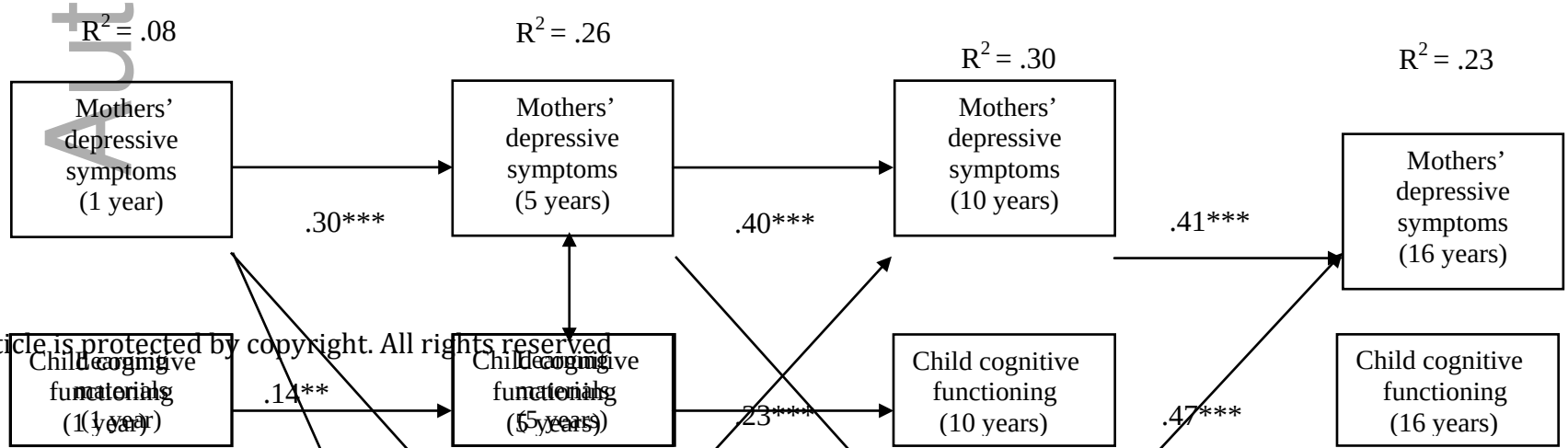


Figure 2. Model of mothers' emotional-verbal responsivity toward child as mediating the association between mothers' depressive symptoms and child cognitive functioning. Standardized coefficients are shown. Covariates are not shown. The model had good fit: χ^2 [150] = 257.11, CFI = .928, RMSEA = .029, SRMR = .033. All paths shown in Figure 1 were included; only statistically significant paths are shown. N = 875. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

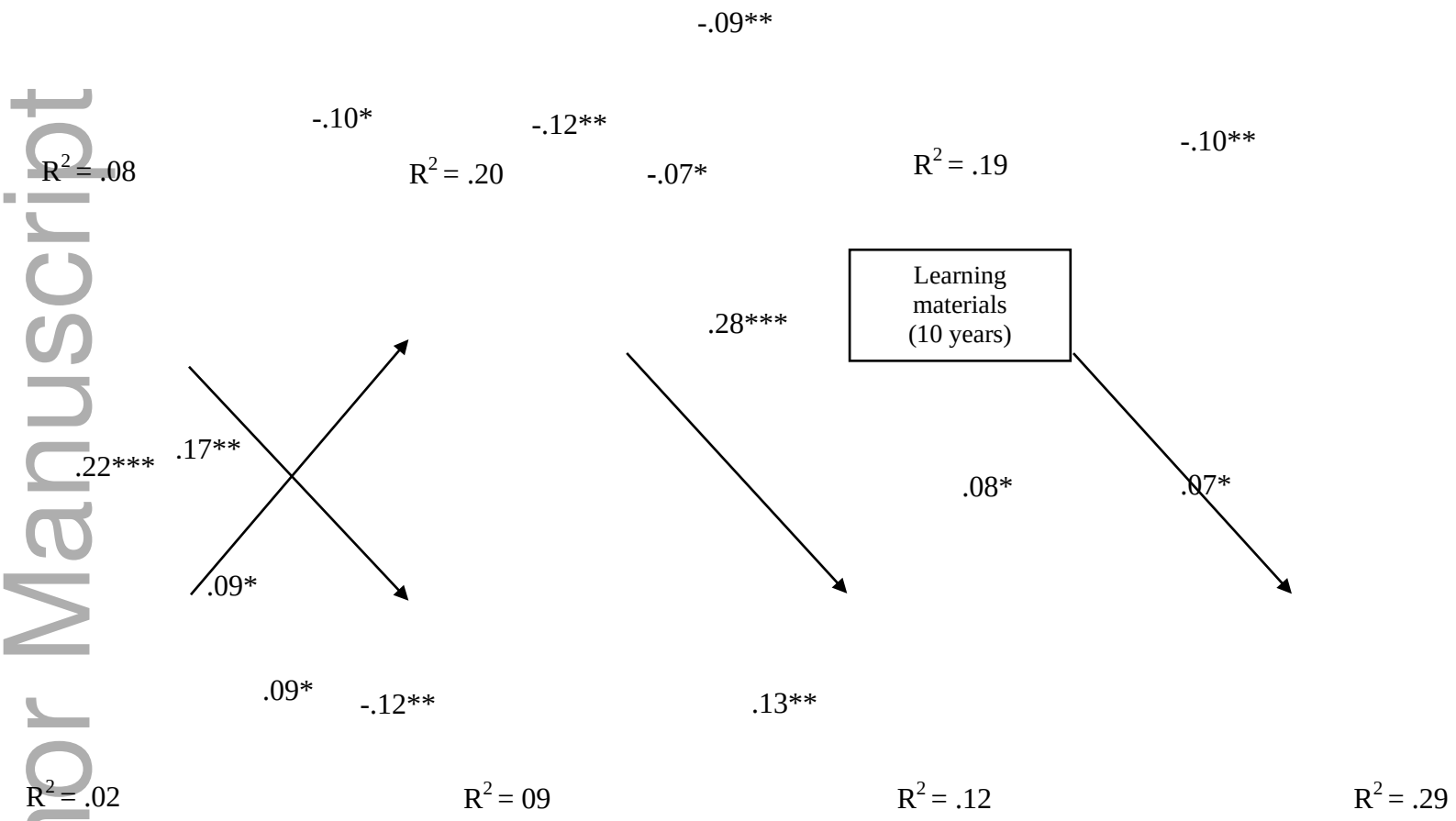


Figure 3. Model of child learning materials in the home as mediating the association between mothers' depressive symptoms and child cognitive functioning. Standardized coefficients are shown. Covariates are not shown. The model had good fit: χ^2 [150] = 288.85, CFI = .913, RMSEA = .033, SRMR = .034. All paths shown in Figure 1 were included; only statistically significant paths are shown. N = 875.

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.