A mediation meta-analysis of the role of maternal responsivity in the association between socioeconomic risk and children's language.

Sahar Borairi[1], Pasco Fearon[2], Sheri Madigan[3], Andre Plamondon[4], Jennifer Jenkins[5]

[1] Department of Applied Psychology and Human Development, University of Toronto;
sahar.borairi@mail.utoronto.ca
[2] Research Department of Clinical, Educational and Health Psychology, University College Lond
p.fearon@ucl.ac.uk
[3] Department of Psychology, University of Calgary
sheri.madigan@ucalgary.ca
[4] FSÉ Department of Educational Foundations and Practices, Laval University
andre.plamondon@fse.ulaval.ca
[5] Department of Applied Psychology and Human Development, University of Toronto
jenny.jenkins@utoronto.ca

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Correspondence concerning this article should be addressed to:
Jennifer Jenkins, Department of Applied Psychology and Human Development,
University of Toronto, 252 Bloor St W., Toronto, ON M5S 1V6, Canada.
Email: jenny.jenkins@utoronto.ca

Abstract

This meta-analysis tested maternal responsivity as a mediator of the association between socioeconomic risk and children's preschool language abilities. The search included studies up to 2017 and meta-analytic structural equation modelling (MASEM), allowed us to examine the magnitude of the indirect effect across 17 studies (*k*=19). The meta-analysis included 6433 predominantly White, English speaking children (mean age= 36 months; 50% female) from Western, industrialized countries. All paths in the model were statistically significant, notably, the indirect effect was significant (*b*=-.052), showing that maternal responsivity may be a proximal intervening variable between socioeconomic risk and children's language development. Moderator analyses found that the indirect effect was stronger for sensitive parenting than warmth and when parenting was assessed in the family home.

Keywords: Meta-analytic structural equation modelling, family resources, language development

A considerable body of literature suggests that children's language development is shaped by distal factors such as the availability of economic resources (Hoff, 2003; Pan et al., 2005; White, 1982) and proximal factors such as caregiver interactions (Madigan et al., 2019). It is important to consider how these distal and proximal factors operate together on child language skills. Ecological models of child development capture the idea that there are multiple embedded levels of the environment that have an effect on children, both directly and indirectly, including broad influences, such as culture, laws and the economics of countries to the child's more immediate experiences, such as the quality of parenting that they receive (e.g., responsive parenting). One way of testing this empirically, has been to use a mediation model to examine the distal to proximal to child outcome associations, capturing the idea that levels of the environment have knock-on effects (Bronfenbrenner & Morris, 1998; Conger et al., 1994; Lerner et al.,2005). Specifically, distal factors such as socioeconomic status (SES) are hypothesized to shape child language via environmentally transmitted effects on parental responsivity. While single studies have examined the indirect effect of socioeconomic status on children's language through parental responsivity (Morisett et al., 1990; Mistry et al., 2008; Raviv et al., 2004), there is currently no integrated synthesis that speaks to the strength of this indirect effect, nor the factors that may moderate it. A novel method known as meta-analytic structural equation modelling (MASEM) combines the advantages of meta-analysis with those of structural equation modelling (SEM) and allows for the examination of the strength of this indirect effect, aggregated across all current studies, as well as potential moderators.

The mediating role of responsivity in the association between socioeconomic risk and children's language

A range of proximal processes in children and the family environment, beyond responsive parenting, could potentially be mediators of the association between socioeconomic status and children's language (e.g., prematurity, birthweight, parental language input, print materials in the home). We wanted to test the mediating role of responsivity for three reasons. First, it has been sufficiently examined in single studies for a meta-analysis to be worthwhile. Second, maternal responsivity has been found to play a causal role in children's language in randomized controlled trials (e.g., Raby et al., 2019; Suskind et al., 2016). Third, responsivity has been identified as a mechanism that strengthens neural connections in regions of the brain responsible for language and has been positively associated with children's global neural structure (e.g., increased brain volume, cortical thickness) and activation in language networks (Romeo et al., 2018).

Responsive caregivers are attuned to both children's emotional and cognitive states: they are not only aware of how children are feeling and respond empathically (Ainsworth et al., 1978), but also recognize what children are interested in and capable of and respond with the right level of support or challenge to help them learn (Vygotsky, 1978). Two aspects of responsive parenting (sensitivity and warmth) have been distinguished. They have both been found to correlate with one another and to be important in children's language development (Hoff, 2003; Tamis-LeMonda et al., 2001). Optimal learning occurs in children when an interactional partner recognizes a child's interest and cognitive level and offers inputs that are just slightly above what a child already understands (Vygotsky, 1978). Sensitive parenting optimizes children's learning conditions, since it involves the provision of attuned, clear, concrete, and developmentally appropriate communicative strategies to facilitate child engagement within a secure parent-child relationship (Ainsworth et al., 1978). Tomasello et al. (2005), Baldwin (1995) and others have argued that the process of establishing shared intentionality or a common ground orientation is at the basis of language learning. Joint attention has been found to improve the efficiency of word learning and this may be because the parent is attuned to the child's gaze and interest and expands the child's language exposure with an elaboration that is just beyond what the child already understands (Tomasello & Farrar, 1986; Vygotsky, 1978). In doing so, children are provided with high quality of linguistic input that is matched to their interests and developmental capacities (Hoff, 2006; Tamis-Lemonda et al., 2014). Likewise, when caregivers are sensitive to their child's signals and needs, they provide an environment rich in "serve and return" experiences. Young children naturally reach out for interaction and initiate communication through babbling, facial expressions, and gestures and adults respond with the same kind of vocalizing and gesturing back at them. This back-and-forth is both engaging and capacity-building. This reciprocal process is fundamental to a child's developing neural architecture especially in the earliest years. Romeo et al., 2018 found that the number of conversational turns between children and adults significantly mediated the relationship between SES and children's verbal-ability and children who experienced more conversational turns exhibited greater activation in left inferior frontal regions (Broca's area) during language processing. Further, it was found that conversational turns and Broca's area activation jointly mediated the relationship between SES and children's language abilities, demonstrating both environmental and neural mechanisms underlying SES disparities in early language skills.

Although sensitivity and warmth underscore distinct domains of parenting they are complementary and may operate symbiotically as “active parenting ingredients” linked to children’s language development. Warm parenting involves offering praise and encouragement and promoting autonomy. Warmth, is also expected to encourage children’s motivation to develop language by supporting mutual engagement in positive interpersonal interactions and by facilitating children’s understanding that language is a tool for communicating desires and intentions with others (Hoff, 2006; Tamis-Lemonda et al., 2014).

The proposed mechanism from SES risk to parental responsivity relates to the challenge parents face in being responsive to their children when juggling multiple priorities and challenges. Parents experiencing socioeconomic disadvantage face a host of challenges such as managing sporadic income, securing stable housing and making difficult trade-offs in how they spend their time attending to these challenges and how much time they are able to spend with their young children (Schilbach et al., 2016). Being preoccupied and stressed by financial challenges has been shown to tax cognitive bandwidth (the ability to perform the basic functions that underlie higher-order behavior and decision-making (Mullainathan & Shafir, 2013) making it much harder for parents to actively and consistently provide their children with the responsive caregiving that has been shown to be important for language development (Landry et al., 2006).

The distal and proximal factors associated with children’s language development operate very early in children’s lives. Fernald et al. (2013) show differences in children’s language as a function of socioeconomic status can be seen as early as 18 months, with a six-month language gap emerging between higher- and lower-SES toddlers by 24 months. Differential trajectories of language growth established by 3 years of age continue to widen until age 5 years, when children enter school, and then level off, resulting in a large gap in vocabulary in children in kindergarten and first grade. These ability gaps show a high level of stability over time and predict later school success (Farkas & Beron, 2004). Thus, it is important to identify pathways of influence to inform prevention and intervention.

Testing Mediation Pathways using Meta-Analytic Structural Equation Modelling

The broad goal of mediation studies is to test a hypothetical causal chain in which one variable X, affects a second variable M, and, in turn, that variable affects a third variable Y. In other words, ‘how or why does X influence Y’. MASEM allows for the examination of the strength of this indirect effect, aggregated across all current studies. While causal influence is a theoretical assumption of the model, the model itself does not provide an empirical test of causal processes, as it is based on a pattern of correlation between factors rather than an experimental manipulation. It is also worth noting that mediation models such as the one presented in this paper only test the association of factors specified in the model (not the range of influences that are possible) and the unidirectionality of effect (although this may not be the only direction of effect operating). The naming convention of pathways, used in single mediation studies, is followed: socioeconomic risk to responsive parenting (path a), responsive parenting to children’s language (path b), and socioeconomic risk to children’s language (path c’), and the mediational pathway socioeconomic risk to child language through responsive parenting (path a*b).

Potential Moderators in Meta-Analytic Structural Equation Modelling

One significant advantage to conducting meta-analyses is to assess potential moderators that may explain existing variation in effect sizes. In this study different types of moderator were examined (type of responsivity, measurement). Moderation analyses help to identify the components of responsivity that are most important as well as for “whom”, “when pathway effect sizes were stronger or weaker. Based on previous research we made the following confirmatory hypotheses about the following moderators:

Type of Responsivity: Sensitivity versus Warmth. With regard to responsivity, Madigan et al. (2019) found that the association between maternal sensitivity and child language was statistically stronger (k = 36; r = 0.27) than that between maternal warmth and child language (k = 13; r = 0.16). It has been argued that the contingent nature of sensitivity, involving parental attention to child gaze and the linguistic expansion within the child's zone of proximal development is particularly important for language learning (Baldwin,1995; Tomasello & Farrar, 1986; Tomasello et al., 2005). Thus, we hypothesized that the indirect effect for sensitivity would be stronger than that for warmth.

Measurement. The diversity of measurement techniques across studies suggest that measurement factors may explain some of the heterogeneity between studies in this area. For example, the strength of pathway associations may vary as a function of the location of the parenting observation (home or lab). Home observations of parenting may be more predictive of outcomes because they occur in a naturalistic setting where they are more likely to capture the "true" picture of parenting behaviors (Gardner, 2000).

Study Design. Longitudinal designs are typically more stringent and less susceptible to bias and are therefore considered to yield a more accurate estimate of effect sizes. Longitudinal designs are also more likely to capture the enduring effect of risk and responsivity on child language (Madigan et al., 2019). Consequently, we hypothesized that the indirect effect for responsivity would be stronger for longitudinal than cross-sectional data.

The following moderator analyses undertaken in this meta-analysis are exploratory, given that previous research has suggested, but not conclusively demonstrated, that these variables may amplify or attenuate pathway associations.

Child Sex. Generally, most studies have found minimal sex-differences in vocabulary development early in development. For example, research suggests that girls may exhibit stronger receptive and expressive language skills around 18- months but these are minimal by two years old (Huttenlocher et al., 1991). Leaper and Smith (2004) found that girls were slightly more talkative than boys, but the overall effect size was negligible and was significant only in the youngest group of children (12–35 months). With respect to parenting, there is evidence that mothers may exhibit less sensitive parenting toward male versus female children (Tamis-Lemonda et al., 2009) although this has not been confirmed using meta-analysis (Madigan et al., 2019). It is important to examine these associations in the context of risk, as there is some evidence to suggest that low SES may be more negative for boys than girls (Barbu et al., 2015).

Child Age. Important age considerations that may explain variation in effect sizes across studies include the age of the child at the time at which responsivity and risk are assessed, and the age of the child when language skills are assessed. Socioeconomic risk and responsivity may have a greater impact on children's language skills at certain developmental stages of language (Rowe, 2012). The importance of responsive parenting may be higher during the early years when brain plasticity is highest (Kolb & Gibb, 2011;Kolb et al., 2012) and this is also the time during which children spend the most time with parents; parental influence may weaken as children begin to interact with teachers and peers (Flynn, 2016).

The Current Study

The aim of the current MASEM was to examine both the direct and indirect associations between socioeconomic risk, responsive parenting, and child language. We targeted evidence from the preschool years because of the early environmental effects described above, stability in language and findings from economics that programs that focus on this period show the largest return on investment (Heckman and Mosso, 2014). We made the confirmatory prediction that responsive parenting would mediate the relation between SES risk and language skills of children. Based on previous research, it was hypothesized that the indirect effect would be stronger for sensitive parenting, home observations and longitudinal studies. Sample characteristics such as child sex and age were also explored as potential moderators.

Methods

Search Strategy

Searches were conducted by a medical librarian in Medline, Embase, PsycINFO, Web of Science, and Dissertation Abstracts up to June 2017. Both database-specific subject headings (when available) and text word fields were searched for the concepts of “language,” “parents,” and “children.” Synonymous terms were first combined with the Boolean “OR.” These 3 concepts were then combined with the Boolean “AND.” In all databases, truncation symbols were used in text word searches when appropriate to capture variations in spelling and phrasing. References of all included studies were also searched. No language or date limits were applied.

Definitional Criteria

With a potentially small number of studies that measured the three constructs necessary for testing our mediation hypothesis (socioeconomic risk, maternal responsivity and child language) we defined the constructs inclusively.

Socioeconomic risk was defined based on the traditional socioeconomic status indices of income (including poverty, income and income to needs ratio) and education). *Child language* was assessed as receptive or expressive language and assessed via parent-report questionnaires (e.g., MacArthur Communicative Development Inventory; Fenson et al.,1993) or standardized assessments (e.g., Peabody Picture Vocabulary Test; Dunn & Dunn, 2007). Responsivity was assessed with an observational measure of sensitivity or warmth (type captured the subcategory) following usual practice for the construct (Mesman et al., 2013; Zaslow et al., 2006). *Sensitivity* refers to a parent's ability to perceive and interpret the child's signals and cues and to respond to those cues and signals promptly and appropriately. *Warmth* was defined as caregiver physical affection or their positive affective quality during contact and involvement with the child.

Study Eligibility Criteria

Studies were screened by two independent coders for the following inclusion criteria: (1) a typically developing sample; (2) a measure of child language, in English, including measures of receptive (e.g., understanding of words) or expressive language (e.g., total utterances); (3) an observational measure of responsivity (including sensitivity or warmth) (4) a measure of socioeconomic risk (low income and/or maternal education), and (5) a statistic that could be transformed into an effect size.

Exclusionary criteria included samples of children with diagnostic language delays, intellectual disabilities, deafness (in parents or children), hearing loss or middle ear disease, autism spectrum disorders, speech anomalies, and brain injuries. Intervention studies were only included if they provided pretest (or baseline) estimates of responsivity and language. Since we were interested in exploring the a, b and c pathways, we excluded studies that did not provide effect sizes for at least two of these pathways. If effect sizes could not be calculated from the statistics provided, the corresponding author was contacted for this information. A total of six authors were contacted to provide associations for these missing pathway associations. However, none of the authors responded as a result six studies were excluded from our final analyses.

A total of 17 studies with 19 samples met full inclusion criteria (see PRISMA flow, Figure 1) and went through data extraction to obtain associative effect sizes for paths a, b and c. The first author extracted all effect size data and potential moderator variables from the 17 studies. A second coder performed data extraction to determine inter-rater reliability. Percent agreement for categorical moderators was 100%, for continuous moderators agreement was 0.90, and agreement on the extraction of effect size data was 90%. Any discrepancies were resolved by review and discussion, and consensus coding was used in data analysis. Sensitivity analyses were conducted to ensure that coding and sample diversity did not adversely affect conclusions, and these are reported in results and Supplemental Tables S1-S4.

[Figure 1 goes here]

Multiple effect sizes from a given study

Although methods exist for conducting meta-analyses with multiple dependent effect sizes (e.g., multilevel approaches) to our knowledge this is not yet available for MASEM (Jak & Cheung, 2020). To maintain independence of data, when multiple effect sizes were reported within a publication, only one effect size was extracted and the following decision rules were applied:

1) *Temporal decisions*. In a longitudinal study, if responsivity and child language outcomes were assessed at multiple time points, we selected the statistic with the longest time between the parent and child assessments (i.e., longitudinal over concurrent). Likewise, the most temporally distant effect size for socioeconomic risk on responsivity and child language was selected when multiple assessments of socioeconomic risk were provided. This decision was made to capture the enduring effect of socioeconomic risk on responsivity and children's language development, and because evaluating mediation within concurrent primary studies has been shown to lead to biased results relative to evaluation in longitudinal studies (Maxwell & Cole, 2007). Therefore, it is prudent to evaluate mediation within longitudinal designs, in which there is a lag between the predictors and the mediator, and between the mediator and the dependent variable. if studies assessed language at multiple time points, the latest time point of language was selected to capture the most developed language skills (Bornstein, et al., 2016; Putnick et al., 2017).
2) *Multiple measures of language skills*. For our main analyses, if a single study provided a measure of receptive and expressive language, these two effect sizes were averaged to provide the most global and representative assessment of child language. In total, k=15 samples reported on both receptive and expressive language outcomes, while k=3 reported on

exclusively on receptive language and only *k*=1 reported exclusively on expressive language. Additional mediation analyses were run separately for non-pooled expressive (*k*=12) and receptive (*k*= 14) language outcomes to provide a more nuanced understanding of the different language domains (reported in Supplemental Table S1)

3) *Multiple indicators of socio-economic risk*. Lastly the traditional construct of socioeconomic status contains the well-correlated constructs of income and education (Abramson et al., 1982). In the current study, *k*=6 samples reported separately on both income and education, *k*=8 reported a composite risk which included education and income, *k*=3 reported solely on maternal education, and *k*=2 reported solely on income. Analysis in the main text presents results when income is prioritized and those in the supplemental when education is prioritized (Supplemental Table S3).

4) *Multiple measures of maternal responsivity*. Our dataset included *k*=5 samples which reported on both sensitivity and warmth, *k*=8 reported solely on sensitivity, and *k*=6 samples reported solely on warmth. For analyses reported in main text, sensitivity was prioritized, since it has been more strongly associated with language outcomes in children (Madigan et al., 2019). Follow-up analyses are presented in Supplemental Table S2 where warmth is prioritized (*k*=11 warmth and *k*=8 with a sensitivity).

5) Data Synthesis

Data extraction from the primary studies yielded 50 correlation estimates from 17 studies (19 samples) all studies included associations for atleast two pathways. The final dataset included no missing data for the association between responsivity and child language, but in one study we were unable to extract a correlation for the association between socioeconomic risk and responsivity, and in five studies we were unable to extract a correlation for the association between socioeconomic risk and language. All data for the moderator variables were complete.

Data Analysis

We used the R package metaSEM (version 1.2.5; Cheung, 2015) which includes dedicated functions to apply One – Stage MASEM. The essence of meta-analytic structural equation model is the combination of meta-analytic techniques to estimate effect sizes across multiple studies, with the capacity for modelling complex associations and testing explicit models that are characteristic of structural equation modelling (SEM). SEM relies on an estimate of the population correlation matrix between measured variables to estimate model parameters and address model fit. In the case of the MASEM, this population matrix is derived from multiple observed studies. In the early versions of MASEM applications, such analyses were conducted in two steps – first deriving a pooled correlation matrix from multiple studies and then fitting a structural equation model to that matrix. A notable disadvantage of this approach is that it does not allow for the estimation of sources of heterogeneity in model parameters by the inclusion of moderator variables, and also is not well suited for handling missing data, which is common in meta-analytic studies. One-stage MASEM (Jak & Cheung, 2020) overcomes these limitations and allows for the simultaneous estimation of model parameters, heterogeneity and continuous moderators.

One-stage MASEM works by effectively treating observed correlations as variables and studies as (weighted) subjects in a typical SEM (Jak & Cheung, 2020). The correlation matrices are decomposed into vectors of mean correlations, random deviations in those correlations and residual error and estimated using full information maximum likelihood, which also flexibly handles missing data. The structural equation model restricts the correlation matrix to be a function of the model parameters and allows likelihood-based tests of model fit by comparing the model-implied correlation matrix to that of a saturated model. The model parameters are estimated as the mean structure of a typical SEM, and the random effects as the covariance structure. Parameters directly estimated in the model (i.e., paths a, b and c) can be regressed on moderators to test whether heterogeneity in those parameters can be explained by the moderator. We thus conducted one-stage meta-analytic structural equation modelling R package meta-SEM. We began by estimating the mediation model of the socioeconomic risk> responsivity > language outcome pathway without any moderator variables, including meta-analytic estimates of the individual paths and the estimate and 95% confidence interval of the indirect effect (socioeconomic risk to language outcomes through parenting) – the direct test of mediation, using likelihood based confidence intervals, which is recommended for meta-analytic SEM (Jak & Cheung, 2020; Cheung, 2020; personal communication). Using the same modelling framework as the mediation analysis above, we tested whether the structural paths within the mediation model varied as a function of the selected study-level moderators. All categorical moderator variables were binary, and coded as zero versus one, so that their respective parameters estimated the difference in a relevant model path between the category coded zero and the one coded one. For continuous moderator variables, model-estimated paths were calculated at +1 and -1 standard deviation of the moderator variable.

Although bootstrapping methods are often used in non-meta-analytic mediation models, there is limited work supporting this approach in meta-analytic applications where the number of studies is often comparatively small, and is not recommended (Cheung, 2020; personal communication). Nevertheless, for the purposes of comparison we also estimated bootstrapped standard errors and confidence intervals for the indirect effect, and these yielded very similar results to those described below.

Given the publication bias towards significant findings, there is a risk of meta-analyses overestimating overall effect sizes. Contour enhanced funnel plots were used to examine publication bias which are useful for detecting publication bias due to the suppression of non-significant findings (Peters et al., 2008). The contour overlay aids the visual interpretation of the funnel plot. For example, if studies appear to be missing in areas of statistical non-significance, then this adds credence to the possibility that the asymmetry is due to publication bias. Conversely, if the supposed missing studies are in areas of higher statistical significance, this would suggest the cause of the asymmetry may be more likely to be due to factors other than publication bias, such as variable study quality (Peters et al., 2008).

Results

Study Characteristics

A detailed description of study and sample characteristics can be found in Tables 1 and 2. Seventeen studies, totaling 19 effects were included and sample size across studies ranged from 30 to 1363 (median =164), with a total of 6433 mother-child dyads. The average child age (months) at socioeconomic status measurement, responsivity observation and language assessment were 22.35, 22.17, and 36.31 respectively. The mean percentage of boys across samples was 50.76 % (SD=5.98).

[Table 1 goes here followed by Table 2]

For descriptive purposes, we estimated the population correlation matrix and between-study heterogeneity of the elements of that matrix prior to formal model fitting. To formally assess for heterogeneity of effect sizes, the Q and I^2 statistics were computed. We ran a random effects model to estimate between-study heterogeneity in the correlation matrices and a significant Q statistic and $I^2 > 50\%$ suggest moderators should be explored. Results indicated that there were substantial between-study differences (Q statistic= 218.7 (df=49), p <.001). Heterogeneity estimates for pathways were as follows: SES risk to responsivity= (I^2=83%, τ^2=0.014, p<0.01), responsivity to language= (I^2=82%, τ^2=0.013, p<.01), SES to language= (I^2=53%, τ^2=0.004, p < 0.01). Moderator analyses were thus conducted to explain this variability (see Table 3) and are described below.

Based on visual inspection of the contour-enhanced funnel plots, there was little indication of publication bias. Egger's test was non-significant for the responsivity to language pathway (p=.13) and for the SES risk to responsivity pathway (p=.47). Egger's test was significant for SES risk to language (p=.032) indicating that some asymmetry is present. However, this is unlikely to be due to publication bias as the small asymmetry arises from an under-representation of large correlations with high standard errors - the opposite of what is expected due to publication bias. The trim and fill method for the risk-to-outcome association led to three studies being added, but this correction led to only a very small change in the meta-analytic estimate (r = -.34, versus r = -.32 in the uncorrected analysis). Given that the asymmetry is unlikely due to publication bias we analysed the original uncorrected estimate throughout this paper.

The average correlations across studies for the a, b, and c paths were estimated to be, respectively, -.31 [95% CI -.37, -.25], .25 [95% CI .31, .19] and -.32 [95% CI -.36, -.28]. Forest plots of univariate random effects meta-analyses for each correlation are presented below in Figure 2. Note that the univariate nature of these analyses leads to some differences in effect sizes and heterogeneity measures relative to the multivariate results presented in Figure 3.

[Figure 2 goes here]

Mediation analysis

We began by estimating the mediation model of socioeconomic risk > parental responsivity > language outcome pathway without any moderator variables, including meta-analytic estimates of the individual paths and the estimate and 95% confidence interval of the indirect effect – i.e., the formal test of mediation. Total, direct, and indirect effects as well as model fit are shown in Figure 3. All effects are significant. The hypothesized indirect effect from socioeconomic risk to language outcomes, through responsivity, is significant but small.

[Figure 3 goes here]

Moderator analyses

The estimates of the indirect effect for each level of moderator and tests of difference in the indirect effect between levels of moderators are shown in Table 3.

<u>*Confirmatory moderator analysis*</u>

Sensitivity versus Warmth. The indirect pathway was significant for both sensitivity and warmth and was significantly stronger for sensitivity than warmth.

Home versus Lab Observations. The indirect effect was significant for both home observations and lab observations and was significantly stronger for home versus lab observations of maternal responsiveness.

Longitudinal versus Cross-Sectional. The indirect effect was significant for both longitudinal and cross-sectional studies with no significant difference between them.

<u>*Exploratory moderator analyses*</u>

Child Age. The age at which language was measured was not a significant moderator. The age at which SES risk was measured moderated the indirect pathway, and the strength of the indirect path was significantly stronger for older children than younger children. The age at which the maternal sensitivity was observed also showed evidence of acting as a moderator, as before, the association was stronger for older children than younger.

Child Sex. There were no significant differences in the strength of the mediation pathway between samples that had a high and low percentage of males

[Table 3 goes here]

Sensitivity Analyses

Supplementary analyses were conducted to determine whether composite or prioritization decisions affected conclusions. First, we carried out separate mediation analyses for receptive and expressive language The indirect effects were significant for both outcomes (see Supplemental Table S1). Second, given that the analysis reported above was based on a prioritization of sensitivity over warmth, supplementary analyses were conducted to examine pathway estimates when warmth was prioritized in place of sensitivity. Results presented in Supplemental Table S2 show that responsive parenting remains a significant mediator in the pathway from SES risk to language outcomes when warmth is prioritized. Third, the main analyses prioritized income over education, Supplemental Table S3 shows the results when education is prioritized over income and the indirect effect remains significant . Lastly, as many of the samples were low on diversity, we removed studies that had very low diversity (i.e., more than 80 % White participants) and re-ran analyses (*k*=9). Responsivity remained a significant mediator of the associations between socioeconomic status and child language (see Supplemental, Table S4).

Discussion

The current study reports a meta-analysis to examine the magnitude of the indirect path from socioeconomic risk to children's language outcomes, through parental responsivity. Results are consistent with the ecological view that the impact of socioeconomic status on children’s language is most accurately explained by the way that socioeconomic status shapes the environment proximal to the child (Lerner, 2006; Masarik & Conger, 2017). Results show that the indirect pathway is significant, but small, explaining 5% of the variance between socioeconomic status and child language. Responsivity has been conceptualized as an important mechanism in both cognitive and socioemotional outcomes cross-culturally (Browne et al., 2018; Mesman et al., 2018) and the results of this meta-analysis also suggested that responsivity was a significant mediator, even in samples with greater diversity. Although the results reported here are based on observational data, and are therefore correlational not causal, causality has been established in studies using experimental research designs via 1) cash transfers to improve parenting and 2) parental responsivity interventions to improve child language, have both been established using a design (Aboud & Yousafzai, 2015; Arriagada et al., 2018;Attanasio et al.,2014; Landry et al.,2006;2008; Lowell et al., 2011; Raby et al., 2019; Suskind et al., 2016) .

The indirect effect was significantly stronger for measures of sensitivity than warmth. These findings are in line with previous studies examining the direct associations between responsivity and children’s language in which stronger associations between sensitive responsivity and children’s language, compared to warmth, have been found (Madigan et al., 2019). Neuroimaging studies have identified distinct neural correlates associated with sensitivity and warmth. Sensitive mothers have been found to have increased activation in prefrontal networks, and maternal warmth has been associated with greater activation in the nucleus accumbens and hippocampal regions (Musser et al., 2012). Indeed, stress has been found to impact the above brain regions associated with sensitivity and warmth (Heshmati et al., 2020; Mychasiuk et al., 2016; Noriuchi et al., 2019). Thus, the psychological stress associated with low SES may be operating at a neural level, lowering caregivers' cognitive bandwidth and ability to provide sensitive and warm parenting. The reduction in parents' cognitive bandwidth may impact sensitivity more than warmth because the prefrontal regions associated with sensitive caregiving are also involved in emotion regulation, executive functioning, empathy, and language processing (Rota et al., 2009; Shmay-Tsoory et al., 2003; 2009; Tops & Boksem, 2011). These cognitive domains are particularly important for parents to carry out scaffolding behaviors, perspective taking, and joint attention which have been associated with language development (Gonzales et al., 2013; Prime et al., 2015; Vygotsky,1978). The adverse effects of low SES may operate differently for warmth. For example, decreased activity in nucleus accumbens, an area linked to emotion processing and modulating reward and pleasure processing, could increase parental anhedonia and depression (Heshmati et al., 2020) and reduce parental warmth. In turn, these effects may have greater impacts on other aspects of children's functioning (e.g., socioemotional development (Goodman et al.,2011; Wang et al., 2015)).

Another finding emerging from this MASEM, is that significant between-study heterogeneity was found for the mediation pathway. Specifically, the mediation pathway was found to be significantly stronger for home versus laboratory observations. It may be that measurement of maternal responsivity in a naturalistic setting captures a "truer" picture of the parenting that children receive (Gardner, 2000). This has important implications for design of future studies (Beals & Tabors, 1993; Bornstein et al., 1999). Both longitudinal and cross-sectional studies showed evidence of reliable mediation and there were no significant differences between the two. This suggests that the mechanisms underlying associations between socioeconomic risk and language outcomes through the effects on responsivity can have immediate and enduring impacts on language.

In the current study, there were no significant differences in the strength of the mediation pathway between samples that had a high and low percentage of males. These findings are in line with most studies which have found negligible sex-differences in vocabulary development by the time children reach two years of age (Huttenlocher et al., 1991). Furthermore, it was found that the strength of the indirect effect differed by child age when SES risk was assessed (stronger in preschool vs infant samples) and by the age of the responsivity assessment (stronger when children are younger children vs infants). These effects seen in older children may reflect the cumulative impact of longer exposure to low SES and responsivity (Guo, 1998) and they also support the finding from economics that early interventions provide a stronger return on investment than later interventions (Heckman & Mosso, 2014).

Providing an integration of evidence on distal to proximal pathways that may be important in language development are potentially useful in the design of interventions. Some interventions for early childhood target only a distal process (e.g., cash transfers), while others target only a proximal process (e.g., parenting). Fernald et al. 2017 reported effects of a large-scale randomized controlled trial for Mexican children showing that the strongest effects for children came from combining a distal and proximal intervention simultaneously (cash transfers with parenting groups). Testing a range of mediators for different child outcomes, doing this cross-culturally and where possible with meta-analysis will help to identify combined distal and proximal targets for intervention. There are currently many large-scale programs being introduced into low- and middle-income countries to support early development (e.g., Crianca Feliz in Brazil (Buccini et al., 2021) and Cuna Mas in Peru (Araujo et al., 2018)).

Although, the evidence that the responsive parenting included in this model is a significant mediator of the relation between SES and children's language outcomes, it is important to note that it is only a partial mediator (as indeed are most mediators given that child development has multiple determinants). The indirect effect accounts for 5% of the association between SES and language. A range of other proximal processes may also mediate the association between socioeconomic risk and child language and the economic status of countries may moderate such effects. These processes include nutrition, pre- and postnatal healthcare, food and housing insecurity, toxicity exposure, the quality and quantity of parent linguistic input, and a nurturing home literacy environment involving early shared book reading (Anderson et al., 2021; Aram et al., 2013;Arriagada et al., 2020; Daelmans et al., 2017; DeBondt et al., 2020; Ellwood-Lowe., et al., 2020; Gonzales et al., 2017). Lastly, it is important to note that a mediation model of language is also potentially confounded by genetic influence given that parental circumstances (socioeconomic status, responsivity) and child language can be correlated because of shared genes or because genetically based characteristics of children elicit different degrees of maternal responsivity (Dale et al., 2015). Longitudinal, cross-lag, reciprocal effect models are helpful in untangling child and parent contributions to dyadic interactions and developmental outcomes (Hamaker et al., 2018; Sokolovic et al., 2021). Future advances in meta-analytic methods, could valuably focus on these reciprocal models.

Limitations

The results of the current meta-analysis must be considered in light of several limitations.

First and foremost, traditional meta-analyses of observational studies are correlational in nature and do not permit conclusions about direction of effect. Second, language outcomes (receptive and expressive vocabulary) were narrowly conceptualized and measured, forms of communication valued by other communities were not represented. For example, linguistic anthropologists have shown that the primary unit of analysis is interaction, within which one can identify sounds, sound patterns, signs, grammatical patterns as important aspects of language development (Blum, 2015; 2017). Third, many of the studies on language acquisition have been conducted in predominantly White samples and measures of parenting have been largely developed in white, middle-class, monolingual, monocultural families. We only included studies conducted in English, although we were also mindful of the challenge for meta-analysis of measurement heterogeneity and generalizability of results based on sample inclusion (Bornstein et a., 2013; Westermeyer & Janca, 1997). As more cross-cultural studies are conducted, with different types of language socialization practices measured (Kuchirko & Tamis-LeMonda, 2019; Nielsen & Haun, 2016), it will be important to examine their roles as mediators between socioeconomic risk and child language. Fourth, we were not able to ascertain differences between absolute versus relative poverty, since only one study in our analyses reported on a primarily low-income sample. As more research emerges from low-income countries it will be important to test whether pathways differ across low- and high-income countries. Lastly, given the prolific dissemination and increased usage of meta-analysis, it is important to investigate and ensure the validity of conclusions. These are of course dependent on the methodological quality of original studies, representativeness (both within and between countries), sample size, and measurement.

Conclusions

Results from this meta-analysis provide evidence that maternal responsivity may be a proximal intervening variable in the relation between socioeconomic risk and language development.This represents one possible process that may explain the association between socioeconomic risk and children's language. Identifying proximal mediators between socioeconomic risk and children's language may help to inform combinations of distal and proximal interventions that could benefit children.

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Tables and Figures

Table 1

Study Characteristics for All Studies included in the MASEM

Study	Date	N	Country	Risk Measurement	Type of Sensitivity	Language Outcomes	Location of Parenting Observations	Study Design
Beckwith et al.	1996	193	USA	Income+Education (Composite risk)	Warmth & SR	Exp+Rec	Lab	Longitudinal
Bee et al.	1992	254	USA	Maternal Education	Warmth	Exp+Rec	Home	Longitudinal
Bornstein et al.	2007	164	USA	Income+Education (Composite risk)	Warmth	Exp+Rec	Home	Cross-Sectional
Gaertner et al.	2013	192	USA	Income	Warmth & SR	Exp+Rec	Lab	Longitudinal
Greenberg-PreTerm et al.	1998	40	USA	Income+Education (Composite risk)	SR	Exp+Rec	Lab	Longitudinal
Greenberg-Full Term et al.	1998	30	USA	Income+Education (Composite risk)	SR	Exp+Rec	Lab	Longitudinal
Gocek-Healthy Controls et al.	2007	39	Canada	Income	Warmth	Exp+Rec	Lab	Cross-Sectional
Gocek-Referred for Mental Health et al.	2007	39	Canada	Income	Warmth	Exp+Rec	Lab	Cross-Sectional
Hann et al.	1996	69	USA	Income+Education (Composite risk)	Warmth &SR	Receptive	Lab	Longitudinal
Keown et al.	2001	42	New Zealand	Income	Warmth &SR	Exp+Rec	Home	Cross-Sectional
Madigan et al.	2013	467	Canada	Income	SR	Receptive	Home	Longitudinal
Mistry et al.	2004	1363	USA	Income	SR	Exp+Rec	Both	Longitudinal
Mol et al.	2014	60	USA	Income+Education (Composite risk)	SR	Receptive	Home	Longitudinal
Olson et al.	1984	120	USA	Income	Warmth	Receptive	Home	Cross-Sectional
Pearson et al.	2011	732	UK	Maternal Education	Warmth	Exp+Rec	Lab	Longitudinal
Ruffman et al.	2006	55	UK	Maternal Education	Warmth & SR	Receptive	Home	Longitudinal
Stein et al.	2008	1201	UK	Income	SR	Exp+Rec	Home	Longitudinal
Vernon-Feagans et al.	2012	1123	USA	Income	SR	Exp+Rec	Home	Longitudinal
Nozadi et al.	2013	250	USA	Income+Education (Composite risk)	SR	Expressive	Lab	Longitudinal

Table 2

Sample Characteristics for All Studies included in the MASEM

Study	SES	Age of Risk Measurement (months)	Age of Parenting Measurement (months)	Age of Language Measurement (months)	% Ethnic Minority	% Male
Beckwith et al.	Diverse	30	30	54	67%	56
Bee et al.	Mid/ High	1	12	24	15%	57.1
Bornstein et al.	Diverse	1	12	24	0%	44.1
Gaertner et al.	Diverse	13	20	44	13%	45
Greenberg-PreTerm et al.	Mid /High	42.73	42.73	42.73	14.2 %	50
Greenberg-Full Term et al.	Mid /High	36	18	36	14.7 %	50.7
Gocek-Healthy Controls et al.	Diverse	20.25	20.25	36	Did not report	52
Gocek-Referred for Mental Health et al.	Diverse	70.74	67.55	70.74	Did not report	36.7
Hann et al.	Diverse	6	24	24	42.6%	57
Keown et al.	Diverse	12	12	49	Predominantly White (% not reported)	49
Madigan et al.	Mid/High	36	36	48	43.3%	40
Mistry et al.	Diverse	3	10	36	24%	50
Mol et al.	Diverse	37.1	20.25	37.1	50%	51
Olson et al.	Diverse	13	20	36	1%	55
Pearson et al.	Diverse	perinatal/infancy (unspecified)	4	36	Did not report	48.5
Ruffman et al.	Mid/High	20.1	20.1	20.1	Did not report	54.3
Stein et al.	Diverse	21.1	21.1	21.1	Ethnicity was unreported. 100% of mothers “adequately” fluent in English.	59
Vernon-Feagans et al.	Low	21.4	21.4	21.4	42.9%	53.8
Nozadi et al.	Mid/High	17.79	17.79	29.77	33.3%	55.3

Table 3

Estimates of the indirect effect for each level of moderator and tests of difference in the indirect effect between levels of moderators (with 95% confidence intervals)

Results	k	Indirect Effect [95 % CI]	Indirect Effect difference [95 % CI]
Categorical Moderators			
**Responsivity Type*			
Warmth	6	-0.018 [-0.002, -0.039]	0.151 [0.073, -0.033]
Sensitivity	13	-0.169 [-0.078, -0.264]	
**Observation Location*			
Laboratory	9	-0.023 [-0.002, -0.039]	0.151 [0.255, 0.048]
Family Home	9	-0.169 [-0.078, -0.264]	
**Study Design*			
Longitudinal	14	-0.052 [-0.027, 0.077]	-0.006 [0.053, -0.048]
Cross-Sectional	5	-0.046 [-0.012, -0.100]	

Continuous Moderators	k	Indirect Effect [95 %CI] z score +1	Indirect Effect [95 %CI] z score -1	Indirect Effect difference [95 % CI]
Child age at risk assessment	19	-0.102 [-0.063, -0.149]	-0.023 [-0.005, -0.044	-0.079 [-0.032, -0.132]
Child age at responsivity assessment	19	-0.108 [-0.061, -0.167]	-0.024 [-0.002, -0.047]	-0.079 [-0.032, -0.132]
Child age at language assessment	19	-0.066 [-0.032, -0.106]	-0.038 [-0.010, -0.070]	-0.028 [0.020, -0.079]
Percentage of boys in sample	19	-0.045 [-0.015, -0.077]	-0.062 [-0.026, -0.105]	0.018 [0.073, -0.033]

*Analyses were confirmatory for categorical moderators

MASEM: SES, RESPONSIVITY, AND LANGUAGE

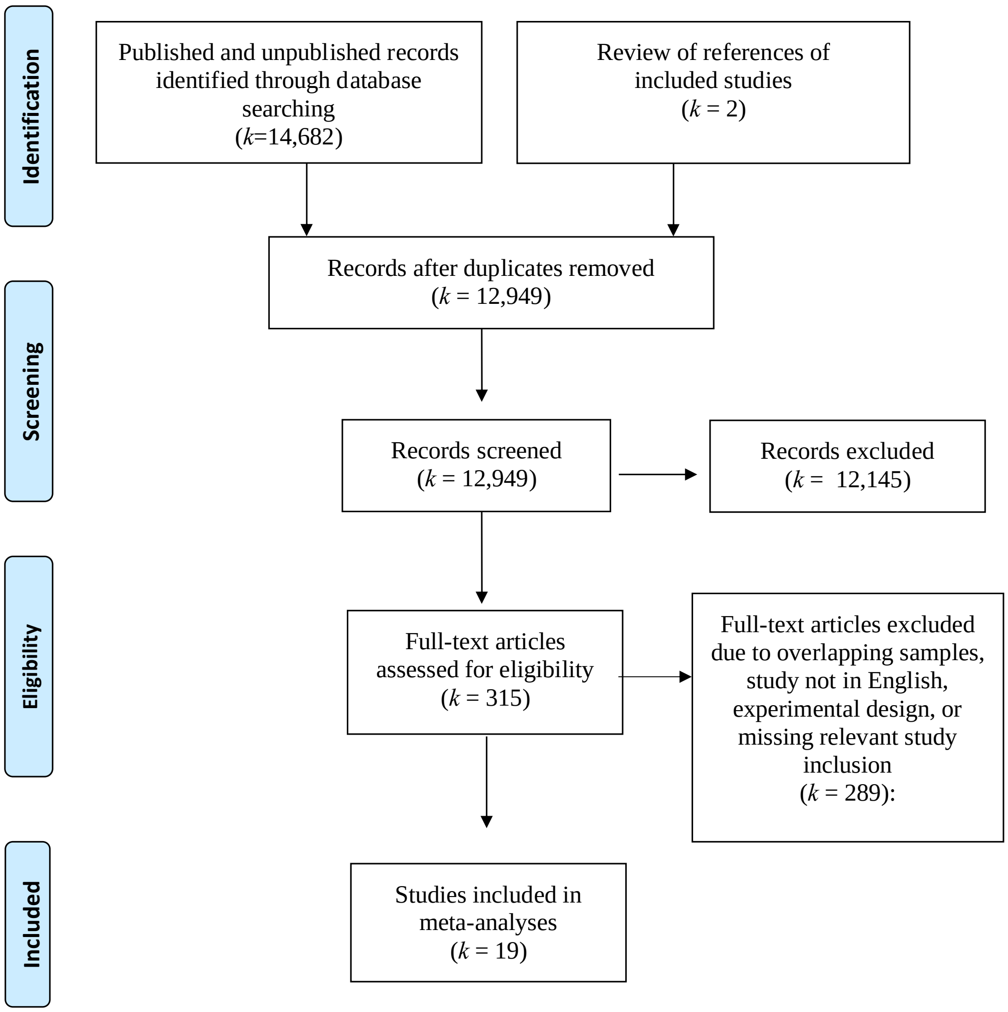


Figure 1. PRISMA flow used to identify studies for detailed analysis of socio-economic risk to children's language via maternal responsivity.

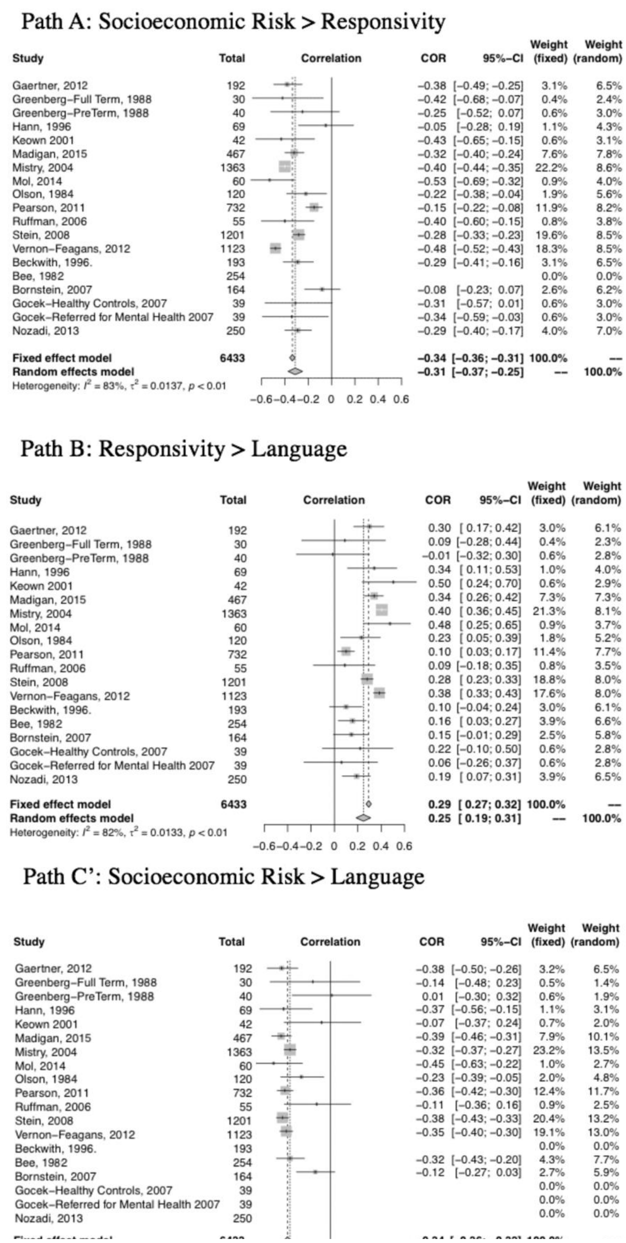


Figure 2: Univariate meta-analyses and forest plots

MASEM: SES, RESPONSIVITY, AND LANGUAGE

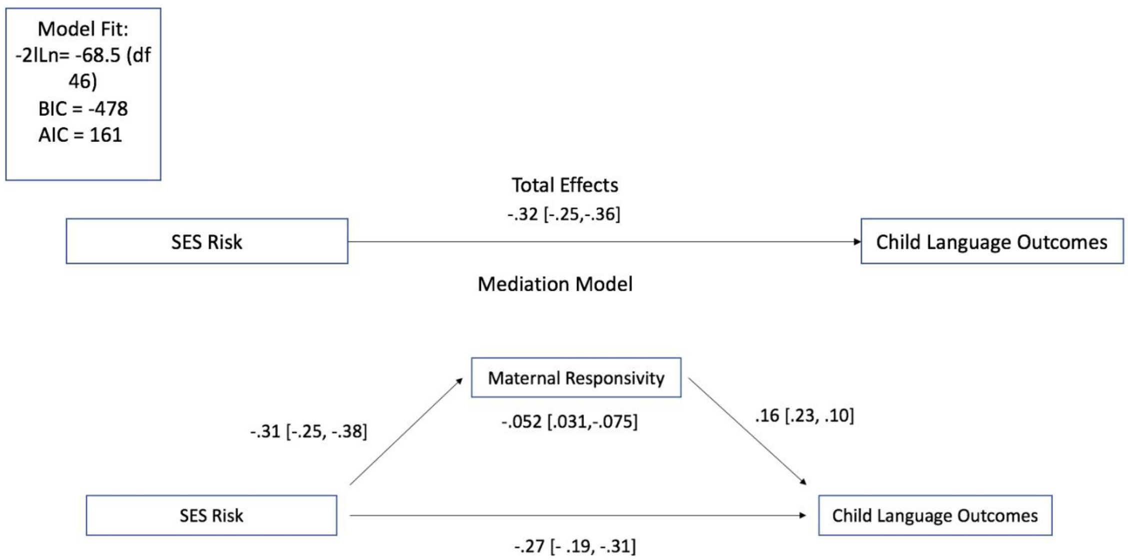


Figure 3. One-stage meta-SEM model of the total, direct and indirect effects (95% Cis in square brackets)

Supplementary Material

Table S1

Language outcome sensitivity analysis: Path estimates for language outcomes when k=12 studies report on exclusively on expressive language and k= 14 studies report exclusively on receptive language

Pathway	Direct Effects				Indirect Effects	
	Est.	95% [CI]	S.E.	p	Est.	95% [CI]
Expressive Language						
SES risk → responsivity	-0.345	[-0.274, -0.418]	0.034	0.000		
Responsivity → expressive language	0.164	[0.249, 0.068]	0.041	0.000		
SES risk →expressive language outcomes	-0.204	[-0.106, -0.287]	0.040			
SES risk → expressive language through responsivity					-0.057	[-0.024, -0.089]
Receptive Language						
SES risk →responsivity	-0.334	[-0.262, -0.407]	0.034	0.000		
Responsivity → receptive language	0.218	[0.299, 0.137]	0.038	0.000		
SES risk → receptive language outcomes	-0.291	[-0.253, -0.327]	0.018			
SES risk → receptive language through responsivity					-0.073	[-0.046, -0.104]

Table S2

Responsive parenting sensitivity analysis: Path estimates for language outcomes when *k*=11 studies report on warmth parenting and *k*=8 studies report on sensitivity

Pathway	Direct Effects				Indirect Effects	
	Est.	95% [CI]	S.E.	p	Est.	95% [CI]
SES risk to responsivity	-0.306	[-0.246, -0.366]	0.029	0.00		
Responsivity to language outcomes	0.137	[0.218, 0.053]	0.040	0.00		
SES risk language outcomes	-0.279	[-0.205, -0.327]	0.031	0.00		
SES risk to language through responsivity					-0.042	[-0.016, - 0.068]

Table S3

Responsive parenting sensitivity analysis: Path estimates for language outcomes when education (k=9) is prioritized over income (k=2), analysis include (k=8 studies) which are a composite of income and education (k=8)

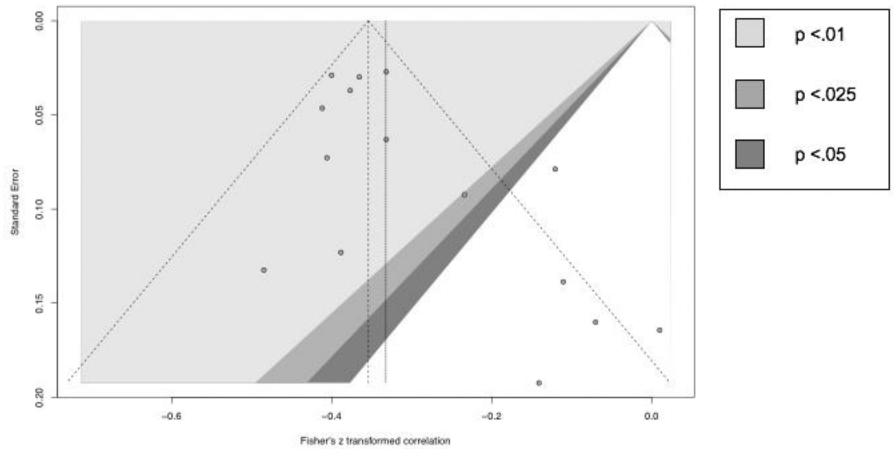
Pathway	Direct Effects				Indirect Effects	
	Est.	95% [CI]	S.E.	p	Est.	95% [CI]
SES risk to responsivity	-0.316	[-0.239, -0.394]	0.037	0.00		
Responsivity to language outcomes	0.177	[0.107, 0.243]	0.033	0.00		
SES risk language outcomes	-0.225	[-0.149, -0.291]	0.034	0.00		
SES risk to language through responsivity					-0.056	[-0.034, -0.081]

Table S4

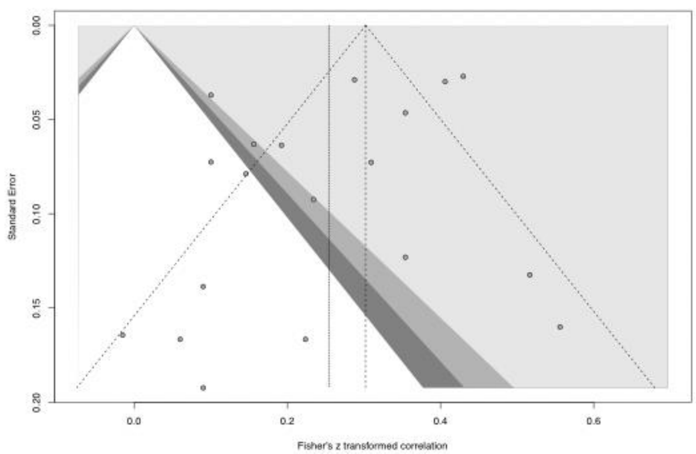
Ethnicity bias sensitivity analysis: Path estimates for language outcomes when non-diverse (>80 % participants) studies are removed (k=9)

Pathway	Direct Effects				Indirect Effects	
	Est.	95% [CI]	S. E	p	Est.	95% [CI]
SES risk to responsivity	-0.315	[-0.206, -0.414]	0.046	0.00		
Responsivity to language outcomes	0.199	[0.288, 0.105]	0.042	0.00		
SES risk language outcomes	-0.269	[-0.226, -0.310]	0.021	0.00		
SES risk to language through responsivity					-0.063	[-0.034, -0.096]

Path A: SES Risk > Language Outcome



Path B: SES Risk > Responsivity



Path C': SES Risk > Language Outcome

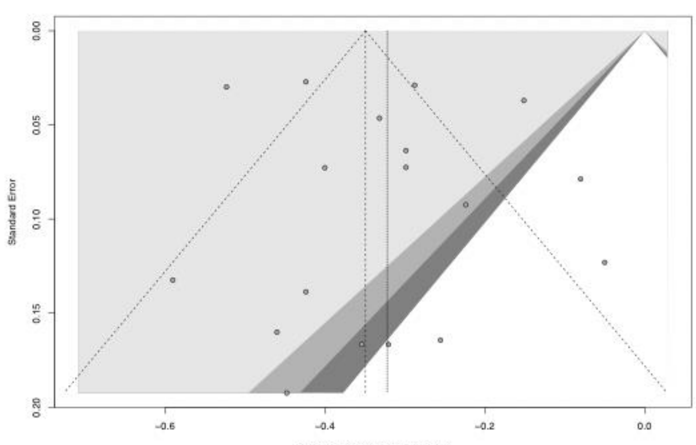


Figure S1. Contour enhanced funnel plots. Effect estimates against standard error