The Effect of Older Sibling, Postnatal Maternal Stress, and Household Factors on Language Development in Two- to Four-Year-Old Children

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Abstract

Previous literature has shown that family structure affects language development. Here, factors relating to older siblings (their presence in the house, sex and age gap), mothers (maternal stress), and household size and residential crowding were examined to systematically examine the different role of these factors. Data from mother-child dyads in a Singaporean birth cohort, (677-855 dyads; 52% males; 58-61% Chinese, 20-24% Malay, 17-19% Indian) collected when children were 24-, 48-, and 54-months old, were analysed. There was a negative effect of having an older sibling, moderated by the siblings' age gap, but not by the older sibling's sex, nor household size or residential crowding. Maternal stress affected language outcomes in some analyses but not others. Implications for understanding the possible effect of family structure on language development are discussed.

Keywords: older siblings, language development, maternal stress, household size, residential crowding, cognitive development

OLDER SIBLINGS AND LANGUAGE DEVELOPMENT

One of the main factors suggested to be critical for language development is the linguistic input that a child receives (e.g., Huttenlocher et al., 1991; Newport et al., 1977; Pan et al., 2005). Most previous research has focused on the language input that a child receives from their primary caregivers. These studies suggest that both the quantity and quality of caregiver's speech later predicts children's language and cognitive outcomes (Hoff, 2003; Gilkerson & Ricards, 2009; Romeo, et al., 2018; Rowe, 2012). However, more and more studies from diverse cultures suggest that looking at the caregiver in isolation is not sufficient to capture environmental language input (e.g., Cristia et al., 2019; Loukatou et al., 2021; Sperry et al., 2019). Existing studies suggest that factors related to household compositions such as the presence of siblings (e.g., Huttenlocher et al., 2007), the presence of other adults (e.g., Ramírez-Esparza et al., 2014), or more generally household size and residential crowding (e.g., Evans et al., 2010), may influence language development.

One factor that might mediate these household characteristics is maternal stress, which has been shown to be augmented by environmental factors such as having more children to care for, or living in more crowded dwellings (Evans et al., 1998). In the current study we analyse data from a unique cohort of over 1,000 children growing up in Singapore, to examine the possible effect of family structure (the presence and characteristics of siblings in study 1, and household size and residential crowding in study 2) on language development. In both these studies we examine maternal stress as a possible mediator between family structure factors and language development.

Older Siblings

Previous epidemiological studies consistently suggest that sibship size is negatively correlated with children's cognitive and educational outcomes (Downey, 2001; Ernst & Angst, 1983; Retherford & Sewell, 1991; Steelman, 1985; Steelman et al., 2002). One of the theoretical models that may explain these findings is the *resource dilution hypothesis* (Blake, 1981). According to this hypothesis, caregivers possess a finite amount of resources that they could allocate to their children. Consequently, having more children will increase a dilution of caregivers’ resources, with less resources allocated to each child. Thus, children with more siblings may be negatively affected by the distribution of caregivers’ resources between siblings. In the context of language acquisition, it has also been found that caregivers use more responsive language towards their oldest child (Gilkerson & Richards, 2009; Jones & Adamson, 1987; Woollett, 1986, but see Fern, 2020, who found that firstborns with hearing aids indeed had a larger count of conversational turns, but normal-hearing firstborns and last-borns received similar numbers of conversational turns), at the expense of the younger sibling when both are present (Huttenlocher, 2007). It has been suggested that the oldest siblings receive on average 1,338 more words per day than the younger siblings (Gilkerson & Richards, 2009). Additionally, previous research indicates that mothers tend to talk less and be less responsive to the younger child while the older child is present (Woollett, 1986). Farrant et al., (2012) found that joint attention and parent-child book reading completely mediated an effect of the number of siblings on children’s vocabulary, suggesting that parents engage in less joint attention episodes and read less and to their children when they have more children to care for. Thus, these findings suggest that caregiver-child interaction and caregivers’ language input to a child is affected by the presence of other children in the household. As a consequence, a child's language development may be adversely influenced by them having an older sibling.

Indeed, previous evidence suggests that the presence of an older sibling is negatively related to language development in children (Black et al., 2005; Havron et al., 2019; Kantarevic & Mechoulan, 2005; Peyre et al., 2016). In order to gain insights into the pathways through which this effect occurs, a recent study (Havron et al., 2019) examined the possible effect of two characteristics of siblings on language development: the older sibling’s sex, and the age gap between siblings. The possible effect of these factors could shed light on the role of sibling's communication behavior on language development. Havron et al. (2019) hypothesized that older sisters would be less detrimental to language development than older brothers, because they are more likely to care for their younger sibling than older brothers do (Tucker et al., 2001), are more prosocial (Abramovitch et al., 1979; Van der Graaff et al., 2018), and because girls show more advanced language skills than boys (Frank et al., 2019). This hypothesis was confirmed: Children who had an older sister performed just as well as first-born children, but children who had an older brother performed significantly worse (Havron et al., 2019). This was replicated in a more recent study, which in addition showed that older sisters have more cognitively-supportive interactions with their younger siblings than older brothers do (Jakiela et al., 2020). As for the possible effect of the age gap between siblings, Havron and colleagues (2019) hypothesized that siblings would benefit more from having a larger age gap with their older siblings, because parents will be less occupied with the older child when the younger sibling is born, and because older children themselves could provide more quality input, being more socially and linguistically advanced than younger children. Contrary to this prediction, there was no significant effect on language development related to the age gap, although in descriptive terms more narrowly spaced siblings showed better language development. A recent study found significant results in the same direction in a larger sample of over 10,000 French children (Gurgand et al., *in preparation*). These findings are somewhat unexpected given previous findings that older siblings in more widely spaced siblings' pairs engage in more prosocial behaviours than those in less widely spaced pairs (Abramovitch et al., 1979), that a positive effect of older siblings on younger siblings' later empathy is stronger in dyads farther apart in age (Jambon et al., 2019), and that younger siblings in such dyads show better cognitive development (Teti et al., 1986). A possible reason for this finding is that it might be easier for parents to provide quality input to both siblings together when the age gap is small. In such a scenario, parents could, for example, read to both children together a book that would be appropriate for their abilities and interest, while the same would be impossible when the two children have a wider age gap. An alternative explanation is that children with a larger age gap would have less constructive interactions, as the older child would be more independent and spend less time with their younger sibling, at least in some cultural settings. For example, a recent study comparing child-directed input in France and Lesotho, found that the majority of child-directed speech in Lesotho was directed to children from other children (mostly siblings and cousins) unlike in France, where almost all child-directed speech came from children's mothers. Other children in Lesotho had a small age gap between them and the younger child, as children with a larger age gap were at school or herding their families' herds (Loukatou et al., 2021).

Household Size and Residential Crowding

A related family structure factor that may affect a child's language development is the number of adults and child members living in the same household (*household size*). This is a complex factor, since different members may have different roles in the household. Multiple children would compete for parental resources, but additional adult members could provide help (the *household size and infant indulgence hypothesis*, Whiting, 1961), and potentially diminish the siblings' negative effect on language development (Munroe & Munroe, 1971, 1980, 1984a, 1984b; Munroe et al., 1997). Another factor related to the family structure is *residential crowding*, with households considered crowded when there is more than one person per room. Previous evidence suggests that living in crowded homes has a possible negative effect on children, including an increase in stress, behavioural problems and delayed cognitive development, regardless of the family's SES (Block et al., 2018; Evans et al., 1998; Maxwell, 1996; Saegert, 1982). Furthermore, evidence suggests that higher residential crowding is negatively related to caregiver-child relationships, with caregivers in more crowded homes being less responsive to their children than parents in less crowded homes (Bradley & Caldwell, 1984; Evans et al., 2010; Evans et al., 1999; Hassan, 1977; Wachs, 1989; Wachs & Camli, 1991). In terms of language input, Evans et al. (1999) demonstrated that parents in larger households speak less to their children and use less complex language. Thus, household size and residential crowding may be important factors in children's language development.

Maternal Stress

Maternal stress is a possible mediator of the effects of all of the environmental factors discussed above on language development for at least two reasons. First, it is likely that environmental factors such as having more children to care for, or living in more crowded dwellings would be stressful for mothers (Evans et al., 1998). Second, it has been shown that maternal stress negatively predicts children's language outcomes (King & Laplante, 2005; Reck et al., 2018). We focus on *maternal* stress and not *parental* stress because mothers are usually the primary caregivers, thus largely influencing child's cognitive development (Csibra & Gergely, 2009; Tamis-LeMonda et al., 2001).

High levels of maternal stress during the perinatal period are related to children's receptive and expressive vocabulary development (King & Laplante, 2005), and verbal intelligence (Laplante et al., 2008; Laplante et al., 2004). Less is known about how postnatal maternal stress is related to children's language development. However, some evidence suggests that it may have a negative impact (Reck et al., 2018). One of the ways by which maternal stress could affect language outcomes is through diminishing the quality of caregiver-child interactions, by influencing the ability of caregivers to engage with the child sensitively and contingently. Indeed, previous research suggests that higher levels of maternal stress are correlated with mothers being less sensitive and more controlling in their interactions with the child (Muller-Nix et al., 2004; Pett et al.; 1994; Pianta & Egeland, 2010). Additionally, there is evidence suggesting that mothers who experience depression and/or anxiety - measures of both are conventionally used as an index of maternal stress - in the postnatal period show differences in their speech to children compared to mothers with no depression/anxiety. These differences include a lower pitch range, less positive and more negative affect in speech, less conversational turns, and no differences in mean length of utterances (MLU) to younger compared to older infants (Brookman et al., 2020; Herrera et al., 2004; Murray et al., 1993; Porritt et al., 2014; Reissland et al., 2003). These modifications to speech in mothers with depression/anxiety have been shown to have a negative effect on children's later expressive vocabulary development (Brookman et al., 2020; Kaplan et al., 2014; Quevedo et al., 2011).

When a child has an older sibling, their mother may experience more stress than when they are firstborns. Previous evidence suggests that the number of children in the household may affect maternal stress. For example, a cross-sectional study conducted in Sweden by Östberg and Hagekull (2000) with around 1000 mothers of children between six months and three years of age demonstrated that mothers who have more children tend to experience higher levels of postpartum stress. This is in accordance with findings of other studies indicating that having more than one child increases maternal stress (Hung et al., 2011; Lavee et al., 1996; Lundberg et al., 1994).

With regard to maternal stress's possible mediating effect between sibling's sex and language development, older sisters might be less stressful for mothers than older brothers, as one study found that girl babies were less stressful to mothers than boy babies (Scher & Sharabany, 2010). Later on, when babies become children, mothers report boys as displaying more externalizing behaviors than girls (e.g., Miner & Clarke-Stewart, 2008).

Household size and residential crowding may also affect language development via their effect on maternal stress. Previous research indicates a greater level of psychological distress among families living in crowded conditions including increased anxiety, conflict, susceptibility to minor issues and increased irritability (Evans et al., 1998; Evans et al., 1989; Fuller et al., 1993; Gove & Hughes, 1983; Lepore et al., 1991; Pierse et al., 2016). The greater amount of psychological distress caused by these factors may in turn disrupt parenting. Indeed, studies with infants and toddlers have demonstrated that parents in crowded households are less responsive, less involved and less vocally stimulating to their children (Corapci, 2004; Corapci & Wachs, 2002; Wachs, 2005). Thus, living in larger and more crowded households may increase parental stress, potentially leading to lower quality parenting, which in turn may have been negatively linked to children's language development.

Additionally, the differential role that adults and children cohabiting with the target child play in this context was not previously explored. As mentioned above, multiple children may be competing for parental attention in a way that increases maternal stress, more adults in the house may provide caretaking help, thus offsetting the cost of having multiple children present. They may, on the other hand, also be a stressful addition to the household. We will thus consider the role of adults and children living in the household, as well as maternal stress as mediating the possible effect of household size and residential crowding, on language outcomes.

The Current Study

In the current study we investigated the possible effect of older siblings as well as household size and residential crowding on children’s language outcome measures, in a sample from a culture that has not previously been examined in this context. We analysed data from Growing Up in Singapore Towards Healthy Outcomes (GUSTO), a population based birth cohort study from Singapore (Soh et al., 2014). This cohort consists of more than a thousand children, and has data on family composition, as well as on mother and child variables. Singapore has a diverse ethnic composition, with three main ethnic groups making up the resident population (Chinese, Malays, and Indian). Family size and cohabiting patterns show large variability in Singapore, and the average household size of 3.16 (Population Trends, 2020) is larger than that in France (2.38; OECD) where a recent study on the effect of the presence of older siblings on language skills has been conducted (Havron et al., 2019). The unique nature of our data set allows us to separately look at the following factors: siblings, household size and residential crowding, and the number of adult and child members of the household, as well as explore the mediating role of maternal stress in the relationship between these factors and children's language outcomes.

First, in study 1a, we tested the relation between having an older sibling, the age gap between siblings, and the sex of the older sibling - and children’s language development in our sample. We hypothesized that children who have an older sibling will score lower on language measures than children who do not have an older sibling. We additionally hypothesized that the negative effect will be smaller when the older sibling is a female. Last, we hypothesized that a smaller age gap will be associated with better language scores than when children are more widely spaced.

Second, in study 1b, we examined whether maternal stress might be a mediating factor in the possible effect of siblings on language development, such that having one older child is associated with higher maternal stress, which in turn is associated with lower language scores for the target child. We also hypothesized a mediating role for maternal stress between the sex of the older sibling and the language development of the younger sibling. Thus, the greater negative effect of an older brother than an older sister might be explained by the fact that female children are less stressful for mothers than male children. We tested this possibility in two ways. First, we looked at the relation between the *target* child’s sex, maternal stress and language scores. If girls are associated with less stress, this should be true for both the target child's sex and the older sibling's sex. We next tested the relation between the older sibling's sex, maternal stress and language scores.

Third, in study 2 we examined the link between household size and residential crowding - and children's language development. We also examined the mediating role of maternal stress in the relationship between household size and residential crowding and language development. We hypothesized that larger and more crowded households will be associated with lower language skills, and that stress will mediate this effect. Next, we attempted to dissociate the role of adult and child members of the household. We predicted a negative effect of the number of child members on language development, but we did not have a direct hypothesis about the possible effect of adult members. Adults may on the one hand provide more childcare, supporting language development, but they may also increase conflict and stress in the house or spend more time talking to each other at the expense of directing their speech at the children. Last, we examined residential crowding, hypothesizing that families living in more crowded dwellings will be associated with more maternal stress and lower language skills than families living in less crowded dwellings when controlling for household size.

Method

Study Design

The data were obtained from the *GUSTO* population based birth cohort study (Soh et al., 2014). This cohort consists of children born to pregnant women who were recruited in the first trimester from two large public hospitals in Singapore (N = 1, 217), Kandang Kerbau Women's and Children's Hospital and the National University Hospital, between June 2009 and September 2010. Ethical approval for the study "Growing up in Singapore towards Healthy Outcomes" was obtained from the National Healthcare Group Domain Specific Review Board and the SingHealth Centralised Institutional Review Board. Mother-child dyads were followed after birth, and data from fathers was also collected. The study is still ongoing, and the children are currently 11 years old. 56.1% of participants were of Chinese ethnicity, 25.4% of Malay ethnicity and 18.5% of Indian ethnicity at the study outset.

Sample

Since the main dependent variable of the current study was the language data collected at two, four and four and a half years of age, participants were included if such language data were available. In the current study, 677 children had language data available at two, four, or four and a half years. At two years of age, language data were available for 401 children. At four years of age, language data were available for 613 children. Finally, at four and a half years of age language data were available for 359 children. There were 289 children with language data available at all three ages[1]. 47.71% of the participants were girls (see Table 1 for participants' details). In study 1a and study 1b we included only full-term born children who had no older sibling or only one older sibling and did not have a twin. We excluded children with more than one older sibling from Study 1, but these were included in Study 2. Regarding ethnicity, 60.71% of participants in study 1 and study 2, were Chinese, 20.09% Malay, and 19.05% Indian.

Preregistration

All variables and analyses reported in this paper were preregistered via Open Science Framework prior to data analysis (Havron et al., 2020; Lovcevic et al., 2020a, 2020b). These preregistrations can be accessed via the following links: Study 1a (https://osf.io/xwnps/), Study 1b (https://osf.io/8dmge/), and Study 2 (https://osf.io/acdnf/). Furthermore, analysis

[1] It is not uncommon to have such missing data in longitudinal studies. To assess whether there were any tendencies for systematic loss of data relevant to our study (e.g., whether children exposed to more stress would be more likely to attrite), we provide distributional graphs for participants who completed and who did not complete all three language testing sessions for variables in studies 1a, 1b, and study 2 in Supplementary Material S1.

scripts and data are available on these links as well. However, we deviated from the preregistrations for Study 1b and Study 2 based on comments which improved the analysis, and we will note where we deviate in what follows. In those cases, the results of the preregistered analyses appear in the supplementary materials.

Materials

Predictors of Language Skills. Predictors included: having an older sibling (binary variable), the age gap between the target child and the older sibling, and the sex of the older sibling (see Table 1 for descriptive statistics).

Control Variables. Control variables included: the target child's sex, birth weight (kg), gestational age (weeks), age at testing, language of test administration, maternal alcohol consumption during pregnancy (grams/day), maternal smoking status at the 26th week of pregnancy, maternal education (six categories: no education, primary, secondary, ITE/NITEC, GCE (polytechnic/diploma), university (bachelor/masters/PhD), paternal education, maternal age at delivery (years), and paternal age at delivery. These data were collected from obstetrical records (gestational age and birth weight) and from questionnaires administered to the parents (see Table 1 for descriptive statistics).

Language Skills (Outcomes Measures). ***Two Years.*** At two years of age, parents filled in the Ages and Stages Questionnaire, 3rd Edition (ASQ-3®), which assesses the child's development from 2-to-60 months of age and has good validity and reliability (Squires et al., 2009, see Table 1 for descriptive statistics). The ASQ-3 has five independent subscales focused on five domains of development: communication, gross motor, fine motor, problem-solving, and personal-social. For the purposes of this study, we only used data from the Communication subscale.

Additionally, at this age, the Bayley Scales of Infant and Toddler Development (version III, BSID-III, Bayley, 2006) were administered in participants' homes by trained examiners who had at least 10 hours and eight cases of supervised administration and scoring (see Table 1 for descriptive statistics). The BSID-III is an individually administered instrument that evaluates cognitive, communicative, and motor development in children from 1-to-42 months of age and has good reliability and validity (Bayley, 2006). In this study, only data from the language scale was used. The Language scale consists of two subscales: receptive communication and expressive communication. The receptive communication subscale consists of 49 items measuring the child's auditory acuity and their ability to understand and respond to verbal stimuli. The expressive communication subscale consists of 48 items that measure the child’s ability to vocalize, name pictures and objects, and communicate with others. Both the ASQ-3 and the BSID-III were administered in the participant's dominant language.

Four Years. At this age, the Peabody Picture Vocabulary Test (PPVT-4, Dunn & Dunn, 2007) was administered to the children in English (see Table 1 for descriptive statistics). The PPVT is a test of the receptive vocabulary in which the child’s task consists of pointing to one of four pictures that is named by the examiner. It consists of 228 items grouped into 19 sets of 12 items arranged in order of increasing difficulty. The PPVT- 4 demonstrates strong psychometric properties (Dunn & Dunn, 2007).

Four and a Half Years. At this age, the Kaufman Brief Intelligence Test, second edition (KBIT-2, Kaufman & Kaufman, 2004) was administered to the children in their dominant language (see Table 1 for descriptive statistics). The KBIT-2 is an individually administered assessment of intellectual ability normed for 4-to -90 years of age that assesses both verbal ability and nonverbal reasoning ability. The administration of the battery results in three scores: a verbal score, a non-verbal score, and an IQ composite. For the purpose of this study, only the verbal score was used. The KBIT-2 demonstrates good validity and reliability (Kaufman & Kaufman, 2004).

In order to ensure that the scores from the different questionnaires have the same weight in our analyses, each test score was transformed into a *z* score. Thus, in our statistical analyses, we used the *z* transformed outcome scores at each testing age: the average score of *z* transformed ASQ-3 and BSID-III scores at age two, *z* transformed PPVT scores at age four, and *z* transformed KBIT-2 scores at age four and a half. In addition, for Study 1b and Study 2, we aggregated language measures at four and four and a half years into a *late language score*, while language measured at two years served as an early language score. As explained in the next section, this was necessary in order to be able to construct models of the possible relation of stress with later language outcomes in a way that only takes into account measurements of stress taken *prior* to the language tests[2].

Postnatal Maternal Stress (The Mediator). Postnatal maternal stress was measured at the age of three, 12, 24, 36 and 54 months by administering the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983), and at three and 24 months by administering the Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987) (see Table 1 for descriptive statistics). Although these inventories were developed as screening tools for anxiety and depression, previous studies have shown that they are sensitive predictors of caregiver stress over time (Green et al., 2017; Elliot et al., 2001; Shewchuk et al., 1998; Ugalde et al., 2014). Due to the high correlation between these scores at different ages (see Supplementary Material Section S2), the z scores for both measures were calculated, and the average z scores were used. Since we were interested in the possible effect of stress on later language scores, we grouped stress scores into two groups according to age of measurement (*early stress* and *late stress*)[3]. Thus, in order to predict language at two years, we included the z-scored or aggregated scores for maternal stress measured at child’s age of three and 12 months. In order

[2] In our preregistration, we did not group language scores together.

[3] In our preregistration, we had grouped all stress measures into one score due to the significant correlations between the stress measures.

to predict language scores at four and four and a half years, we used z-scores or aggregated scores for maternal stress measured at 24 and 36 months of age. We did not include stress measured at 54 months in the analysis as this was taken after the last language measure. For those ages where stress measures from two inventories existed, the average *z* scores were used as a measure of maternal stress (see Table 1 for average stress scores at each testing age).

Study 1a

The first aim was to replicate the previous findings of an overall negative effect of the presence of older siblings on language outcomes (Black et al., 2005; Havron et al., 2019; Peyre et al., 2016) by comparing children with no older sibling to children with one older sibling. The second aim was to assess whether the age gap between children and the sex of the older sibling affects children's language skills (as was done in Havron et al., 2019). This is a direct replication in a new sample, that is to say, the analysis is identical to the one in Havron et al. (2019).

Statistical Analyses

Since in our sample, each child had between one and three observations, we ran linear mixed-effects models to analyse the data. First, we fitted three linear models, one for each testing age (two, four, and four and a half years) with the child's precise age at testing and with aforementioned control variables but without predictors (control variables were: child's sex, birth weight, gestational age, age at testing, the language of test administration, maternal alcohol consumption, maternal smoking status, maternal education, maternal age at delivery, paternal age at delivery, paternal education, and household income). In case of missing values, we used the Multivariate Imputation via Chained Equations method as a principled way to predict missing values from observed values. This method was implemented with the R package *mice* (Van Buuren, & Groothuis-Oudshoorn, 2011) imputing the datapoints on a variable by variable basis by specifying an imputation model per variable. To impute missing values for continuous variables, the predictive mean matching method (Little & Rubin, 1987) was specified, whereas for categorical variables the Bayesian polytomous regression method was used. The predictive mean matching method handles missing values by selecting a datapoint from the original data which has a predicted value close to the predicted value of the missing datapoint. Bayesian polytomous regression method works in the same way but for categorical variables. Specifically, a missing value on variable *x* is replaced with the value of variable *x* from a participant whose regression-predicted score is closest to the regression-predicted score of the participant for whom the value is missing. These methods thus impute the data based on predicted values of data points that exist in the dataset and are therefore less sensitive to model misspecifications as other imputation methods (White et al., 2011). Linear models were fitted on datasets after imputation. Next, residuals were extracted from these models and combined into one dataset used in our main mixed-effects regression analysis to explain any residual variance left after adjusting for our control variables (the predictors were: having an older sibling, the age gap, and the sex of older sibling). The reason the adjustment was done this way is to enable us to control for the exact age at the time of evaluation, which would not be possible if the adjustments were done directly within the main model. In the analyses, the mean-centered age was obtained by subtracting the average age for each age group from each individual participant’s age at testing, in order to have an interpretable intercept of age. The presence of an older sibling and the older sibling’s sex were sum-coded, while the age gap was mean-centered. For our main analyses, we first run a linear mixed-effects regression model with the adjusted language scores (the measure of child’s language skills) as the dependent variable, age at testing (two, four, and four and a half years of age) as a within-participant independent variable, and the presence of an older sibling as a between-subject independent variable with a random intercept for participants

(Model 1). In a second model, we added the between-subject independent variables of the older sibling's sex, and the age gap between the child and the older sibling (Model 2). The models were fitted using the *lmer* function of the *lme4* package (Bates et al., 2015) in R (R core team, 2020). In the main analyses, missing data were not imputed, but in cases where a child was missing language scores at all three ages, the child was excluded from analysis.

The significance of models was assessed using Satterthwaite's method using the *anova* function of the *lmerTest* package (Kuznetsova et al., 2017). As a measure of effect size, Cohen's d was calculated from the *F*-statistic using the function *F_to_d* from the package *effectsize* (Ben-Shachar et al., 2020). Additionally, in order to evaluate the evidence for the null hypotheses, Bayes Factors (BFs) were determined using the marginal likelihoods (bridgesampling) method. In order to interpret the BFs, we used the conventional cut-offs based on Jeffreys (1998), with a BF greater than 3 representing sufficient evidence for the experimental hypothesis, and a BF less than .33 representing sufficient evidence for the null hypothesis. BFs with values between .33 and 3 indicate that the data are inconclusive. BFs were determined using the functions *bayesfactor_models* and *brm* from the R packages *bayestestR* (Makowski, et al., 2019) and *brms* (Bürkner, 2017). Note that when the null hypothesis testing and BFs give contradictory results, we discuss the results in terms of their significance, while also mentioning whether these were supported by the Bayesian analyses as a measure of robustness of these results.

We also reran the main models excluding the children for which English was not the dominant language. While ASQ-3, BSID-III, and KBIT-2 were administered in the child's dominant language, PPVT was only administered in English regardless of the child's dominant language. Thus, in order to control that PPVT administration in English did not influence our results, all main models were also conducted without children for which English was the non-dominant language[4].

Results

Model 1: Having an Older Sibling Versus Having No Older Sibling. The fitted LME model revealed a significant main effect of the presence of an older sibling (*F*(1, 648.51) = 7.28, *p* = .01, *BF* = 5.45). The BF suggests substantial evidence for the experimental hypothesis. Children with no older sibling demonstrated higher language scores (*M* = .05, *SE* = .04) compared to children with one older sibling (*M* = -.12, *SE* = .05, *p* = .01, *Cohen's d* = .21, 95 % *CIs*: .06, .37, see Figure 1). There was no significant main effect of age at testing (*F*(1, 810.39) = .02, *p* = .89, *BF* = .01, *Cohen's d* = .01 (95 % *CIs*: -.13, .15 , see Table 2 for model summary), which was supported by BF indicating the evidence for null hypothesis.

Model 2: Having an Older Sister vs. Having an Older Brother. The fitted LME model for the sex of older sibling and the age gap between siblings revealed a significant main effect of age gap (*F*(1, 205.16) = 5.83, *p* = .02, *BF* = .03, *Cohen's d* = .34 (95 % *CIs*: .06, .61), indicating that children with a smaller age gap between them and their older siblings show better language skills than those with a larger age gap (though note that the BF shows evidence for a null effect). There was no significant main effect of the older sibling's sex (*F*(1, 212.80) = .57, *p* = .45, *BF* = .21, *Cohen's d* = .10 (95 % *CIs*: -.17, .37), no significant main effect of age at testing (*F*(1, 282.40) = .001, *p* = .98, *BF* = .001, *Cohen's d* = .004 (95 % *CIs*: -.23, .24) and no significant age gap by older sibling's sex interaction (*F*(1, 205.21) = .10, *p* =.75, *BF* < .0001, *Cohen's d* = .05 (95 % *CIs*: -.23, .32, see Table 3 for

[4] The results of these models are reported in Supplementary Materials (section S3). Comparable results were obtained.

model summary; see Figures 2 and 3) with BFs showing evidence for null hypothesis in all three cases.

Discussion Study 1a

In Study 1a, we replicated previous studies on the negative effect of having an older sibling on language development (e.g., Havron et al., 2019), thus demonstrating better language skills in children with no older sibling compared to children with one older sibling. We also found a significant effect of age gap, such that a smaller age gap between target child and the older sibling predicted better language scores, in line with a result from two recent studies (Havron et al., 2019, though it was not statistically significant in that study; Gurgand et al., in preparation, where it was significant). Finally, we did not find evidence for sex differences in the possible effect of the older sibling on language outcomes, although descriptively our result was consistent with previous results in that children with older sisters showed better languages scores than children with older brothers.

Study 1b

The first aim of Study 1b was to assess whether maternal stress mediates the relation between having an older sibling and language skills in children. The second aim was to examine whether maternal stress mediates the relation between sibling sex and language skills in children. In study 1a, we did not find that sibling sex was linked to language outcomes. We nevertheless examine whether there is a mediating effect of maternal stress, since controlling for maternal stress might change this outcome.

We should note here that there are different theoretical views on conducting a mediation analysis in cases when there is no direct effect between two variables. According to the traditional school of thought, mediation analysis should be conducted only if there is a direct effect of variable X on variable Y (Baron & Kenny, 1986; Judd & Kenny, 1981). On the other hand, a more recent school of thought suggests that mediation analysis, if theoretically warranted, can be conducted even if there is no direct effect between two variables. For one thing, the indirect effects assessed by mediation analysis may have greater explanatory power than direct effects (Agler & DeBoeck, 2017; Loeys,et al., 2015; O'Rourke & MacKinnon, 2015; Rucker, et al., 2011); for another thing, if there are two effects in opposite directions (i.e., a direct and an indirect effect in opposite directions) they may suppress each other, resulting in a near-zero total effect (MacKinnon, et al., 2000). Thus, in order to understand the potential role of maternal stress in the context of sibling effects on language development, we conducted mediation analyses regardless of the presence of direct effects.

Analyses

Three mediation analyses were run: one mediation with the presence of an older sibling as an independent variable (Mediation 1), another with the target child's sex as an independent variable (Mediation 2), and a third with the older sibling's sex as an independent variable (Mediation 3). Since the outcome variable (language skills) and mediation variable (maternal stress) were measured at two time points (early/late), two waves mediation analyses, which are the mediation analyses for longitudinal data measured at two time-points, were conducted[5]. Thus, the first wave of mediation analysis included one of the independent variables (the presence of an older sibling, child's sex, sibling's sex), early maternal stress as a mediator variable, and early language skills as the outcome variable. The second wave of mediation analysis included one of the independent variables (the presence of older sibling, child's sex, sibling's sex), late maternal stress as a mediator variable, and late language skills as the outcome variable. The overall indirect effect, which is the effect of an independent

[5] These analyses deviate from the preregistration. While we proposed to aggregate measures of maternal stress in the preregistration, the present analysis is a 2-waves mediation analyses to account for early and late measures of maternal stress. The results of the preregistered analyses are reported in Supplementary Material (Section S4).

variable on the outcome variable that goes through the mediator variable, was calculated by summing up the indirect effects for each wave. The two waves mediation analyses were conducted for each independent variable separately in four steps using the R package *mediation* (Tingley et al., 2014). In Step 1, a linear model was fitted to assess the direct effect of independent variable (older sibling in Mediation 1, target child's sex in Mediation 2, older sibling's sex in Mediation 3) on the dependent variable (early/late language skills). Step 2 assessed the effect of the independent variable on the mediator variable (early/late maternal stress), while step 3 assessed the effect of the mediator variable on the dependent variable while controlling for the effect of the independent variable. Finally, in step 4 we run the causal mediation analysis, thus, assessing whether the relation between the independent variable and dependent variable is mediated by the mediator variable (indirect effect). The significance of indirect effects was tested using bootstrapping procedures. Unstandardized indirect effects were computed for each of 1,000 bootstrapped samples, and the 95% confidence intervals were computed by determining the indirect effects at the 2.5th and 97.5th percentiles. Additionally, Bayesian mediation models were fitted using the function *brm* from R package *brms* (Bürkner, 2017).

Results

Mediation 1: The Presence of an Older Sibling and Maternal Stress. Table 4 presents the results of step 1, step 2, and step 3 of the mediation analysis. The results of the causal mediation analysis (step 4) demonstrated no significant indirect effect of the presence of an older sibling on language skill through maternal stress was not significant (*Overall Indirect effect* = -.001, p = .78, 95 % *CIs*: -.02, .01,). The results of the Bayesian mediation analysis confirm these results (*Overall Indirect effect* = -.001, 95% *CIs*: -.02, .01) with maternal stress accounting for only 0.32 % of the relation between the presence of an older sibling and language skills. Thus, the results do not support the hypothesis that the effect of the presence of an older sibling on language skills was mediated by maternal stress.

Mediation 2: The Target Child's Sex and Maternal Stress. The results demonstrated no significant indirect effect of the target child's sex on language skills that goes through the mediator, maternal stress (*Overall Indirect effect* = -.004, p = .66, 95 % *CIs*: -.03, .01). The results of the Bayesian mediation analysis confirm these results (*Overall Indirect effect* = .001, 95 % *CIs*: -.01, .01) with maternal stress accounting for 14.66 % of relation between the target child's sex and language skills. These results suggest that the effect of the target child's sex on language skills was not mediated by maternal stress.

Mediation 3: The Older Sibling's Sex and Maternal Stress. There was no significant indirect effect of the older sibling's sex on language skills that goes through maternal stress (*Overall Indirect effect* = -.001, p = .95, 95 % *CIs*: -.06, .05). The results of the Bayesian mediation analysis confirmed these results (*Overall Indirect effect* = -.0001, 95 % *CIs*: -.03, .03). Thus, mediation 3 indicates that maternal stress does not mediate the relation between the older sibling's sex and language skills.

Discussion Study 1b

Study 1b examined the potential mediating effect of maternal stress in the relation between language outcomes and having an older sibling, the target child's sex, and the older sibling's sex. While we found that the presence of an older sibling and the target child's sex (but not sibling's sex) predicted language outcomes such that having an older sibling and being male were both associated with lower language scores, these relations were not mediated by maternal stress.

Study 2

In Study 2, we go beyond looking at the possible effect of a single older sibling and explore the possible effect of the presence of other household members on children's language skills, as well as the role of maternal stress therein, by particularly focusing on the effects of household size and residential crowding.

Sample. Since in Study 2 we include all children regardless of the number of older siblings, the sample size in Study 2 differs from the sample size in study 1a and study 1b. In the current study, 855 children had language data available at two, four, or four and a half years. At two years of age, language data were available for 511 children. At four years of age, language data were available for 771 children. Finally, at four and a half years of age language data were available for 467 children. There were 379 children with language data available at all three ages. 47.6 % of participants were girls, and 58.25% of participants were Chinese, 24.33% Malay, and 17.31% Indian (see Table 5 for participants' details).

Analyses

We ran two sets of analyses[6]. The aim of the first set of analysis is first to assess whether household size, residential crowding and maternal stress influence language skills in children (model 1) and then to assess whether maternal stress mediates the relation between the number of household members and children's language scores (mediation 1). In the second set of analyses, the first aim is to assess whether the number of adults, the number of children in the household, residential crowding, and maternal stress influence language skills in children (model 2), and the second aim is to assess whether maternal stress mediates the relation between the number of adults (mediation 2.1), the number of children (mediation 2.2) in the household, residential crowding (mediation 2.3) and children's language scores. As in studies 1a and 1b, residuals from the analysis predicting language outcomes from the control factors were used as a dependent variable. Thus, in model 1, the dependent variable

[6] The analyses deviate from the preregistration. While we proposed to aggregate measures of maternal stress in the preregistration, the present analysis is a 2-waves mediation analyses to account for early and late measures of maternal stress. The results of the preregistered analyses are reported in Supplementary Material and are comparable (Section S4).
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(language skills) was regressed on the household size, residential crowding, maternal stress and a dummy indicator of testing time (early = 0, late = 1). In the model 2, the dependent variable (language skills) was regressed on the number of adult members, number of child members, residential crowding, maternal stress and a dummy indicator of testing time (early = 0, late = 1). As in Study 1a, we again ran a control analysis excluding children for which PPVT was not administered in children's dominant language (Supplementary Material S3). Mediation analyses were conducted in the same way as in study 1b.

Results

Model 1: The Effect of Household Size, Residential Crowding, and Maternal Stress. The fitted LME model showed no significant main effects of household size (*F*(1, 449.33) = 2.00, *p* = .16, *BF* = .20, *Cohen's d* = .09, 95 % *CIs*: -.09, .28) nor residential density (*F*(1, 438.22) = .28, *p* =.6, *BF* = .22, *Cohen's d* = .05, 95 % *CIs*: -.14, .24), maternal stress (*F*(1, 698.75) = 1.87, *p* =.17, *BF* = .36, *Cohen's d* = .10, 95 % *CIs*: -.05, .25), nor testing time (*F*(1, 400.97) = .21, *p* =.65, *BF* = .15, *Cohen's d* = .05, 95 % *CIs*: -.15, .24). BFs also show strong support for the null.

Mediation 1: Household Size and Maternal Stress. We found no significant indirect effect of household size on language skills through the maternal stress (*Overall Indirect effect* = -.001, *p* = .85, 95 % *CIs*: -.01, .01, see Table 6). The results of the Bayesian mediation analysis confirm these results (*Overall Indirect effect* = -.0005, 95% *CIs*: -.01, .003). These results suggest that the effect of household size on language skills was not mediated by maternal stress.

Model 2: The effect of Adult Members, Child Members, Residential Crowding and Maternal Stress. The fitted *LME* model revealed a significant main effect of number of adult members (*F*(1, 451.03) = 4.32, *p* = .04, *BF* = 1.66, *Cohen's d* = .20, 95 % *CIs*: .01, .38), but no main effects of number of child members (F(1, 444.61) = .001, p = .98, *BF* = .08, *Cohen's d* = .003, 95 % *CIs*: -.18, .19), maternal stress (F(1, 697.34) = 2.04, p = .15, *BF* = .36, *Cohen's d* = .11, 95 % *CIs*: -.04, .26), nor testing time (F(1, 401.54) = .18, p = .67, *BF* = .15, *Cohen's d* = .04, 95 % *CIs*: -.15, .24). These results suggested that the greater number of adults in the household results in greater language skills in children, however, the *BF* only gives anecdotal support for this hypothesis.

Mediation 2.1: The Number of Adult Members and Maternal Stress. The casual mediation analysis demonstrated no significant indirect effect of number of adult members on children's language skills, via maternal stress (*Overall Indirect effect* = -.001, p = .83, 95 % *CIs*: -.01, .00, see Table 6), which was confirmed by Bayesian mediation analysis (*Overall Indirect effect* = .0002, 95 % *CIs*: -.004, .01) with maternal stress accounting for only 0.24 % of relation between the number of adults and language skills. These results suggest that the effect of the number of adult members on language skills was not mediated by maternal stress.

Mediation 2.2: The Number of Child Members and Maternal Stress. We found no significant indirect effect of number of child members on children's language skills via maternal stress (*Overall Indirect effect* = -.0005, p = .80, 95 % *CIs*: -.01, .01), which was confirmed by the Bayesian mediation analysis (*Overall Indirect effect* = -.001, 95 % *CIs*: -.01, .004) with maternal stress accounting for only 1.26 % of relation between the number of children in household and children's language skills. Thus, the effect of the number of child members on language skills was not mediated by maternal stress.

Mediation 2.3: Residential Crowding and Maternal Stress. The results showed no significant indirect effect of residential crowding on language skills through maternal stress (*Overall Indirect effect* = .002, p = .91, 95 % *CIs*: -.02, .03, see Table 6). The results of the Bayesian mediation analysis confirm these results (*Overall Indirect effect* = .002, 95 % *CIs*:

-.01, .02) suggesting that the relation of residential crowding and language skills was not mediated by maternal stress. Although the effect of residential crowding on both early and late maternal stress was significant (see step 2 for mediation 2.3 in Table 6), these results suggest that maternal stress does not mediate the relation between residential crowding and language skills in children.

Discussion Study 2

Study 2 set out to examine the relation between household factors beyond the presence of a single older sibling and language outcomes, with and without the mediating effects of maternal stress. In our analyses of the relation between the overall household size and maternal stress - and language skills, we found that stress, but not household size, affected language outcomes, with higher stress predicting lower language scores. A similar pattern was found in the analyses looking at the possible effect of child members separately, where we again found a significant effect of stress, but not the effect of child members, on language outcomes. On the other hand, results demonstrated the positive effect of number of adult members on language outcomes. However, however, the *BF* only gives anecdotal support for this effect. Finally, our analysis of the possible effect of residential crowding suggests that it is related to maternal stress, which in turn has a marginally significant effect on language outcomes. However, the causal mediation effect did not reach statistical significance, suggesting that maternal stress did not mediate the relation between residential density and language skills in children.

General Discussion

Several family structure factors have been previously shown to adversely affect children's language acquisition outcomes. Here we focused on the presence, age and sex of an older sibling, and household size and residential crowding. We analysed a multi-ethnic child cohort from Singapore, a society much different from the mostly Western cultures previously tested, examining the generalizability and possible reasons for this recurrent pattern. Looking more in depth into these factors, we also examined whether their relation with language outcomes was mediated by maternal stress, given that they may increase maternal stress, and that maternal stress has been previously shown to adversely affect children's language outcomes. We start by discussing the possible effect of older siblings, and the (lack of) a mediating role of maternal stress before moving on to household size, and residential crowding.

Older siblings are generally found to have a negative association with language acquisition, such that the more older siblings a child has, the lower their language skills (e.g., Black et al., 2005; Peyre et al., 2016). In study 1a we tested the possible effect of having an older sibling, the age gap between siblings, and the sex of the older sibling on children's language development. In study 1b, we examined whether maternal stress is a mediating factor in the effect of siblings on language development, such that having an older child, and the child being a male, is associated with higher maternal stress, which is in turn associated with lower language scores for the younger of the two siblings.

In study 1a, we found that, like in previous studies on mostly Western cultures, having an older sibling was associated with lower language scores, providing corroborating support for this pattern from a non-Western society. Thus, while previous studies seeing larger families as a risk factor originated from Western countries, their result does replicate to Singapore, a non-Western culture. However, this result should be replicated in yet other cultures, which significantly differ from both Singapore and the other Western countries studied. Specifically, we recommend examining this question in non-urban settings with a low level of child-directed speech from adults, where it has been suggested children become more attuned to learning from overheard and other children's speech (see Casillas et al., 2020; Ochs & Schieffelin, 1995).

We also found a significant effect of age gap, such that siblings with a narrower age gap showed higher language scores than siblings with a wider age gap. This result is in line with a result from two recent studies (Havron et al., 2019, though it was not statistically significant; Gurgand et al., in preparation). One possible explanation for this finding is that when siblings are closer in age it is easier for parents to engage them in a shared activity that is developmentally appropriate for both children (e.g., reading a story which is suitable for both ages). An additional explanation is that more narrowly spaced siblings tend to have closer relationships (Furman & Burhmester, 1985; though see also Samek & Rueter, 2011 who did not find a relationship between the age gap and relationship quality). Thus, this finding still leaves open whether it is parents' or siblings' linguistic input that affects language acquisition when there are older siblings in the house.

Finally, our results did not show that the older sibling's sex was related to the younger sibling's language scores. This is in contrast with previous findings (Havron et al., 2019; Jakiela et al., 2020), and may have three different reasons. The first is that our study was simply underpowered to detect such an effect. This interpretation is supported by the fact that our obtained BFs only moderately supported the null. The second is that the effect in previous studies was a false positive, as indeed, Gurgand et al., (in prepration) also did not find an effect of the sibling's sex (though they did find an interaction between the sibling's sex and the age gap between siblings such that when the age gap is smaller, children with an older sister do score higher than those with older brothers, and even than firstborns). While these are both viable interpretations, a more theoretically interesting interpretation is that our sample of Singaporean children is inherently different from the French sample used in Havron et al. (2019) and the Kenyan one used in Jakiela et al. (2020). However, given that we did not compare these cultures directly, any discussion of such possibility would be speculative, and we therefore refrain from it in the present article. In addition, remember that

Singapore is made up of three major ethnic groups (which we did not look at separately in this study, due to low statistical power for this comparison), and it is thus not suitable to make sweeping generalizations about the population.

In study 1b, we investigated the possibility that maternal stress mediates the effect of having an older sibling, as well as the effect of the sex of the target child and their older sibling, on language development. First, unlike hypothesized, we found that having two children was not associated with more maternal stress than having one child. The finding that having two children was not associated with increased maternal stress can contribute to understanding the possible causes of the decades-long finding that having an older sibling is associated with lower language skills. If maternal stress is not a reason for the negative effect of older siblings on language development, this leaves open one other proposed route: That parents are more occupied with the older sibling at the expense of providing high-quality input to younger siblings (despite not being emotionally occupied with the burden of also having an older child). In other words, this is a mere matter of allocation of time, or a differential treatment of the two children (e.g., Bornstein et al., 2019). Indeed, it was previously shown, in US families, that when both siblings are present, parents may be more responsive to the older child, at the expense of providing (quality) language input to the younger child (Huttenlocher et al., 2007; see also Hoff-Ginsberg & Krueger, 1998). Given the lack of a maternal stress effect in the present study, this may be a more likely explanation for the older sibling effect than the emotional burden on parents.

However, it is also possible, as with any null effect, that there was no effect of maternal stress simply because of statistical power issues. This would be in line with previous literature which showed that maternal stress is indeed negatively associated with language development (e.g., Reck et al., 2018). The way maternal stress contributed to language development in previous studies could be by lowering the amount and quality of maternal linguistic input (e.g., Porritt et al., 2014). Previous studies found delayed response onset to infants' vocalizations by depressed mothers (Bettes, 1988). Additionally, it was found that mothers with depression are less likely than non-depressed mothers to adjust their speech input to younger babies by shortening the mean length of their utterances (Reissland et al., 2003). Our findings in study 2 support this option, because when we use a larger sample from our study (not limiting ourselves to children who have only one older sibling or none), we do find an effect of maternal stress on language scores. We elaborate more on this below when we discuss study 2. Maternal stress neither mediated the effect of the older sibling's sex on the younger siblings' language development, nor was it significantly related to either the sex of the target child themselves nor the sex of the older sibling.

We next looked at the possible effect of our second set of family structure factors, household size and residential crowding. In study 2, we first examined the role of household size generally, and then dissociated the role of adult and child members of the household. In addition, we examined the role of residential crowding. We found no effect of household size on language scores nor on maternal stress. On the other hand, our results suggest that the number of adult members positively affects children's language skills. However, this effect should be interpreted with caution, since the Bayes factors only provide anecdotal support for this hypothesis suggesting that the data are rather insufficient. Furthermore, we did not find an effect of residential crowding on language scores. This is contrary to previous research which showed that these factors do influence cognitive and language development, such that larger households and denser residences are associated with lower language and lower cognitive scores (Evans et al., 1999; 2010). One reason for this difference in finding might be that in Singapore many parents are working full-time and children might, to a great extent, be raised by grandparents or live-in hired help (Graham et al., 2002). The added stress or hardship associated with larger households or denser habitation might be offset by the help offered by these allo-maternal carers. As with studies 1a and 1b, it is also possible that this effect is due to a smaller sample size than previous studies (study 2 in Evans et al., 2010 had 10,000 children, however, note that study 1 in that paper, as well as in Evans et al., 1999 had only several dozen children).

As already mentioned above, in study 2, unlike in study 1b, we *did* find an effect of maternal stress on children's language development, which is in line with previous studies (e.g., Reck et al., 2018). This might be because we were able to include a larger sample from our cohort in study 2 and in study 1b, since we included families with more than two children (studies 1a & 1b: 677 children, versus study 2: 856 children). Reck et al. (2018) used a small sample of mother-child dyads (34 mothers with anxiety disorder and 47 healthy mothers) and found that the strongest predictors of children's language development were maternal anxiety cognitions and joint activity in mother-infant interaction. Here, we complement these findings in three ways: We examine a subclinical sample, thus showing that maternal stress is related to language development not only when mothers fit diagnostic criteria for an anxiety disorder; we examine a much larger sample; and we examine a different culture (dyads in Reck et al., 2018 were German). These three facts speak to the generalizability of the effect. Given these findings, it might be advisable for physicians and public health nurses who cater to mothers to note signs of distress and gently refer mothers to therapy - both for their own health, and the cognitive development of their young children. Additionally, in study 2 we found that residential crowding affects maternal stress, however, maternal stress did not mediate the relationship between residential crowding and language skills.

To summarize, we find a negative effect of having an older sibling on language development. In addition, when siblings are closer together in age, their language scores are better than when they are further apart. The sibling's sex, however, did not significantly affect children's outcomes. We did not find that the effect of having a sibling on language scores is mediated by maternal stress. Other factors (child and sibling sex, and household size) were likewise not mediated by maternal stress. These results might be the result of insufficient statistical power, or false positive results in previous studies, but a more theoretically interesting possibility is that they are the result of cultural differences between our Singaporean sample and previously studied samples (all samples were Western). Last, we found that residential crowding affects maternal stress, but maternal stress did not account for the relation between residential crowding and language skills. Our findings shed light on open questions about the role of family structure variables such as older siblings and household size and density on language development within a given child's social environment.

Given our current studies' limitations (limited power, inability to systematically compare across cultures, no direct access to the language input parents provide children), we hope to encourage future studies addressing these issues. For one, larger cohorts should preferably be used (as is being done in Gurgand, in preparation, examining a cohort of 10,000 French children). Second, we encourage cross-cultural studies, or at least studies on specific cultures that differ from previous samples studied (for example: non-Western, containing larger families, containing non-nuclear family residence, more traditional, with lower average income or education levels). In terms of cross-cultural studies, we are now working on an analysis of the relationship between sibship size and characteristics of children's language development during the first covid19 lockdown. In terms of looking directly at how parental input is affected by family structure, we are now working on a study examining this directly in a small sample of children, but it is highly recommended to conduct such studies with large samples and corpora. While this is a large and expensive effort to undertake, it might be possible to utilise existing datasets and recordings to achieve this goal. For example, Havron et al. (in preparation) systematically gathered data on family structure (number of children and nuclear vs. extended family) in a major archive of child-centered language, CHIld Language Data Exchange System (CHILDES, MacWhinney, 2000): future studies may be able to analyse the amount and quality of input to children in CHILDES as a factor of the number of siblings they have (there was almost no representation of extended families, so it will not be possible to analyse this variable).

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Table 1

Characteristics of children in the analysis sample with no older sibling or one older sibling

Variable	Children with no sibling or one older sibling (*n* = 677)	Children without an older sibling (*n* = 407)	Children with one older sibling (*n* = 270)
Sex of the older sibling (male)	-	-	39.88 %
Age gap (months)	-	-	*M* = 49.18 (*SD* = 38.16)

Language skills at 2 years	*n* = 401	*n* = 246	*n* = 155
ASQ-3 communication score	*M* = 47.54 (*SD* = 14.27)	*M* = 47.22 (*SD* = 14.28)	*M* = 48.08 (*SD* = 14.29)
BSID-III Receptive Communication score	*M* = 9.58 (*SD* = 2.88)	*M* = 9.63 (*SD* = 3.02)	*M* = 9.49 (*SD* = 2.65)
BSID-III Expressive Communication score	*M* = 9.36 (*SD* = 2.55)	*M* = 9.45 (*SD* = 2.65)	*M* = 9.22 (*SD* = 2.39)
Age of testing	*M* = 24.05 (*SD* = .58)	*M* = 24.07 (*SD* = .57)	*M* = 24.01 (*SD* = .60)
Language skills at 4 years	*n* = 613	*n* = 378	*n* = 235
PPVT4	*M* = 51.27 (*SD* = 20.57)	*M* = 53.35 (*SD* = 21.17)	*M* = 47.92 (*SD* = 19.14)
Age of testing (months)	*M* = 48.61 (*SD* = .51)	*M* = 48.62 (*SD* = .51)	*M* = 48.6 (*SD* = .52)
Language skills at 4.5 years	*n* = 359	*n* = 233	*n* = 126
KBIT-s verbal subtest score	*M* = 87.54 (*SD* = 15.94)	*M* = 89 (*SD* = 16.56)	*M* = 84.84 (*SD* = 14.42)
Age of testing (months)	*M* = 54.54 (*SD* = 5.22)	*M* = 54.54 (*SD* = 5.06)	*M* = 54.54 (*SD* = 5.54)
Predictor of cognitive skills			
Gender (male)	52.29 %	50.37 %	51.11 %
Gestational age (in weeks)	*M* = 38.8 (*SD* = 1.5)	*M* = 38.9 (*SD* = 1.5)	*M* = 38.7 (*SD* = 1.5)
Birth weight (in kg)	*M* = 3.1 (*SD* = .45)	*M* = 3.08 (*SD* = .45)	*M* = 3.13 (*SD* = .45)

Mother's age at delivery (years)	*M* = 30.14 (*SD* = 4.82)	*M* = 29.99 (*SD* = 4.74)	*M* = 31.3 (*SD* = 5.28)
Father's age at delivery (years)	*M* = 33.5 (*SD* = 5.89)	*M* = 33.14 (*SD* = 5.68)	*M* = 36.13 (*SD* = 6.81)
Alcohol during pregnancy (grams per day)	*M* = .01 (*SD* = .16)	*M* = .003 (*SD* = .04)	*M* = .02 (*SD* = .25)
Maternal smoking during pregnancy	2.22 %	1.47 %	3.33 %
Maternal education (*median*)	Polytechnic/diploma	Polytechnic/diploma	Polytechnic/diploma
Paternal education (*median*)	Polytechnic/diploma	Polytechnic/diploma	Polytechnic/diploma
Household income (kSGD/month, *median*)	4000 - 5900	4000 - 5900	4000 - 5900
Postnatal maternal stress			
STAI (3 months)	*M* = 36.38 (*SD* = 9.81)	*M* = 36.40 (*SD* = 9.55)	*M* = 36.35 (*SD* = 10.23)
STAI (12 months)	*M* = 71.72 (*SD* = 19.33)	*M* = 72.53 (*SD* = 19.29)	*M* = 70.38 (*SD* = 19.31)
STAI (24 months)	*M* = 70.01 (*SD* = 19.45)	*M* = 69.85 (*SD* = 18.88)	*M* = 70.3 (*SD* = 20.39)
STAI (36 months)	*M* = 69.43 (*SD* = 18.78)	*M* = 70.23 (*SD* = 18.66)	*M* = 67.94 (*SD* = 18.9)

STAI (54 months)	*M* = 69.14 (*SD* = 18.36)	*M* = 69.32 (*SD* = 18.17)	*M* = 68.78 (*SD* = 18.72)
EPDS (3 months)	*M* = 6.67 (*SD* = 4.79)	*M* = 6.82 (*SD* = 4.6)	*M* = 6.43 (*SD* = 5.09)
EPDS (24 months)	*M* = 6.3 (*SD* = 4.91)	*M* = 6.3 (*SD* = 4.71)	*M* = 6.31 (*SD* = 5.23)

Table 2

Summary of adjusted LME models fitted for language skills as dependent variable and the presence of older sibling and age at testing as independent variables

Model and predictor	*β*	*SE*	*p*
Intercept	.05	.07	.47
Age at Testing	-.0001	.001	.89
Older Sibling (reference: without older sibling)	-.16	.06	.007**

** $p < .01$

Table 3

Summary of adjusted LME models fitted for child's language skills as the dependent variable and the older sibling's sex, age gap, and age at testing as independent variables

Model and predictor	*β*	*SE*	*p*
Intercept	*.14*	*.13*	*.31*
Age at Testing	.0001	.003	.98
Age Gap	-.003	.002	.02*
Sex (reference: brother)	-.06	.08	.45
Age Gap: Sex	.001	.001	.75

$^{*} p < .05$

Table 4

The results of Step 1 (effect of IV on DV), Step 2 (effect of IV on mediator), and Step 3 (effect of mediator on DV) for the mediation analyses in Study 1b ($p < .05$; ** $p < .01$, *** $p < .001$)*

	b	*F*	*p*	*BF*	*Cohen's d*	*95 % CIs*
Mediation 1 - having an older sibling (IV), language skills (DV), maternal stress (mediator)						
Step 1 (*df* = 1, 317)						
Older Sibling on Early Language Skills	.09	.86	.35	.39	.10	-.12, .32
Older Sibling on Late Language Skills**	-.28	9.52	.002	24.91	.35	.12, .57
Step 2 (*df* = 1, 317)						
Older Siblings on Early Stress	-.17	2.68	.10	.97	.18	-.04, .40
Older Siblings on Late Stress	-.06	.29	.59	.31	.06	-.16, .28

Step 3 (*df* = 1, 316)						
Early Stress on Early Language Skills	-.05	.87	.35	.08	.11	-.12, .33
Early Stress on Late Language Skills	.02	.23	.63	3.51	.05	-.17, .27
Late Stress on Late Language Skills	-.03	.29	.59	3.41	.06	-.16, .28
Mediation 2 - the sex of the target child (IV), language skills (DV), maternal stress (mediator)						
Step 1 (*df* = 1, 317)						
Child's Sex on Early Language Skills**	-.30	10.17	.002	35	.36	.14, .58
Child's Sex on Late Language Skills	-.11	1.60	.21	.49	.14	-.08, .36
Step 2 (*df* = 1, 317)						
Child's Sex on Early Maternal Stress	-.12	1.55	.21	.53	.14	-.08, .36
Child's Sex on Late Maternal Stress	-.12	1.27	.26	.49	.13	-.09, .35

Step 3 (*df* = 1, 316)						
Early Maternal Stress on Early Language Skills	-.07	1.58	.21	10.45	.14	-.08, .36
Early Maternal Stress on Late Language Skills	.03	.44	.51	.08	.07	-.15, .30
Late Maternal Stress on Late Language Skills	-.02	.27	.60	.07	.06	-.16, .28
Mediation 3 - the sex of the sibling (IV), language skills (DV), maternal stress (mediator)						
Step 1 (*df* = 1, 107)						
Sibling's Sex on Early Language Skills	-.02	.03	.87	.37	.03	-.35, .41
Sibling's Sex on Late Language Skills	.07	.22	.64	.41	.09	-.29, .47
Step 2 (*df* = 1, 107)						
Sibling's Sex on Early Maternal Stress	.03	.03	.86	.45	.03	-.34, .41

Sibling's Sex on Late Maternal Stress	.01	.002	.96	.46	.01	-.37, .39
Step 3 (*df* = 1, 106)						
Early Maternal Stress on Early Language Skills*	-.18	5.58	.02	1.11	.46	.07, .84
Early Maternal Stress on Late Language Skills	-.13	2.63	.11	.30	.32	-.97, .70
Late Maternal Stress on Late Language Skills	-.11	2.15	.15	.23	.28	-.10, .67

Table 5

Sample characteristics in Study 2

Household size (excluding the target child and mother)		Child members (excluding the target child)		Adult members (excluding the mother)	
No members	5	No child members	361*	No adult members	9**

One member	197	One child member	291**	One adult member	426
Two members	184	Two child members	140	Two adult members	152
Three members	186	Three or more	63	Three adult members	151
Four members	163			Four or more	117
Five or more	120				
Total:	855	Total:	855	Total:	855

* Note that this number differs from the number of children with no older siblings in Study 1 and 2 (n = 407), since here we only include participants with no other child members at home, while in the Study 1 and 2 we include participants who do not have an older sibling, but may have other children at home (e.g., relatives).

** There are 21 households that have one child member in the household that is not their own child (e.g., niece or nephew).

***There are four mothers that did not have adult members in the household but had an older child or children at home.

Table 6

The results of Step 1 (effect of IV on DV), Step 2 (effect of IV on mediator), and Step 3 (effect of mediator on DV) for the mediation analyses in Study 2 ($p < .05$; ** $p < .01$, *** $p < .001$)*

	b	*F*	*p*	*BF*	*Cohen's d*	*95 % CIs*
Mediation 1 - household size (IV), language skills (DV), maternal stress (mediator)						
Step 1 (*df* = 1, 402)						
Household Size on Early Language Skills	.01	.11	.74	.07	.03	-.16, .23
Household Size on Late Language Skills	.01	.22	.64	.07	.05	-.15, .24
Step 2 (*df* = 1, 402)						
Household Size on Early Maternal Stress	.03	1.51	.24	.15	.12	-.07, .32
Household Size on Late Maternal Stress	.04	1.73	.19	.18	.13	-.06, .33
Step 3 (*df* = 1, 401)						
Early Maternal Stress on Early Language Skills*	-.12	6.06	.01	.18	.25	.05, .44

Early Maternal Stress on Late Language Skills	-.01	.08	.77	.01	.03	-.17, .22
Late Maternal Stress on Late Language Skills	-.05	1.39	.24	.02	.12	-.08, .31
Mediation 2.1 - number of adult members of the household (IV), language skills (DV), maternal stress (mediator)						
Step 1 (*df* = 1, 402)						
Number of Adults on Early Language Skills	-.01	.05	.82	.10	.02	-.17, .22
Number of Adults on Late Language Skills*	.07	4.14	.04	.69	.20	.01, .40
Step 2 (*df* = 1, 402)						
Number of Adults on Early Maternal Stress	.07	3.22	.07	.47	.18	-.02, .37
Number of Adults on Late Maternal Stress	.04	1.11	.29	.18	.11	-.09, .30
Step 3 (*df* = 1, 401)						

Early Maternal Stress on Early Language Skills*	-.12	5.88	.02	.22	.24	.05, .44
Early Maternal Stress on Late Language Skills	-.02	.20	.66	.09	.04	-.15, .24
Late Maternal Stress on Late Language Skills	-.05	1.59	.21	.16	.13	-.07, .32
Mediation 2.2 number of child members of the household (IV), language skills (DV), maternal stress (mediator)						
Step 1 (*df* = 1, 402)						
Number of Children on Early Language Skills	.03	.60	.44	.14	.08	-.12, .27
Number of Children on Late Language Skills	-.06	2.48	.12	.35	.16	-.04, .35
Step 2 (*df* = 1, 402)						

Number of Children on Early Maternal Stress	-.01	.03	.87	.11	.02	-.18, .21
Number of Children on Late Maternal Stress	.04	.63	.43	.16	.08	-.12, .27
Step 3 (*df* = 1, 401)						
Early Maternal Stress on Early Language Skills*	-.12	5.91	.02	.33	.24	.05, .44
Early Maternal Stress on Late Language Skills	-.01	.07	.78	.04	.03	-.17, .22
Late Maternal Stress on Late Language Skills	-.05	1.19	.28	.07	.11	-.09, .30
Mediation 2.3 - residential crowding (IV), language skills (DV), maternal stress (mediator)						
Step 1 (*df* = 1, 335)						

Residential Crowding on Early Language Skills	.14	2.13	.15	.70	.16	-.06, .37
Residential Crowding on Late Language Skills	.04	.20	.65	.25	.05	-.16, .26
Step 2 (*df* = 1, 335)						
Residential Crowding on Early Maternal Stress**	.33	11.81	.001	80.66	.38	.16, .59
Residential Crowding on Late Maternal Stress*	.22	4.02	.046	2.01	.22	.00, .43
Step 3 (*df* = 1, 334)						
Early Maternal Stress on Early Language Skills*	-.14	6.58	.01	2.50	.28	.06, .50
Early Maternal Stress on Late Language Skills	.01	.02	.89	.03	.02	-.20, .23

Late Maternal Stress on Late Language Skills	-.05	.98	.32	.05	.11	-.11, .32

Figure 1

Language skills of children with no older siblings compared to children with one older sibling (The circles represent individual data points, dark blue symbols represent the means, the error bars represent ±2 SD, and the boxes encompass interquartile ranges)

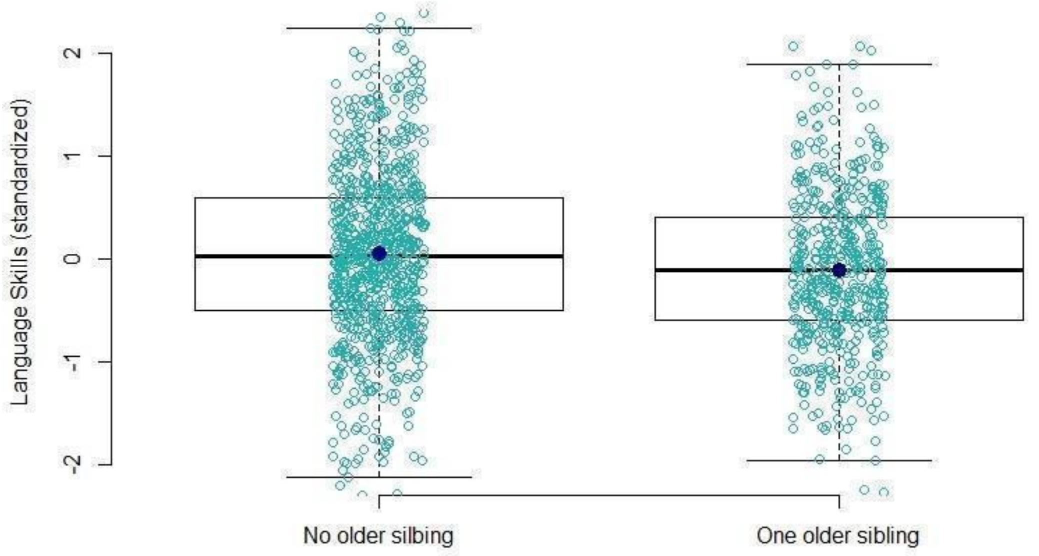

Figure 2

Language skills of children with one older brother compared to children with one older sister (The circles represent individual data points, dark blue symbols represent the means, the error bars represent ±2 SD, and the boxes encompass interquartile ranges)

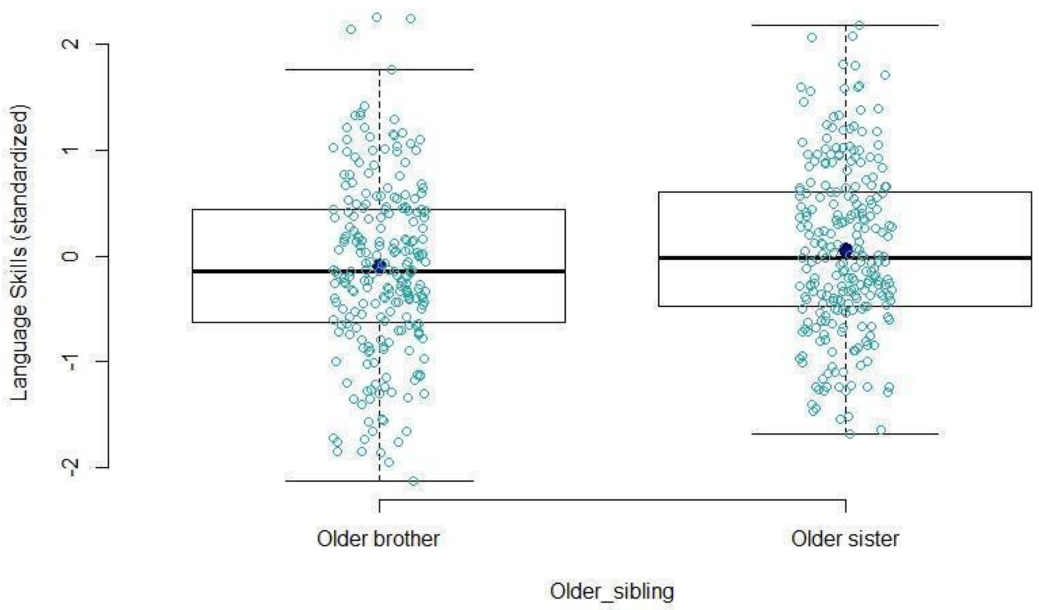

Figure 3

Scatterplot depicting the relation between language skills and age gap between participants and their older siblings, separately for children with an older brother (blue circles) and an older sister (orange circles). Dashed lines represent the best-fitting regressions