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RESEARCH ARTICLE

The influence of sibship composition on language development at 2 years of age in the ELFE birth cohort study

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Abstract

The number of older siblings a child has is negatively correlated with the child's verbal skills, an effect that is well known in the literature. However, few studies have examined the effect of older siblings' sex, of the age gap between siblings, of having foreign-speaking parents, as well as the mediating role of parental interaction. Using data from 12,296 children (49.3% female) from the French ELFE birth cohort, we analyzed the effect of these characteristics of the siblings and their family on children's expressive vocabulary measured using the French MacArthur-Bates Communicative Development Inventory. Children's vocabulary at age 2 years was negatively associated with the number of older siblings (−0.08 SD per additional sibling), and this effect was partly mediated by parental interactions. In analyses restricted to children with one older sibling, the vocabulary score was negatively correlated with the age gap between the target child and their older sibling. The vocabulary score was not correlated to their sibling's sex, contrary to the result of a previous study. In addition, the effect of the number of siblings was less negative in foreign speaking families that in French speaking families, suggesting that older siblings might partly compensate for the effect of having foreign-speaking parents. Overall, our results are consistent with the resource dilution (stating that parents have limited resources to distribute among their children) and inconsistent with the confluence model (stating that a child's cognitive ability is correlated to the mean cognitive ability of the family).

KEYWORDS
confluence model, language development, parental interactions, preregistered, resource dilution model, siblings

Research Highlights

- Our results are consistent with the resource dilution model and inconsistent with the confluence model
- The negative effect of the number of siblings on expressive vocabulary is partly mediated by parental interactions
- Larger age gaps between a child and their older sibling are associated with lower expressive vocabulary score

1 | INTRODUCTION

1.1 | The older sibling effect

Previous studies have shown that the number of older siblings a child has is negatively correlated with vocabulary (Karwath et al., 2014), verbal skills (Havron et al., 2019; Peyre et al., 2016), and even general intelligence (Deary et al., 2004) and educational attainment (Bagger et al., 2013; Black et al., 2005). These results are in line with Blake's (1981) resource-dilution model, stating that a family has limited resources to distribute among children: the more children there are, the fewer material resources per child (Downey, 1995; Powell & Steelman, 1989, 1993) and the less time spent with each child (Lawson & Mace, 2009). These results are also consistent with the confluence model (Zajonc & Markus, 1975), which states that a child's intellectual environment is made up of the average cognitive ability in the family, and, as children have lower cognitive abilities than adults, having more children in the family brings the average down.

1.2 | An older sibling or an older brother effect?

Havron et al. (2019) recently showed that children without an older sibling performed better on language tests than those with an older sibling. However, this effect was found only when the older sibling was a boy. Children with an older sister had language development scores comparable to first-born children. One mechanism that could explain this result is that older sisters may engage in caretaking behaviors more often than older brothers (Abramovitch et al., 1979), thus providing their younger siblings with more language input, and compensating for the depletion in parental attention. The other hypothesis put forward by the authors is that eldest sons demand more parental attention than eldest daughters, at the expense of younger siblings. Parents with an eldest son would therefore allocate a greater proportion of their investment to caring for him than to caring for the other children. While the first explanation is based on the assumption that sisters compensate for the depletion of parental investment, the second assumes that competition for parental investment is stronger when siblings are males, thus leading to an unequal sharing of this investment among children. Finally, a third hypothesis is that, as girls acquire language faster than boys (Adani & Cepanec, 2019), families with an older girl have, on average, higher average language abilities than families with an older boy of the same age, which should benefit the younger child more according to the confluence model. This older sister effect has been replicated by some (Jakiela et al., 2020) but not others (Havron et al., 2021), and would therefore deserve further exploration.

1.3 | The age gap effect

Another aspect of sibship that is expected to influence cognitive development is the age difference between siblings. According to the confluence model, a greater age difference improves the general intellectual environment of children by increasing the average intellectual maturity of the family (Zajonc, 1976). In line with this hypothesis, several studies have shown that an increase in the age difference between siblings was associated with better educational achievement for older and younger siblings (Powell & Steelman, 1990, 1993 for older and younger siblings; Buckles & Munnich, 2012 and Karwath et al., 2014 for older siblings only).

However, Havron's findings (2019, 2021) suggested the opposite (although only marginally significant in the former study) effect with regards to language development: the age gap between siblings was negatively correlated with target children's (aged 2–6 years) language skills. The authors raised two possible explanations for this finding: first, parents can perhaps more easily find a common activity suitable for both siblings when they are closer in age, thus reducing the dilution effect. This would be because when siblings are close in age, they do not have to engage in separate activities appropriate to each child's age; although Thorpe et al. (2003) suggested that in the case of very closely spaced siblings such as twins, patterns of family interactions may disadvantage language development, an effect not accounted for by the perinatal and obstetric features specific to twins (Rutter et al., 2003). Siblings closer in age may also have a stronger relationship and are more likely to interact, which may facilitate language development (Furman & Buhrmester, 1985; though see also Samek & Rueter, 2011 who did not find an effect of age gap on relationship quality).

Finally, a more recent study (Dhamrait et al., 2020) found a non-linear relationship (U-shape) between interpregnancy intervals and children's developmental vulnerability at age 5 years, with an age gap of under 6 months or over 24 months being associated with an increased risk in developmental vulnerability. Thus, there is a need for further investigation of age gap effects.

1.4 | The mediating role of parental interactions

As stated earlier, according to the resource dilution model (Blake, 1981), parents with more children have less resources and time to allocate to each child. Indeed, studies suggest that first born children (who were the only children at least for some time) receive more cognitive stimulations or quality time with their parents than later born children do (Lehmann et al., 2018; Price, 2008), potentially enhancing their language development (Snow, 2019). Thus, parental interactions are predicted to be a mediator of the older sibling effect. Another possible mediator of this effect may be the time children spend on screens. Indeed, the hypothesis would be that children with more siblings may spend more time using screens. In turn, exposure to screens have been shown to be related to a decrease in cognitive development (Madigan et al., 2019), although maybe that screen exposure is not intrinsically deleterious, but substitute to activities that would stimulate more cognitive development.

1.5 | Interaction with language spoken at home

In bilingual families, children with siblings tend to have a more advanced level of the language of the country of residence,

compared to children without siblings (Bridges & Hoff, 2012; Tsinivits & Unsworth, 2020). This may be the case because in foreign-speaking families, having siblings might compensate for the loss of parental input in the local language, because the child and its siblings interact using the local language (Sorenson Duncan & Paradis, 2020). Thus, in families where parents do not speak the local language at home, older siblings might serve as a source of language exposure and therefore moderate the negative older sibling effect.

1.6 | Open questions

When exploring the effect of older siblings' sex, previous studies only compared children with one older sister or one older brother (Havron et al., 2019; Jakiela et al., 2020). A more general analysis of the number of older siblings, and of the proportion of brothers and sisters among the siblings could not be carried out, due to the small number of children with more than one older sibling. Yet, these variables may affect a child's cognitive development. Based on both the resource-dilution model (Blake, 1981) and the confluence model (Zajonc & Markus, 1975) we predict that the more numerous the older siblings, the worse the language skills of the target child. Based on previous results, we may predict that having mostly sisters might be more beneficial for children's cognitive development than having mostly brothers, although we could not find literature examining this specific question.

The fluctuating effects of the age gap with the older sibling in the literature make predictions uncertain, and warrant replication studies. In addition, given the predicted effect of the older sibling's sex, one may wonder whether it varies as a function of age gap (an interaction between older sibling sex and age gap on language development, which was not significant in Havron et al., 2019).

1.7 | The present study

The main goal of the present study was thus to examine the effect of older sisters and brothers on language development in a large dataset (more than 12,000 children), assessing its generalizability to children with more than one older sibling, and its interaction with the age gap between siblings.

More specifically, our research questions are the following:

1. Is having one older sibling negatively related to language development, compared to having none? (replication of Havron et al., 2019).
2. Is there a cumulative effect of the number of siblings on language development (the more siblings, the lower the language score)?
3. Does the negative effect of an older sibling on their younger sibling's language development depend on their sex? (replication of Havron et al., 2019).
4. Is the negative effect of the number of elders on language development larger as the proportion of brothers increases?
5. Is the age gap between the target child and an older sibling negatively correlated with language development, and is there an interaction between the age gap and the sex of the sibling? (replication of Havron et al., 2019).
6. Is the association between the number of siblings and language development mediated by parental interactions, and by screen exposure?

Finally, we will carry out a post-hoc analysis of whether the primary language spoken at home with the parents (local or foreign) moderates the older sibling effect.

2 | METHODS

2.1 | Study design

We used data from ELFE (*Étude Longitudinale Française depuis l'Enfance*, French Longitudinal Study since Childhood), which is a nationwide French longitudinal birth cohort launched in 2011 (Charles et al., 2019). A total of 349 maternity units were randomly selected in metropolitan France out of which 320 agreed to participate. Children and mothers were recruited at birth/delivery. Exclusion criteria included multiple births of more than two children, children born before 33 weeks of amenorrhea, mothers aged <18 years, inability to read either French, Arabic, Turkish, or English, and parents who were not capable of giving informed consent. Fathers provided written consent for the child's participation when present at inclusion or when informed about their rights to oppose it. The study and each wave of data collection were approved by either the national advisory committee on information processing in health research (CCTIRS), or the National Statistics Council and the Committee for the protection of persons engaged in research (CPP). Written informed consent was obtained from parents both for themselves and for the child at inclusion.

2.2 | Participants

A total of 18,329 newborns were included in the cohort, with a participation rate of 51%. There were 12,661 eligible children with language-skills data and information about the siblings (number, sex and age gap) available at 2 years. Among them, we used the data from the 12,296 children with 0, 1, 2, or 3 older siblings, as the number of children with 4 or more older siblings was considered too low to allow meaningful inference ($N = 365$) for the planned analyses, and were therefore excluded from the analysis. 49.3% of the target children were females. See Table 2 below for descriptive information about the participants.

2.3 | Measures

2.3.1 | Language skills

The outcome of interest was expressive vocabulary at 2 years of age, measured with the French MacArthur-Bates Communicative

TABLE 1 Number of participants according to the number of older sisters and brothers

	Number of older brothers			
Number of older sisters	0	1	2	3
0	5457	2433	493	68
1	2250	794	145	
2	440	156		
3	60			

Development Inventory (CDI-2). During a phone interview, parents were asked to indicate which words from a list of 100 their child could say spontaneously. The score is the number of the words produced by the child, out of 100. The MacArthur-Bates short form has high test-retest reliability and strong associations with the corresponding scores from the longer version (Kern et al., 2010). Furthermore, concurrent validity correlations with direct child assessments demonstrate high validity for parent report of vocabulary at 24 months using the CDI-2 ($r > 0.7$) (Dale, 1991).

2.3.2 | Sibship composition

Our main predictor variables were the number of older siblings (0–3, measured at 1 year, including siblings, step-sibling, and unrelated children living in the home) and the sex of the older siblings (in most of these kinds of studies, the sibling's sex and not gender is known. Despite this, most of the factors we suggest contribute to this effect are social in nature. We thus use the terms male/female and brother/sister interchangeably despite differences between them). In the subset of children who only had one older sibling, we also analyzed the effect of the age gap between the target child and the older sibling. The information was collected through a questionnaire administered by phone to the parents. Sibship composition of the participants is shown in Table 1. There were 5457 children with no sibling, 4683 with one, 1727 with two, and 429 with three.

2.3.3 | Covariates

In order to control for as many potentially confounding factors as possible, our models were adjusted for the following variables: the sex of the target child, alcohol during pregnancy (units/week), tobacco smoking during pregnancy (%), birth weight (kg), gestational age at birth (weeks), maternal age at delivery (years), paternal age at delivery (years), parental education (mean education of the parents), household income (k€/month), breastfeeding initiation (y/n). These covariates have been found to play a role in the prediction of cognitive outcomes in previous studies (Bhutta et al., 2002; Eriksen et al., 2013; Guez et al., 2021; Kramer, 2008; Matte et al., 2001; O'Leary et al., 2009; Peyre et al., 2019; Reilly et al., 2010; Sexton et al., 1990; Violato et al., 2010).

2.3.4 | Parental interaction

We created a score for interactions between parents and the Elfe target child, using questions from parental questionnaires (at age 2 months, 1, and 2 years) about everyday interactions such as playing games or singing with the child (see the supplementary S1 for the list of questions). A higher score indicates more parental interactions. The score is scaled.

2.3.5 | Screen exposure

We used a measure of total screen time (hr/day) at 2 years (scaled).

2.3.6 | Language spoken at home

First language spoken by the mother to the child, either French or foreign.

2.4 | Statistical analysis

All analyses were performed using RStudio (Version 1.3.1093) and R (Version 4.1.2). Multiple imputations of the covariates were implemented using the MICE (Multivariate Imputation via Chained Equations) package (version 3.13.0), with 20 data sets. We pooled adjusted estimates and 95% confidence intervals.

The planned analyses detailed below were all preregistered on OSF. (https://osf.io/ux8k4/). We ran a multivariable linear regression model, with the vocabulary score at age 2 years as the dependent variable, adjusted for the variables above mentioned covariates.

Analysis 1: Is having an older sibling negatively related to the vocabulary score, compared to having none?

In order to perform a replication of Havron et al. (2019), we restricted the analysis to children with zero or a single older sibling ($N = 10{,}140$):

Vocabulary ~ Having_Sibling + Covariates

Analysis 2: Is there a cumulative effect of the number of older siblings on vocabulary (the more the brothers and sisters, the lower the vocabulary score)?

This analysis includes all children with 0–3 siblings ($N = 12{,}296$).

Vocabulary ~ Number_Siblings + Covariates

Analysis 3: Does the effect of an older sibling depend on their sex?

In order to perform a replication of Havron et al. (2019), we restricted the analysis to children with one older sibling ($N = 4683$). Sister, value = 1, brother, value = 0.

Vocabulary ~ Sex + Covariates

Analysis 4: Is the effect of the number of older siblings on vocabulary greater as the proportion of brothers increases?

We restricted the analysis to children with older siblings (1, 2, or 3) ($N = 6839$). The Number_Siblings and Proportion_Brothers *(Number_Brothers/Number_Siblings)* variables were centered.

Vocabulary ~ Number_Siblings + Proportion_Brothers + Number_Siblings: Proportion_Brothers + Covariates

Analysis 5: Is the age gap between the target child and an older sibling negatively correlated with vocabulary score, and is there an interaction between the age gap and the sex of the sibling?

In order to perform a replication of Havron et al. (2019), we restricted the analysis to children with a single older sibling, and for age gaps ranging from 1 to 7 years such that there were at least 100 participants in each age gap category ($N = 4332$). The Age_gap and Sex variables were centered.

Vocabulary ~ Age_gap + Sex + Age_gap:Sex + Covariates

Exploratory analyses: We assessed whether the association measured in the second analysis was mediated by the level of parental stimulation and the level of screen exposure, using the parental interaction score and the screen exposure score presented earlier as mediators, in a structural equation model (SEM).

We tested the direct relationship between the dependent variable and the independent variable, as well as the indirect effect mediated by the parental stimulation and the screen exposure score.

We used a measure of total screen time (hr/day) at 2 years instead of the preregistered (as exploratory analysis) measure of television watching with the child at age 1 year. This enabled us to have a more precise score of screen exposure in general, and not restricted to television watching in presence of the parents.

Other preregistered (as exploratory) analyses of lesser interest are reported in Supplementary (shape of the age gap effect, S2, moderation of the sibling effect by socio-economic status, S3).

As a post-hoc exploratory analysis, we also assessed whether the association between the number of older siblings and the vocabulary varied depending on the primary language spoken at home with the parents. We restricted the analysis to children with 0–3 siblings, for whom the language spoken at home (either French (1 =) or foreign (= 0)) was reported (N = 12,037). The Number_Siblings and Language_Spoken_At_Home variables were centered.

Vocabulary ~ Number_Siblings*Language_Spoken_At_Home + Number_Siblings + Language_Spoken_At_Home + Covariates

3 | RESULTS

3.1 | Descriptive results

See Table 2.

3.2 | Preregistered analyses

1. **Is having one older sibling negatively related to the vocabulary score, compared to having none?**

As predicted, analysis 1 showed that the language development scores of children with an older sibling were lower than those without older siblings, with a difference of about 2 words out of 100 (−2.04 words, SE = 0.51, β (standardized coefficient) = −0.08, $p < 0.0001$, see S4 for the complete results).

2. **Is there a cumulative effect of the number of older siblings on vocabulary?**

As hypothesized, vocabulary scores were negatively associated with the number of older siblings (−1.96 words per older sibling, SE = 0.30, $\beta = -0.08$, $p < 0.001$, see S5) (Figure 1).

3. **Does the negative effect of an older sibling on their younger sibling's vocabulary depend on their sex?**

Contrary to our predictions, the vocabulary score of children with an older sister or an older brother did not differ significantly (+0.97 words for children having an older sister, SE = 0.72, $\beta = 0.04$, $p = 0.18$, see S6), although descriptively it is in the direction of our hypothesis.

4. **Does the effect of the number of older siblings on vocabulary increase with the proportion of brothers?**

In model 4, we found a significant association between the target child's vocabulary and the number of older siblings (−1.67 word per older sibling, SE = 0.53, $\beta = -0.07$, $p = 0.002$), and the proportion of brothers (−1.70, SE = 0.69, $\beta = -0.07$, $p = 0.014$), and no interaction between the two (−2.09, SE = 1.38, $\beta = -0.08$, $p = 0.13$), see S7.

Post-hoc analysis: Does the effect of the number of older siblings on vocabulary increase with the number of brothers?

In hindsight, it appeared to us that Analysis 4 may have been suboptimal, with the 5 proportion categories. We reanalyzed by replacing the proportion of brothers by the number of brothers (0, 1, 2, or 3), and the number of siblings by the number of sisters (0, 1, 2, 3), in order to be able to compare the estimates for brothers and sisters (N = 12,296):

Vocabulary ~ Number_Sisters + Number_Brothers + Number_Sisters Number_Brothers + Covariates*

The association of the number of sisters with the vocabulary score was significantly negative (−1.31, SE = 0.40, $\beta = -0.05$, $p = 0.001$), the association of the number of brothers was significantly negative and seemed larger (−2.53, SE = 0.39, $\beta = -0.10$, $p < 0.001$). The interaction term was not significant (0.27, SE = 0.71, $\beta = -0.01$, $p = 0.71$). See S8 for complete results. We assessed whether the estimate of the number of sisters and of brothers significantly differed at alpha = 0.05 by conducting a Z-test using the formula $Z = \frac{(b_{(Number\ Sisters)} - b_{(Number\ Brothers)})}{\sqrt{(SE_{(Number\ Sisters)}{}^2 + SE_{(Number\ Brothers)}{}^2)}}$. $Z = 2.18 > 1.96$ so the effect of the number of brothers is significantly more negative than the effect of the number of sisters.

5. **Is the age gap between the target child and an older sibling negatively correlated with vocabulary score, and is there an interaction between the age gap and the sex of the sibling?**

In model 5, there was a main effect of age gap (−1.63 words per year, SE = 0.27, $\beta = -0.07$, $p < 0.001$), no significant association of the older sibling's sex (+1.19 words for children having an older sister, SE = 0.74, $\beta = 0.05$, $p = 0.11$), and no significant interaction between the age gap and the sex of the older sibling (−0.94 words per year difference between children having an older brother and sister, SE = 0.51, $\beta = -0.04$, $p = 0.07$) (Figure 2), see S9.

TABLE 2 Description of the sample by number of siblings

	All ($N = 12,296$)	Children without an older sibling ($N = 5457$)	Children with 1 older sibling ($N = 4683$)	Children with 2 older siblings ($N = 1727$)	Children with 3 older siblings ($N = 429$)
Target child characteristics					
Sex (female)	49.3%	49.5%	49.3%	48.6%	47.6%
Gestational age (in weeks)	39.2 (1.5)	39.2 (1.5)	39.2 (1.4)	39.2 (1.4)	39.1 (1.4)
Birth weight (kg)	3.32 (0.49)	3.25 (0.49)	3.37 (0.48)	3.39 (0.50)	3.40 (0.51)
Parental stimulation score[a]	−0.0007 (0.39)	0.09 (0.35)	−0.06 (0.40)	−0.10 (0.43)	−0.10 (0.43)
Screen score[b]	−0.02 (0.42)	0.01 (0.43)	−0.05 (0.40)	−0.03 (0.41)	0.04 (0.45)
MacArthur-Bates score					
MacArthur-Bates score (number of words out of 100)	72.5 (25.2)	74.3 (24.7)	72.1 (25.2)	69.4 (25.8)	67.5 (26.9)
Sibship characteristics					
Sex of the older sibling (female)	–	–	48.0%	–	–
Proportion of brothers	51.6%	–	52.0%	51.5%	50.5%
Age Gap (years)	–	–	3.6 (1.7)	–	–
Familial characteristics					
Mother's age at delivery (years)	31.2 (4.7)	29.4 (4.5)	31.9 (4.2)	33.7 (4.1)	35.3 (4.2)
Father's age at delivery (years)	33.7 (5.8)	31.8 (5.7)	34.3 (5.3)	36.4 (5.2)	38.7 (5.8)
Breastfeeding initiation	72.2%	73.0%	71.2%	74.1%	69.1%
Alcohol during pregnancy (drinks per week)	0.06 (0.46)	0.03 (0.32)	0.06 (0.53)	0.08 (0.51)	0.02 (0.74)
Maternal smoking during pregnancy	17.3%	17.5%	16.6%	18.1%	16.9%
Parental education[c]	3.85 (1.00)	3.93 (0.95)	3.88 (0.96)	3.71 (1.09)	3.35 (1.27)
Household income at 2 years (k€/month)	3.84 (2.22)	3.74 (2.21)	3.89 (2.07)	4.03 (2.58)	3.80 (2.28)

Numbers between parentheses are the standard deviations.
[a]Score of parental interactions: mean of 18 z-scored questions asked to the parents such that a high score indicates more parental interactions.
[b]Score of screen exposure: mean of 17 z-scored questions asked to the parents such that a high score indicates a high level of screen exposure.
[c]Parental education: mean of the highest diploma of the two parents, highest diploma with 0 = none, 1 = primary education, 2 = middle school level, 3 = high school diploma, 4 = 2 years after high school diploma, 5 = more than 2 years after high school diploma.

Nevertheless, the marginal interaction and the trends evident in Figure 2 drove us to conduct two additional post-hoc analyses.

When restricting the analysis to age gap 1 and 2 years ($N = 1904$), there was a significant association between the sex of the older sibling and the MacArthur-Bates score of the target child, in favor of children having an older sister (+2.6 words, SE = 1.1, $\beta = 0.11$, $p = 0.01$), a significant effect of age gap (−4.2 words per year, SE = 1.2, $\beta = -0.18$, $p < 0.001$), and no sex by age gap interaction (−1.7 words per year difference between children having an older brother and sister, SE = 2.3, $\beta = -0.07$, $p = 0.46$), see S10.

When restricting the analysis to an age gap of 1 year ($N = 572$), there was an even stronger sibling sex effect in favor of children having an older sister (+4.1 words, SE = 1.8, $\beta = 0.19$, $p = 0.03$), see S11. Furthermore, children with one older sibling and with an age gap of 1 year had a higher MacArthur-Bates score (vocabulary score) than children with no older sibling (+3.1 words, SE = 1.1, $\beta = 0.13$, $p = 0.003$), see S12, contrary to the general trend across all age gaps (analysis 1).

Because this effect seems to run against the predictions of the confluence model, we ran an additional post-hoc test of the confluence model, showing that the mean age of the older siblings (a proxy for mean mental age) was negatively associated with language skills (reported in S13).

3.3 | Exploratory analysis

3.3.1 | Mediation model between vocabulary score and the number of older siblings

In the SEM model (see Figure 3, and supplementary S14), we found that the negative association of the number of older siblings on the vocabulary score was partly mediated by decreased parental interactions: each additional sibling was associated with a 0.21 SD (SE = 0.012, $p < 0.001$) decrease in parental stimulation with the target child, and a 1 SD decrease in parental stimulation score was associated with a 4.9

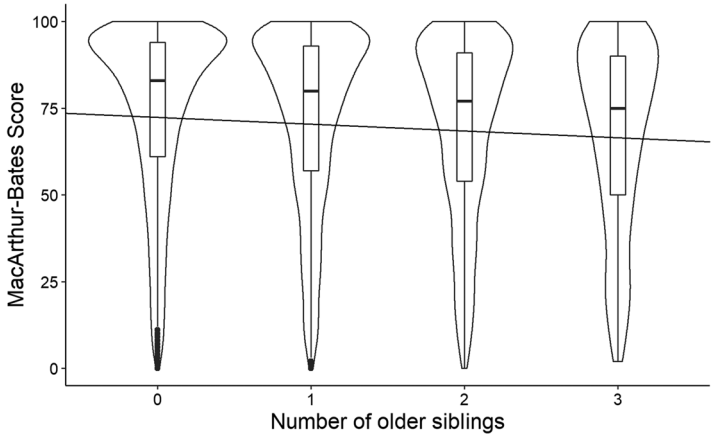

FIGURE 1 Expressive vocabulary score (MacArthur-Bates) of Elfe children as a function of the number of older siblings ($N = 12{,}296$). *Note*. The graph represents boxplots and the shape of the distribution (violin plot). The dots are outliers. The line indicates the linear trend of the older sibling effect, adjusted for sex of the target child, alcohol during pregnancy, tobacco smoking during pregnancy, birth weight, gestational age at birth, maternal age at delivery, paternal age at delivery, parental education, household income, and breastfeeding initiation).

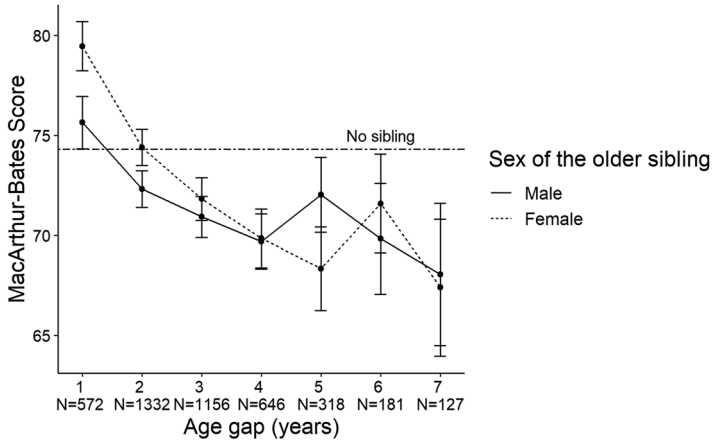

FIGURE 2 Expressive vocabulary score (MacArthur-Bates) of Elfe children with one older sibling ($N = 4332$), as a function of the sex of the older sibling and of the age gap. *Note*. The expressive vocabulary score is adjusted for the covariates (sex of the target child, alcohol during pregnancy, tobacco smoking during pregnancy, birth weight, gestational age at birth, maternal age at delivery, paternal age at delivery, parental education, household income, and breastfeeding initiation) Error bars represent ± 1 standard error. The horizontal line indicates the mean vocabulary score of children with no older sibling.

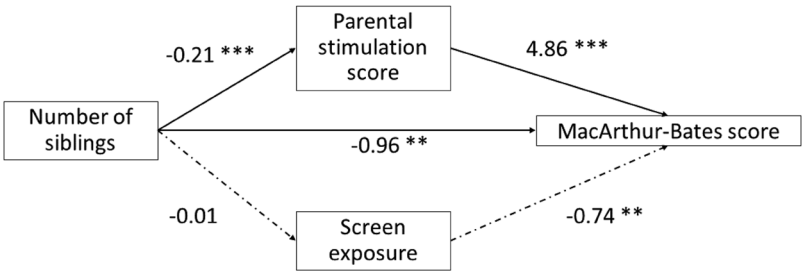

FIGURE 3 The mediation analysis (SEM). *Note*. Full arrows indicate a negative total (direct or indirect) effect, dotted arrows indicate a positive one. All variables are adjusted for the covariates (sex of the target child, alcohol during pregnancy, tobacco smoking during pregnancy, birth weight, gestational age at birth, maternal age at delivery, paternal age at delivery, parental education, household income and breastfeeding initiation). *** indicates p-value < 0.001, ** indicates p-value < 0.01

word decrease of the vocabulary score (SE = 0.23, $p < 0.001$). Thus, for each additional sibling, parental stimulation mediated a 1-word decrease in vocabulary (SE = 0.08, $p < 0.001$), that is, half of the total effect of older siblings (−1.96 word per sibling, analysis 4).

Conversely, the number of older siblings was not significantly associated with the screen exposure (−0.006 SD per sibling, SE = 0.012, $p = 0.64$), which itself was negatively associated with the MacArthur-Bates score (−0.74 word per SD of screen exposure, SE = 0.22, $p = 0.001$). Overall, this indirect effect through screen exposure was not significant (0.004 words, SE = 0.009, $p = 0.64$).

3.4 | Post-hoc analyses

3.4.1 | Is the older sibling effect dependent on the language spoken at home?

We wondered whether, in foreign-language-speaking families, older siblings might play a compensatory role, by enriching the French-language input to the target child. Thus, we added the primary language spoken at home as a factor in analysis 2 (1: French, $N = 11539$, 2: Foreign, $N = 498$), see Figure 4. We found a significant interaction

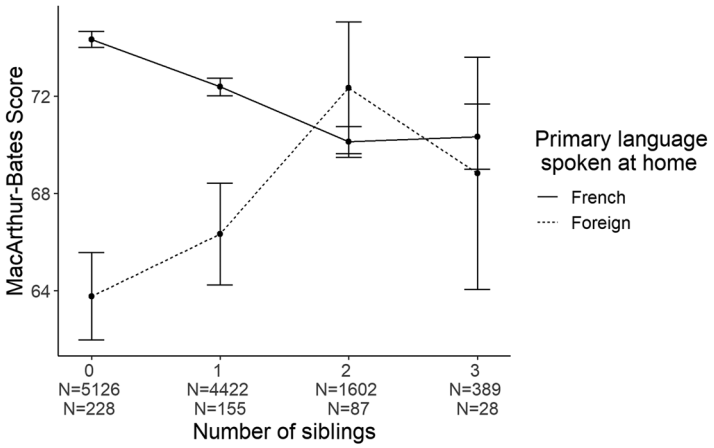

FIGURE 4 Expressive vocabulary score (MacArthur-Bates) of Elfe children, as a function of the number of older siblings and of the language spoken at home. The sample size for each number of older siblings is written below, for French then foreign families. *Note.* $N = 11{,}539$ for French, $N = 498$ for Foreign. The expressive vocabulary score is adjusted for the covariates (sex of the target child, alcohol during pregnancy, tobacco smoking during pregnancy, birth weight, gestational age at birth, maternal age at delivery, paternal age at delivery, parental education, household income, and breastfeeding initiation). Error bars represent +/−1 standard error.

between the number of siblings and the language spoken at home (4.83 words/sibling difference between French and foreign-speaking families, SE = 1.24, $\beta = 0.19$, $p < 0.001$). The number of siblings and the vocabulary score were significantly negatively associated (−2.08 words per sibling, SE = 0.31, $\beta = -0.08$, $p < 0.001$), the language spoken at home and the vocabulary score were negatively associated as well (−7.06 words for foreign vs. French language, SE = 1.13, $\beta = -0.28$, $p < 0.001$), see S15. When analyzing separately French-speaking and foreign language-speaking families, the effect of the number of siblings was significantly negative for French-speaking families (−2.25 words per sibling, SE = 0.31, $\beta = -0.09$, $p < 0.001$, see S16), whereas it was positive but not significantly higher than 0 for foreign language speaking families (+1.93 word per sibling, SE = 1.48, $\beta = 0.07$, $p = 0.19$, see S17).

4 | DISCUSSION

The main aim of this study was to assess the associations between language development and various sibship characteristics such as the number of older siblings, sex of the older siblings, and age gap between them. We also aimed at evaluating the mediating effect of parental interactions and screen exposure on the relation between number of siblings and language development. Finally, we were interested as well in investigating whether the language spoken at home had a differential effect on the relation between number of siblings and language development.

4.1 | The older sibling effect

We replicated the well-known negative correlation between the number of siblings and the expressive vocabulary for children with 0–3 older siblings. All else being equal, and controlling for several variables including parental education and income, each additional older sibling was associated with a decrease of about 2 points (2 words out of 100) in the MacArthur-Bates score. This result is consistent with previous studies showing that an increase in the number of siblings is associated with a decrease in vocabulary scores, verbal intelligence and educational attainment (Black et al., 2005; Havron et al., 2019; Peyre et al., 2016). This is also in line with both the resource dilution model (Blake, 1981) as well as the confluence model (Zajonc & Markus, 1975).

4.2 | The age gap effect

According to the confluence model, the older the siblings, the higher their cognitive ability and so the less detrimental they would be for their younger siblings. Our results are inconsistent with this hypothesis, as we found that, in 2-children families, the age gap between the target child and the older sibling was *negatively* associated with the language development score. Furthermore, a complementary analysis (see supplementary S13) showed that the mean age (a proxy of mental age) of the older siblings was negatively associated with language development, even when the number of siblings was added as a covariate. This is also inconsistent with the confluence model. A possible proximal explanation more consistent with the resource dilution model would be that parents who have children closer in age can set up shared activities and discussions and thus do not need to split their resources as much compared to parents having children very far apart in age. Another possible (and non-exclusive) explanation is that older children compete more than younger children for parental resources, thus aggravating the resource dilution problem. Both of these explanations share the idea that not all household members contribute equally to the child's development. We find that vocabulary score negatively correlates with age gap, but this finding may seem to contradict previous findings that twins seem to have lower levels of language than singletons (Thorpe, 2006, particularly in males; Thorpe et al., 2003). This effect is not accounted for by obstetric or perinatal factors (Rutter et al., 2003). However, having twins is a very special situation for parents, which is very different from having two single-born children, even if the spacing is a 1-year interval. This specific situation may induce lower quality interactions between the children and their parents.

A recent study analyzed detailed recordings of three 2–3 year old French children, all of whom had at least one older sibling (Loukatou et al., 2021). Input from other children comprised only 1%–7% of the input directed to children, while maternal input accounted for 65%–90% of the input. The authors also found that child-directed speech overheard by the child, that is, speech directed at other children, had structural characteristics that were similar to maternal speech directed to the child. That is, it is possible that overhearing speech directed to a sibling is at least somewhat beneficial (Loukatou et al., 2021; Thorpe et al., 2003), and if this is indeed the case, that the effect could be stronger when siblings are closer in age. Indeed, in an exploratory regression (in the results, and Suppl S12) we showed that, as Figure 2 suggests, children with no older sibling scored lower than children with one older sibling with an age spacing of 1 year (a difference of about 3 points in the MacArthur-Bates score). Therefore, having an older sibling very close in age is related to an even better vocabulary development at age 2 than being a firstborn. In addition to overheard speech, an additional explanation could be that parents of two closely spaced siblings can offer them identical activities and thus almost do not have to split their resources when interacting with their children, so their interactions are similar to that of parents with an only child.

In addition, there may be interactions between the siblings that are beneficial for vocabulary development, although measures of sibling interactions would be required to confirm this hypothesis. This would mean that having a sibling and being able to interact with them could be beneficial for children's vocabulary. It has previously been shown that having siblings is beneficial for children's social-communicative skills (Hoff, 2006), the ability to join in conversations (Dunn & Shatz, 1989), and some aspects of syntactic development (Oshima-Takane et al., 1996), but this effect could be hidden because of the dilution of the parent's resources, when compared to firstborns.

4.3 | Sibling's sex effect

Havron et al. (2019) and Jakiela et al. (2020) found a positive association between having an older sister and language development of a younger sibling. However, Havron et al. (2021) did not find a significant effect in a cohort of Singaporean children, although it was in the same direction.

In the present study, evidence for an effect of sibling sex on child language development was rather weak across the entire sample. However, we observed a positive effect of having an older sister compared to an older brother when restricted to the case of children with just one older sibling, and with an age gap of 1 or 2 years. A first hypothesis for this effect may be that for these age gaps but not larger age gaps, parents with an older daughter interact more with their lastborn than parents with an older son. However, a supplementary analysis of the effect of the sex of the older sibling on parental interactions suggested no difference between small (1–2) and larger (> 2) age gaps (Suppl S18). Another hypothesis may be that sisters directly benefit their younger siblings' language development, thanks to higher language skills than brothers of the same age. Indeed, the positive effect of having a sister was restricted to age gaps of 1–2, so to 3–4 years-old older sisters. These are the ages where the scientific literature reports the largest difference in language ability between boys and girls (Bornstein et al., 2004; Peyre et al., 2019; Toivainen et al., 2017). Thus there may be a beneficial effect of having a sister on language development restricted to when sisters are well-known to have better language abilities than brothers (as predicted by the confluence model). And indeed, when the age gap was larger, there was no difference in the effect of having an older sister or an older brother on language scores (Figure 2), although when considering several siblings, the association between the number of brothers and language skills was more negative than the association between the number of sisters and language skills.

4.4 | Mediation by parental interactions and screen exposure

As discussed above, the negative effect of the number of siblings can be explained in part by a decrease in parental interactions. In our data, an increase of 1 sibling is correlated with a decrease by about 0.2 standard deviations in the parental-interactions score. About half of the negative effect of the number of siblings on vocabulary can be accounted for by diminished parental interactions in our model. Similar results were found by Snow (2019): children heard fewer utterances from caregivers when an older sibling was present. Farrant and Zubrick (2012) even found that the effect of number of siblings on child vocabulary (at 34 months) was completely mediated by parental interactions (similar results were found by Thorpe et al. (2003)). These results support the resource dilution model.

We did not find a significant mediation by screen exposure, although screen time was negatively associated with child's vocabulary.

4.5 | Moderation by language spoken at home

Another interesting result is that children show a negative correlation between the number of siblings and vocabulary only when the main language spoken at home with the parents is French. In foreign-language-speaking families, the effect of the number of older siblings was positive, although not significantly different from 0 (but significantly different from the negative effect in French-speaking families). This is consistent with the idea that in foreign-speaking families, having siblings might compensate for the loss of parental input, because the child speaks in the local language with their siblings (Sorenson Duncan & Paradis, 2020). This is also in line with literature showing an advantage in the language (of the country of residence) for children with siblings compared to those without siblings in bilingual families (Bridges & Hoff, 2012; Tsinivits & Unsworth, 2020). However, another explanation for these results might be that in foreign-speaking families, parents of first-born children may underestimate their child expressive vocabulary because they are less familiar with the French words than

parents of several children who may have been more exposed to French words.

4.6 | Limitations

A limitation of the current study is that the MacArthur-Bates score measuring vocabulary development was based on questionnaires administered by phone to the parents. Parents with more children might know less about the target child's vocabulary, due to less time spent with each child alone which could be a bias in our study. If this lack of knowledge led to an underestimation of the target child vocabulary, then this might be an alternative explanation to the negative older sibling effect. However, it is not clear why underestimation would be more likely than overestimation or no bias. If anything, overestimating might be more likely, if parents display social desirability biases and do not want their child to appear below average. At any rate, many other studies, using more objective measures, also find a negative effect of siblings on language development, so it seems highly unlikely that this effect would be entirely due to bias. Additionally, parents who overestimate their child expressive vocabulary might also overestimate their interactions with their child, due to social desirability bias. This may have led to a slight overestimation of the mediating role of parental interactions.

It is also important to note that our results were limited to French children not completely representative of the general population (Thierry et al., 2018). Our results may also not be generalizable to populations with very different socioeconomic, cultural, and ethnic characteristics. We also focused on expressive language (vocabulary), so these results might not generalize to other aspects of language such as receptive language. Finally, our study focused on 2 year-old children, but the present results may also be generalizable to older children, although we may expect the effects to be less large, since older children may tend to have a wider range of interactions outside of the family circle and thus their cognitive and language development might be less sensitive to it.

5 | CONCLUSION

To conclude, we replicated the well-known negative associations between the number of siblings and the vocabulary development, and we showed that part of this effect can be accounted for by diminished parental interactions, in line with the resource dilution model. In addition, the association between number of siblings and vocabulary development was not negative when looking at children of foreign-language-speaking parents, suggesting a benefit of having siblings in this case. We also showed that there was a negative association between language development and the age difference between the target child and their older sibling, contrary to the confluence model. We did not generally replicate the association between the sex of the older sibling and language development, except for one older sibling at a 1- or 2-year age gap, so further studies may be needed to confirm this result.

AUTHOR CONTRIBUTIONS

Conceptualization: Lilas Gurgand, Naomi Havron, Loïa Lamarque, Hugo Peyre, Franck Ramus. Data curation: Lilas Gurgand, Loïa Lamarque. Formal Analysis: Lilas Gurgand, Naomi Havron, Loïa Lamarque, Hugo Peyre, Franck Ramus. Funding acquisition: Elfe Cohort. Investigation: Elfe Cohort. Methodology: Elfe Cohort. Project administration: Elfe Cohort. Resources: Elfe Cohort. Software: Lilas Gurgand, Loïa Lamarque. Supervision: Hugo Peyre, Franck Ramus. Visualization: Lilas Gurgand. Writing – original draft: Lilas Gurgand. Writing – review & editing: Jonathan Bernard, Naomi Havron, Hugo Peyre, Franck Ramus.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The data are available upon request to the Elfe Data Access Committee.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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