

Analysing the effect of sibling number on input and output in the first 18 months:

2 Supplementals

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The supplementary materials below present further analyses on our sample. We include this data here for sake of completeness and transparency, but do not include it in the reported results owing to small sample sizes and consistency across findings. All scripts and data for our analysis can be found on the project's OSF wiki at <https://osf.io/rm3ec/>.

The analyses below (S1:S5) show:

- S1: re-analysis of caregiver input variables using data from day-long audio recordings
- S2: re-analysis of caregiver input variables with both dizygotic twins excluded
- S3: summary of speakers classed as two main caregivers in our input data
- S4: correlations of input and output measures with maternal factors (age, education) and number of siblings
- S5: re-analysis of caregiver input variables using discrete sibling number as our main variable of interest
- S6: re-analysis of caregiver input variables with one outlier infant

Consistent with our main analysis, all analyses here draw on data from age 10 months, given that the majority of infants did not produce their first word until around 0;11, according to CDI reports. In addition, the twin removed from the main analyses is also removed from the data analysed here.

S1: Effect of siblings on infants' input - audio recordings

Our main results analyse input data from the hour-long video recordings taken in the home on a monthly basis. We opted to use the video data in the main analysis due to consistency in data collection across time-points (one hour of video recording per month, per child). We re-ran our analysis using the home-recorded audio data, which captures a

snapshot from a 16h daylong recording using a LENA device (<https://www.lena.org/>) worn in a vest. Three or four hours were transcribed per monthly recording; four hours in the 10-13-month recordings, and three hours in the 14-17-month recordings. These transcribed sections were selected based on the most talkative hours in each recording, as determined by an algorithm that ranked hour-long subregions according to LENA's CVC and CTC metrics over the entire 16h recording.

Initial model comparisons including the caregiver input/object presence as a dependent variable and age and sex as fixed effects showed no effect for sex on either measure, but an effect of age on both. Age, but not sex, was thus included in our regression models; data was included from age 10 months onwards.

We tested our two input variables using nested model comparisons, where (1) is the baseline model and (2) includes siblings as the variable of interest.

1. caregiver input/object presence (log-transformed) \sim age (months) + (1|subject)
2. caregiver input/object presence (log-transformed) \sim sibling group + age (months) + (1|subject)

Outputs from these model comparisons and full model outputs including estimates are shown in Tables 1 and 2. Results were consistent with the video data for object presence, where a significant effect was found for sibling group. Unlike the video data, this effect was not found in the model testing overall input.

Table 1

Results of nested model comparisons testing the effect of sibling group on caregiver input/object presence in the audio data. Linear mixed-effects regression models compared our two input measures (object words produced in caregiver input and object presence) in relation to sibling group (0 vs. 1 vs. 2+) in the audio data. Age in months was included as a fixed effect; subject was included as a random effect.

Model	Df	Chisq	p value
Caregiver input	2	2.81	0.24
Object presence	2	19.45	0.00

Table 2

Full model outputs from two linear mixed effects regression models comparing our input measures (object words produced in caregiver input and object presence) in relation to sibling group (0 vs. 1 vs. 2+), for the audio data. Age in months was included as a fixed effect in both models and subject was included as a random effect.

Variable	Effect	Estimate	Std. Error	df	t value	p value
Caregiver input	Intercept	5.23	0.18	168.46	29.32	<0.001
	SibGroupOne	0.13	0.20	43.00	0.65	0.518
	SibGroup2+	-0.28	0.22	43.00	-1.26	0.214
	month	0.03	0.01	301.00	3.04	0.003
Object presence	Intercept	0.37	0.04	341.27	8.42	<0.001
	SibGroupOne	-0.09	0.03	43.00	-3.13	0.003
	SibGroup2+	-0.15	0.03	43.00	-4.68	<0.001
	month	0.02	0.00	301.00	6.50	<0.001

46 **S2: re-analysis of caregiver input variables with both dizygotic twins excluded**

47 As stated in the main paper, there was one pair of dizygotic twins in the original
 48 dataset. We retain one infant in the main analysis in order to maximise sample size, but
 49 we acknowledge that this is not a perfect solution given that the presence of another twin
 50 in the home (counted as a sibling in the main analysis) may affect caregiver interactions in
 51 a different way than the presence of an older sibling. By removing both twins from our
 52 data and re-analysing the input measures, we can confirm that our results were consistent
 53 with and without one of the twins included in our data (n=42). See Tables 3 and 4.

Table 3

Results of nested model comparisons testing the effect of sibling group on caregiver input/object presence in the video data, with both dizygotic twins removed from our sample (n=42). Linear mixed-effects regression models compared our two input measures (object words produced in caregiver input and object presence) in relation to sibling group. Age in months was included as a fixed effect for both models; sex was included for caregiver input only following model structures in the main analysis. Subject was included as a random effect.

Model	Df	Chisq	p value
Caregiver input	2	8.50	0.01
Object presence	2	27.74	0.00

Table 4

Full model output from linear mixed effects regression models comparing our two input measures (object words produced in caregiver input and object presence) over time in relation to sibling group, with both dizygotic twins removed from our sample (n=42). Age in months was included as a fixed effect in both models, sex was included in the model testing caregiver input; subject was included as a random effect.

Variable	Effect	Estimate	Std. Error	df	t value	p value
Caregiver input	Intercept	4.88	0.18	185.20	27.49	<0.001
	SibGroupOne	-0.05	0.15	42.00	-0.32	0.754
	SibGroup2+	-0.49	0.16	42.00	-2.99	0.005
	month	0.03	0.01	294.00	3.02	0.003
	sexM	-0.21	0.13	42.00	-1.64	0.108
Object presence	Intercept	0.56	0.05	316.24	12.42	<0.001
	SibGroupOne	-0.14	0.03	42.00	-3.97	<0.001
	SibGroup2+	-0.22	0.04	42.00	-5.89	<0.001
	month	0.01	0.00	294.00	3.10	0.002

54 **S3: Speakers in the dataset**

55 The table below provides a summary of which two caregivers produced the most
 56 words in each video recording analyzed in the main manuscript. This was usually the
 57 mother and/or the father. In the case where the infant had two mothers, their data was
 58 aggregated into the ‘Mother’ category; in all but two sessions from this family, the two
 59 mothers were the two main caregivers. There were 344 hour-long video recordings in total
 60 across the 43 infants in the data set; two speakers were present in 146 of these.

Table 5

Numer of sessions in which each adult speaker is one of the two main caregivers. There were 344 hour-long video sessions in total, and two caregivers were present in 146 of these.

Speaker	Caregiver 1	Caregiver 2
Mother	282	16
Father	45	82
Grandmother	11	23
Babysitter	4	4
Grandfather	1	5
Other Adult	1	7
Aunt	0	7
Uncle	0	2

S4: Correlations with maternal factors

We tested the extent to which maternal factors such as age and education level correlate with number of siblings, productive vocabulary measures, and amount of input. Spearman's correlation tests confirmed a significant negative correlation between sibling number and words produced in the infant's input by the mother ($\rho=-0.36$, $p=.028$). No other correlations were significant, though weak positive correlations were identified between amount of input and productive vocabulary, and maternal age and sibling number. See Figure 1.

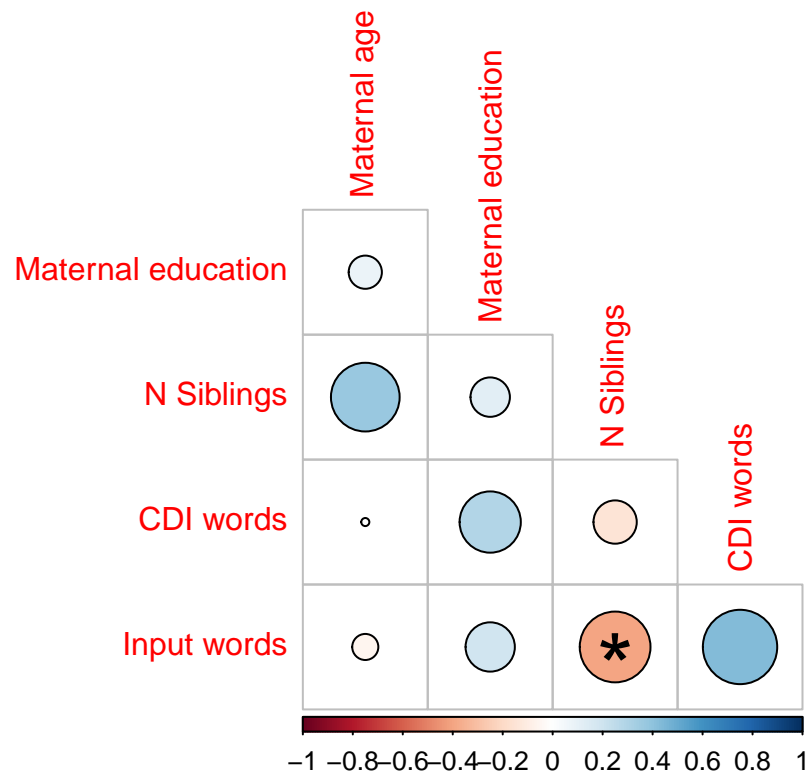


Figure 1. Correlation matrix showing Spearman's correlation coefficients between maternal factors (age and education), number of siblings, and number of words reported to be produced by the child at age 18 months. Colours and circles represent direction and strength of correlation, whereby bolder colours and larger circles indicate a stronger correlation between variables; blue and red indicate positive/negative correlations, respectively. Asterisk indicate a significant p value at $p < .05$.

69 **S5: Discrete sibling number**

70 Our main analyses report the effects of sibling group (infants with 0, 1 or 2+ siblings)
 71 on our two input measures (number of input words produced by caregivers and object
 72 presence). We opted to go with this measure of sibling number owing to more balanced
 73 group sizes. Since discrete sibling number (raw number of siblings) also revealed siblings to
 74 be a significant predictor of vocabulary size at 18 months, here we re-run our input models
 75 using discrete sibling number as a fixed effect, instead of sibling group, to test whether this
 76 effect is consistent across our input measures.

77 Once again, initial model comparisons including the caregiver input/object presence
 78 as a dependent variable and age/sex as fixed effects showed no effect for sex on either
 79 measure, but an effect of age on both. Age, but not sex, was thus included in our
 80 regression models; data was included from age 10 months on-wards. As above, we tested
 81 our two input variables using nested model comparisons, where (1) is the baseline model
 82 and (2) includes siblings as the variable of interest.

- 83 1. caregiver input/object presence (log-transformed) \sim age (months) + (1|subject)
- 84 2. caregiver input/object presence (log-transformed) \sim sibling number + age (months)
- 85 + (1|subject)

86 Outputs from model comparisons and full model outputs including estimates are
 87 shown in Tables 6 and 7. Results were consistent with those reported for sibling group,
 88 suggesting both characterizations of siblinghood capture similar relationships among our
 89 variables.

Table 6

Results of nested model comparisons testing the effect of discrete sibling number on caregiver input/object presence in the video data. Linear mixed-effects regression models compared our two input measures (object words produced in caregiver input and object presence) in relation to sibling number ($R = 0-4$). Age in months was included as a fixed effect; subject was included as a random effect.

Model	Df	Chisq	p value
Caregiver input	1	5.40	0.02
Object presence	2	30.45	0.00

Table 7

Full model outputs from two linear mixed effects regression models comparing our input measures (object words produced in caregiver input and object presence) in relation to discrete sibling number ($R = 0-4$), for the video data. Age in months was included as a fixed effect in both models and subject was included as a random effect.

Variable	Effect	Estimate	Std. Error	df	t value	p value
Caregiver input	Intercept	4.80	0.16	272.03	30.38	<0.001
	n Siblings	-0.15	0.06	43.00	-2.40	0.021
	month	0.03	0.01	301.00	3.02	0.003
Object presence	Intercept	0.55	0.04	328.26	12.39	<0.001
	n Siblings	-0.08	0.01	43.00	-5.31	<0.001
	month	0.01	0.00	301.00	2.98	0.003

90 **S6: Possible outlier for input data removed**

91 One infant heard substantially more (>3 SDs above the mean) nouns in their input
 92 and nouns with object presence than the other 42 infants in the main sample for four of
 93 their recording sessions. We retain this infant in the main analysis, but confirm here that
 94 results reported for sibling group were consistent when this child was removed from the
 95 analysis of input data ($n=42$). See Tables 8 and 9.

Table 8

Results of nested model comparisons testing the effect of sibling group on caregiver input/object presence in the video data, with one infant identified as an outlier removed from our sample ($n=42$). Linear mixed-effects regression models compared our two input measures (object words produced in caregiver input and object presence) in relation to sibling group. Age in months was included as a fixed effect for both models; sex was included for caregiver input only following model structures in the main analysis. Subject was included as a random effect.

Model	Df	Chisq	p value
Caregiver input	2	9.02	0.01
Object presence	2	25.87	0.00

Table 9

Full model output from linear mixed effects regression models comparing our two input measures (object words produced in caregiver input and object presence) over time in relation to sibling group, with one infant removed who was identified as an outlier ($n=42$). Age in months was included as a fixed effect in both models, sex was included in the model testing caregiver input; subject was included as a random effect.

Variable	Effect	Estimate	Std. Error	df	t value	p value
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Caregiver input	Intercept	4.85	0.17	204.78	27.94	<0.001
	SibGroupOne	0.06	0.14	42.00	0.40	0.688
	SibGroup2+	-0.43	0.15	42.00	-2.81	0.008
	month	0.03	0.01	294.00	2.91	0.004
	sexM	-0.22	0.12	42.00	-1.87	0.069
Object presence	Intercept	0.56	0.05	311.42	12.24	<0.001
	SibGroupOne	-0.12	0.03	42.00	-3.66	<0.001
	SibGroup2+	-0.22	0.04	42.00	-5.71	<0.001
	month	0.01	0.00	294.00	3.07	0.002

S7: Change to input variables over time

We re-plotted Figures 2 and 3 from the main paper with age on the x-axis, to determine whether there was any age-related changes in these variables. Note that age was a significant factor in both linear mixed effects models testing caregiver input/object presence as dependent variables.

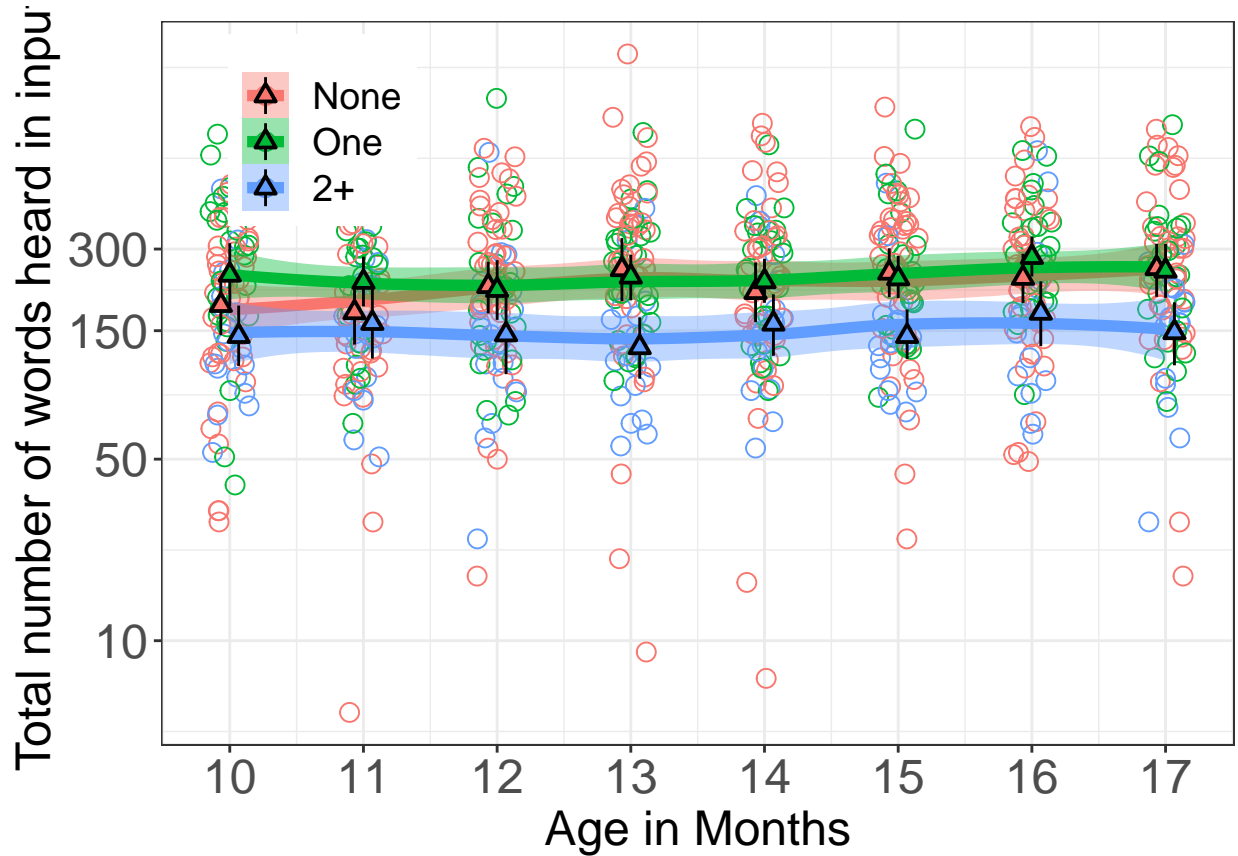


Figure 2. Number of input words produced by caregivers over time ($n=43$). Colors denote sibling group; line with colored confidence band reflects local estimator (loess) fit over individual infants' input at each month. Triangles indicate mean with bootstrapped CIs computed over each month's data. Points (jittered horizontally) show individual infants' input at each month.

Inspection of both Figures 2 and 3 suggest that both measures were relatively consistent in the data over time, across each sibling group.

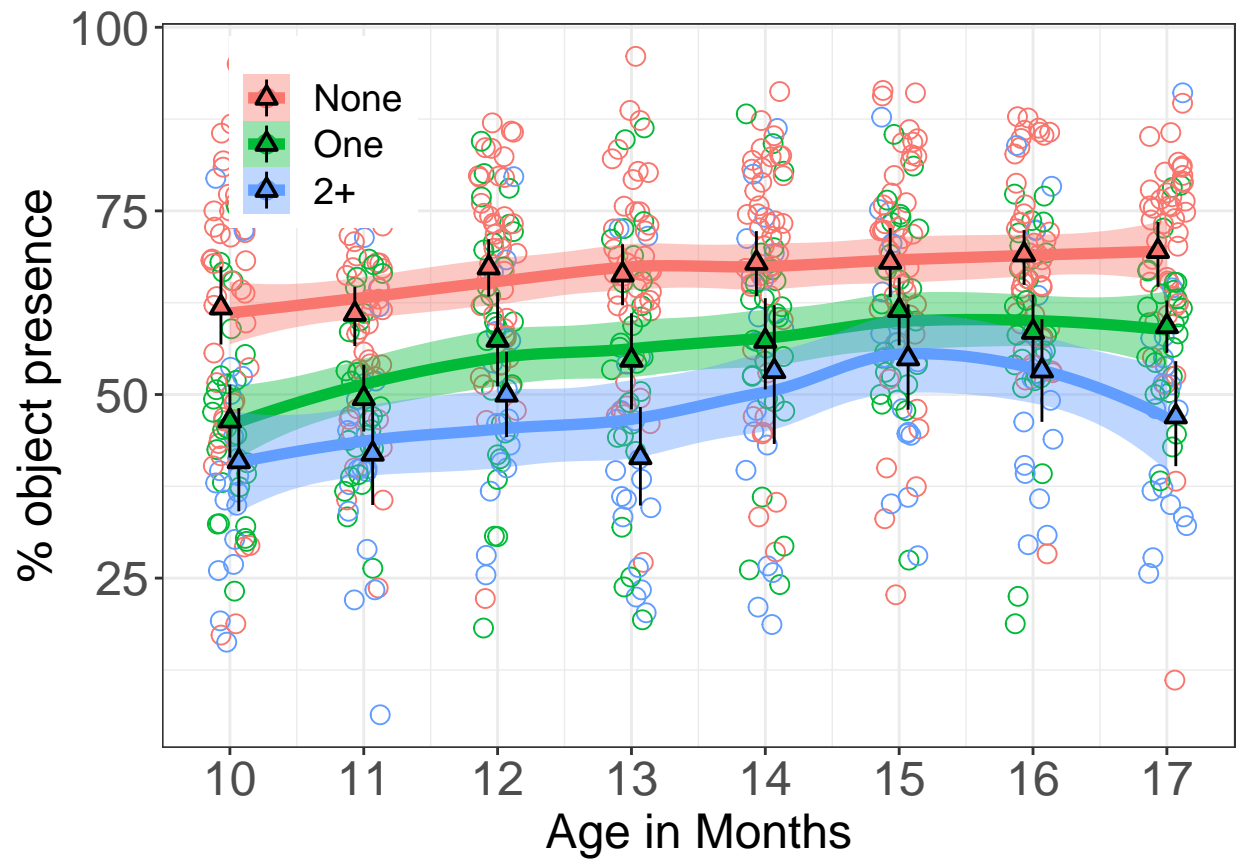


Figure 3. Amount (%) of object presence in infants' input over time ($n=43$). Colors denote sibling group; line with colored confidence band reflects local estimator (loess) fit over object presence at each month. Triangles indicate mean with bootstrapped CIs computed over each month's data. Points (jittered horizontally) show object presence in individual infants' inputs at each month.