

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

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 we
 49 acknowledge that this is not a perfect solution given that the presence of another twin in the
 50 home (counted as a sibling in the main analysis) may affect caregiver interactions in a
 51 different way than the presence of an older sibling. By removing both twins from our data
 52 and re-analysing the input measures, we can confirm that our results were consistent with
 53 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 words
 56 in each video recording analyzed in the main manuscript. This was usually the mother
 57 and/or the father. In the case where the infant had two mothers, their data was aggregated
 58 into the ‘Mother’ category; in all but two sessions from this family, the two mothers were the
 59 two main caregivers. There were 344 hour-long video recordings in total across the 43 infants
 60 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.

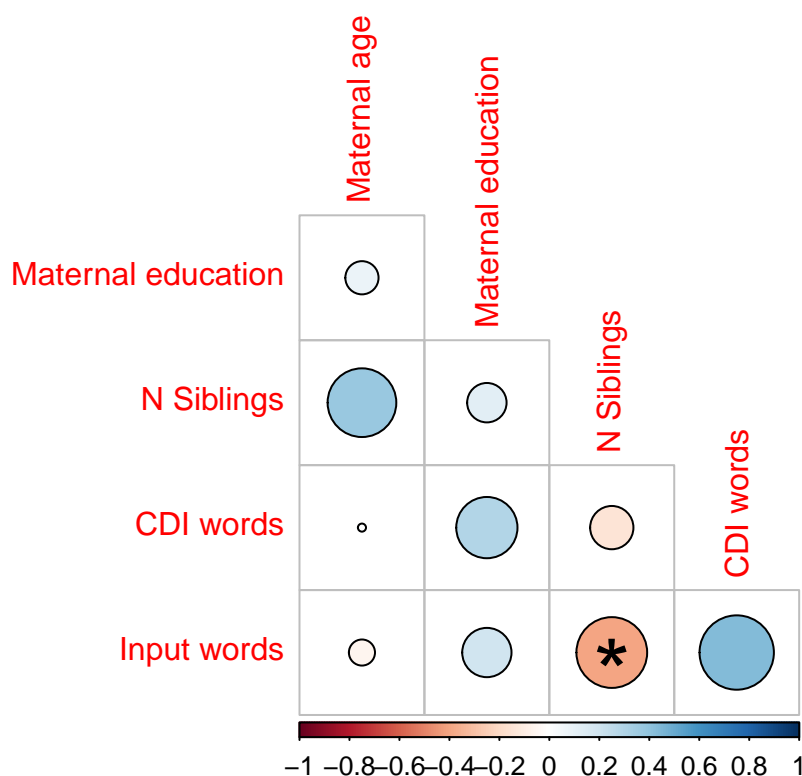


Figure 1. Correlation matrix showing Spearman's correlation coefficients between maternal factors (age and education), number of siblings, and number of words reported to be produced by the child at age 18 months. Colours and circles represent direction and strength of correlation, whereby bolder colours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

S5: Discrete sibling number

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

effect is consistent across our input measures.

Once again, initial model comparisons including the caregiver input/object presence as a dependent variable and age/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 on-wards. As above, 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 number + age (months) + (1|subject)

Outputs from model comparisons and full model outputs including estimates are shown in Tables 6 and 7. Results were consistent with those reported for sibling group, suggesting both characterizations of siblinghood capture similar relationships among our 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	272.05	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

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

90 One infant heard substantially more (>3 SDs above the mean) nouns in their input and
 91 nouns with object presence than the other 42 infants in the main sample for four of their
 92 recording sessions. We retain this infant in the main analysis, but confirm here that results
 93 reported for sibling group were consistent when this child was removed from the analysis of
 94 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 notable age-related changes in these variables.

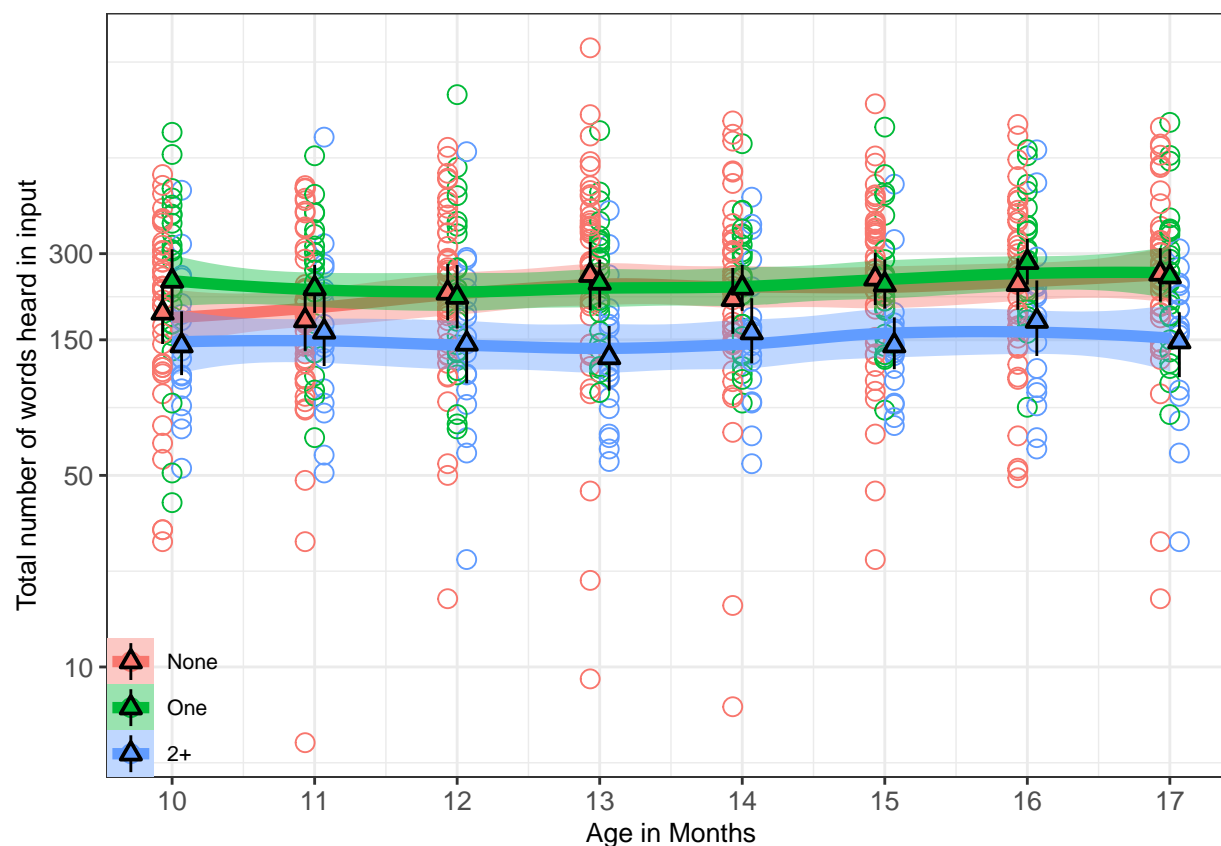


Figure 2. Number of input words produced by caregivers over time ($n=43$). Colors denote sibling group; line with colored confidence band reflects local estimator (loess) fit over individual infants' input at each month. Triangles indicate mean with bootstrapped CIs computed over each month's data. Points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

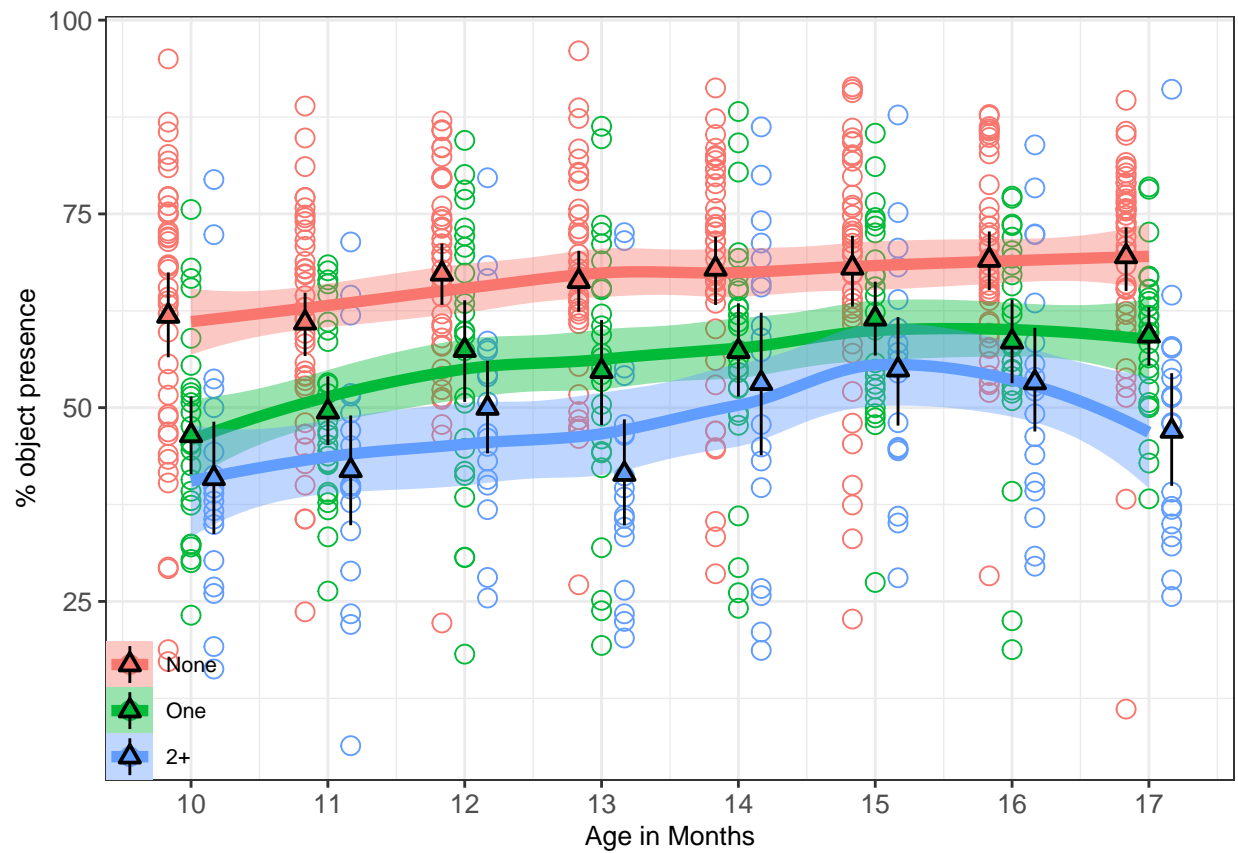


Figure 3. Amount (%) of object presence in infants' input over time ($n=43$). Colors denote sibling group; line with colored confidence band reflects local estimator (loess) fit over object presence at each month. Triangles indicate mean with bootstrapped CIs computed over each month's data. Points (dodged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