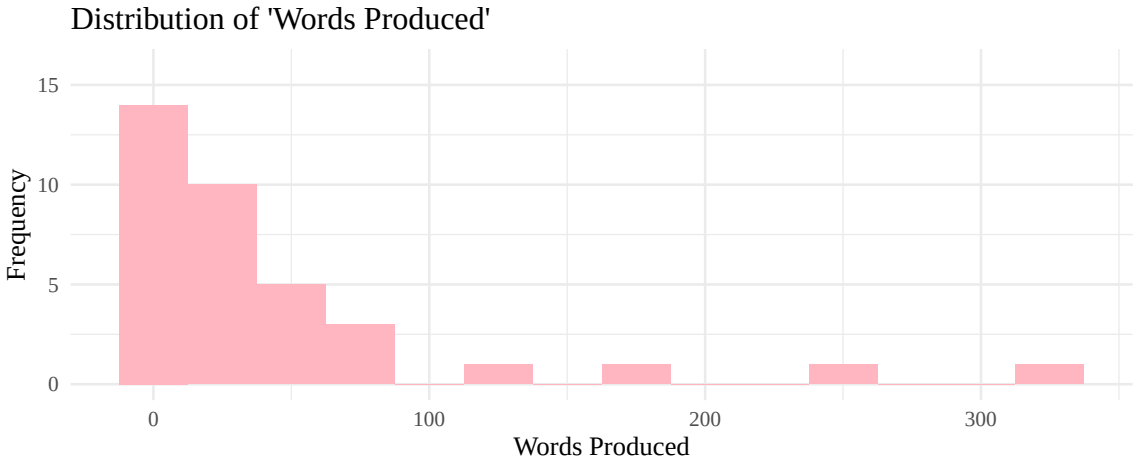
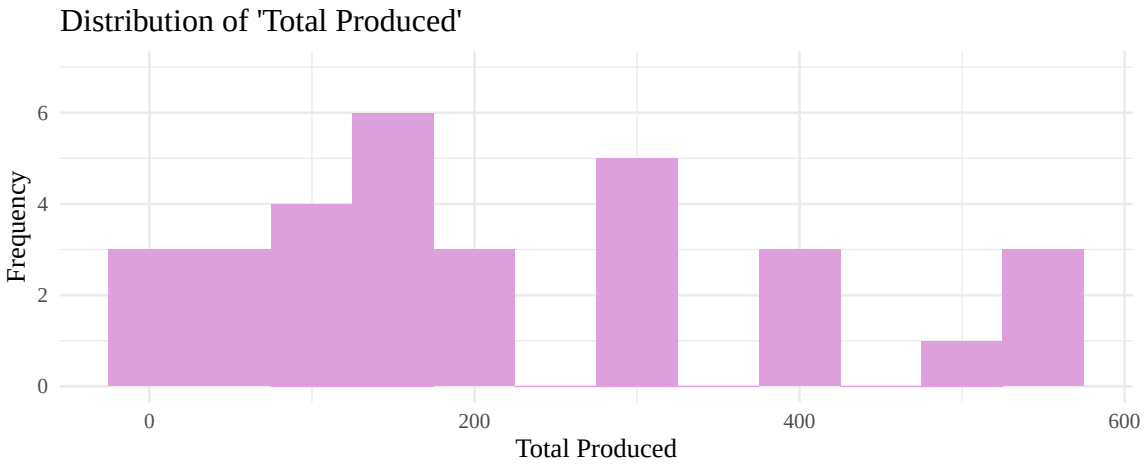
Multilevel Analysis and Visualizations

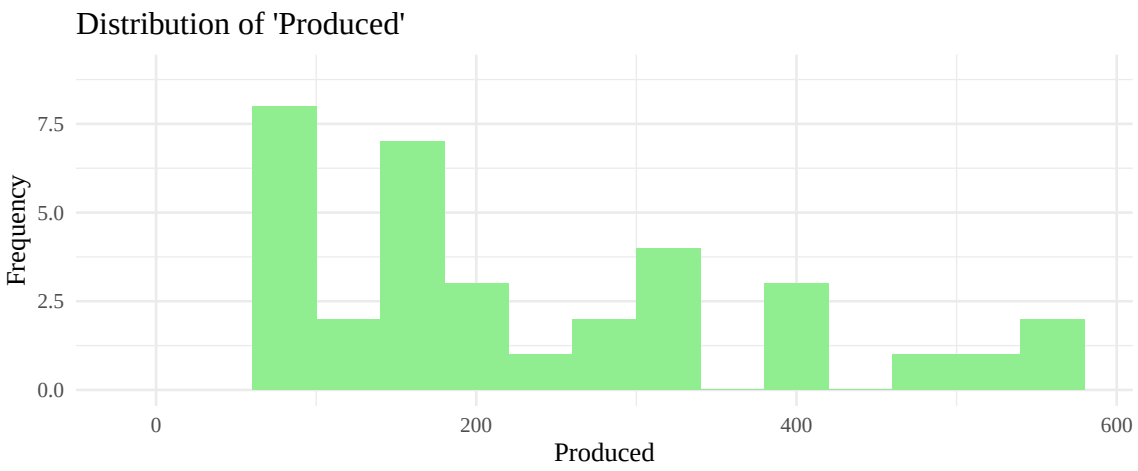
Visualization of the Data

MacArthur-Bates Communicative Development Inventory

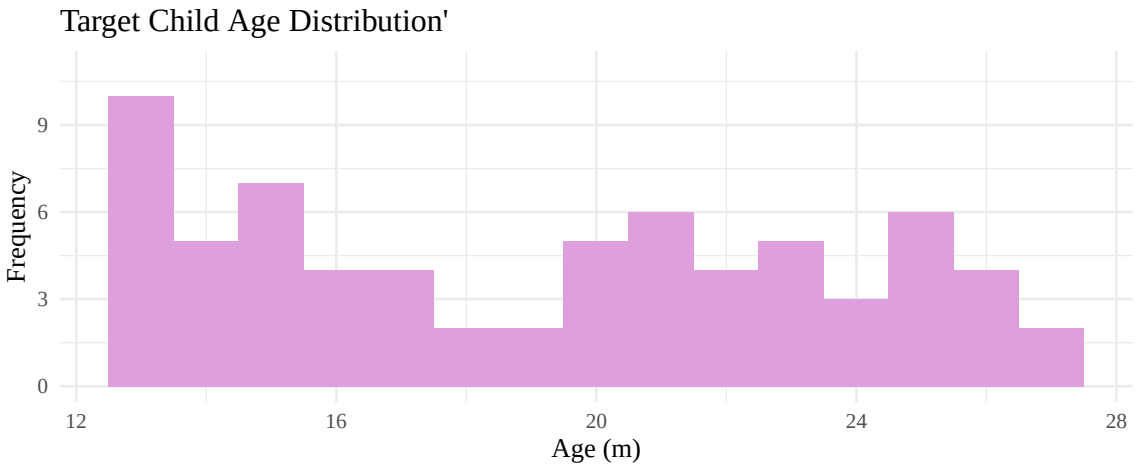
Parents who consented to participation were sent questionnaires asking about their reading beliefs, habits, household details, and more. Of those questionnaires was the MB-CDI. Depending on age, different versions were deployed — WG for children <19 months and WS for children >19 months. Parents who answered the WG version fall under the "Words Produced" graph while parents who answered the WS version fall under the "Total Produced" graph. These are the variables that will be used in the multilevel analysis.

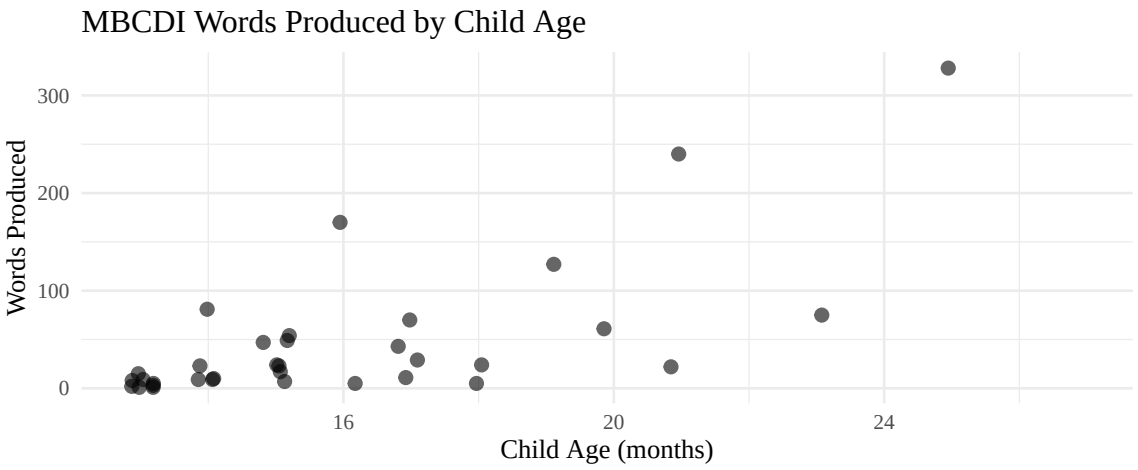


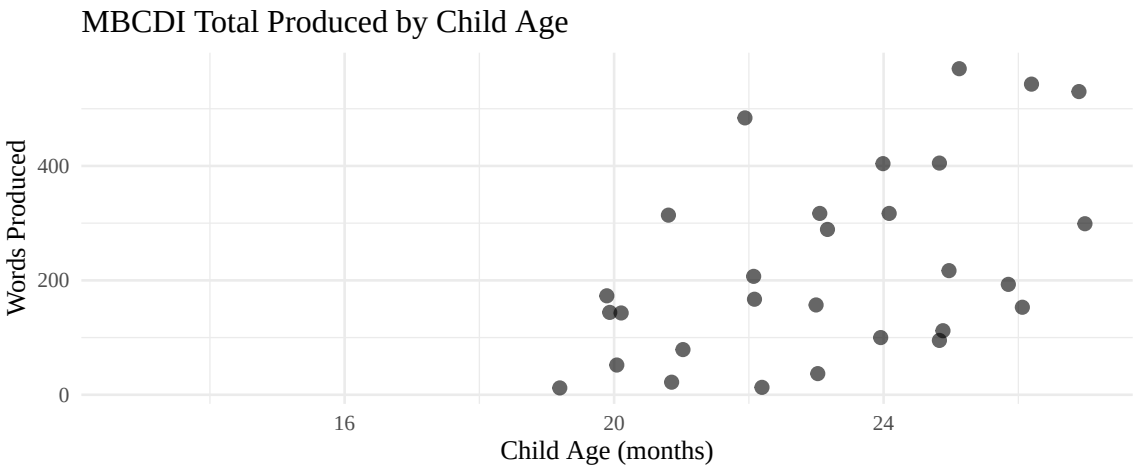




Age Breakdown







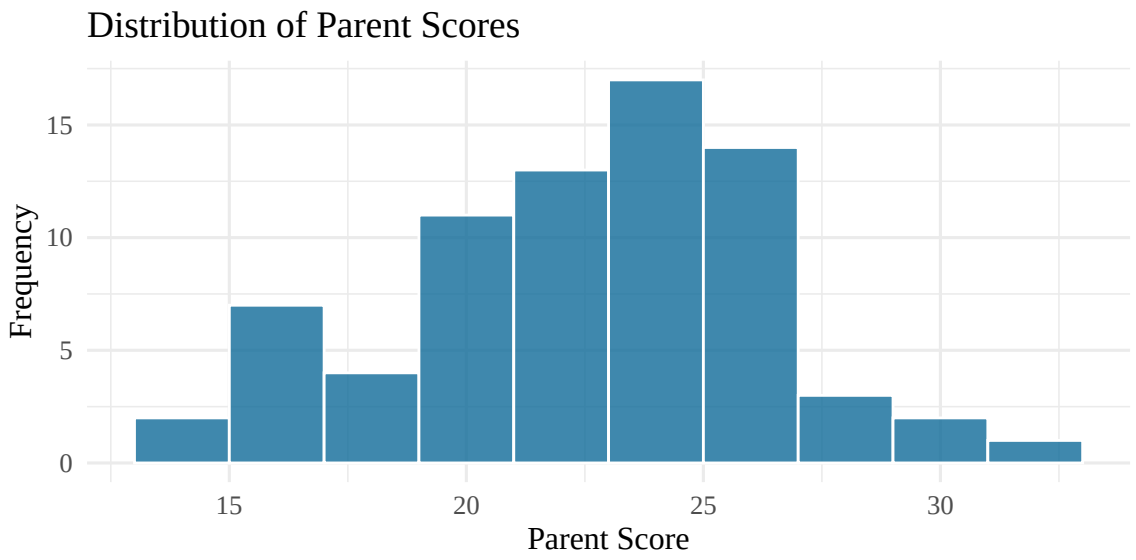
Children and Parent Scores

Specific questions were used to calculate respective parent and child scores. Each score takes into account 5 questions. The child score is a score that describes children's behaviors during reading session such as pointing at things on the page. The parent score is what parents do during the session, such as extending beyond the text of the book.

Parent Score

Scores are out of 40 and the questions used to calculate the parent score are as followed:

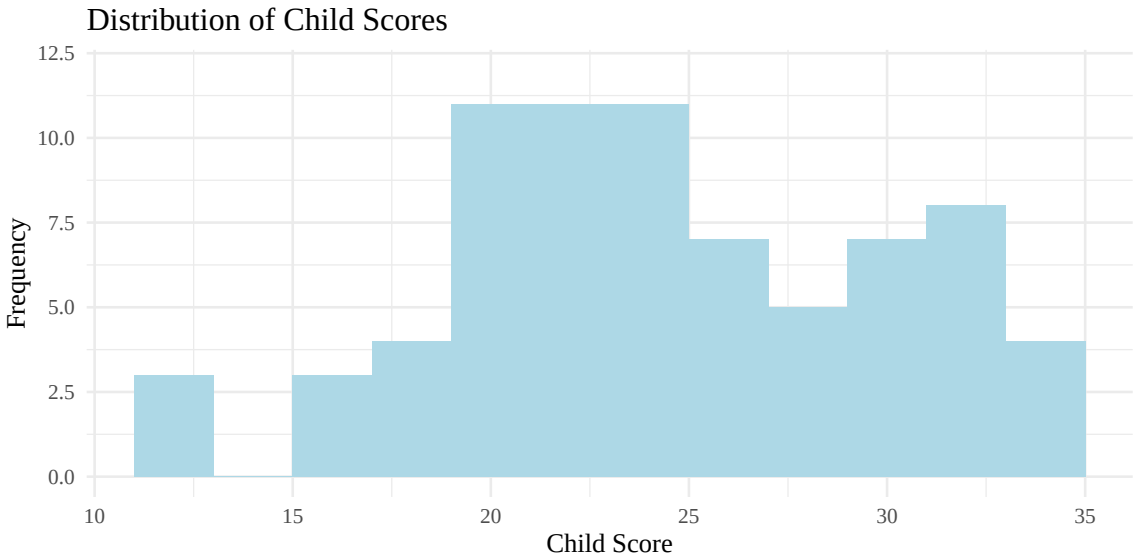
1. When you read to your child to what extent does your child quietly listen to the story, or is reading an interactive activity?
2. When you read to your child, how often do you read the text on the page exactly as it appears?
3. When you read to your child, how often do you make up your own story and talk about the pictures on the page?
4. When you read to your child, how often do you name objects or actions in the pictures?
5. When you read to your child, how often do you ask your child questions about the objects or events in the story or in the pictures?



Child Score

Scores are out of 40 and the questions used to calculate the child score are as followed:

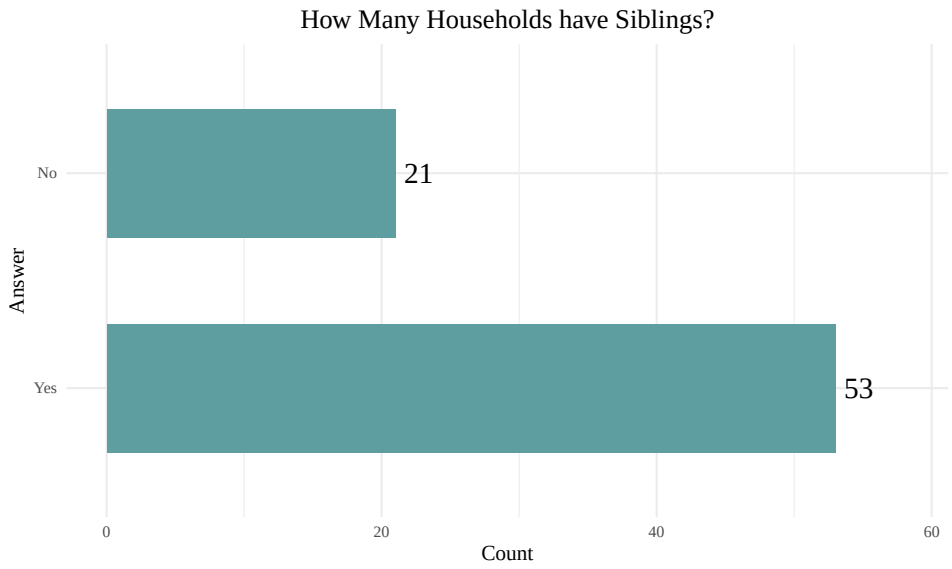
1. When you read to your child, how often does your child touch things on the pages of the book?
2. When you read to your child, how often does your child snuggle and look at items on the page?
3. When you read to your child, how often does your child vocalize or make sounds or say words while you're reading?
4. When you read to your child, how often does your child point to objects on the page?
5. When you read to your child, how often does your child repeat words right after you say them?

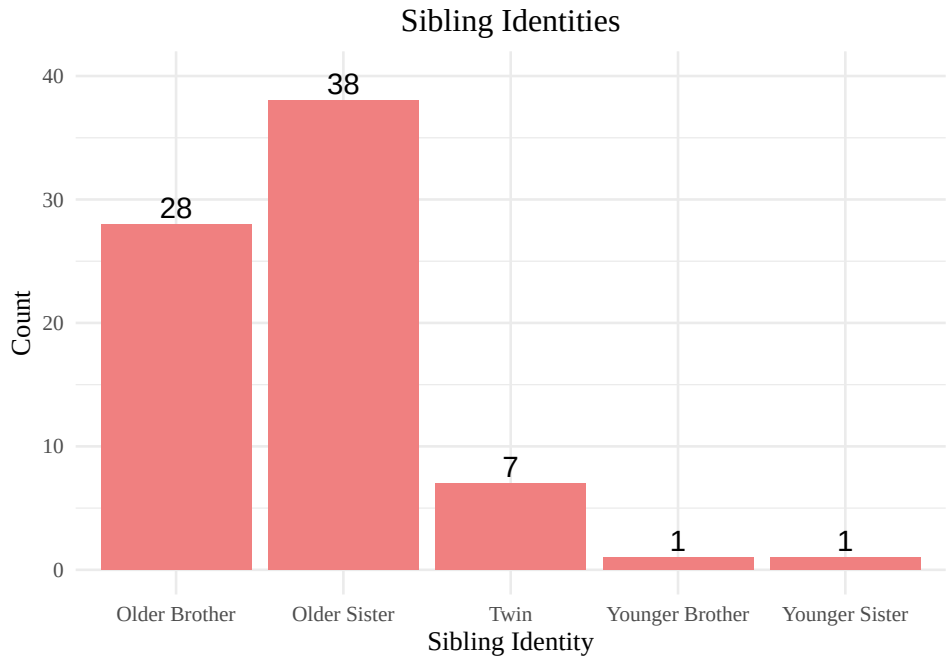


Household Details

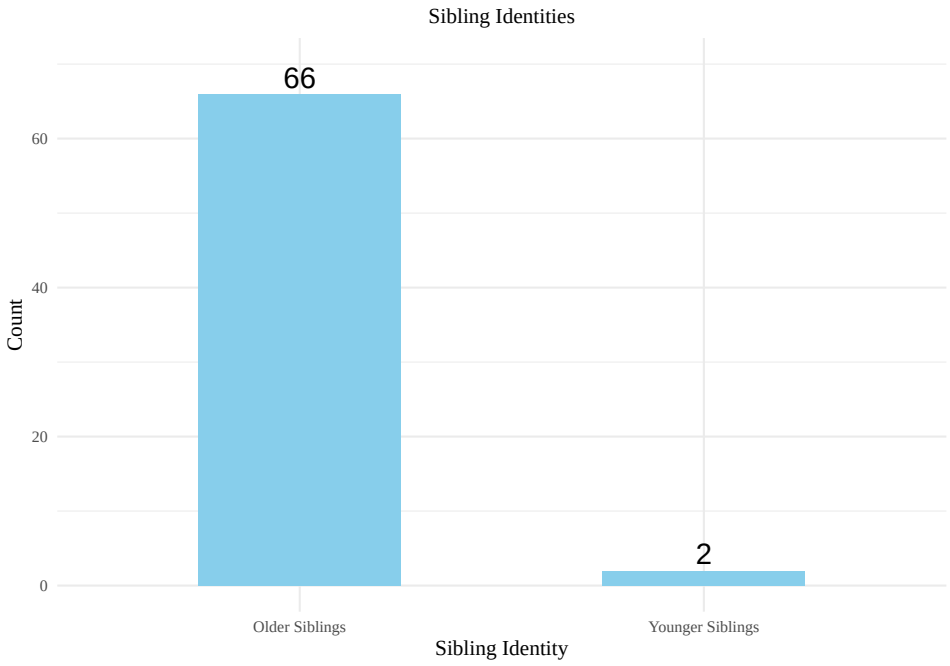
Sibling Count and Identity

After looking at the parent and child scores, the specific household details, specifically about sibling count and identity was graphed. `Sibling Identity` refers to the sibling's relation to the target child.

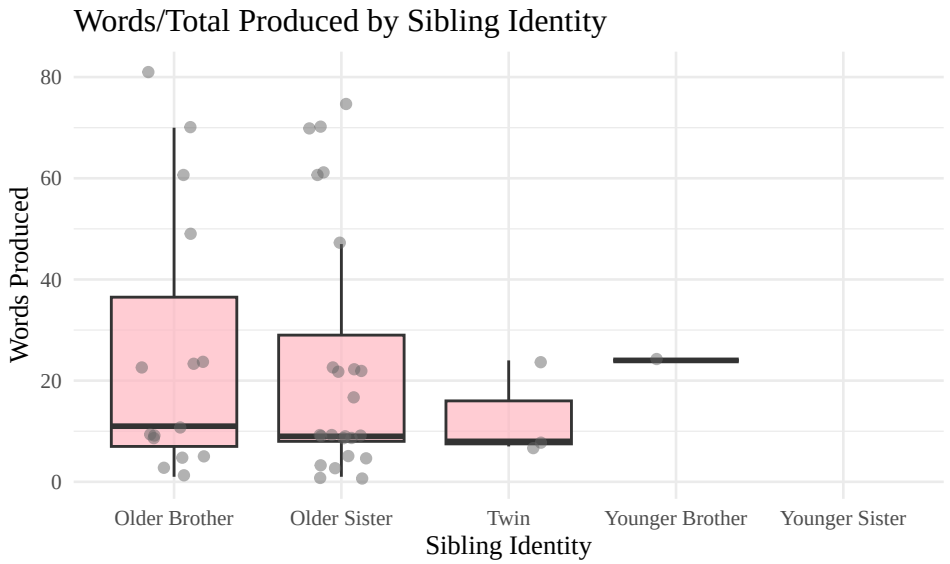


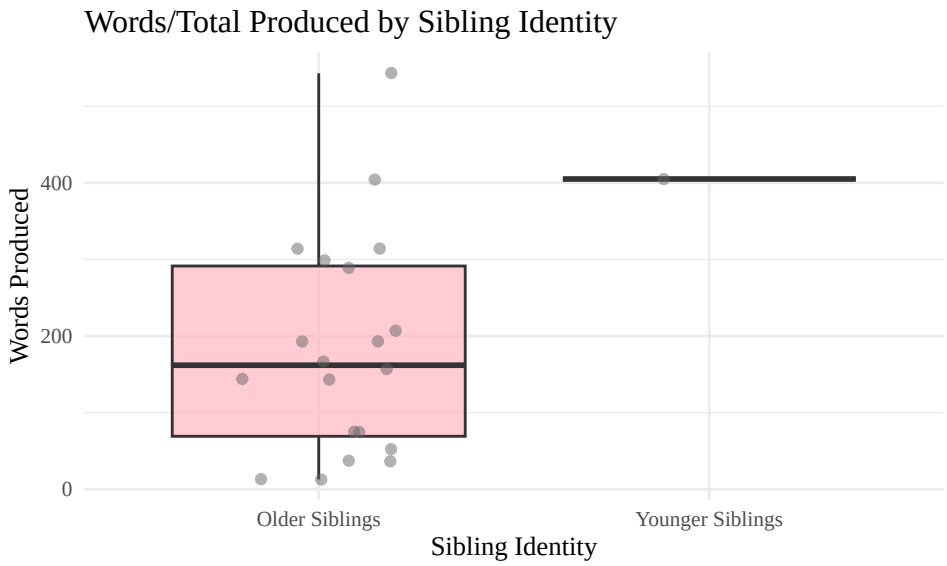


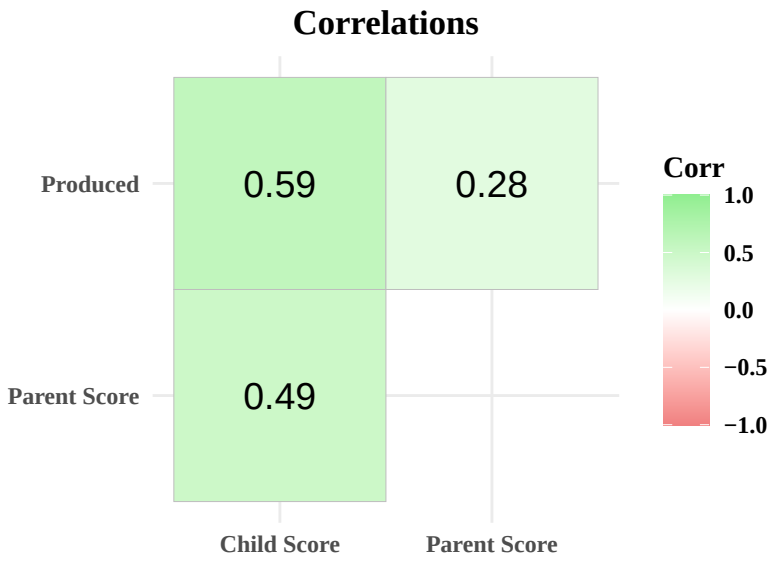
Due to the low number of observations in the individual younger and older sibling categories, the identities were combined into broader groups ("Older Siblings" and "Younger Siblings") to improve interpret ability and ensure sufficient sample size for analysis.



Production, Correlation, and Parent/Child Score by Sibling Identity Because some sibling data derived from WG questionnaires and some from WS questionnaires, the visualization compiles both the `Total Produced` and `Words Produced` into one visualization categorized by sibling identity. This was done with both the full sibling identity groups and the condensed version.








```
##
##  Spearman's rank correlation rho
##
## data:  combined$Produced and combined$child_score
## S = 17865, p-value = 4.27e-09
## alternative hypothesis: true rho is not equal to 0
## sample estimates:
##       rho
## 0.6435175
```

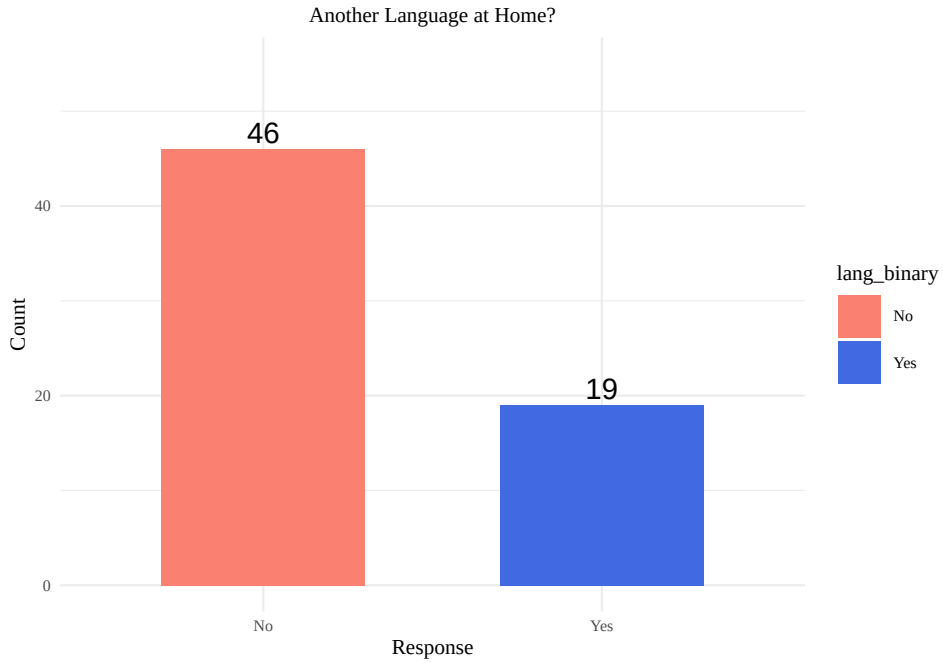
```
##
##  Spearman's rank correlation rho
##
## data:  combined$Produced and combined$parent_score
## S = 32434, p-value = 0.003406
```

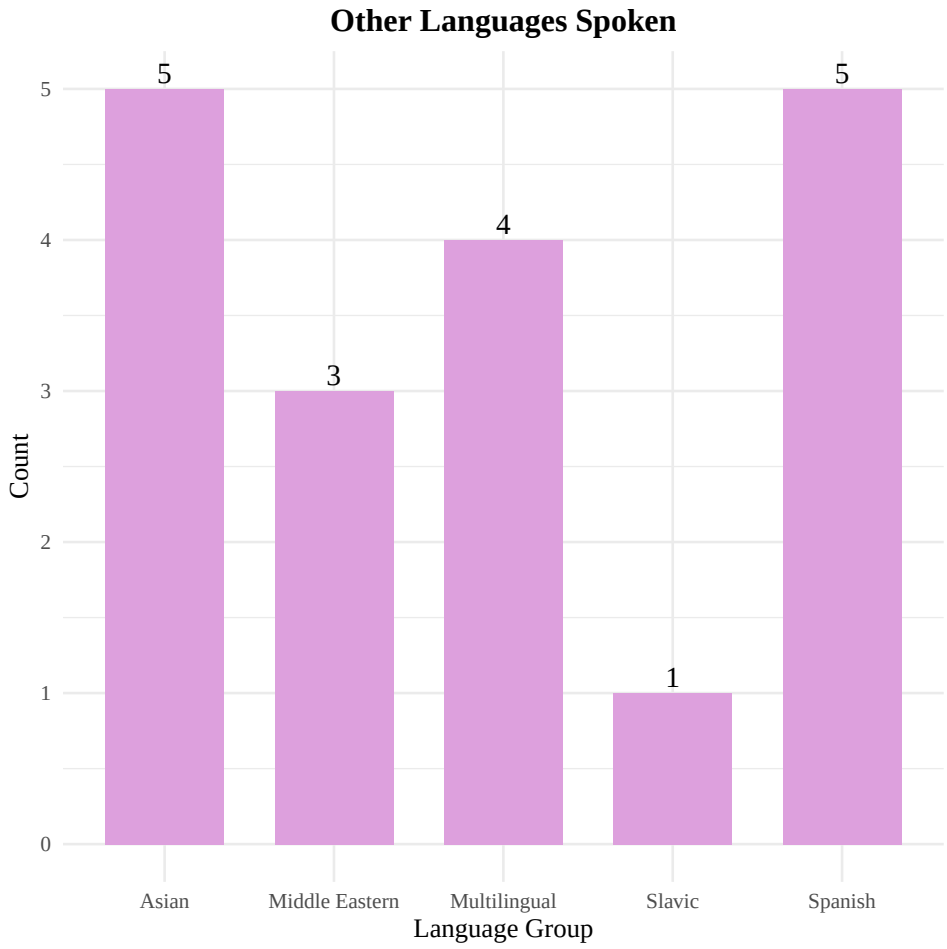
```
## alternative hypothesis: true rho is not equal to 0
## sample estimates:
##       rho
## 0.3528253


##
##  Spearman's rank correlation rho
##
## data:  combined$parent_score and combined$child_score
## S = 38135, p-value = 0.0001064
## alternative hypothesis: true rho is not equal to 0
## sample estimates:
##       rho
## 0.4352421
```

Multilingual Households

Multilingual households were also looked at. Out of 65 families, only 19 have another language, that is not English, spoken at home. The responses were also categorized by language group. `Multilingual` refers to households that speak more than one language group.





Frequentist Analysis of Data: Total Produced & Words Produced

Descriptive Statistics

Variable	Mean	SD	N
Child Age (m)	19.118	4.586	68
Child Score	24.849	5.507	73
Parent Score	23.123	3.789	73
Words Produced	45.889	69.758	36
Total Produced	228.533	168.695	30

While most variables have around 70 participants, `Words Produced` and `Total Produced` have smaller N due to half the participants being WG and the other half being WS. This can lower power and increase uncertainty.

`Child Score` and `Parent Score` means were fairly close to each other, however the SDs suggest variability, indicating that some children and parents score much higher and some much lower.

`Words Produced` and `Total Produced` had a very large difference in mean and SDs, which suggest that some children were producing very few words while others were producing very many. This is to be expected

because `Words Produced` data derived from WG, which were given to children <19 months of age, while `Total Produced` came from WS, given to children >19 months.

But what about the data of children with siblings?

Variable	Mean	SD	N
Child Age (m)	19.020	4.603	49
Child Score	24.547	5.195	53
Parent Score	22.736	3.574	53
Words Produced	25.000	23.865	26
Total Produced	231.273	168.200	22

Comparing Groups

To compare between two independent groups, a Mann-Whitney U Test would be ideal due to the skewed outcome (`Total & Words Produced`) and small sample sizes (within `Younger Siblings`). The advantages to this analysis is that it does not assume normality, can be used with ordinal data/skewed continuous data, and robust to outliers. It is important to note that this analysis is less powerful than a t-test *if* the data is really normally distributed and it tests for a difference in distributions, not specifically means.

```
## [1] "W = 547.5, p = 0.205"
```

This Mann-Whitney U tested whether `Produced` differs between children - who have other children in the home (Yes), and those who do not (No). It indicated that there was no significant difference in language production between children with siblings and those without, W = 547.5, p = 0.21.

While there was no difference between children with and without siblings, we wondered if there was a difference within the subset of children who had siblings and if having an older versus a younger sibling was related to language production.

```
## [1] "W = 29.5, p = 0.239"
```

A Mann–Whitney U test was conducted to compare language production between children with older siblings and those with younger siblings. However, the Younger Siblings group only included two observations, limiting the validity of the comparison. The test was not statistically significant, W = 29.5, p=0.24, but results should be interpreted with caution given the small sample size in the Younger Siblings group. These results are from preliminary data, thus these results are not yet conclusive.

Initial analyses examined whether the presence of siblings (Yes/No) and, among those with siblings, whether having an older versus younger sibling were associated with differences in language production. Mann–Whitney U tests revealed no significant differences in either comparison.

To further explore whether specific sibling identities (e.g., older brother, older sister, younger brother, younger sister) are associated with differences in language production, a one-way ANOVA was conducted to compare Produced across these groups.

Table 3: ANOVA Table

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sib_Identity	3	110638	36879.35	2.84	0.046
Residuals	57	739461	12973.00	NA	NA

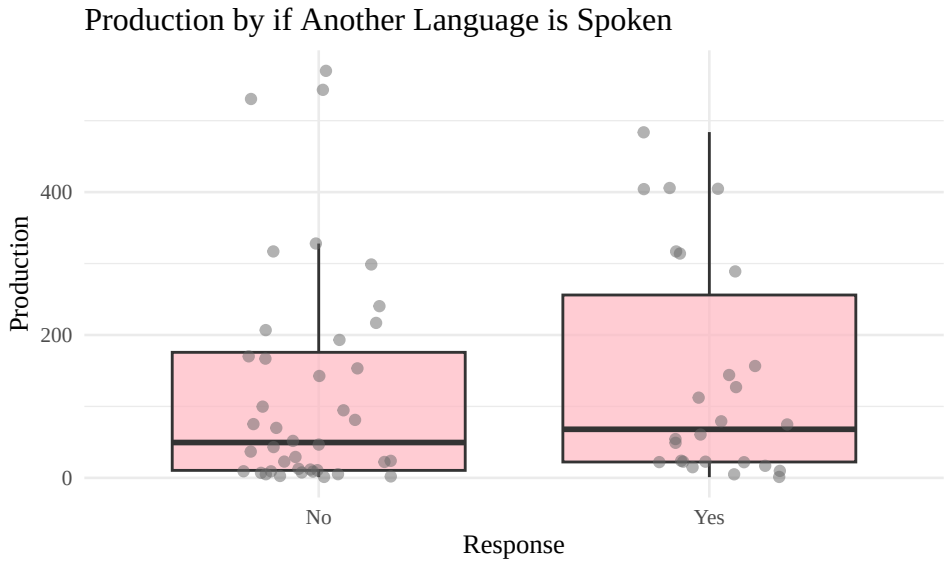
Results from the ANOVA indicated significant effect of sibling identity on language production F(3,57)=2.84, suggesting that at least one group mean differed. Since the ANOVA was significant, post-hoc tests (Tukey's HSD) were conducted to determine which groups differ.

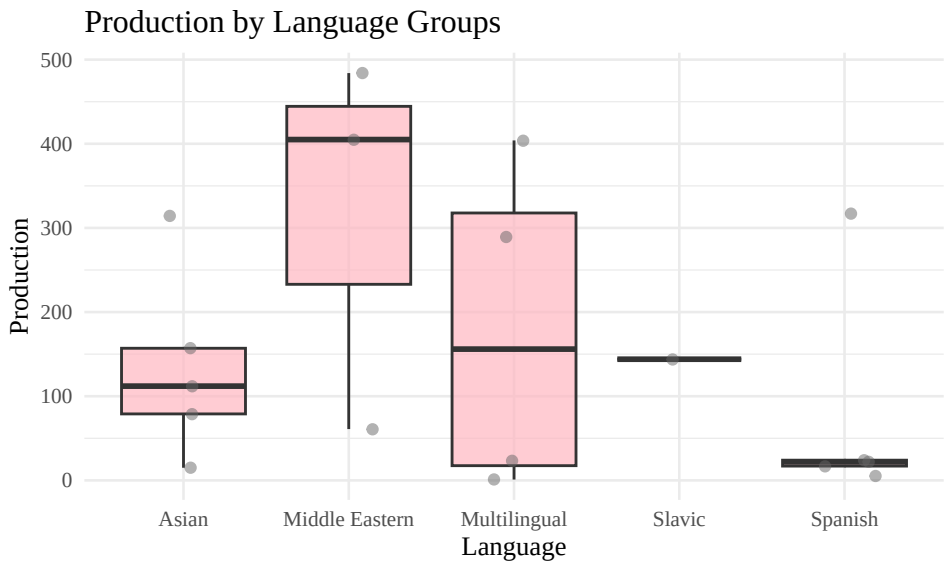
Table 4: Tukey HSD Pos-Hoc Comparison

	Comparison	Difference	Lower CI	Upper CI	Adj. P-Value
Older Sister-Older Brother	Older Sister-Older Brother	-12.53	-92.99	67.94	0.980
Younger Brother-Older Brother	Younger Brother-Older Brother	-62.00	-369.90	245.90	0.950
Younger Sister-Older Brother	Younger Sister-Older Brother	319.00	11.09	626.90	0.040
Younger Brother-Older Sister	Younger Brother-Older Sister	-49.47	-355.10	256.10	0.970
Younger Sister-Older Sister	Younger Sister-Older Sister	331.53	25.94	637.10	0.028
Younger Sister-Younger Brother	Younger Sister-Younger Brother	381.00	-45.29	807.30	0.096

Post-hoc comparisons using Tukey's HSD test indicated that children with a younger sister (M = ...) produced significantly more words than those with an older brother, p = .040, and those with an older sister, p = .028. No other pairwise comparisons were significant. These results should be interpreted with caution, as the younger sibling groups currently have small sample sizes, and data collection is ongoing.

Analysis by Language






```
## [1] "W = 461, p = 0.443"
```

```
## [1] "W = 510.5, p = 0.261"
```