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Speech Fluency Measurement for Aphasia Patients

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Background & Introduction

- Aphasia is a communication disorder that results from damages to parts of the brain that controls language and speech.
- It usually happens after a sudden stroke or brain injury.
- Depending on which part of the brain that's injured, this results in different types of Aphasia. The disorder can range from mild to severe.
- The WAB Aphasia Quotient Score determines which Aphasia group each patient belongs to.
- Common symptom among Aphasia patients: difficulty producing and understanding language
- Research Goal: Quantifying the different behaviors in Aphasia patients to improve the reliability and validity of **fluency measurement,** and exploring the patterns among the different Aphasia groups.

Exploratory Data Analysis

Data / Data Processing

- There are 5 datasets that were collected through FLUCALC (an automated language analysis tool). Each dataset consists between 202-559 data points and has been recorded through various aphasia tests.
- Each of the datasets can be categorized into three of the following tasks: narrative, expositional, and procedural.
  - All the plots are based on the Cinderella (narrative) task. The Cinderella task is performed by asking the patients to retell the story of Cinderella and record their response.
- The following predictor variables are listed: log % *phrase repetitions* and log % *word revisions*,
- There were a handful of anomalies in the the dataset; most of them were related to the specific aphasia groups (missing data/incorrectly labeled data).

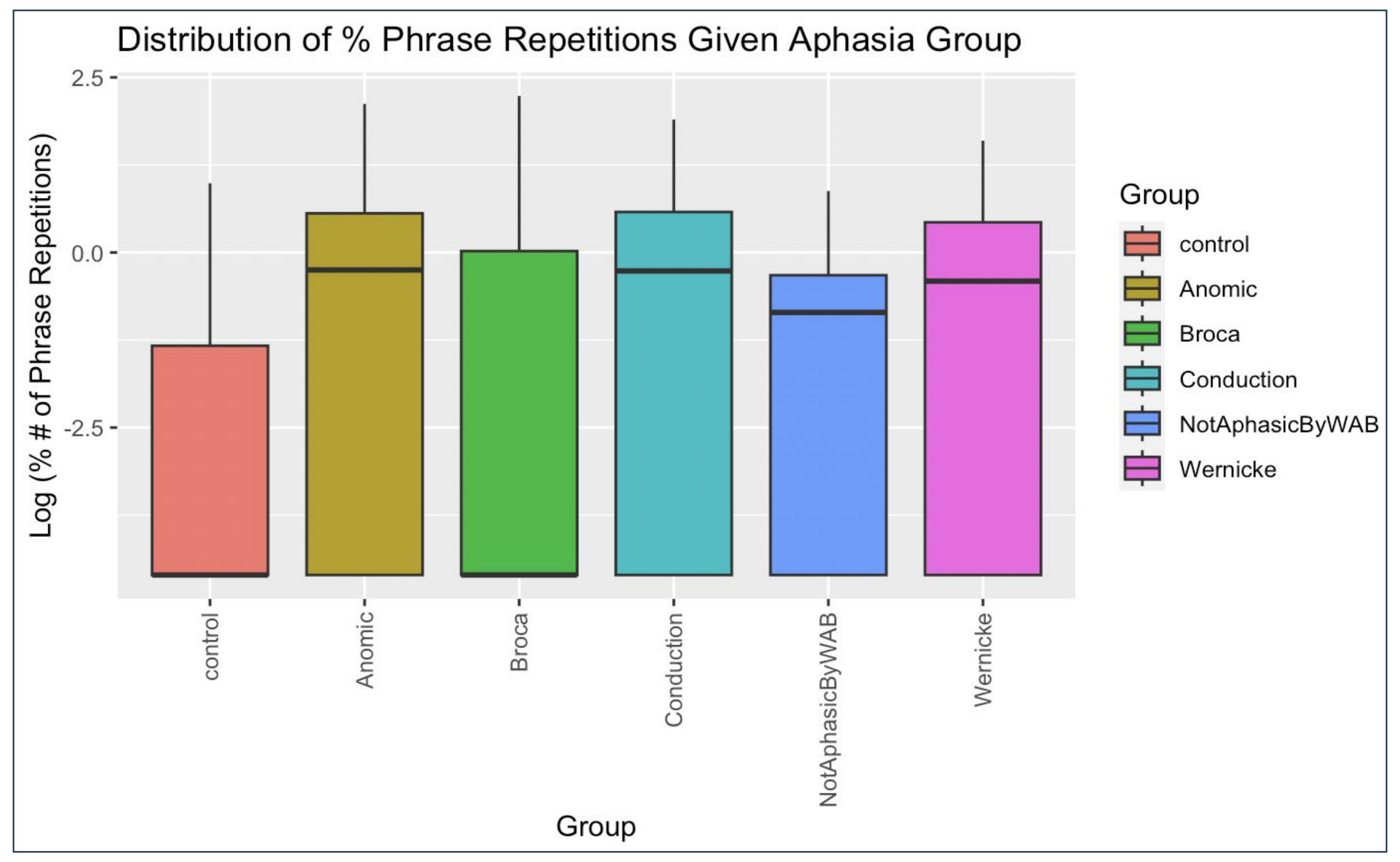


Figure 1: Boxplot for log % phrase repetitions for Cinderella dataset

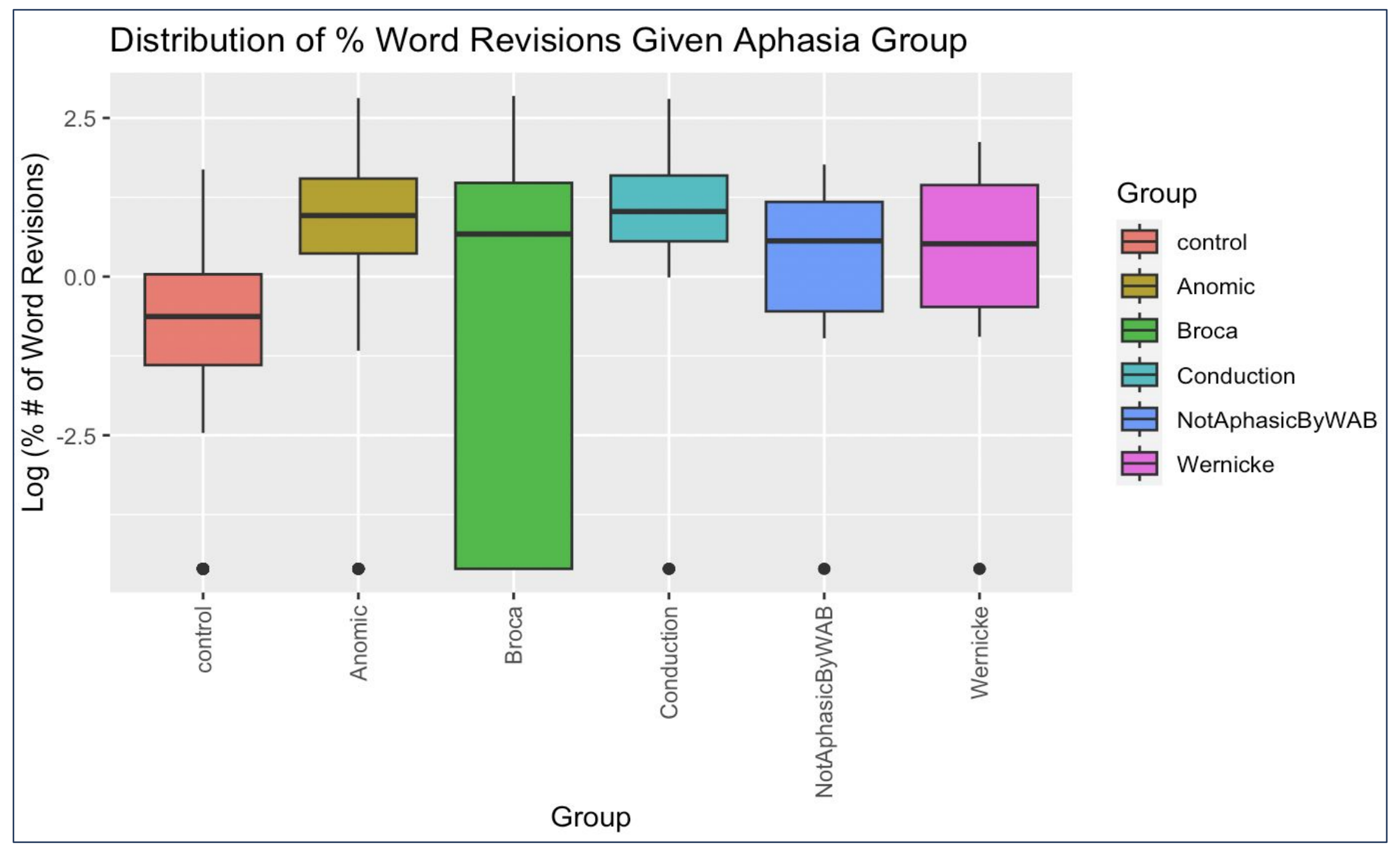


Figure 2: Boxplot for log % word revisions for Cinderella dataset

Boxplots for Cinderella Task Dataset

- The boxplots above show the distribution across all aphasia groups for each predictor variables.
  - The predictor variables were all log transformed in order to compare the medians of each group more properly.
- Figure 1 has the predictor "log % of phrase repetition" on the y-axis. It shows that the medians across all aphasia groups are different. The control group has the lowest median compared to that of the other aphasia groups, which aligns with our expectation.
- Figure 2 has the predictor "log % of word revisions" on the y-axis. The Broca's group has a much spreaded distribution since there are around 30% of the observations that are 0.
- Based on initial inspection, there seems to be differences in the distribution and median for all of the predictor variables. The control group has the lowest median, while Conduction and Wernicke (2 of the most severe types of Aphasia based on the WAB AQ score) have the highest medians.

Analysis & Results

Analyzing Patterns Across Aphasia Types: ANOVA Tests

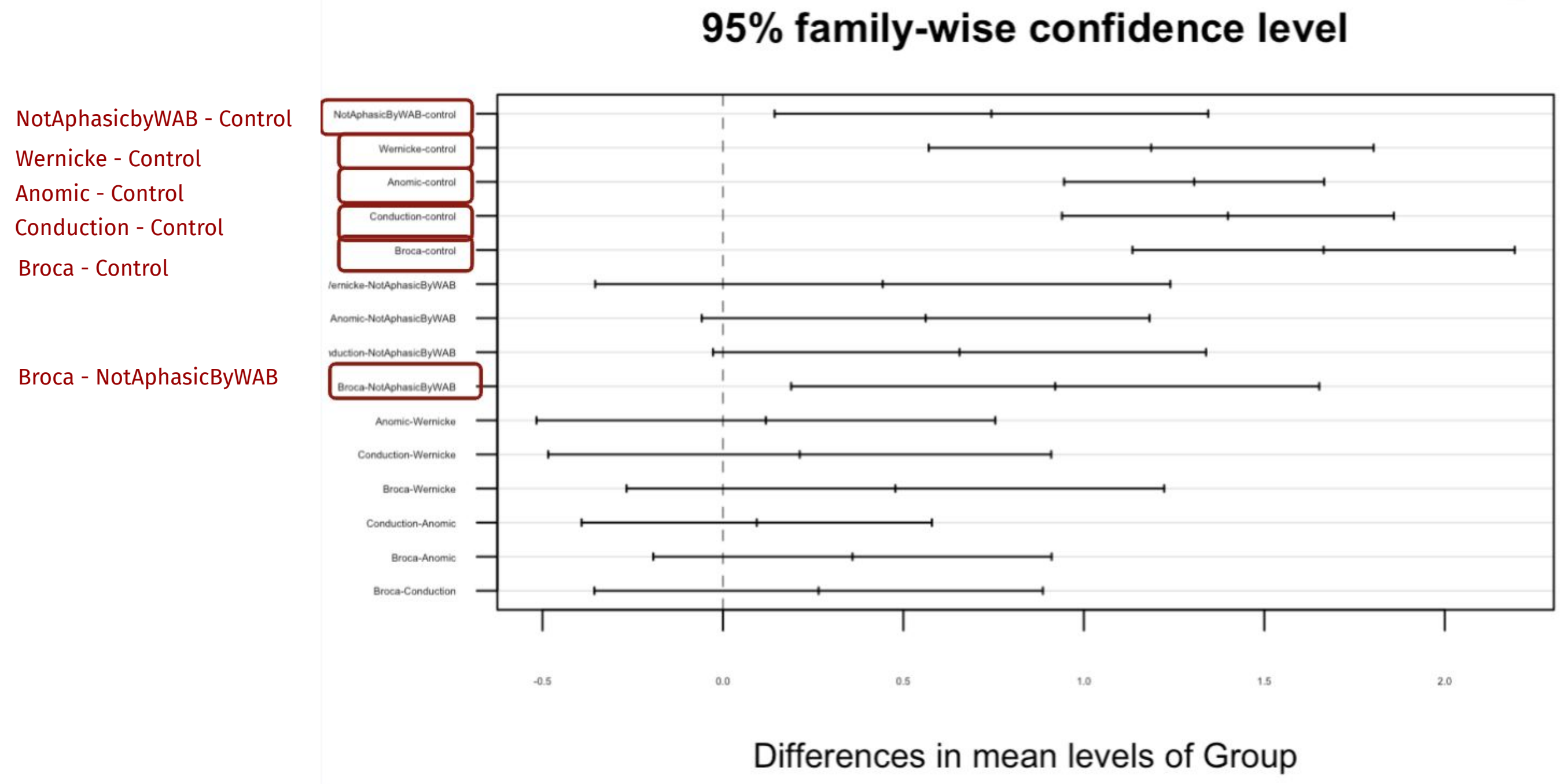


Figure 3: 95% family-wise confidence interval for log % phrase repetitions

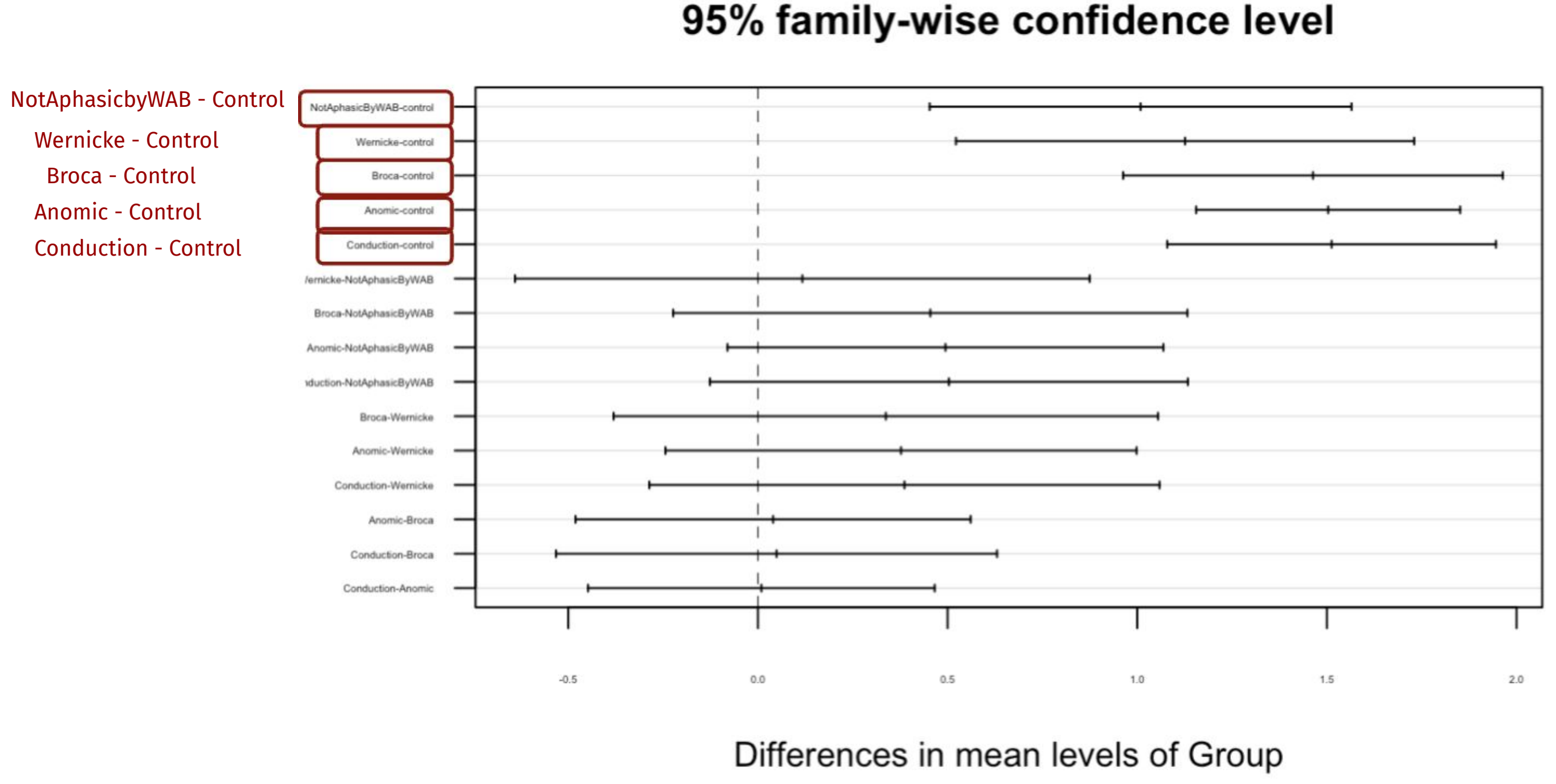
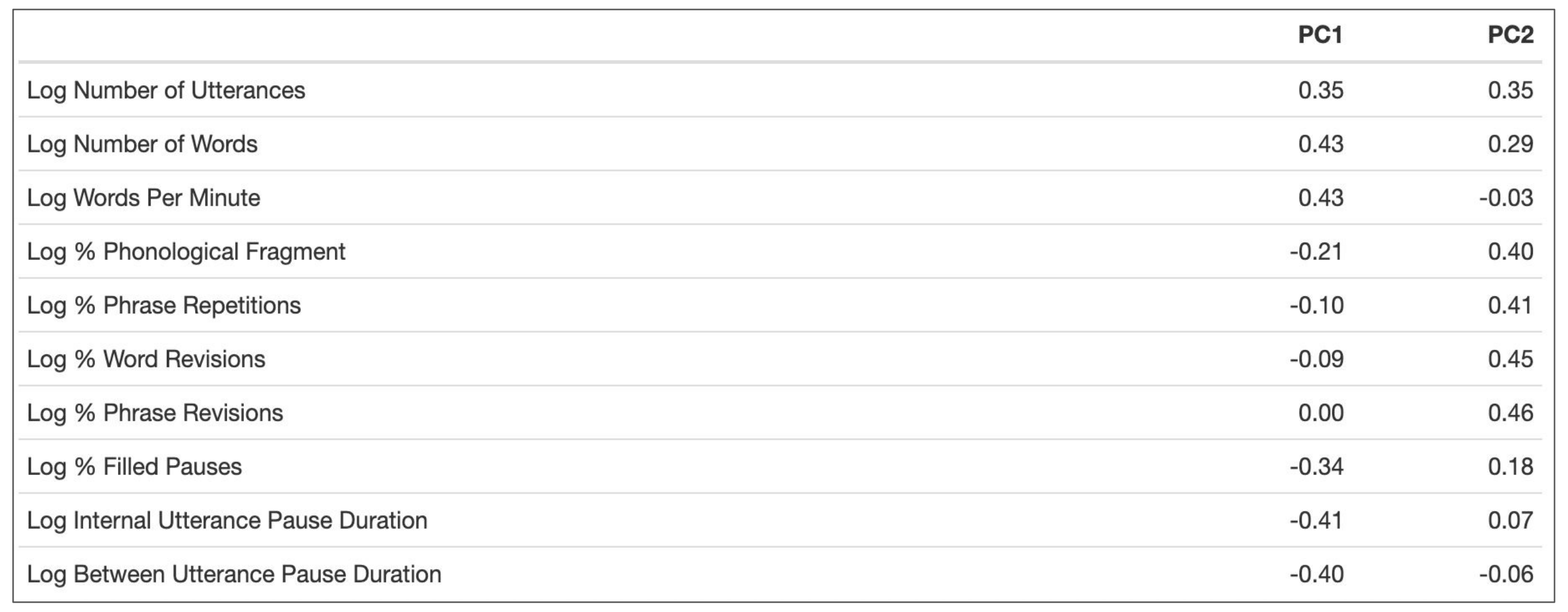


Figure 4: 95% family-wise confidence interval for log % word revisions

- Since we obtain a p-value of < 0.05 after running the ANOVA tests, we conclude that at least one Aphasia group has a significantly different mean than that of the other Aphasia groups for all the important variables (log transformed and added a constant of 0.01) we selected after doing EDA.
- In Figure 3 and 4, we see the 95% confidence intervals of log % *phrase repetitions* and log % *word revisions* between pairwise Aphasia groups. The intervals that do not overlap the middle dotted line (mean = 0) suggest significant differences in the mean. For all significant variables, the pairs with significant differences include *Broca - Anomic, Control - Anomic,* and *Control - Conduction*.

Analyzing Patterns Across Aphasia Types: Principal Component Analysis



	PC1	PC2
Log Number of Utterances	0.35	0.35
Log Number of Words	0.43	0.29
Log Words Per Minute	0.43	-0.03
Log % Phonological Fragment	-0.21	0.40
Log % Phrase Repetitions	-0.10	0.41
Log % Word Revisions	-0.09	0.45
Log % Phrase Revisions	0.00	0.46
Log % Filled Pauses	-0.34	0.18
Log Internal Utterance Pause Duration	-0.41	0.07
Log Between Utterance Pause Duration	-0.40	-0.06

Table 1: Correlation between variables and PCs

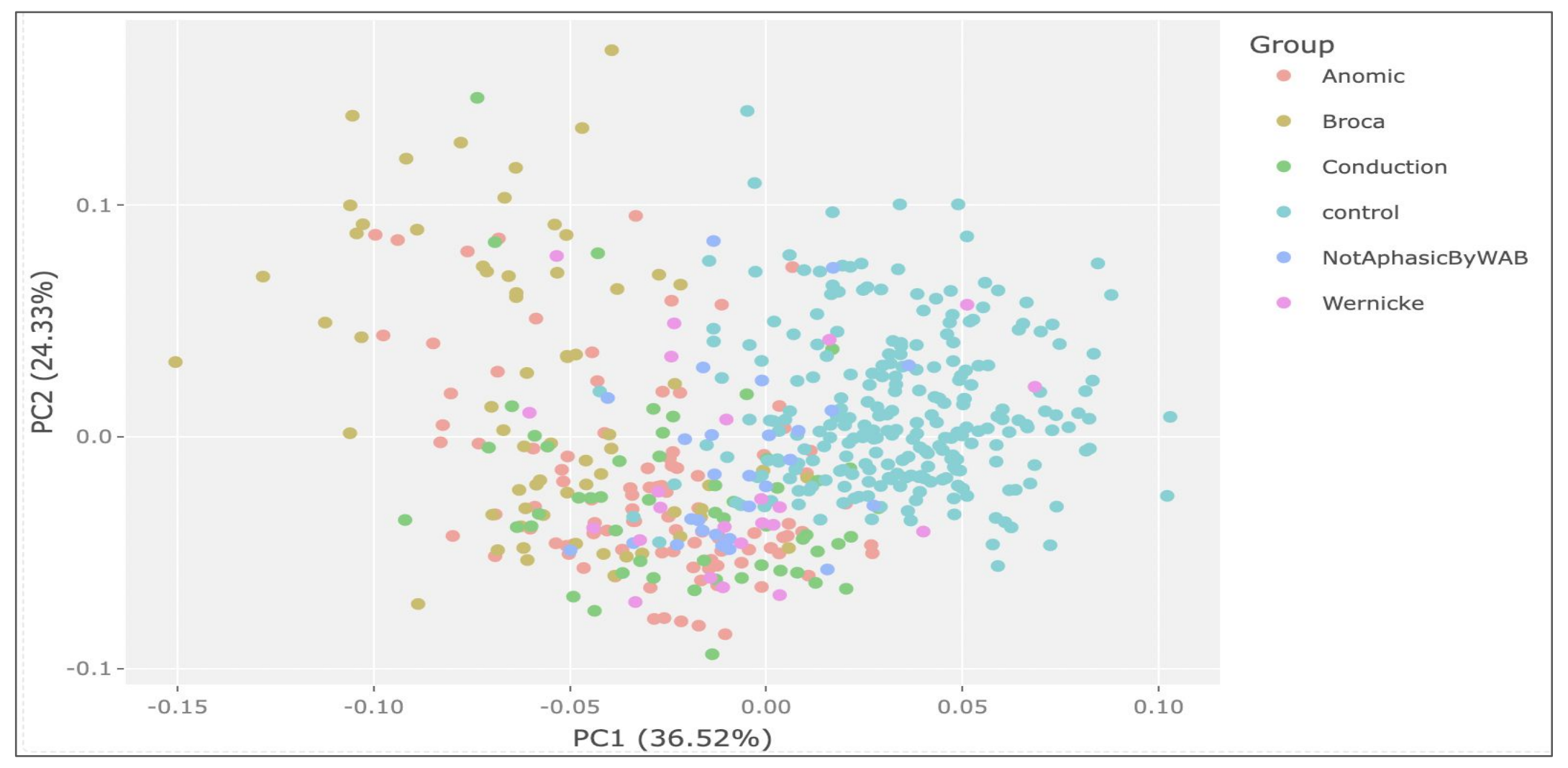


Figure 5: PCA Scatter Plot by Aphasia Groups

- PC1 captures 36.52% while PC2 captures 24.33% of the total variance in the data, based on figure 5.
- The log *number of utterances* and log *number of words* are positively correlated with each other, while log % *phrase repetitions* and log % *word revisions* are positively correlated with each other.
- The predictors log *number of utterances*, log *number of words*, and log *words per minute* contribute the most to the variance captured by PC1.
- We observe a cluster for the control group; it has positive PC1 values, whereas other groups have negative PC1 values. There are no identifiable patterns for PC2 by Aphasia groups (see figure 5).

Conclusions & Future Work

- We observe that some Aphasia groups have significantly different means for the predictors of interest.
- There might be a better way to more accurately classify the patients into each Aphasia group based on the specific variables we looked at, other than the WAB AQ score.
- In the future, we hope to contribute to the development of methods for quantifying fluency behaviors on a larger scale.
  - The data we used was collected from multiple different Aphasia labs, which could result in biases/inconsistencies in the dataset.
  - The results we have are only based on the Cinderella dataset; other tasks may yield different results.
- We would like to give special thanks to Dr. Joel Greenhouse, Dr. Davida Fromm, and Dr. Zach Branson for guiding us throughout the research process and providing us valuable feedback over the semester.