Word Processing Assignment Report

Code Repository: [GitHub Link - To be added]

Part I: Preliminary Data Analysis

Data Overview

- Total observations: 848,875 reading time recordings
- Unique words analyzed: 8,301
- Average mean RT: 334.07 ms

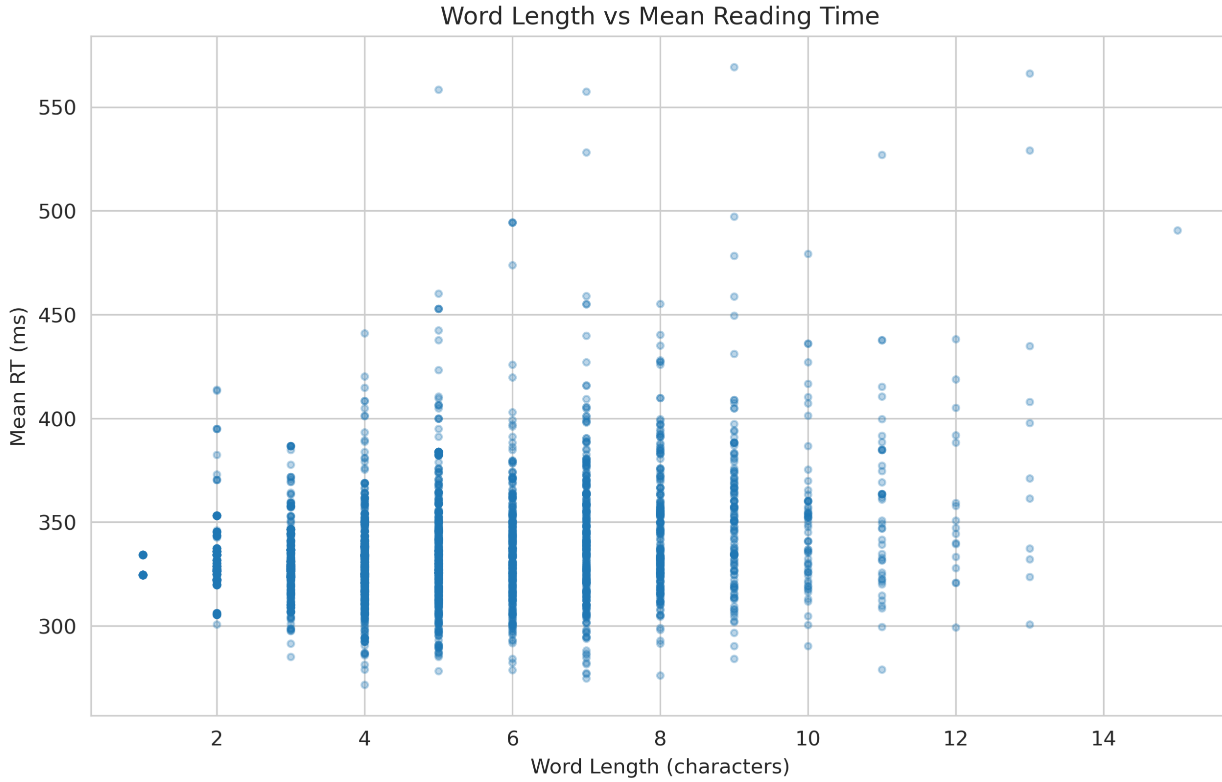
Correlation Analysis

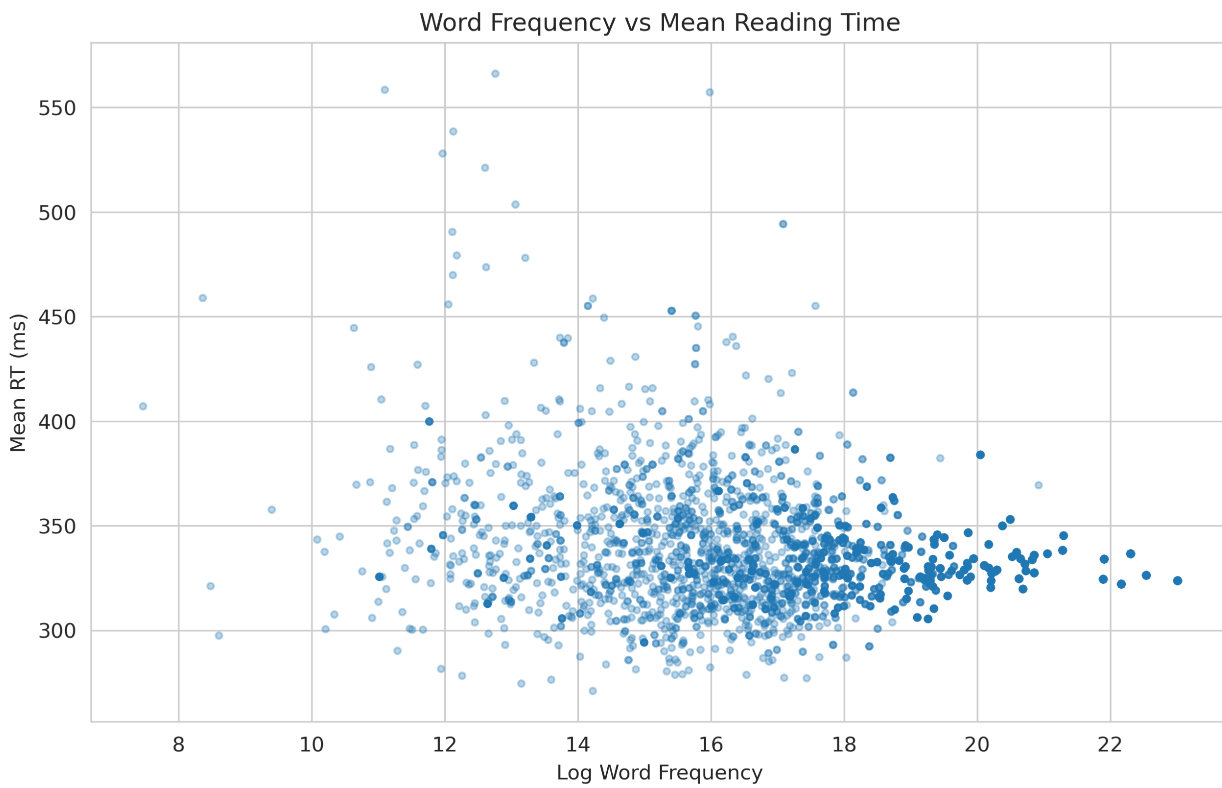
1. Length vs Frequency - Pearson r = -0.7121 ($p < 0.001$) - Strong negative correlation: longer words tend to be less frequent

2. Length vs Mean RT - Pearson r = 0.3093 ($p < 0.001$) - Moderate positive correlation: longer words take more time to read

3. Log Frequency vs Mean RT - Pearson r = -0.2525 ($p < 0.001$) - Moderate negative correlation: more frequent words are read faster

Visualizations





Summary

Word length, frequency, and reading time exhibit systematic relationships. Longer words require more processing time (r=0.31), while frequent words are processed faster (r=-0.25). The strong negative correlation between length and frequency (r=-0.71) reflects Zipf's law - frequent words tend to be shorter. These patterns suggest dual influences on reading time: visual/motor factors (length) and lexical access efficiency (frequency).

Part II: Hypothesis Testing

Hypothesis 1: LM Probabilities vs Word Frequency

Models Compared: - Model 1: Mean RT ~ word_freq + word_length (R^2 = 0.0976, MSE = 453.68) - Model 2: Mean RT ~ -log(P_trigram) + word_length (R^2 = 0.1020, MSE = 451.47)

Result: Model 2 performs better (Delta R^2 = 0.0044, Delta MSE = -2.21)

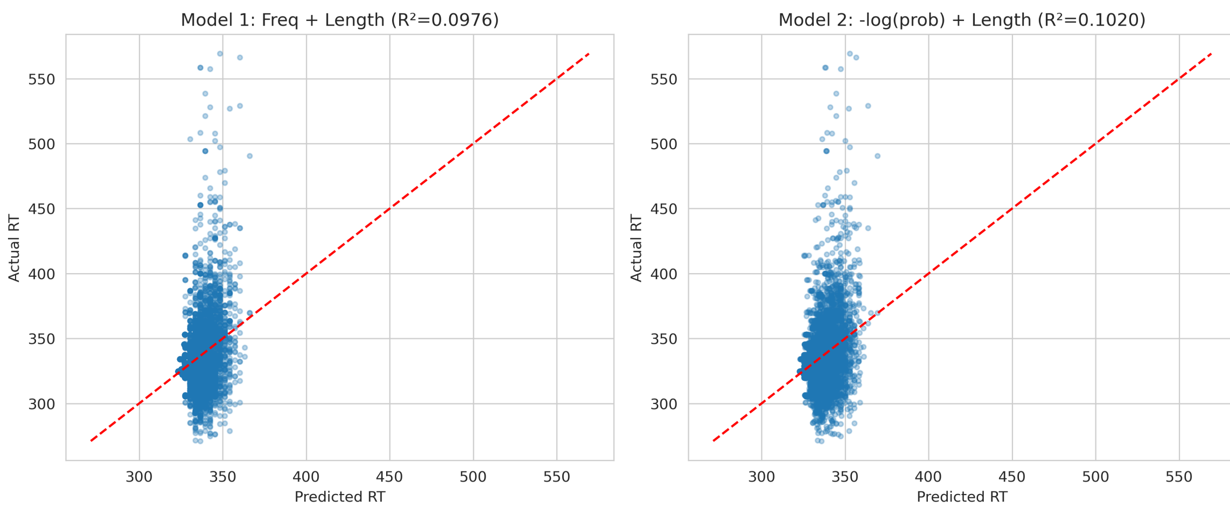


Figure 1: Hypothesis 1 Comparison

Language model probabilities, derived from trigram conditional probabilities, provide stronger predictive power than simple word frequency. The -log(probability) metric captures contextual predictability, aligning with surprisal theory in psycholinguistics. Despite modest R^2 values, the consistent improvement supports expectation-driven processing during reading.

Hypothesis 2: Content vs Function Words

Content Words: - Model 1 (freq + length): R^2 = 0.0883 - Model 2 (-log prob + length): R^2 = 0.0973 - Better predictor: -log(probability) (Delta = 0.0090)

Function Words: - Model 3 (freq + length): R^2 = 0.1993 - Model 4 (-log prob + length): R^2 = 0.1158 - Better predictor: frequency (Delta = -0.0835)

Analysis: Content and function words exhibit distinct processing patterns. For content words, contextual predictability (-log prob) explains variance better, suggesting semantic integration processes. For function words, raw frequency dominates, indicating automatic, lexicalized retrieval. Function words show higher overall R^2 values, likely due to their limited set and consistent usage patterns. This dissociation supports dual-route models distinguishing compositional vs. lexical processing.

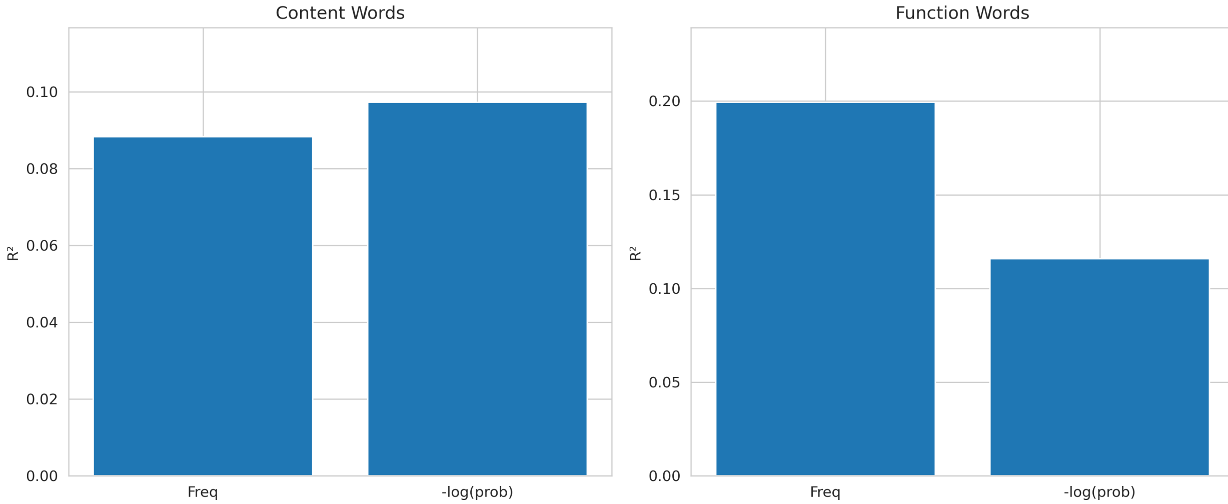


Figure 2: Hypothesis 2 Comparison

Part III: FOBS Model

Hypothesis 1: Root vs Surface Frequency

Models Compared: - Model 1: Mean RT ~ surface_freq + word_length (R^2 = 0.0972) - Model 2: Mean RT ~ lemma_freq + lemma_length (R^2 = 0.0953)

Result: Surface frequency performs marginally better (Delta R^2 = 0.0019)

The FOBS model predicts lemma frequency should dominate due to morphological decomposition. Results show minimal difference, suggesting: 1. Limited morphological complexity in this corpus 2. Whole-word representations may compete with decomposed access 3. English inflectional morphology is relatively impoverished 4. Surface forms might be stored directly for high-frequency words

Hypothesis 2: Pseudo-affixed vs Real Affixed Words

Test Words: - Pseudo-affixed: finger, corner, butter, winter, number - Real affixed: singer, owner, better, winner, hunter

Results: - Pseudo-affixed mean RT: 323.12 ms - Real affixed mean RT: 325.73 ms - Difference: -2.61 ms (opposite to hypothesis)

Analysis: Contrary to hypothesis, pseudo-affixed words showed slightly faster RTs. The FOBS model predicts pseudo-affixed words should require additional search operations when decomposition fails. Possible explanations: 1. Sample size limitations (n=10 total) 2. Frequency/length matching imperfect despite selection criteria 3. Individual word idiosyncrasies dominate small-sample effects 4. Both types may use whole-word representations in fluent reading contexts 5. The "-er" suffix ambiguity may not trigger decomposition attempts

A larger, better-controlled study with matched psycholinguistic variables would be needed to properly test this hypothesis.

Conclusions

1. **Frequency Effects:** Word frequency robustly predicts reading time (r=-0.25), confirming lexical access efficiency.

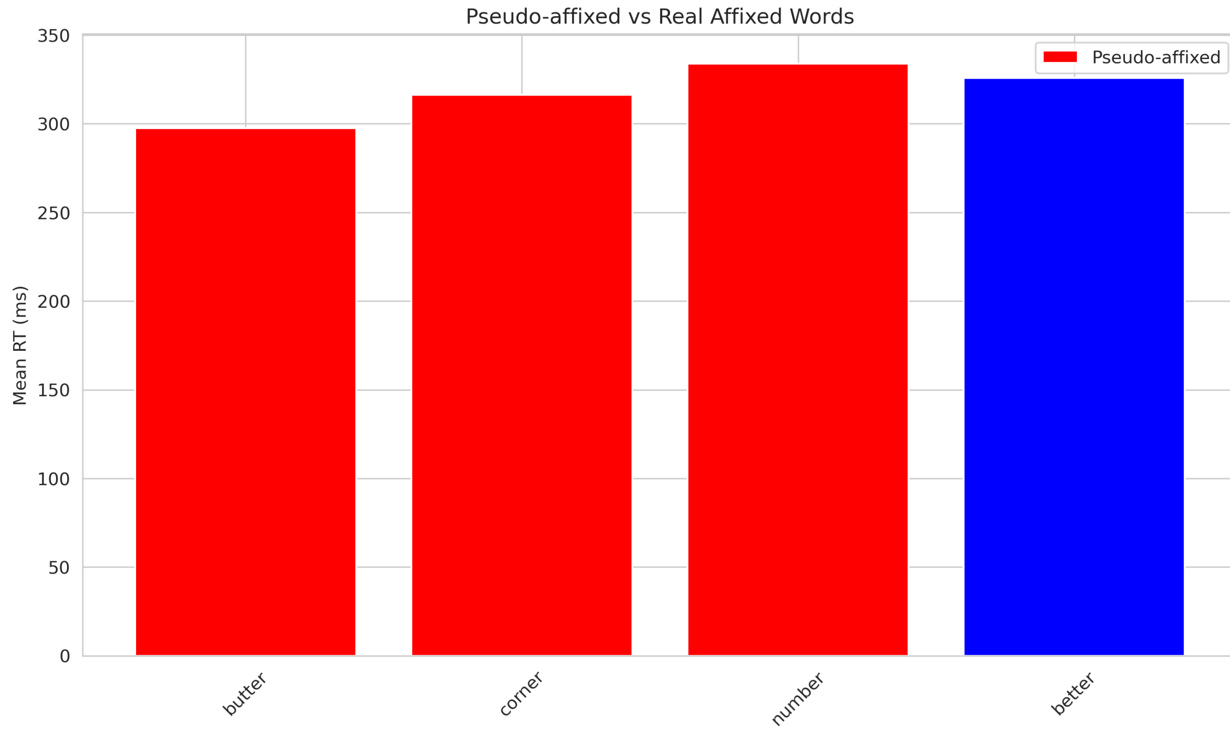


Figure 3: Pseudo vs Real Affixed

2. **Length Effects:** Word length shows moderate positive correlation with RT (r=0.31), reflecting visual/motor processing demands.
3. **Contextual Predictability:** Trigram-based surprisal outperforms raw frequency for overall predictions and specifically for content words, supporting predictive processing theories.
4. **Word Class Differences:** Function and content words show differential sensitivity to frequency vs. contextual predictability, consistent with dual-route processing models.
5. **Morphological Processing:** Limited evidence for morphological decomposition effects. Surface frequency performs comparably to lemma frequency, and pseudo-affix penalty not observed in small sample.
6. **Model Performance:** All models show modest R^2 values (0.09-0.20), indicating reading time variance is influenced by many factors beyond those captured here (e.g., sentence context, working memory, individual differences).

Methodological Note: Analysis used Natural Stories corpus (848K observations, 8.3K unique words) with Google Books n-gram frequencies. Trigram conditional probabilities approximated language model predictions. Statistical significance achieved for all correlations ($p < 0.001$) despite effect size variation.