The Influence of Lexical Frequency, Phonotactic Probability, and Neighborhood Density on Word Identification

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Introduction

- Lexical frequency, neighborhood density, and phonotactic probability influence speech perception (Vitevitch & Luce 1999)
- Most apparent in free response tasks (Sommers et al 1997); is masking noise sufficient to produce robust effects in a forced-choice task?
- Confusability based on acoustic similarity of particular segments also influences perceptual results (Cutler et al 2004)

This Study: A two-alternative forced choice task for identification of monosyllabic English words in noise

Higher accuracy with higher lexical frequency, lower neighborhood density, and higher phonotactic probability

Effects of neighborhood density and phonotactic probability are largely due to confusability of particular vowels

Distributional patterns

Measurements come from CVC English words in IPhOD (Vaden et al 2009)

Lexical frequency: Log frequency of the counts for each word
Neighborhood density: Number of words which differ from the word in a single segment
Phonotactic probability: Mean biphone probability of the phoneme sequences in the word

All positively correlated with each other (Frauenfelder et al 1993)

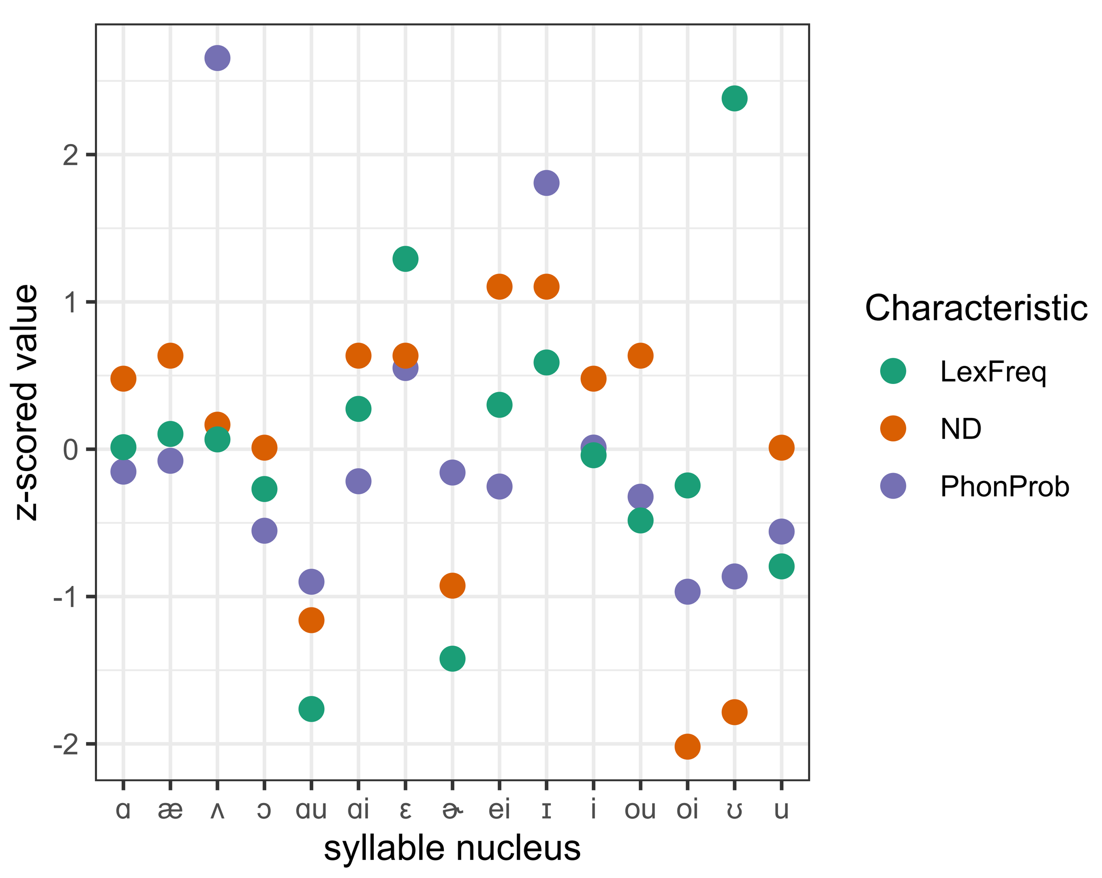

Figure 1: Z-scored lexical frequency, neighborhood density, and phonotactic probability aggregated by vowel. Vowel quality is a major predictor of these characteristics.

Methodology

Participants: 64 native speakers of American English completed the study online
Stimuli: 80 monosyllabic CVC English words combined with speech-shaped noise at -3 SNR
Task: Identifying each stimulus as matching one of two written words differing only in the vowel

- e.g. hear *back* and identify it as either "back" or "bake"
- Pairs of response options were chosen to separately control their relative lexical frequency, neighborhood density, and phonotactic probability

Main Results

	Estimate	SE	z	p-value
(Intercept)	2.01	0.205	9.84	< 0.001
log Lexical Frequency	0.179	0.0527	3.39	< 0.001
Neighborhood Density	-0.239	0.0748	-3.2	0.00138
Phonotactic Probability	0.59	0.0674	8.76	< 0.001

Table 1: Mixed effects logistic regression model for accuracy.

	Estimate	SE	z	p-value
(Intercept)	2.73	0.33	8.26	< 0.001
log Lexical Frequency	0.184	0.0651	2.83	0.00471
Neighborhood Density	-0.0639	0.0105	-0.611	0.542
Phonotactic Probability	0.113	0.0967	1.17	0.242
Vowel /æ/	-1.05	0.31	-3.38	< 0.001
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Table 2:Mixed effects logistic regression model for accuracy, including vowel quality as a factor. Reference Vowel = /ɑ/; for space reasons, not all rows for this factor are shown.

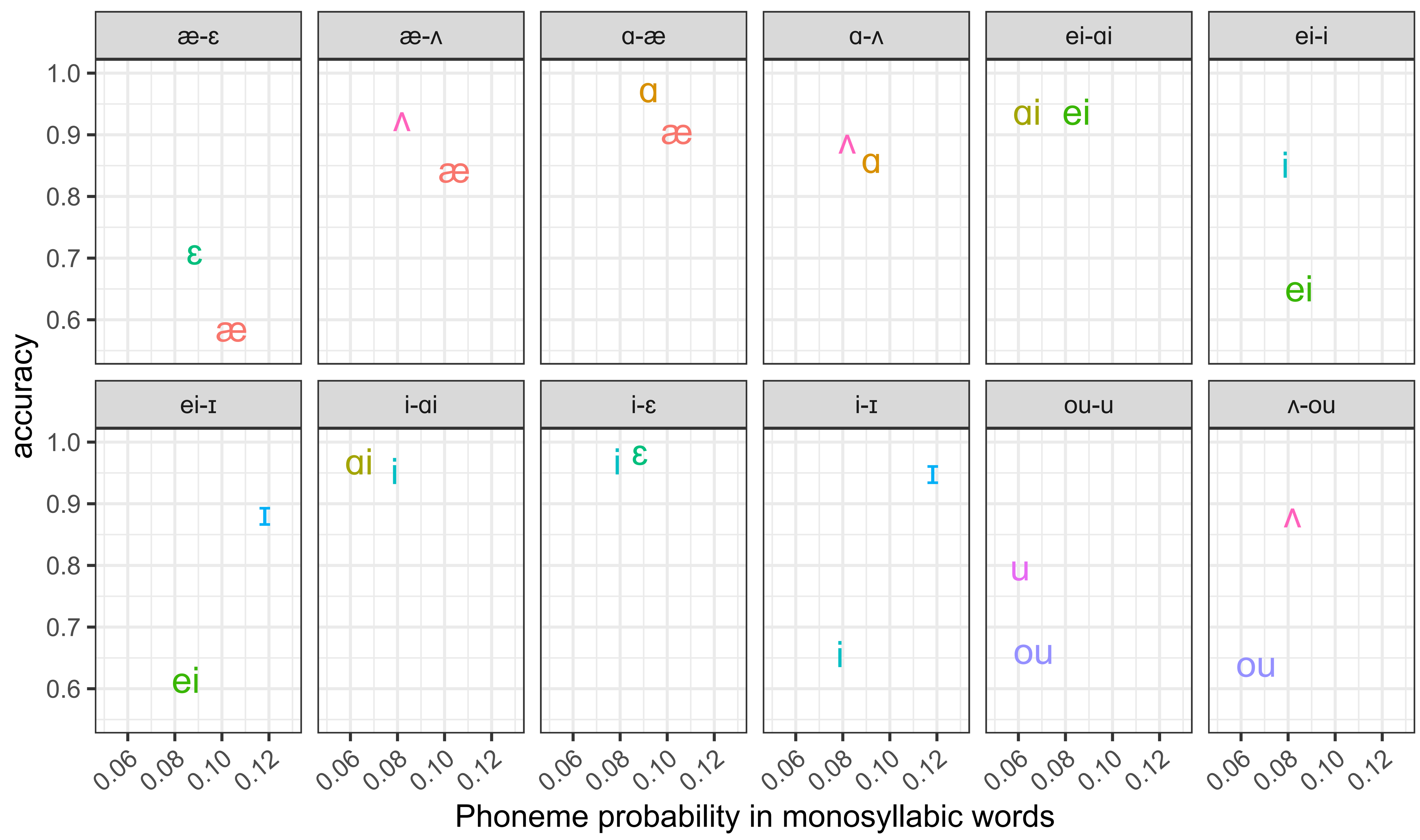

Figure 2: Accuracy by vowel pair, vowel and phoneme probability of that vowel.

Accuracy varied substantially based on vowel quality and by the vowels in the two response options. However, directional confusions were not strongly predicted by the relative probability of the vowels.

Conclusions

- Evidence for independent effects of lexical frequency, neighborhood density, and phonotactic probability, observable in a forced choice task
- What is the direction of causality in the relationship between acoustic confusability and phoneme frequency?
  - More common vowels might be selected as responses more often because they build up activation faster
  - Vowels which are more difficult to perceive are more prone to sound change, reducing their overall probability

Selected References

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