Weighing Phonetic Patterns in Non-Native English Speech

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Introduction

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2. **Accentedness Perception**

   Native (L1) listeners can detect foreign accent even in very short non-native (L2) speech samples

   30ms-long stimuli (Flege,1984), ERP N100 (Steinschneider et. al., 1999)

Research Questions

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2. Do some phonetic patterns contribute more to accent than others?
3. Why some phonetic patterns are more accented than others?

Theoretical and Practical Importance

The "So What?" question

1. The nature of foreign accent and its relationship with L1 grammar

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2. Help English teachers/learners

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1. The nature of foreign accent and its relationship with L1 grammar
2. Help English teachers/learners
3. Help design improved speech analysis algorithm

Background: Phonetic Patterns in L2 Speech

- Consonant errors affect accentedness
  VOT, Liquids

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  Duration, Formants, Vowel space

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- What about syllables?
  Segment Insertion, Segment Deletion

  (Magen, 1998; Van Den Doel, 2006)

Background: the Ranking of Errors

Magen (1998):speaker 1

Epenthetic schwa, -ed ending, **tense-lax**, final/s/, tʃ to ʃ, lexical and phrasal stress

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Background: the Ranking of Errors

Van Den Doel (2006): 222 American Listeners

Lexical Stress, Uvular-r >>

Voicing, Epenthesis in /lm/, /w/ to /v/, /æ/ to /e/ >>

Coda weakening in ”off” and ”that” >>

VOT shortening on /t^h/,/ʌ/ to /ɑ/,intonation >>

yod-insertion in ”news”

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- Phonological Environment was not well controlled

Background II: General Observations

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- Some phonetic patterns are more accented than others
- But Why?

Background: Rationale

1. Occurrences in L1 Speech
   L1 dialectal variations vs. non-dialectal variations
   ”ask”/æsk/ vs. /æks/ ; ”five”/faɪv/ vs. /fa:v/

2. Perceptual Categorizability

   The perception of consonants, especially obstruent consonants, is relatively more categorical while the perception of vowels is relatively more continuous.
   (Altmann et al., 2014; Kronrod et al., 2012)

3. Lexical Identification

   Consonants are more important than vowels in lexical identification (Nespor et al., 2003)

Background: Rationale

- Occurrences in L1 Speech

Word	Pronunciations	Frequency
thick	[θɪk]	91%
	[θɪkˈ]	5%
	[θik]	2%
	[t̪ɪk]	2%

Table 1: L1 Pronunciations for “thick” (SAA)

Background: Rationale

- Vowels are relatively less categorizable

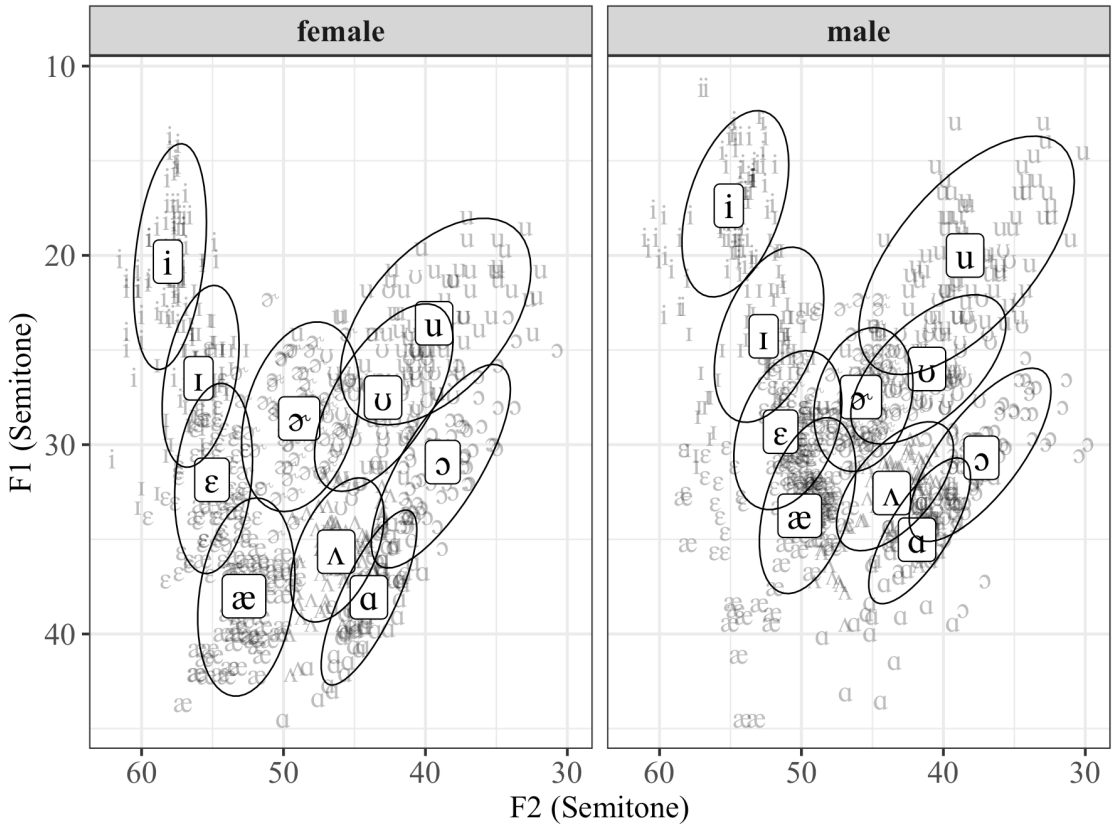

Figure 1: L1 Vowel Space (Peterson & Barney, 1952)

Background: Rationale

- Lexical Identification

Pronunciation	Consonant Change	Vowel Change
/ˈɜɹmi/	early	army
/ˈɛltəmət/	estimate	ultimate
/dɪ ˈzɔɹt/	resort	dessert
/ˈkʰibrə/	zebra	cobra

Table 2: Word Reconstruction Test (van Ooijen, 1996)

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1. Participants preferred **Vowel Change** (van Ooijen, 1996)
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2. Vowel changes are less accented?

Background: Summary

1. L1 speech exhibits variations (Dialectal and Contextual)
   (e.g., coda-deletion, /θ/ -> /t/, /faɪv/ -> /fa:v/)
   -> Are they less accented?

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1. L1 speech exhibits variations (Dialectal and Contextual)
   (e.g., coda-deletion, /θ/ -> /t/, /faɪv/ -> /fa:v/)
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3. Consonants are more important in lexical identification.
   -> Consonant changes could be more accented

Experiment 1: Tasks

1. Design a perception study to obtain accentedness ratings;
2. Rank the phonetic patterns by accentedness;

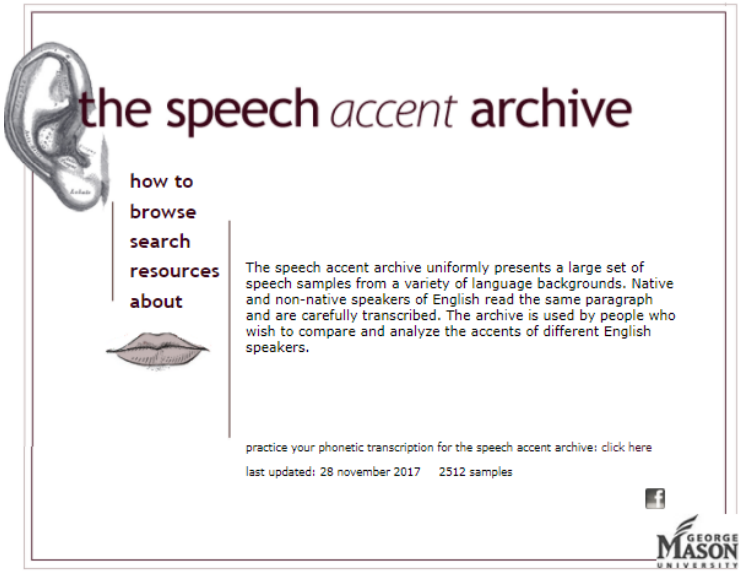
Experiment 1: Stimuli Design

Stimuli:

- One potential “error” per stimulus
- A larger variety of potential “errors”
- No prosody manipulation

Experiment 1: Corpus

Stimuli collection:
Natural speech samples from the Speech Accent Achieve (Weinberger, 2016)



accent.gmu.edu

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- **References:** The most common L1 productions (e.g., [θɪk] for “thick”)

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Stimuli Classification:

- **References:** The most common L1 productions (e.g., [θɪk] for “thick”)
- **Match**: L2 Stimuli that **match** the L1 productions (i.e., [θɪk])
- **Mismatch**: differ from the **Match** stimuli by **only one** element
  1. Consonant Mismatch (e.g., [tɪk])
  2. Vowel Mismatch (e.g., [θik])
  3. Syllable Mismatch (e.g., [æskə])

Experiment 1: Stimuli Examples

Stimuli Illustration:

Table 3: Types of Stimuli

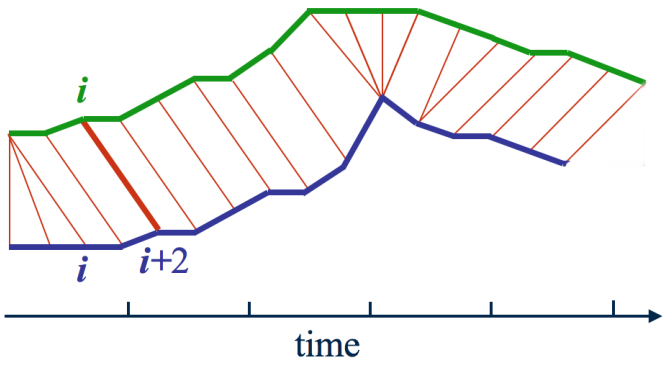
Contexts	Consonant Mismatch	Vowel Mismatch	Syllable Mismatch	Match
please call	[pliz kʰɑl]	[pʰliz kʰol]	[pʰəliz kʰɑl]	[pʰliz kʰɑl]
ask her	[æsk hər]	[ɑsk həɹ]	[æs_ həɹ]	[æsk (h)əɹ]
six spoons	[sɪks spunʃ]	[siks spunz]	[sɪks əspunz]	[sɪks spunz]
five thick	[faɪv tɪk]	[fav θɪk]	[faɪvə θɪk]	[faɪv θɪk]
small plastic	[smɑl̩ pʰlæstɪk]	[smɑl pʰlæstik]	[smɑl pʰlæs_ɪk]	[smɑl pʰlæstɪk]

Experiment 1: Prosody

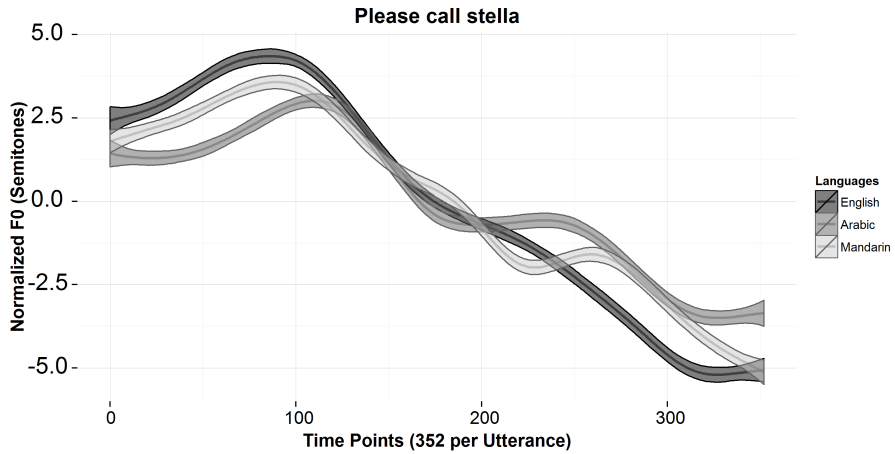
Control prosody in the least intrusive manner.
Prosody is a **CONTROLLING** variable.

Method: Dynamic Time Warping (DTW)

- No acoustic manipulation required
- Align F0 contours of two utterances
- Produce a DTW score which represents alignment cost
- The bigger the DTW score, bigger the intonational difference



(Tsiporkova, 2007)



(Morrill & Gao,2016)

Experiment 1: Procedure

- Platform: Amazon Mechanical Turk
- Requirements for participants: US IPs, at least 95% acceptance rate.
- Procedure:

Introduction

This experiment will ask you to listen to samples of sound snippets. You'll be asked to judge whether the snippets are foreign-accented. It will take about 15 minutes to complete and you will be paid $0.50 for your time. This experiment is part of a series of studies being conducted by Dr. Steven Weinberger at George Mason University. The elicitation of speech samples has been approved by the George Mason Institutional Review Board.

Clicking on the **agree** button below indicates that:

- you voluntarily agree to participate
- you are at least 18 years of age
- you are a native speaker of English
- you will use headphones/earbuds to listen to the sound files

If you do not agree to all of these, please close this window in your browser now.

This experiment requires you to listen to AUDIO. If your browser does not support audio, or you are not in a quiet place, please do not agree to participate in this HIT. Also, PLEASE DO NOT PARTICIPATE IN THIS HIT MORE THAN ONCE -- we cannot pay duplicate HITs!

Agree

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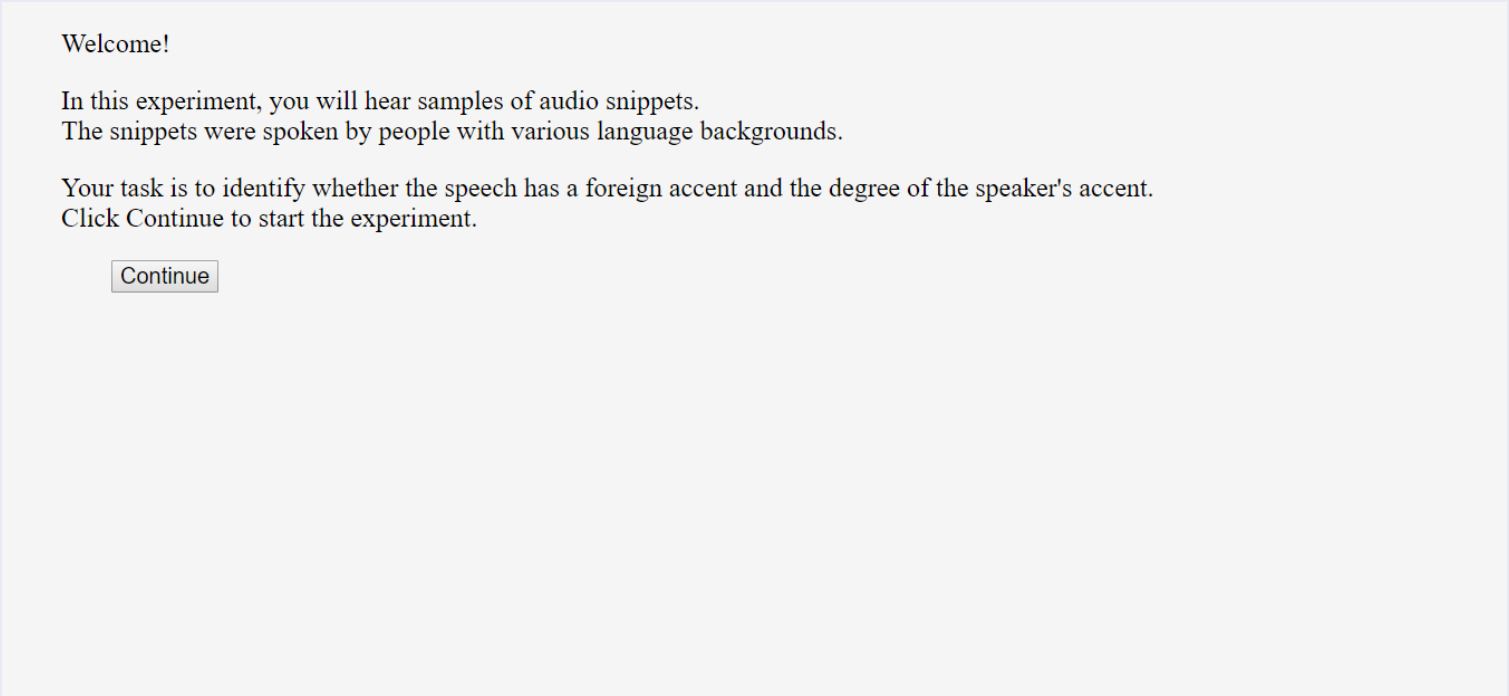
Instruction



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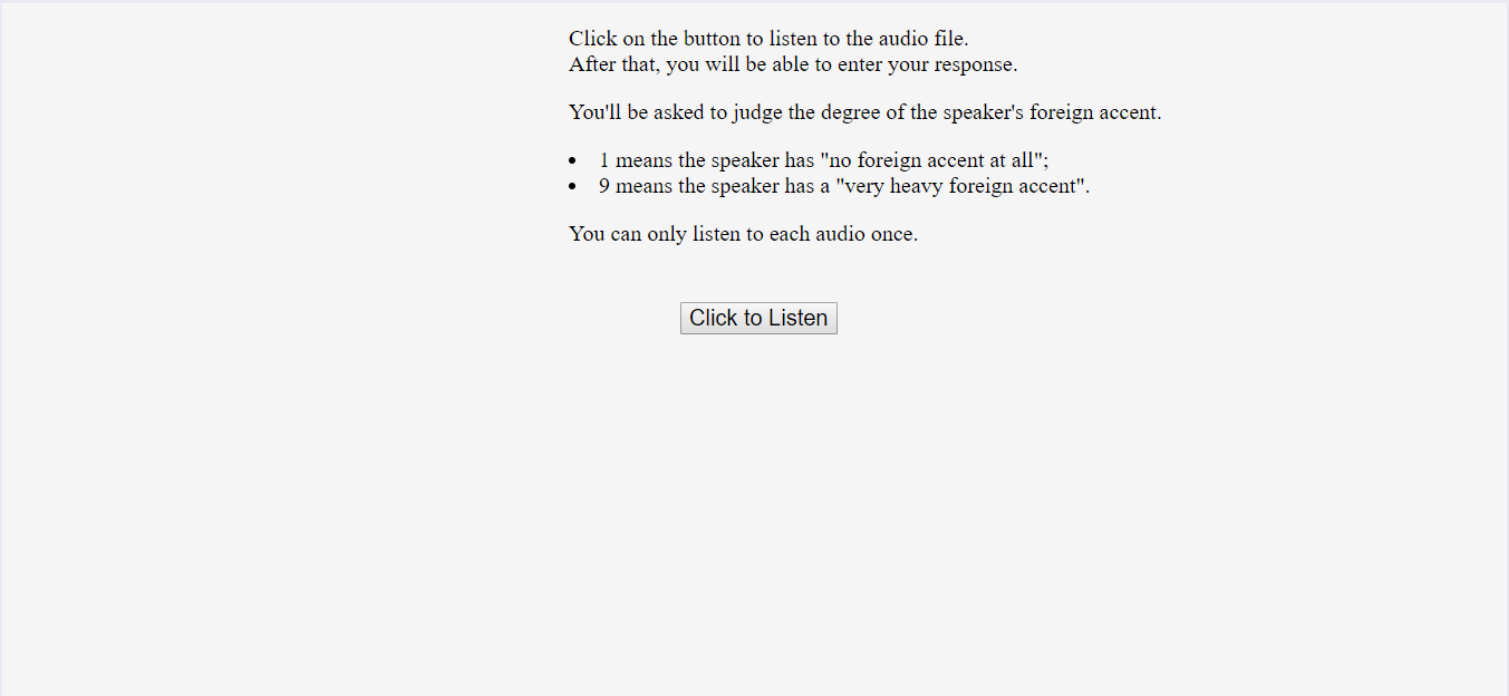
Trials:Listen to snippets (Block Randomization)



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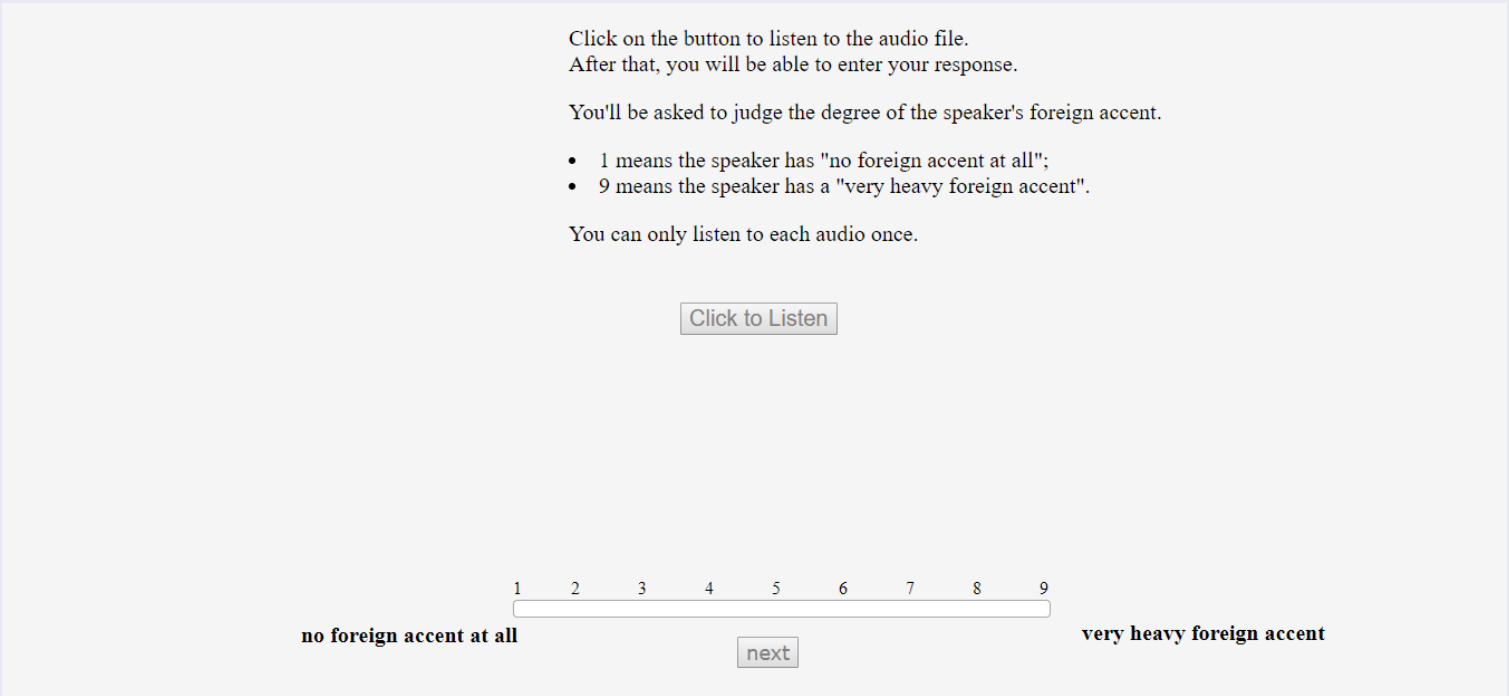
Trials:Make accentedness judgment



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Demographics

Please provide us with some information about you and how you did the experiment. We will keep this information private (it will not be associated with your worker id), and it will help us very much when we analyze the data.

Gender

female male

Age

Language background

List your native language

List any other languages you speak

Please tell us your occupation.

Please tell us your birth place (city/state/country).

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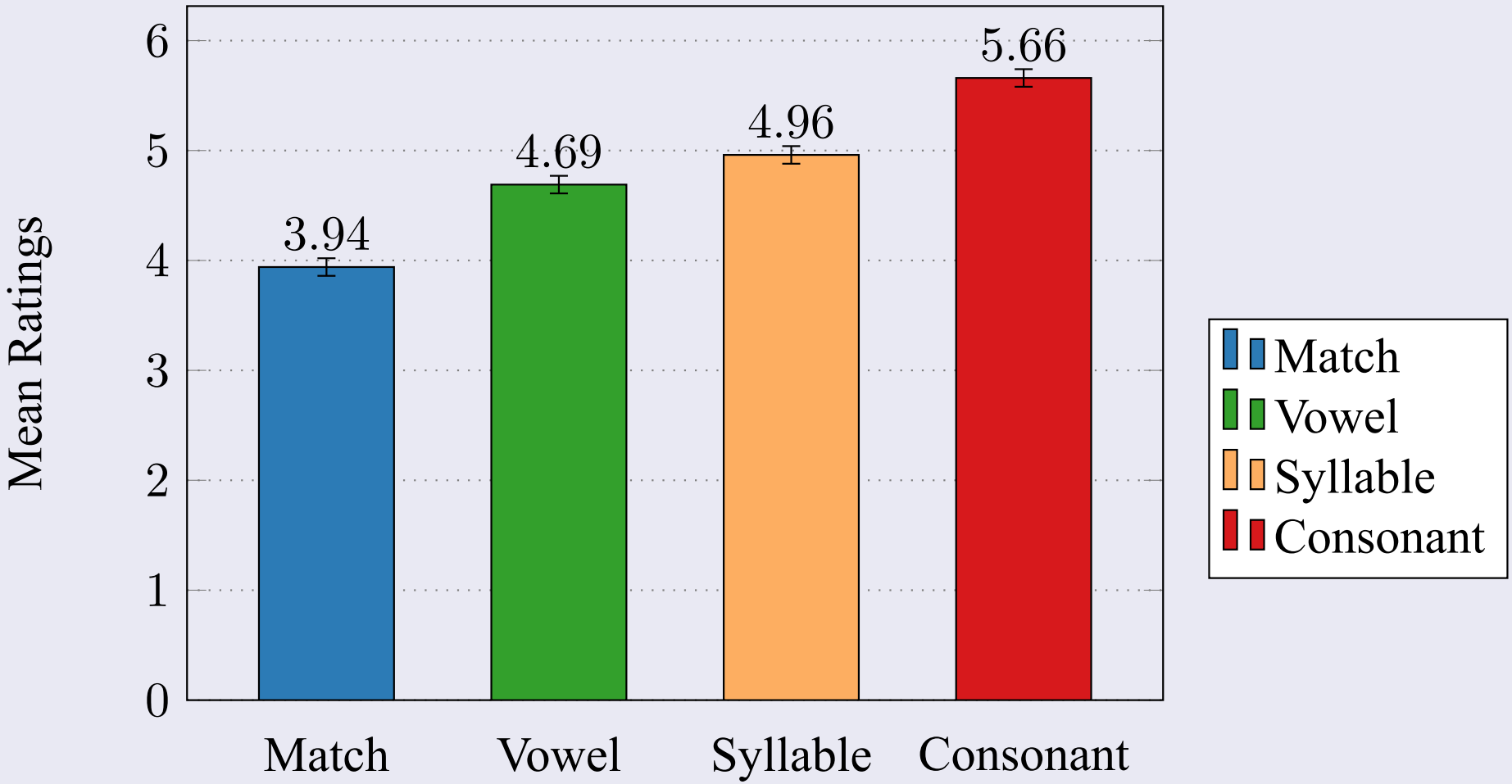
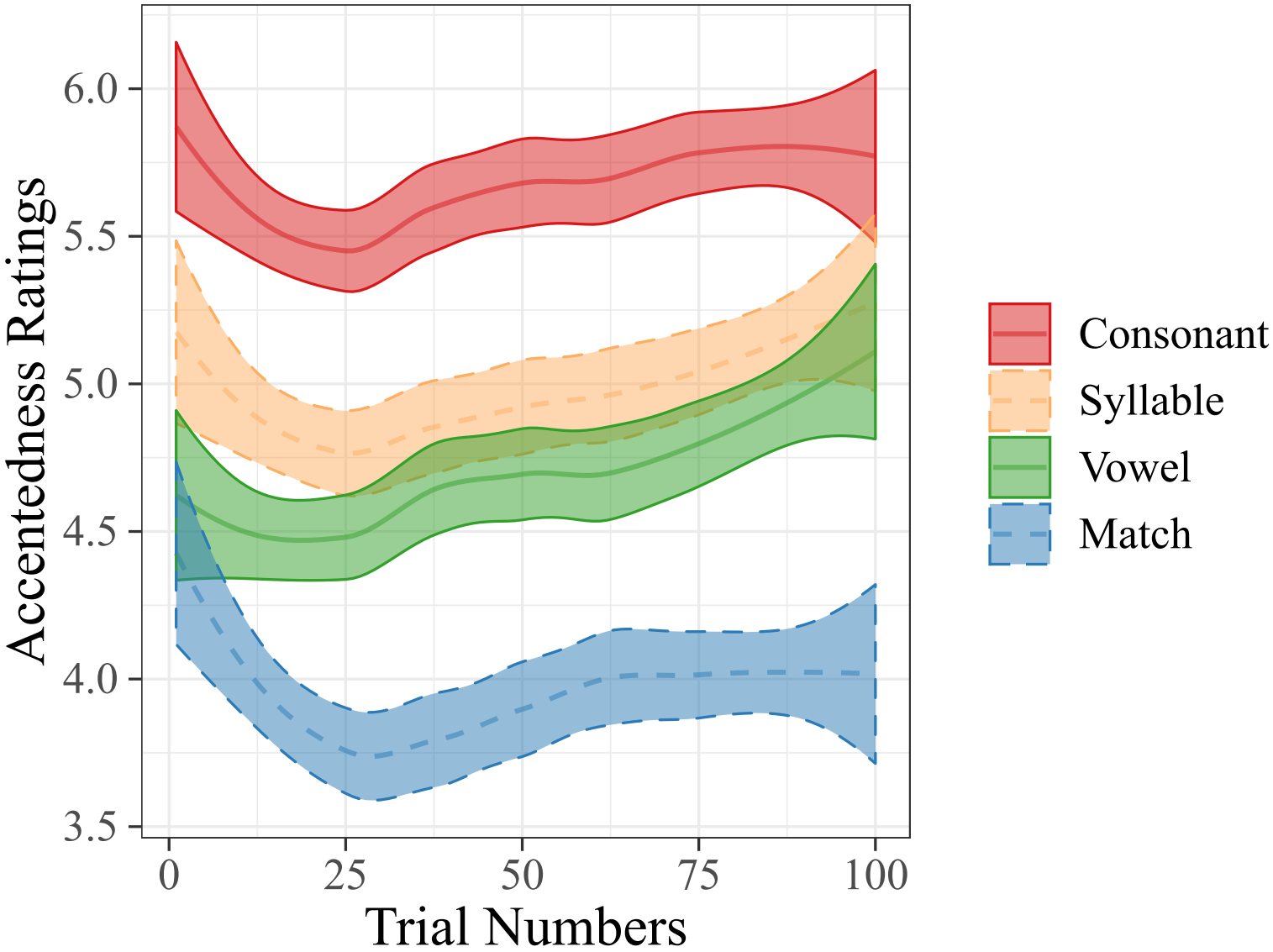
- Age: range 20-66 (M=33.50, SD=12.51)
- Completion Time: M=12.33 min, SD=3.2 min;
  Maximum time allowed:30 min

Experiment 1: Results

Meaning Ratings by Type



Experiment 1: Ratings across Time



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4. Ratings increased over time.

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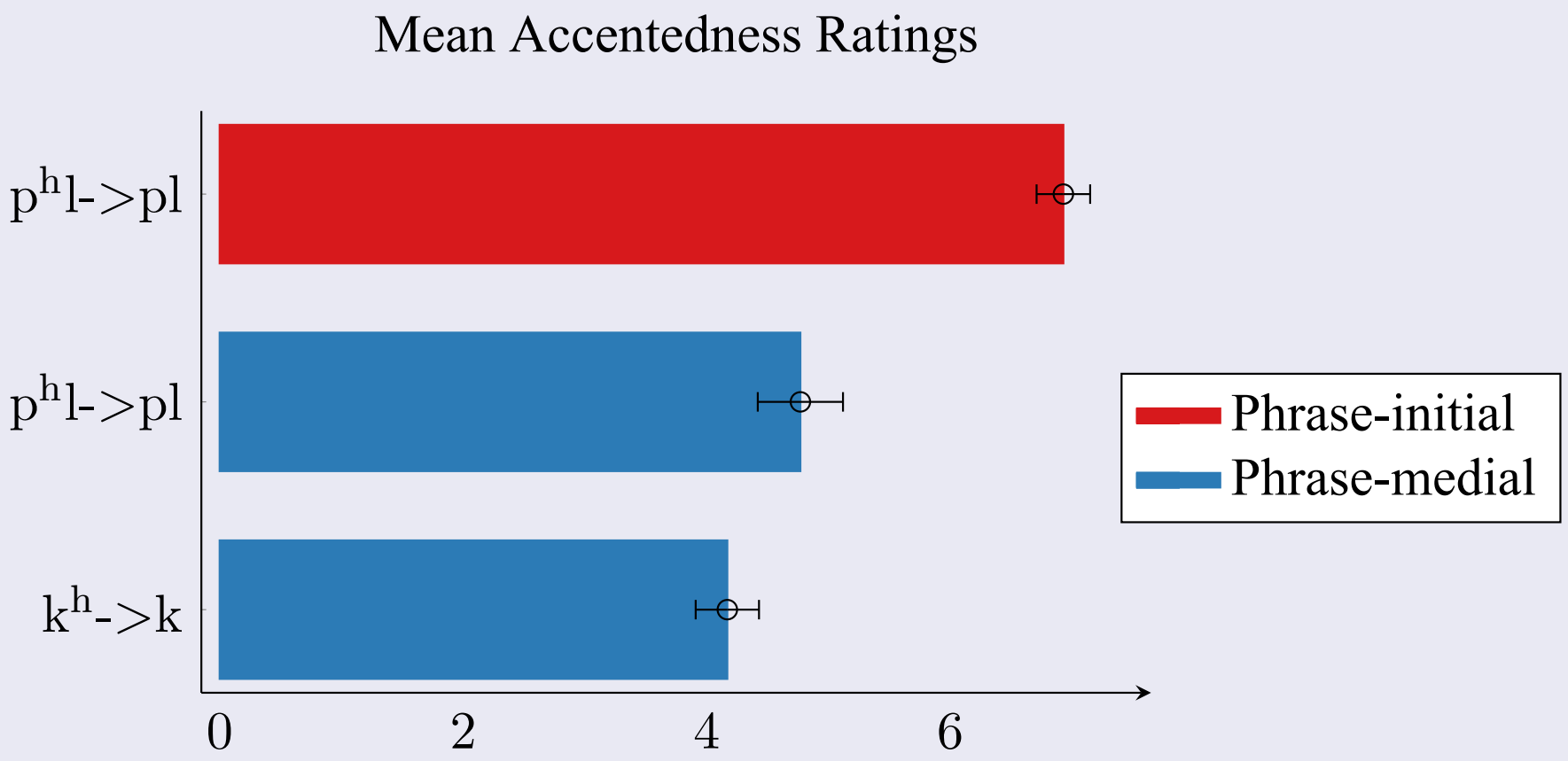
   (χ^2=46.80, p <.001)
5. DTW and the interactions between trial and type of stimuli did not contribute significantly to model fit.

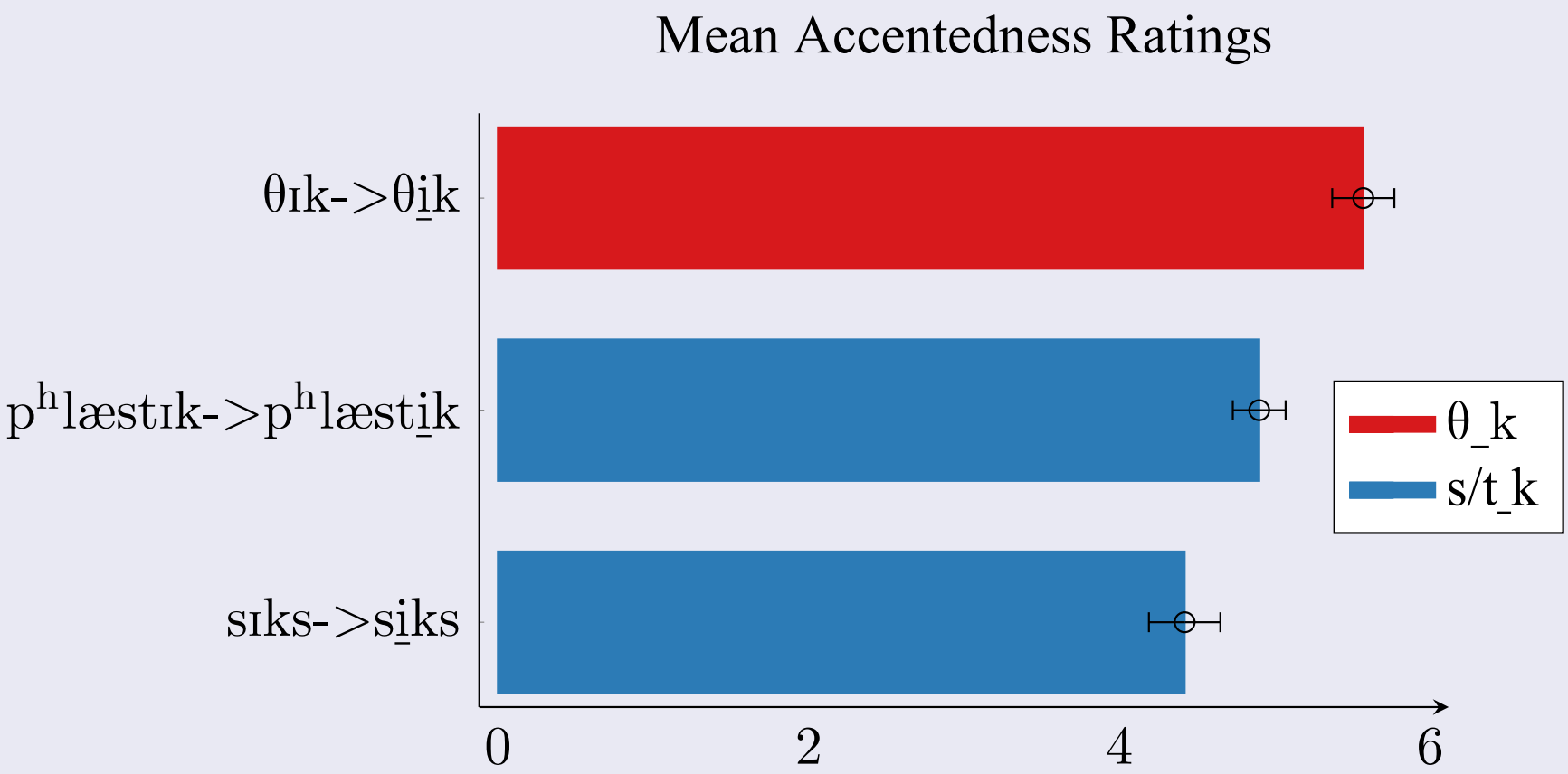
The current study IV: Phonological Environment

VOT Shortening



The current study IV: Phonological Environment

Vowel Raising



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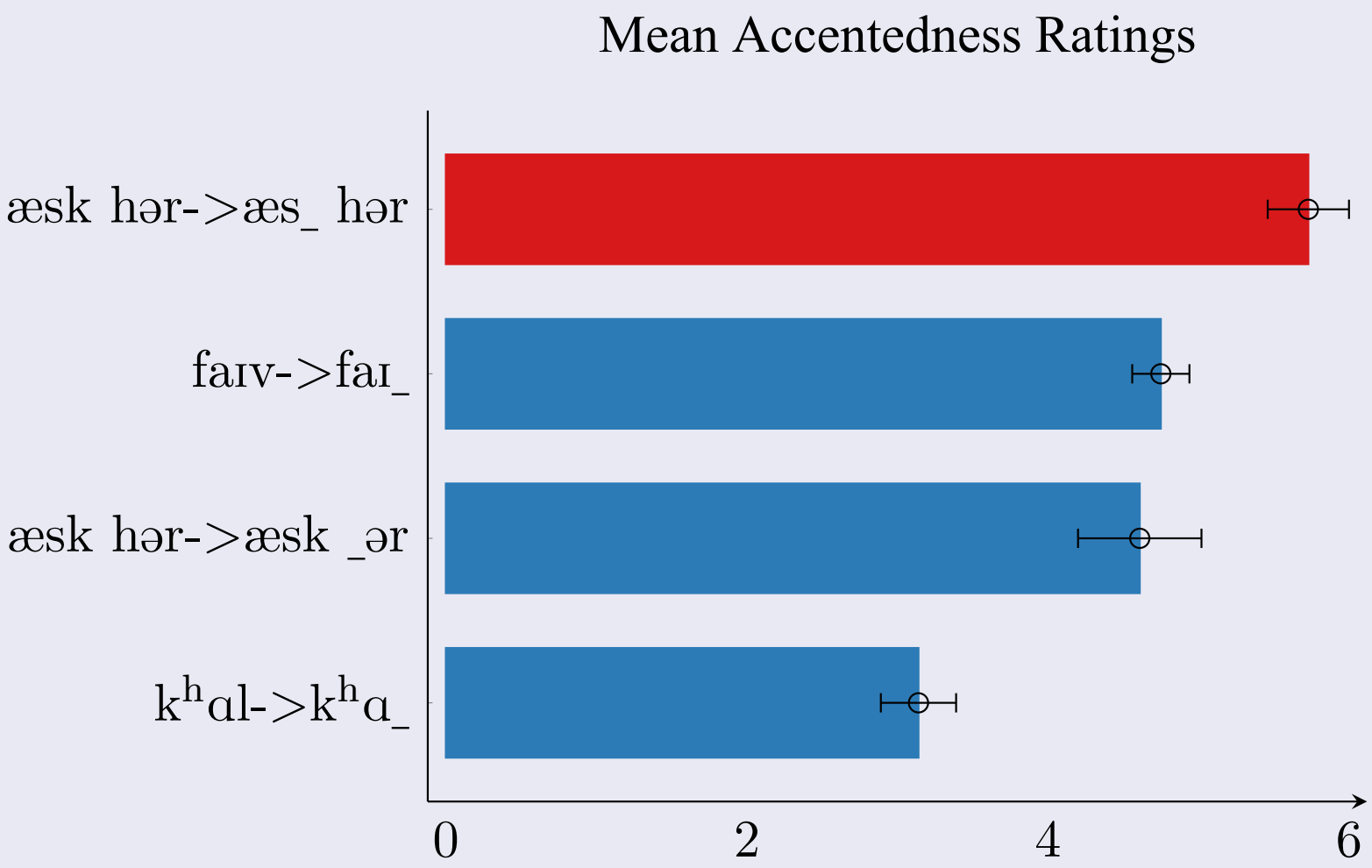
Consonant Deletion



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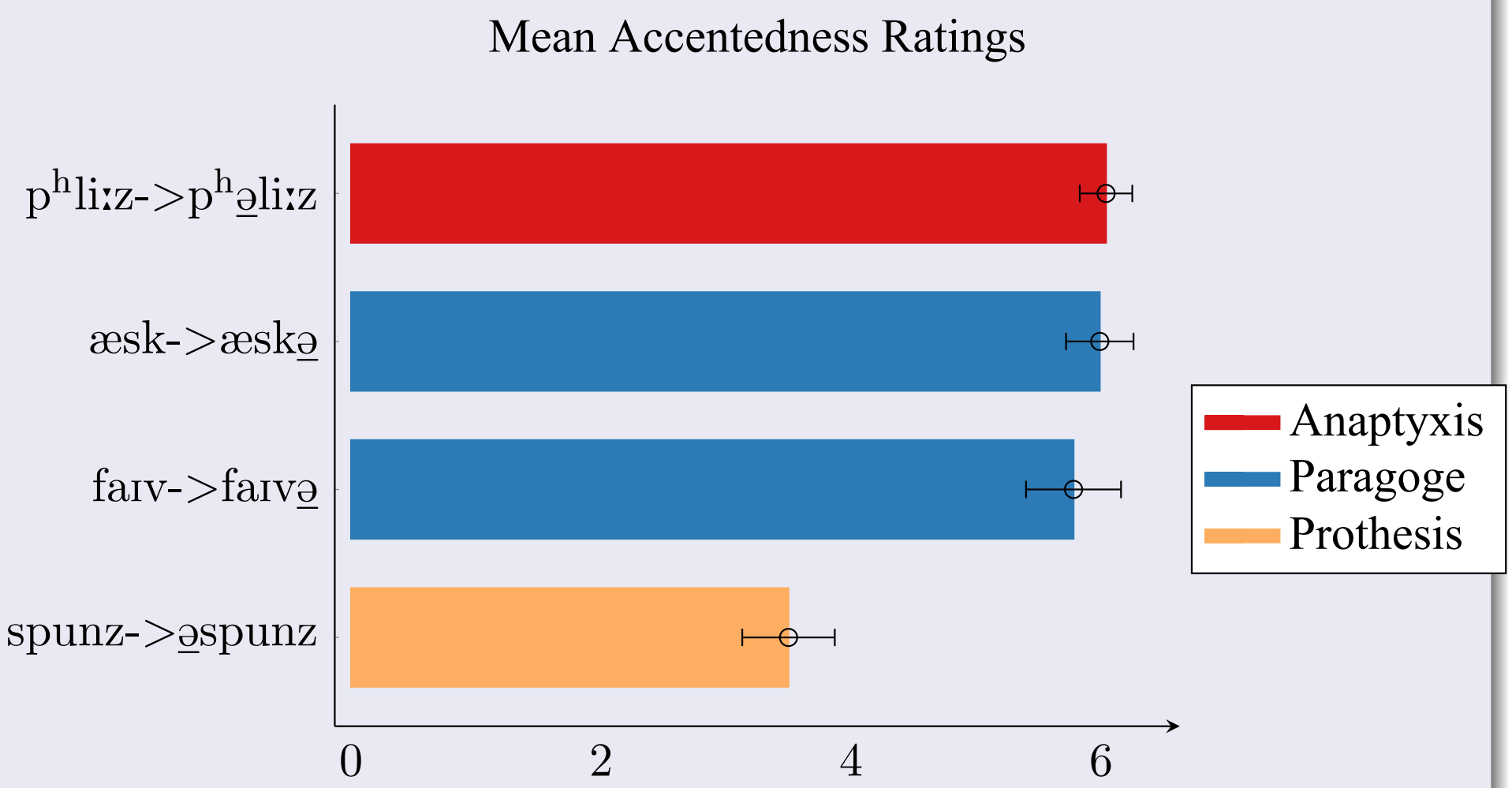
Vowel Epenthesis



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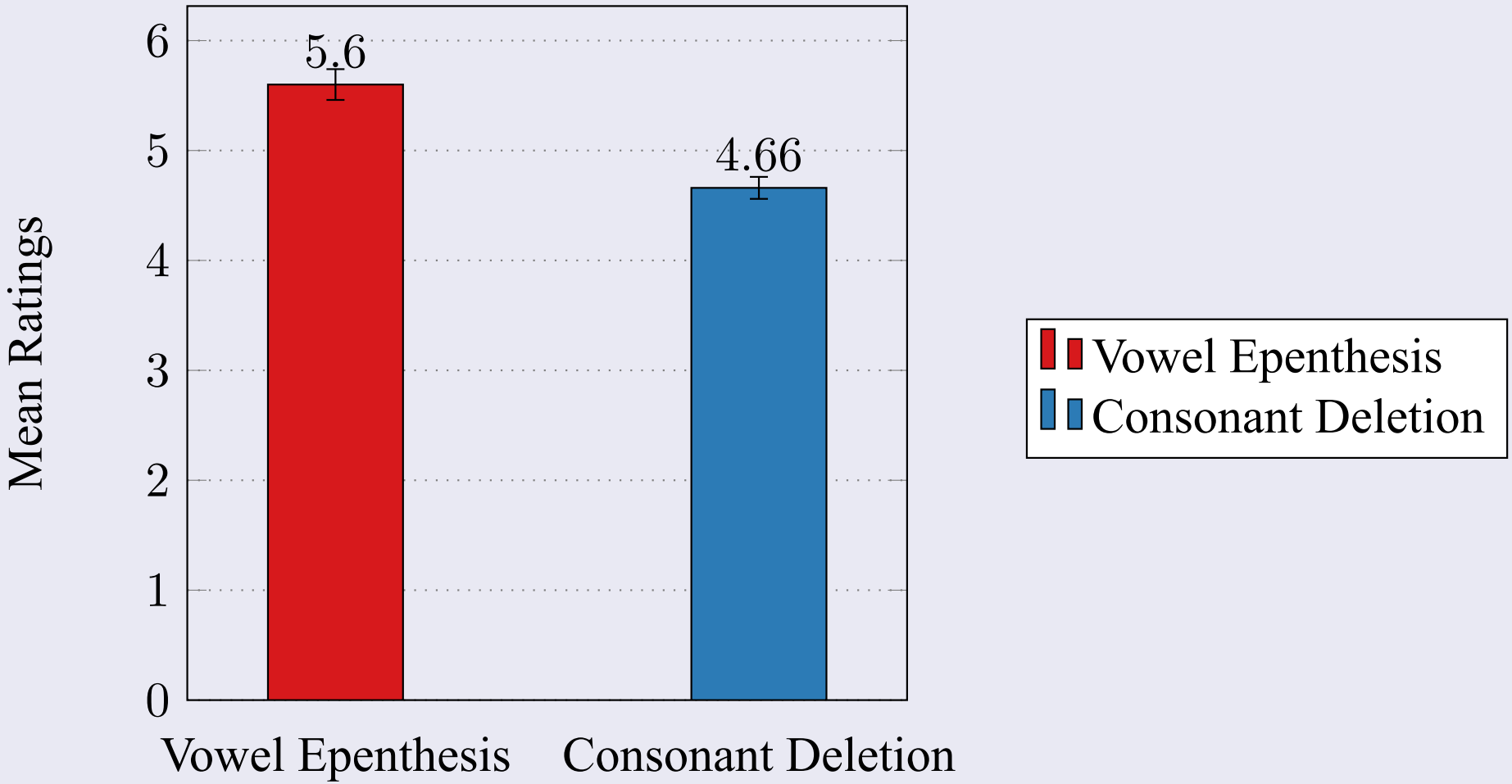
Epenthesis v.s. Deletion



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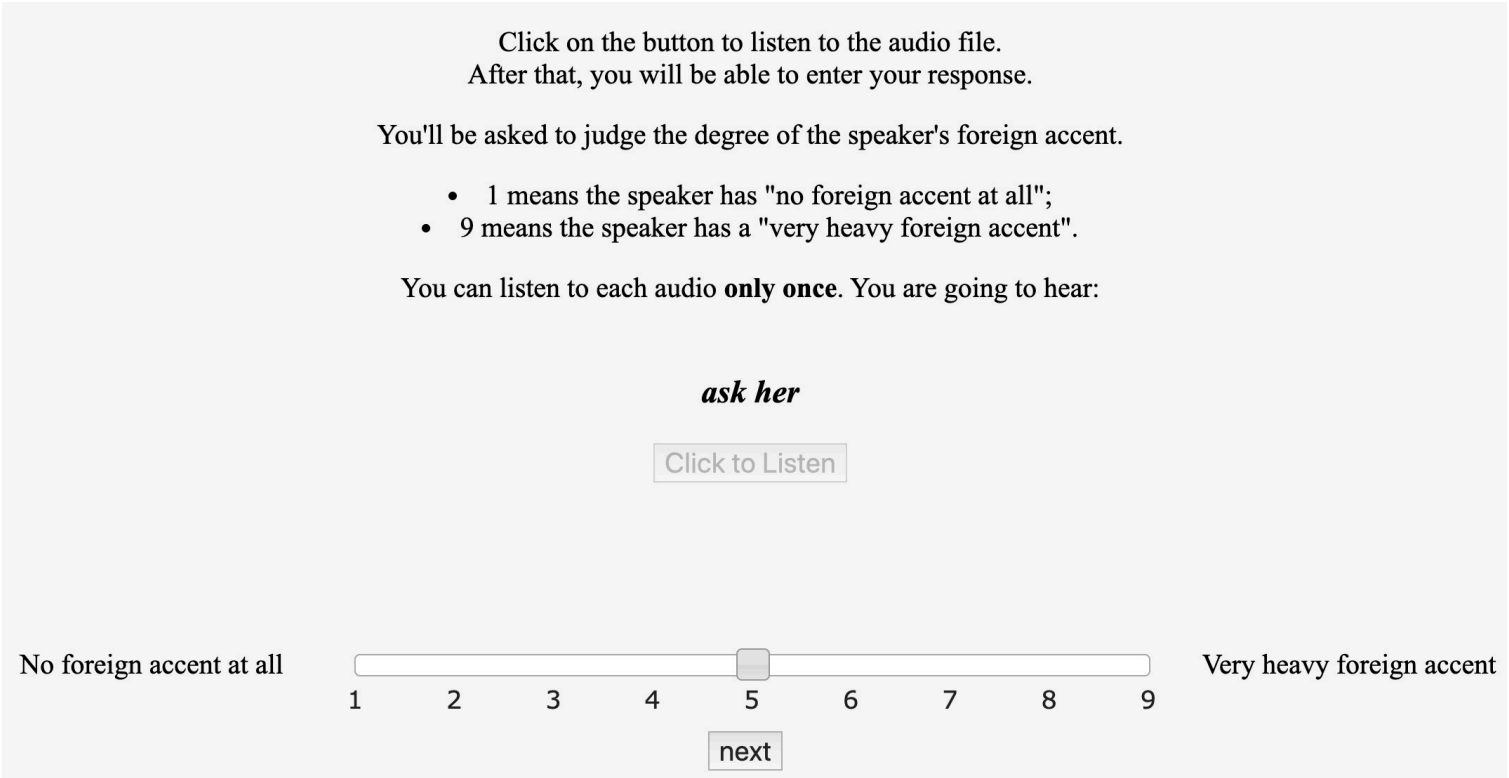
Experiment 2 II:Procedure



Experiment 2: Rater Demographics

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- 133 participants,
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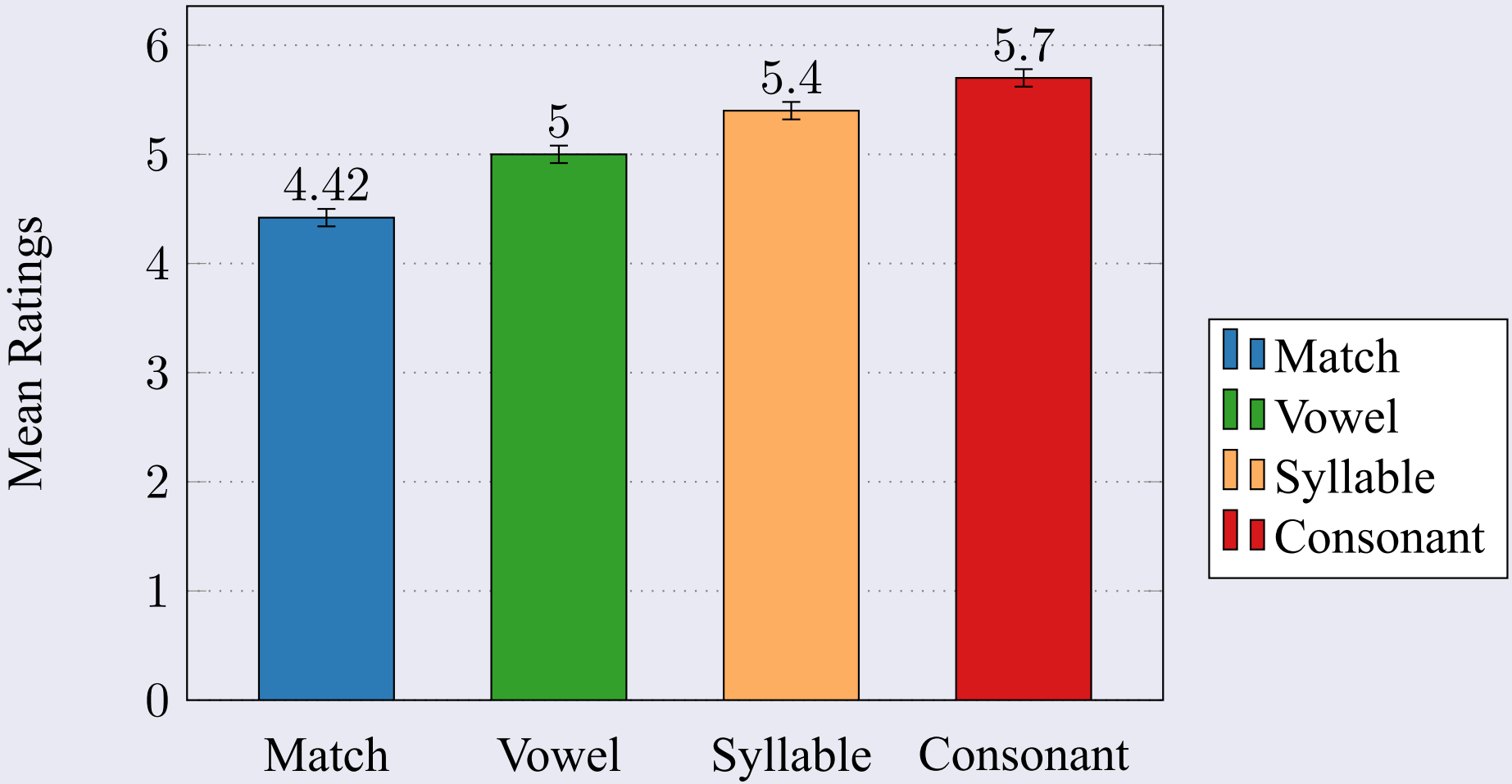
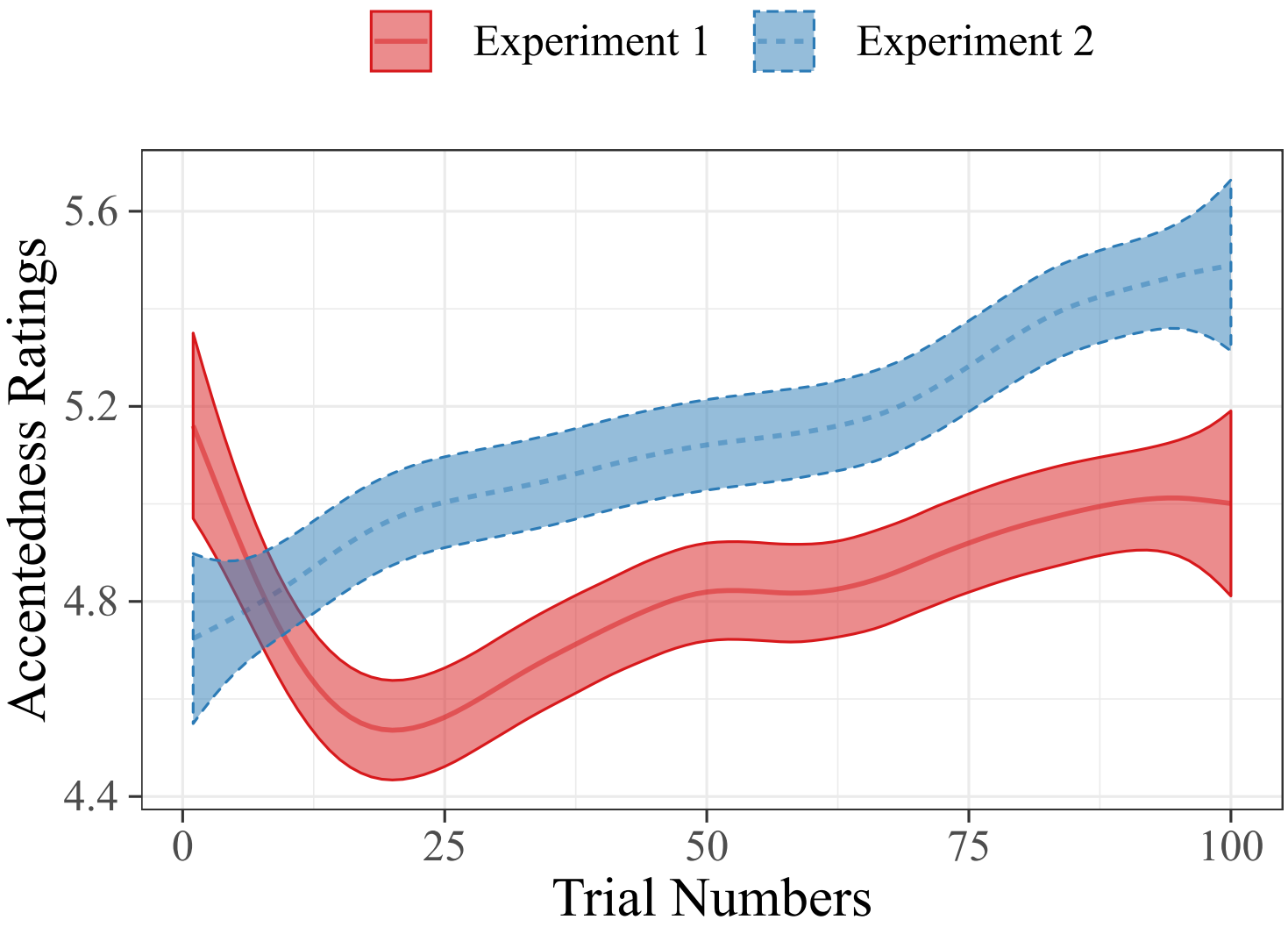
- Age: range 19-69 (M=38.42, SD=11.84)
- Completion Time: M=15.96 min, SD=5.47 min;
  Maximum time allowed:40 min

Experiment 2: Results

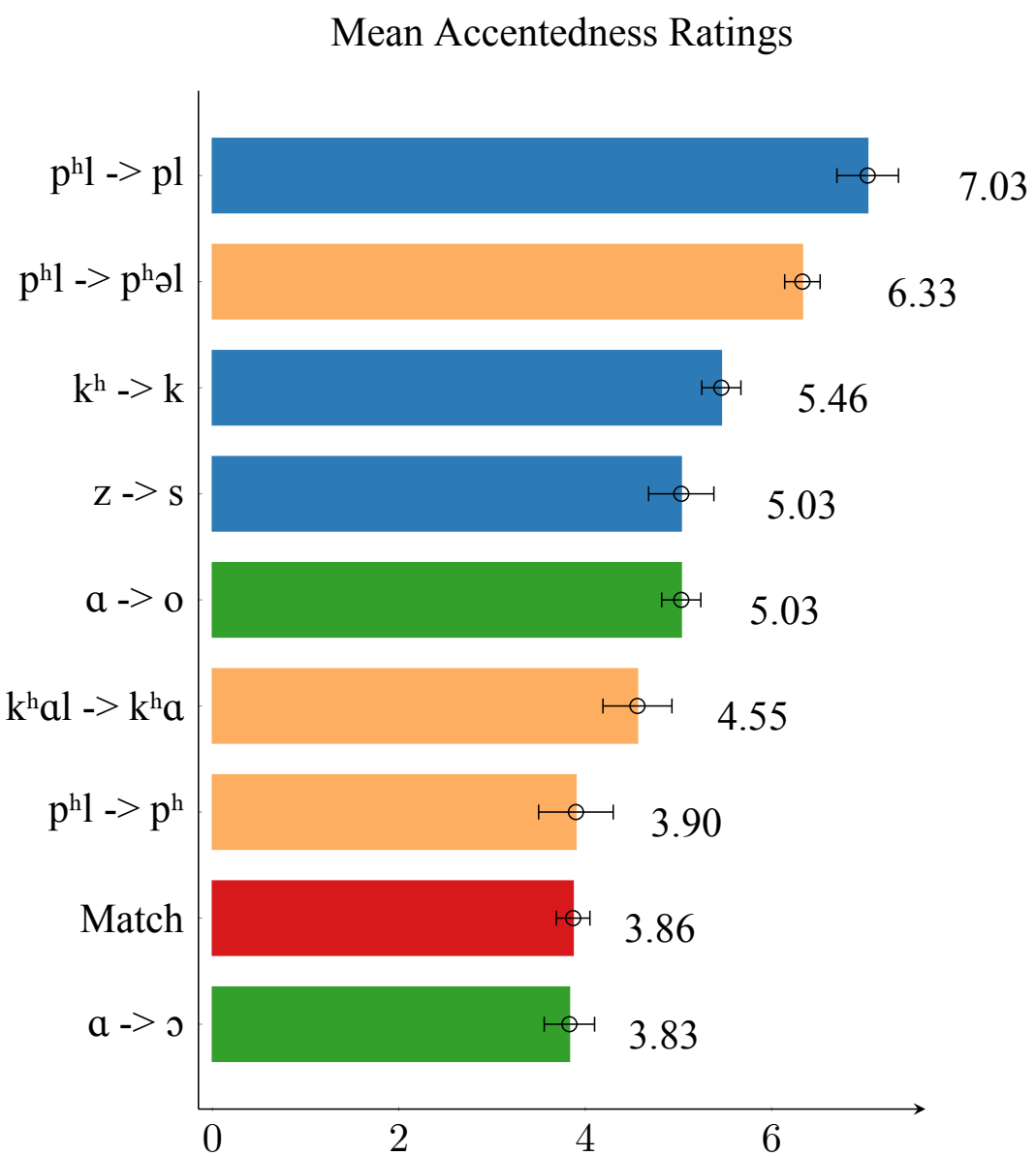
Meaning Ratings by Type



Experiment 2: Ratings across Time (SSANOVA)



Experiment 2: Rankings



Ranking 1:

pʰl -> pl; pʰl-> pʰəl

⇓

z -> s; ɑ -> o

⇓

ɑ -> ɔ; Match

Ranking 2:

pʰl -> pl

⇓

kʰ -> k

⇓

ɑ -> ɔ; Match;pʰl -> pʰ; kʰɑl -> kʰɑ

Ranking 3:

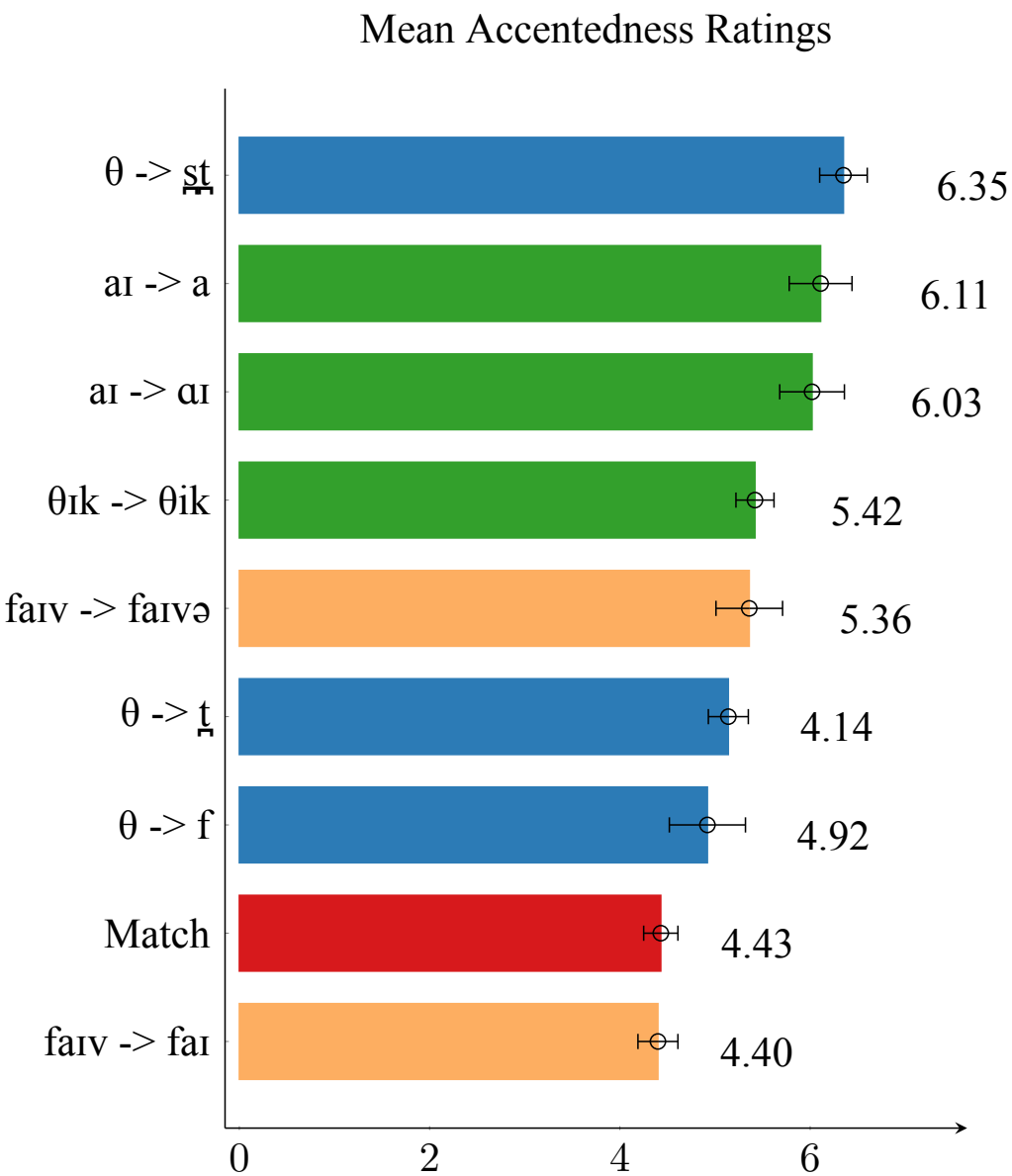
pʰl-> pʰəl; kʰ -> k

⇓

ɑ -> ɔ; Match; pʰl -> pʰ; kʰɑl -> kʰɑ

z -> s; ɑ -> o; kʰ -> k (No significant difference)

Experiment 2: Rankings



Ranking 1:

θ-> st
⇓
faɪv -> faɪvə; θɪk -> θik
⇓
faɪv -> faɪ; Match

Ranking 2:

θ-> st
⇓
faɪv -> faɪ; Match; θ -> f; θ -> t

Ranking 3:

aɪ -> ɑɪ; aɪ -> a
⇓
faɪv -> faɪ; Match; θ -> f

aɪ -> ɑɪ; aɪ -> a; faɪv -> faɪvə; θɪk -> θik (no significant difference)

Experiment 2: Summary

- **Frequency of Occurrences of a Mismatch in L1 speech**
  e.g., thik [tɪk] vs. [θɪk], call [k^hɑl] vs. [k^hɔl]

Experiment 2: Summary

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- **Implications:**
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- **Practical angle**
  Control for frequency of occurrences of a "Mismatch" in L1 speech

Experiment 3: Method

The Naïve Discriminative Learning Model

Rescorla-Wagner learning theory (1972): learners attempt to predict an outcome based on available cues.

Cue: Four-legged
Outcome: Puppy, Kitten, lion, etc.

Experiment 3: Method

The Naïve Discriminative Learning Model

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Table 4: The Top Six most likely L1 Pronunciations of "Five"

Outcome	Cues	Frequency
Five	faɪv	56
Five	faːv	14
Five	faɪv̞	11
Five	faɪf	6
Five	faːv̞	5
Five	fɑɪv	4

Experiment 3: Method

The Naïve Discriminative Learning Model

Data: Productions from 100 L1 American English Speakers
Cues: Trigram sequences
Outcomes: Words

Table 4: Association Strengths

Outcomes	Cues	Association Strengths
ask	#æs	0.166
ask	æsk	0.167
ask	sk#	0.667
her	#ə͡#	1.000
her	#hə͡	0.500
her	hə͡#	0.500

Experiment 3: Method

Table 5: Association Strengths

Outcomes	Cues	Association Strengths
ask	#æs	0.166
ask	æsk	0.167
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Pronunciation	Association Strength	NDL-distance
[æsk.ɚ]	$(0.166 + 0.167 + 0.667 + 1.000) \div 2 = 1.000$	$1 - 1.000 = 0.000$

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Pronunciation	Association Strength	NDL-distance
[ask.hɚ]	$(0 + 0 + 0.667 + 0.500 + 0.500) \div 2 = 0.834$	$1 - 0.834 = 0.166$

Experiment 3: The NDL model

Model was constructed using the *ndl* package in R (Arppe et al., 2018)

What are considered

- Trigram cues: English phonotactics & sound change

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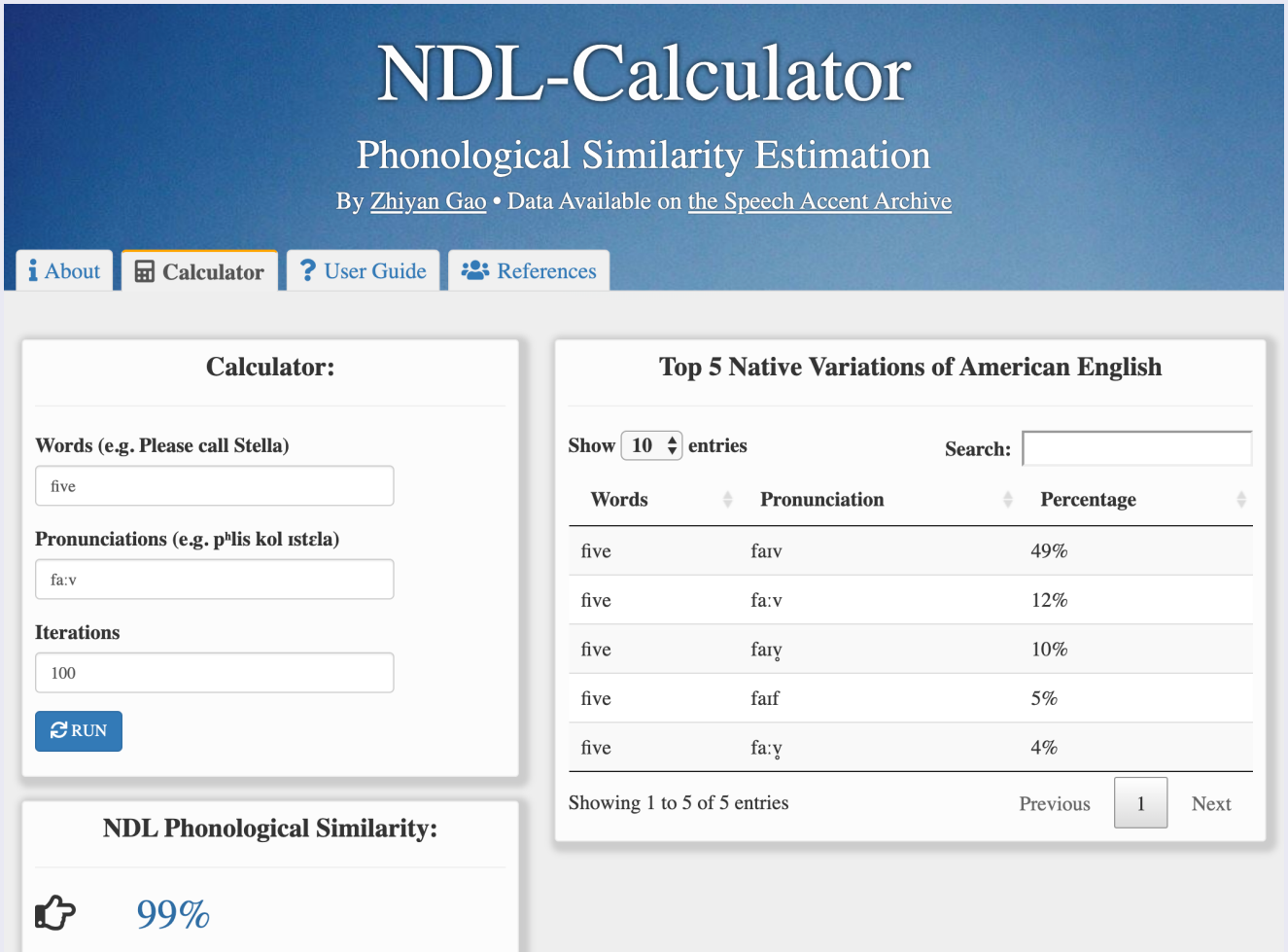
What are considered

- Trigram cues: English phonotactics & sound change
- Diacritic symbols: sub-phonemic information ("æ̭sk" vs. "æsk")
- Lexical outcomes: lexical information
- Frequency of a word in English
  e.g., how frequent "ask" occurs in L1 English (Google N-gram Corpus)

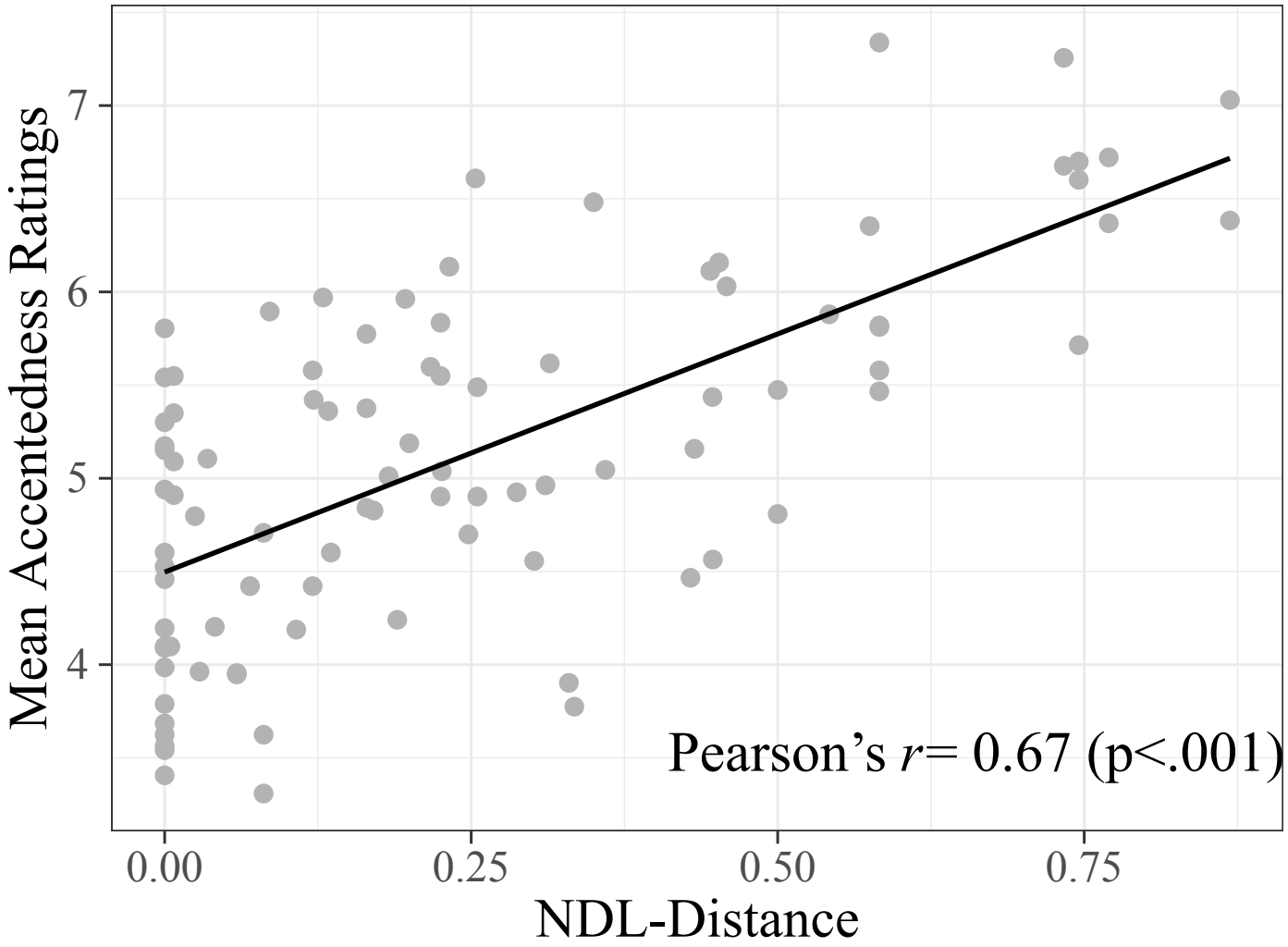
Experiment 3: The NDL model

Try out the NDL model at
`https://gaozhiyan.shinyapps.io/ndl_calculator/`

A Web Application



Experiment 3: Results



Experiment 3: Results

Linear Mixed-effects model:

- fixed effects: NDL-distance, Type of Stimuli (Contrast-coded), Trial Number, DTW scores
- Random effects: (Type of Stimuli) Raters, stimuli

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- fixed effects: NDL-distance, Type of Stimuli (Contrast-coded), Trial Number, DTW scores
- Random effects: (Type of Stimuli) Raters, stimuli

Results:

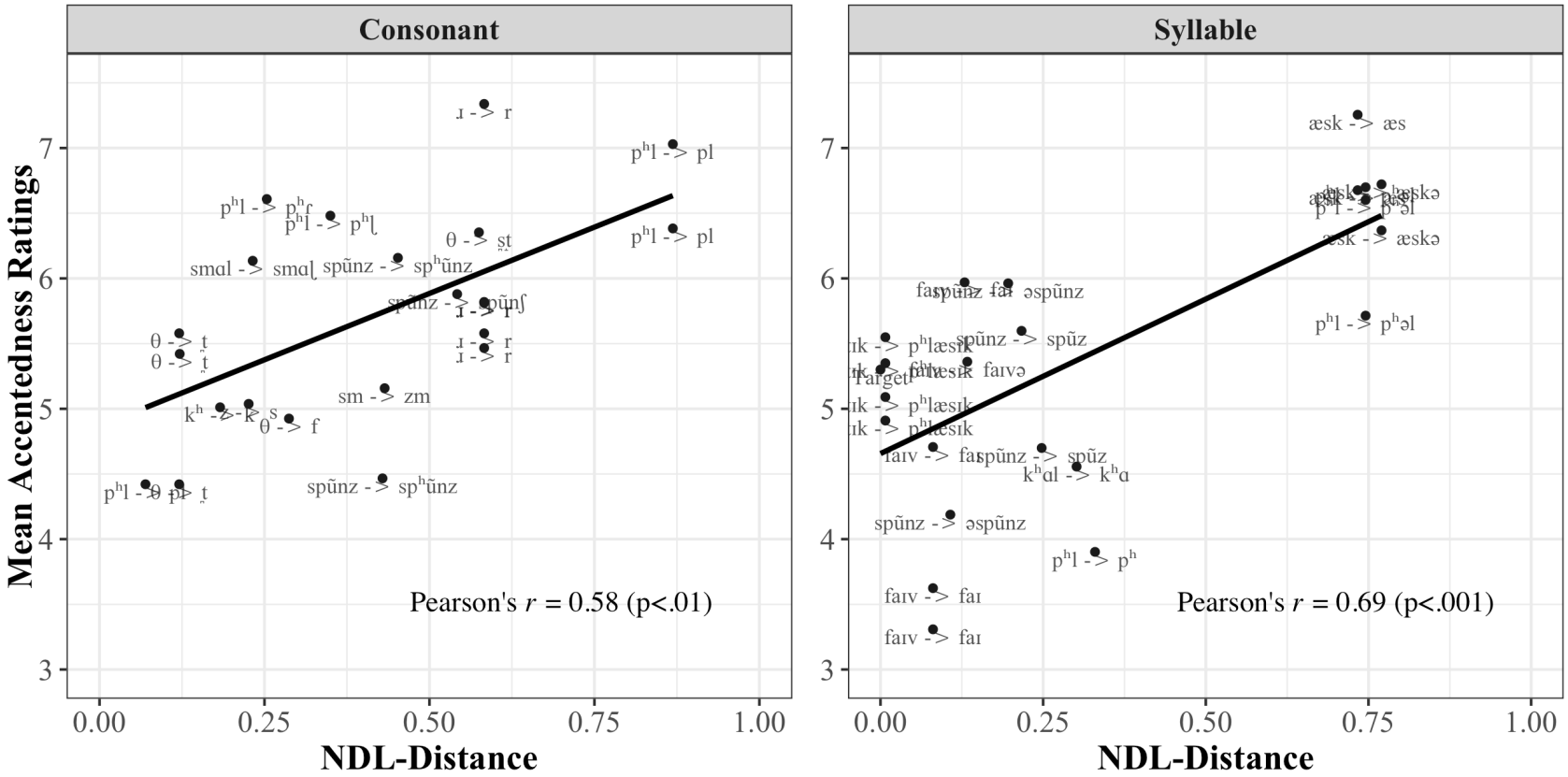
- NDL-distances significantly con- tributed to model fit ($\beta = 1.74$, $\chi 2 = 8.79$, $p<.01$)
- The three stimuli contrasts did not contribute significantly to model fit.
- Trial number contributed significantly to model fit ($\beta = 0.6$, $\chi 2 = 72.24$, $p<.001$),

Experiment 3: Interpretations

Interpretations:

- Consonant variations are not necessarily weighted more heavily than syllable or vowel variations.
- Rating differences between the 4 types of stimuli can be explained by NDL-distances.

Experiment 3: Consonants & Syllable

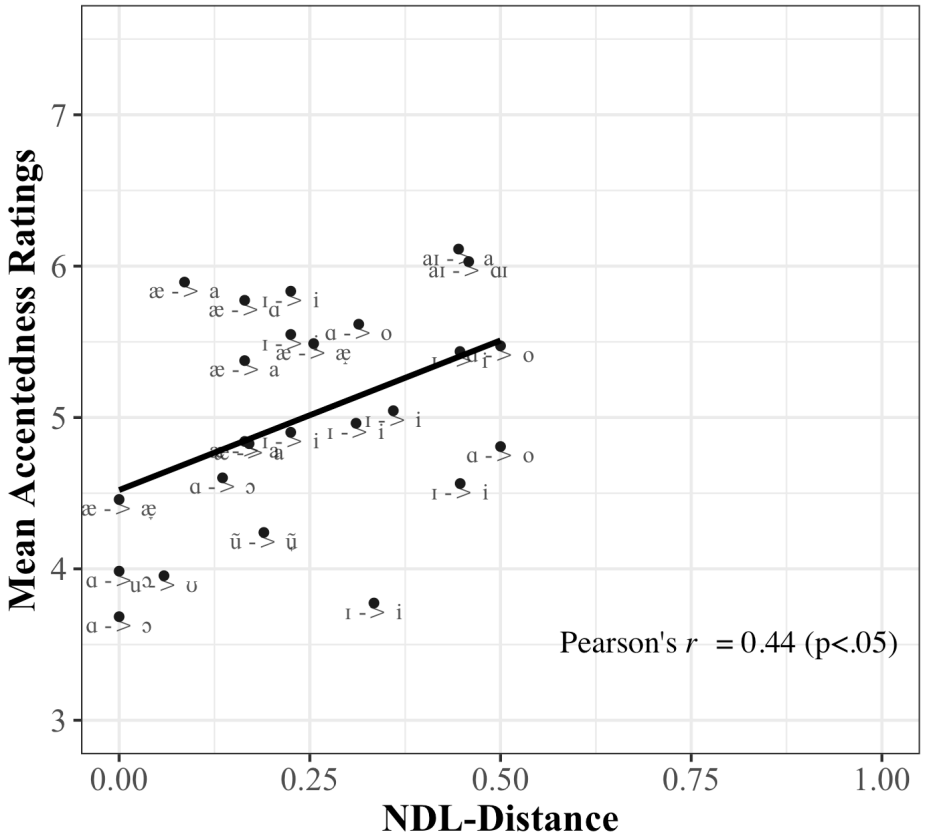


Observations:

Clear positive correlation.

Not that good for non-English sounds (e.g., retroflex [ɻ])

Experiment 3: Vowels



Observations:

Positive correlation.

Restricted Range

Experiment 3: Variability of Segments

Words	Pronunciations	Frequency
small	[smɑlˠ]	41%
small	[smɔl]	16%
small	[smɔlˠ]	14%
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Outcomes	Cues	Strengths
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small	mɑlˠ	0.094
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- Vowels are more variable in L1 speech than consonants
- Trigrams involving vowels have smaller association strengths

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Vowel changes affect association strength **less**;
Consonant changes affect association strength **more**
The effect of syllable changes depends on whether consonants are affected

Experiment 3: Summary

- Experiment 3 modeled raters' L1 phonetic and phonological knowledge of the 5 contexts.

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- The model achieved moderate success in approximating raters' accentedness judgments.
- Consonant changes are not necessarily more accented than syllable or vowel changes.

The Current Study: Conclusions

Experiment 1:

1. Consonant mismatches are more accented than syllable and vowel mismatches
2. Phonological contexts affect accentedness judgment
3. Intelligibility might have affected accentedness judgment

The Current Study: Conclusions

Experiment 2:
–> added a training phase, controlled for intelligibility

1. Consonant and syllable mismatches are more accented than vowel mismatches

2. Accentedness ratings are higher when the intended meanings are known

The Current Study: Conclusions

Experiment 3:
–> controlled for frequency of occurrences in L1 speech with NDL-distance

1. Rating differences can be explained by NDL-distance

2. Reasons for consonant mismatches to be more accented:

   Consonants in L1 speech are less variable than vowels

The Current Study: Limitations & Future Directions

Acoustic information:

1. Reliability of the IPA transcriptions
   (We measured benchmark acoustic signals, but that is not enough)

2. Effects of gradient acoustic information on accentedness
   (We conducted some analyses, results are not conclusive)

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Sociolinguistic issues

1. Raters' familiarity of certain L2 accents
2. Raters' own L1 dialects
3. other factors: age, gender, educational attainment, socioeconomic status, etc.

Final Remarks

This dissertation contributes to the field of foreign accent by providing accentedness rankings of various phonetic patterns in L2 speech.

In lieu of ad hoc explanations for why some phonetic patterns are more accented than others, this dissertation directly examines how raters' L1 knowledge affected their accentedness judgment on L2 speech, providing insights into the nature of foreign accent perception.

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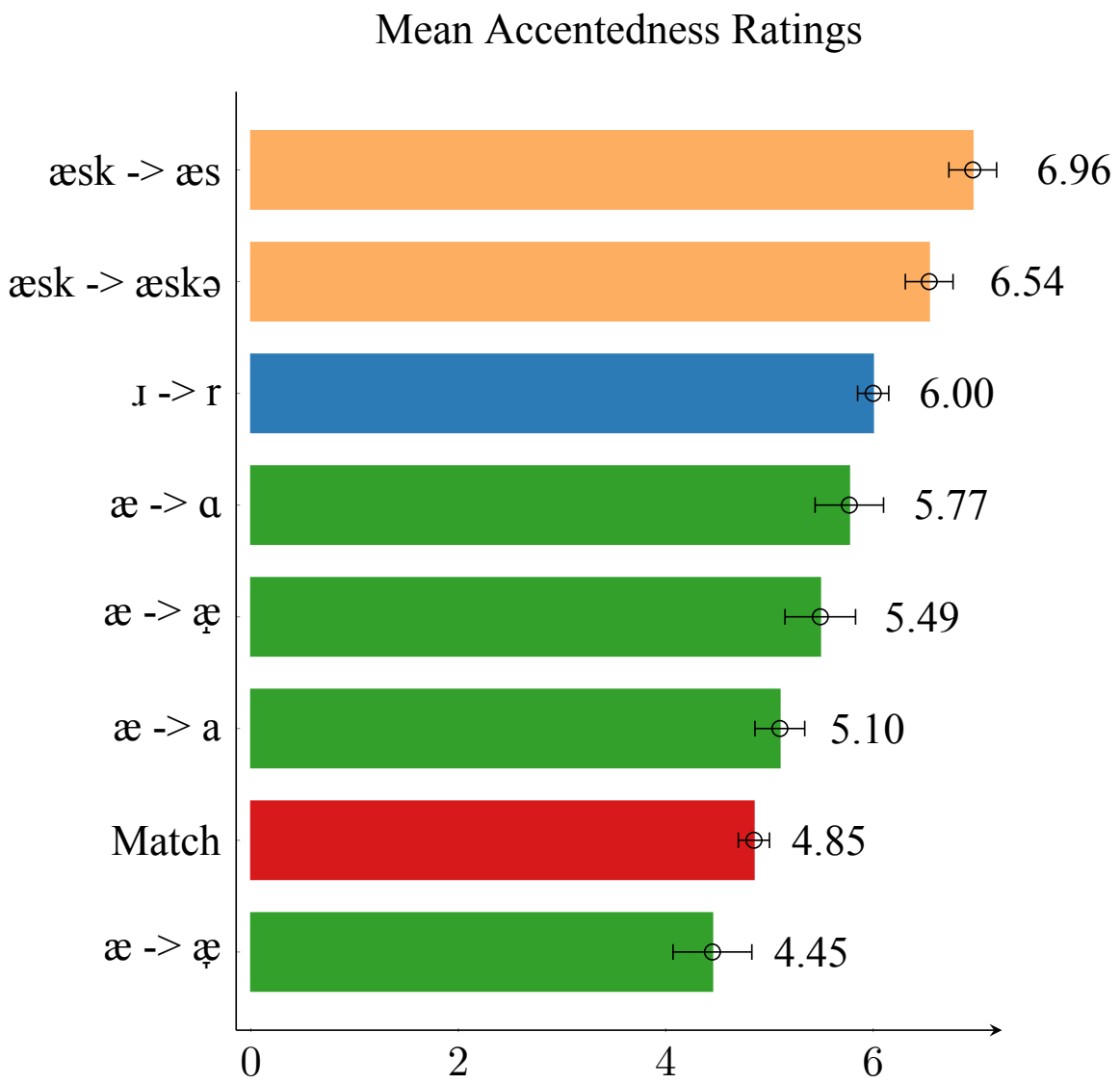
Thank You!

Supplemental Materials I: Ratings

ask her

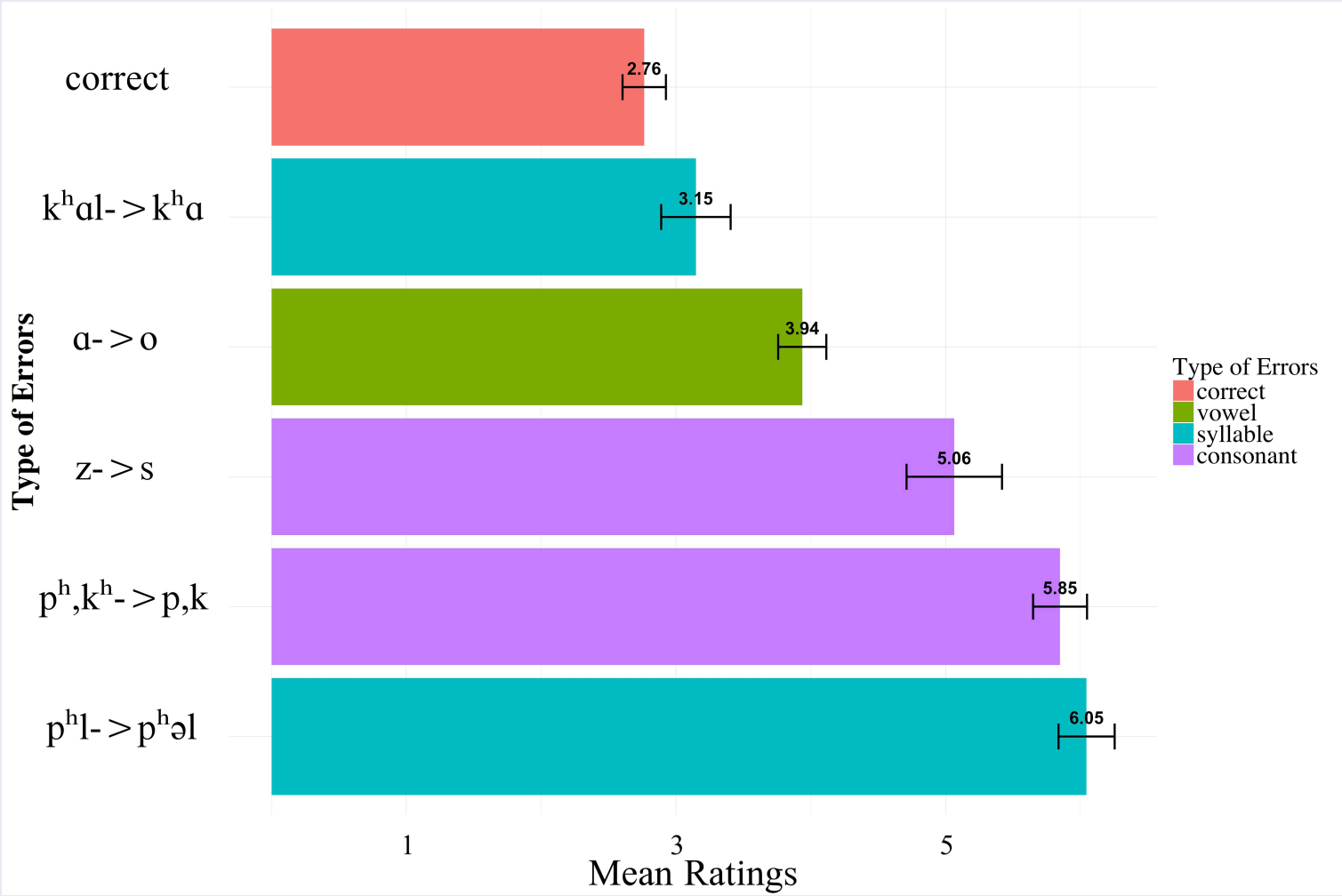


Supplemental Materials I: Ratings

six spoons

Supplemental Materials I: Ratings

please call



Supplemental Materials I: Ratings

small plastic