Weighing Phonetic Patterns in Non-Native English Speech

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Committee:

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Introduction

Everyone has an “accent”.

Non-native speakers have a ***“Foreign Accent”***.

We want to know:

- what makes a non-native speech foreign-accented.
- and Why

Introduction

1. **Foreign Accent**

   *The **perceivable** deviation of non-native speech from the native speech norm .*

   (Munro & Derwing, 1998, pp.66)

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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

We focus specifically on segmental and structural aspects of L2 speech.

We ask:

1. Do some phonetic/phonological patterns in L2 speech contribute more to **foreign accent** than others?

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We focus specifically on segmental and structural aspects of L2 speech.

We ask:

1. Do some phonetic/phonological patterns in L2 speech contribute more to **foreign accent** than others?
2. Why are some phonetic/phonological patterns 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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The “So What?” question

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

Background: Findings in Previous Research

- Consonant errors affect accentedness
  VOT, Liquids

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- Vowels are complicated
  Duration, Formants, Vowel space

  (Major, 1987;McCullough,2013;Chan, Hall, and Assgari,2016)

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- Vowels are complicated
  Duration, Formants, Vowel space

  (Major, 1987;McCullough,2013;Chan, Hall, and Assgari,2016)

- 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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Stop voicing,/s/ to /z/, vowel reduction

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Stop voicing,/s/ to /z/, vowel reduction, **tense-lax**

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 deletion in "off" and "that" >>

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

yod-insertion in "news"

Background: Limitations

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We are going to fix (avoid) these problems!

Background II: General Observations

Previous research has found that

- Some patterns are more accented than others.

  But Why?

Background: Rationale

3 potential reasons:

1. Occurrences in L1 Speech
   L1 dialectal variations vs. non-dialectal variations
   ”ask”/æsk/ vs. /æks/ vs. /æskə/; ”five”/faɪv/ vs. /faːv/ vs. /fav/

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

- Does **Frequency of Occurrences** of a pattern in L1 speech affect accentedness?

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

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

Background: Rationale

- Does the **Categorizability of Segments** affect accentedness?

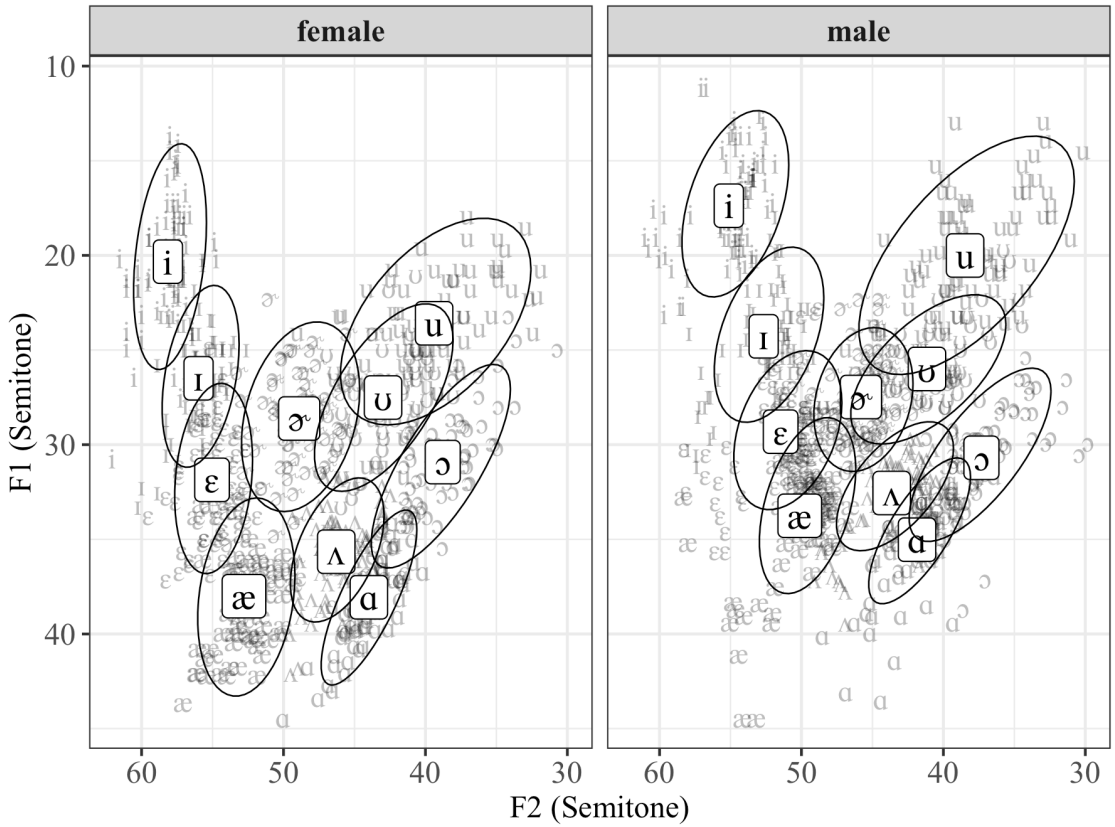

Figure 1: L1 Vowel Space (Peterson & Barney, 1952)

Background: Rationale

- Does **Lexical Identification** play a role?

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)

[ˈɜɹmi] –> Early or Army?

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1. **Vowel Changes** are preferred (van Ooijen, 1996)
   →Vowel changes are more tolerable ?
2. Vowel changes are less accented?

Background: Summary

1. L1 speech exhibits variations (Dialectal and Contextual)
   (e.g., coda-deletion, /θ/→/t/, /faɪv/→/faːv/)
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3. Consonants are more important in lexical identification.
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4. What about syllables?.
   -> Deletion is less accented than epenthesis?

Overview

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   a pilot study, collecting accentedness ratings on 100 L2 stimuli

2. Experiment 2:
   (1) added a training phase, controlled for intelligibility, (2) provided accentedness rankings, (3) hypothesized potential reasons for accentedness judgements

3. Experiment 3:
   (1) modelled L1 phonetic/phonological knowledge, (2) investigated potential reasons for accentedness judgments

Experiment 1: Tasks

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

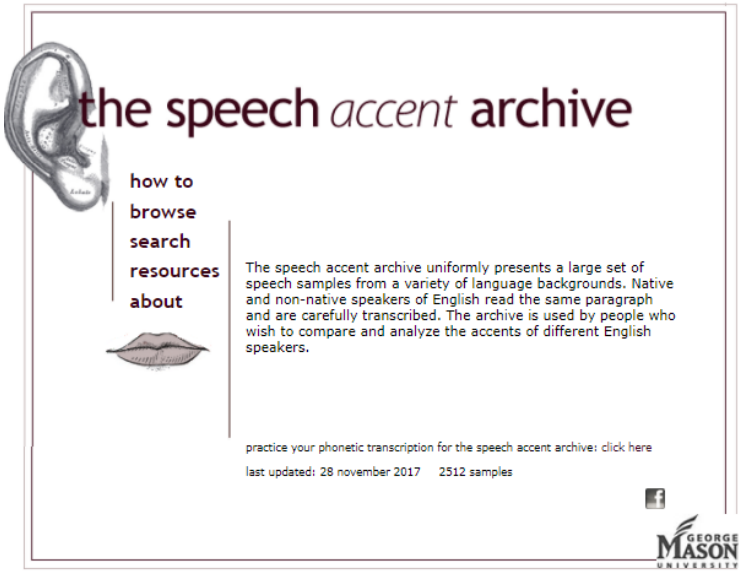
Experiment 1: Stimuli Design

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, 2019)



accent.gmu.edu

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Stimuli Classification:

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

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Stimuli Classification:

- **References:** The most common L1 productions (L1 targets) (e.g., [θɪk] for “thick”)
- **Match**: L2 Stimuli that **match** the L1 targets (i.e., [θɪk])
- **Mismatch**: L1 stimuli that **differ** from the L1 targets 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	Match	Consonant	Vowel	Syllable
please call	[pʰliz kʰɑl]	[pliz kʰɑl]	[pʰliz kʰol]	[pʰəliz kʰɑl]
ask her	[æsk (h)əɹ]	[æsk hər]	[ɑsk həɹ]	[æs_ həɹ]
six spoons	[sɪks spunz]	[sɪks spunʃ]	[siks spunz]	[sɪks əspunz]
five thick	[faɪv θɪk]	[faɪv tɪk]	[fav θɪk]	[faɪvə θɪk]
small plastic	[smɑl pʰlæstɪk]	[smɑl̩ pʰlæstɪk]	[smɑl pʰlæstik]	[smɑl pʰlæs_ɪk]

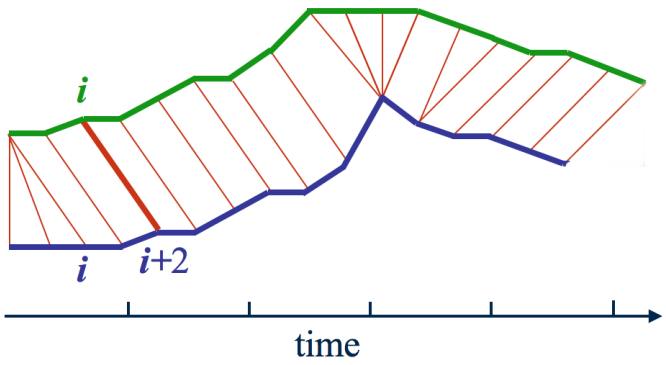
All transcriptions were verified via acoustic analysis of the sound files

Experiment 1: Prosody

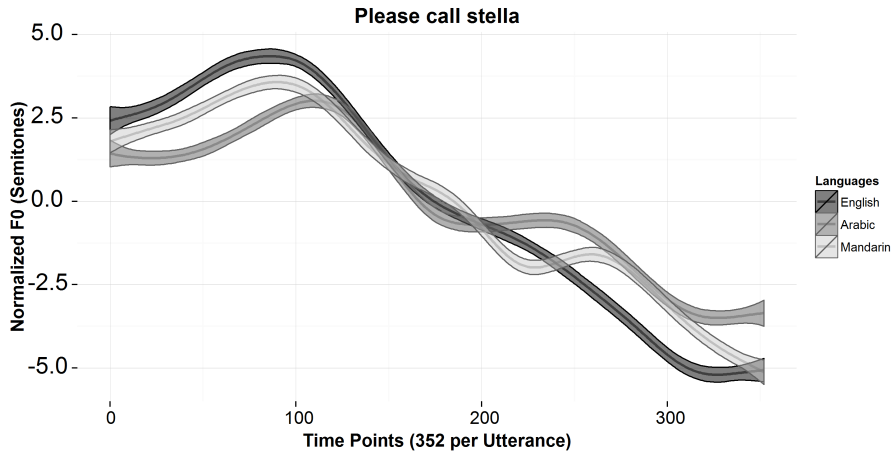
Control prosody in the least intrusive manner.
Prosody is a **CONTROLLING** variable.

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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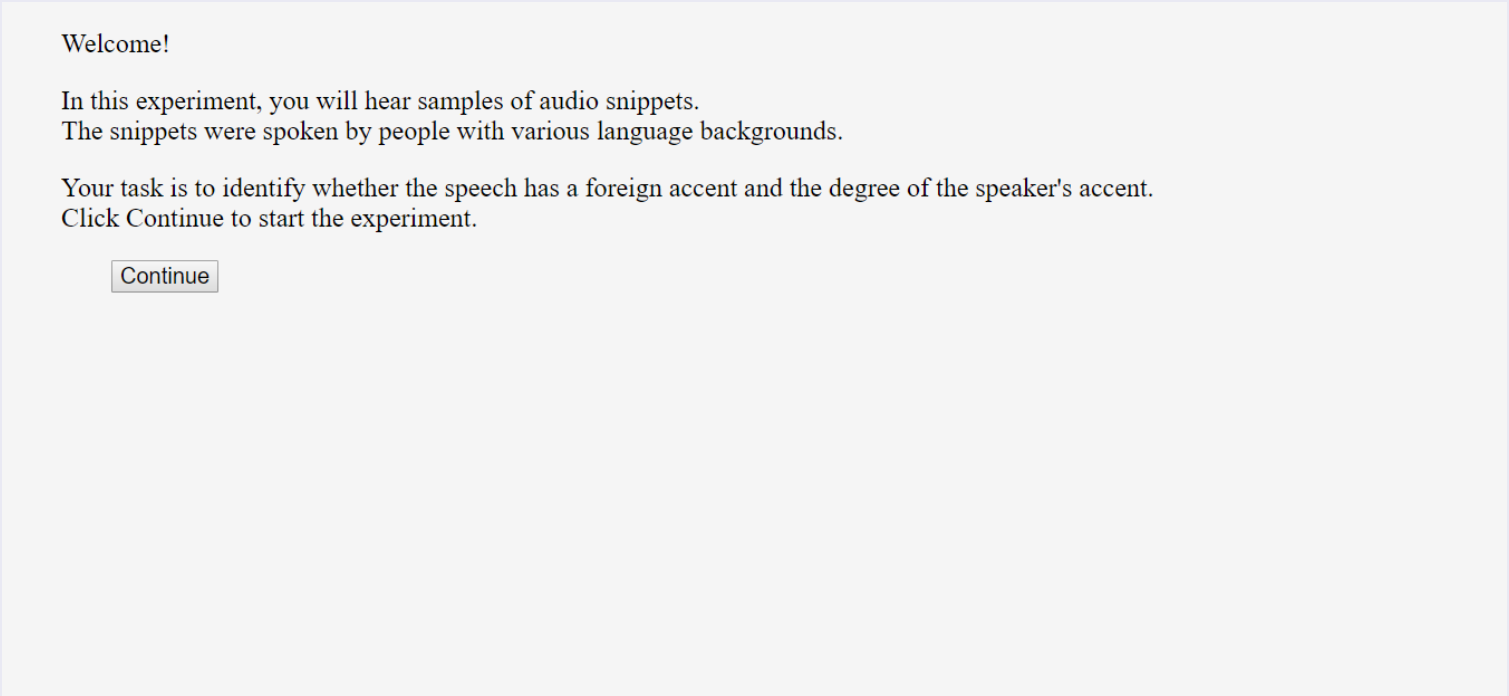

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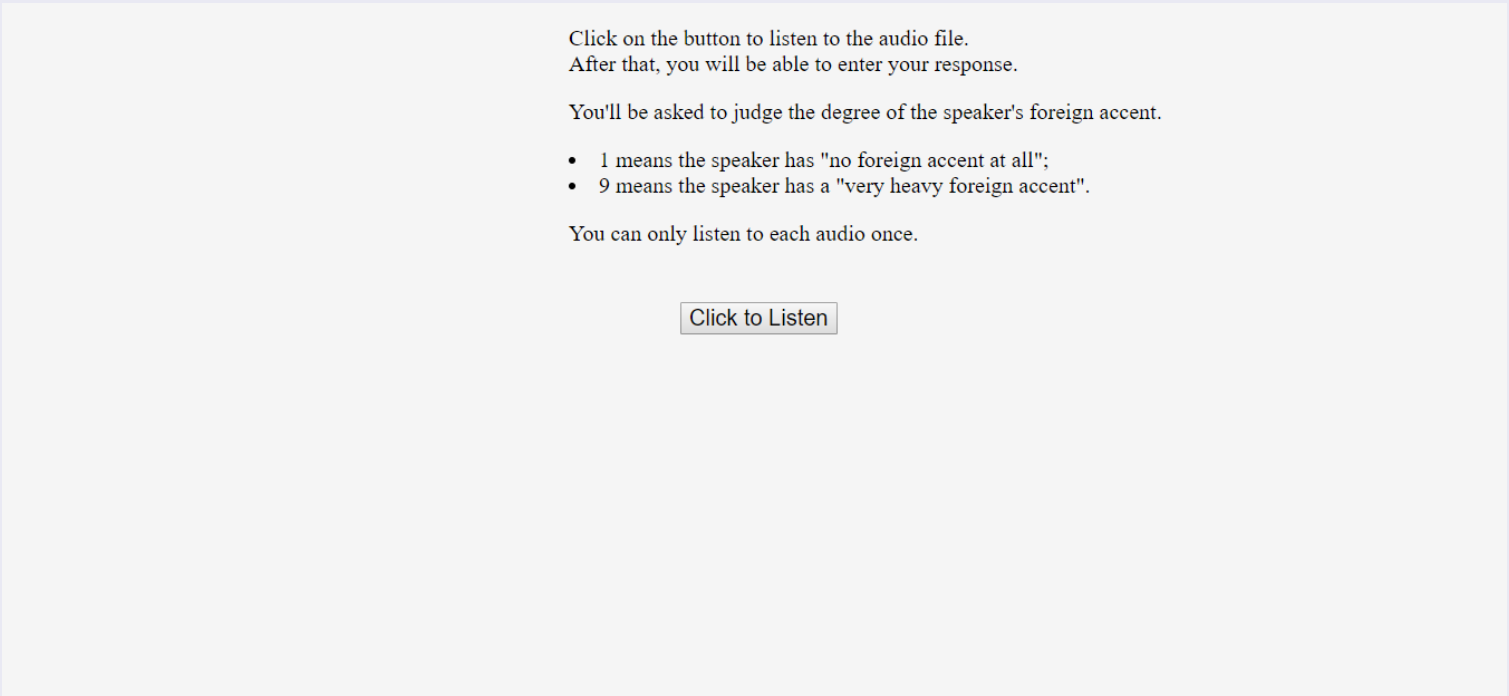
Trials:Listen to snippets (Block Randomization)



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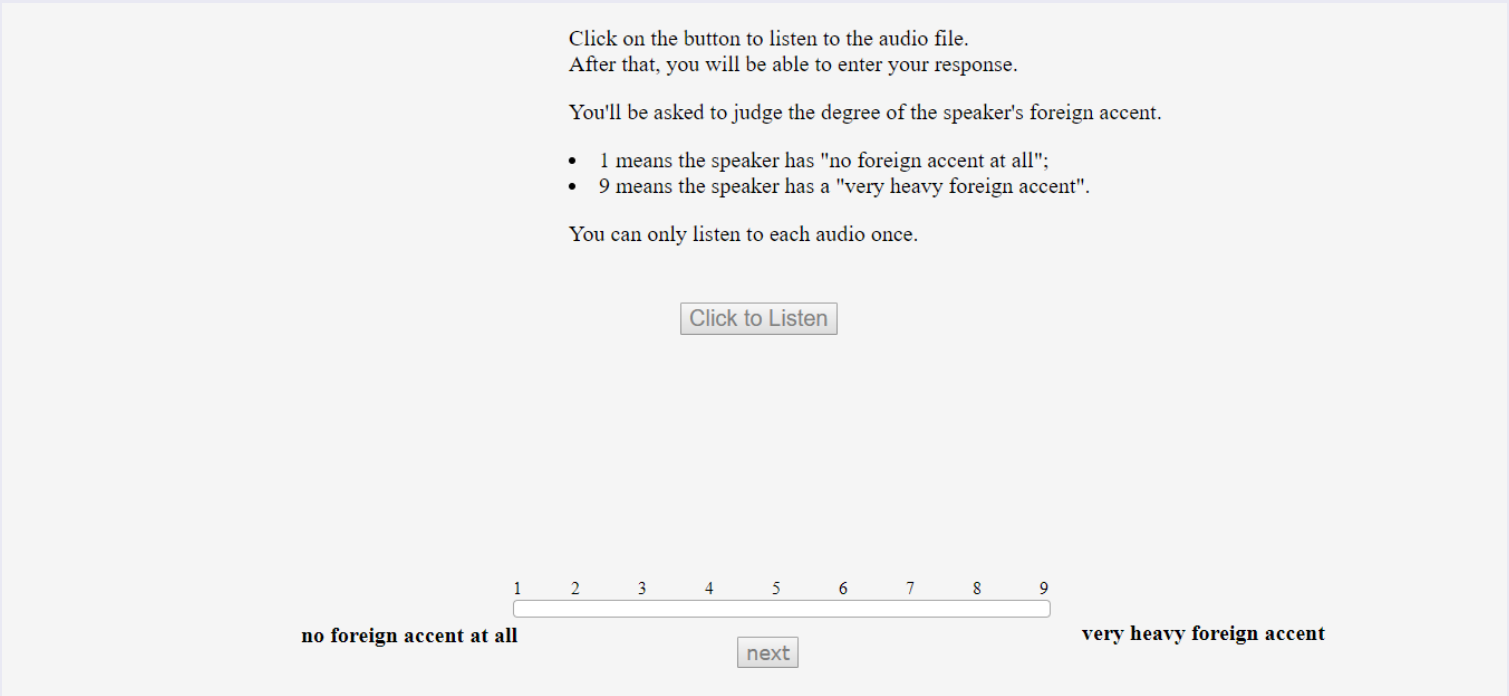
Trials:Make accentedness judgment



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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.

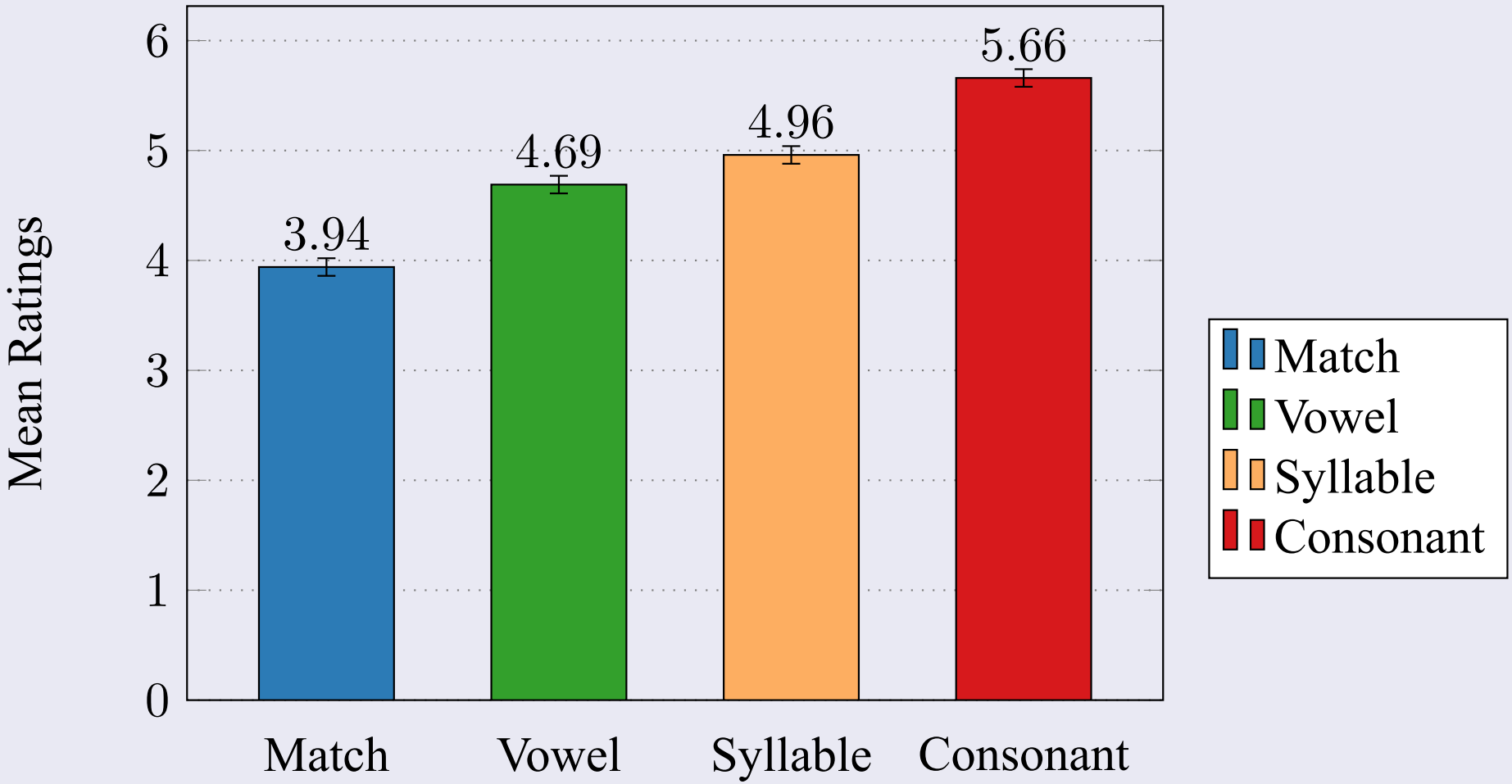
Please tell us your birth place (city/state/country).

Experiment 1: Rater Demographics

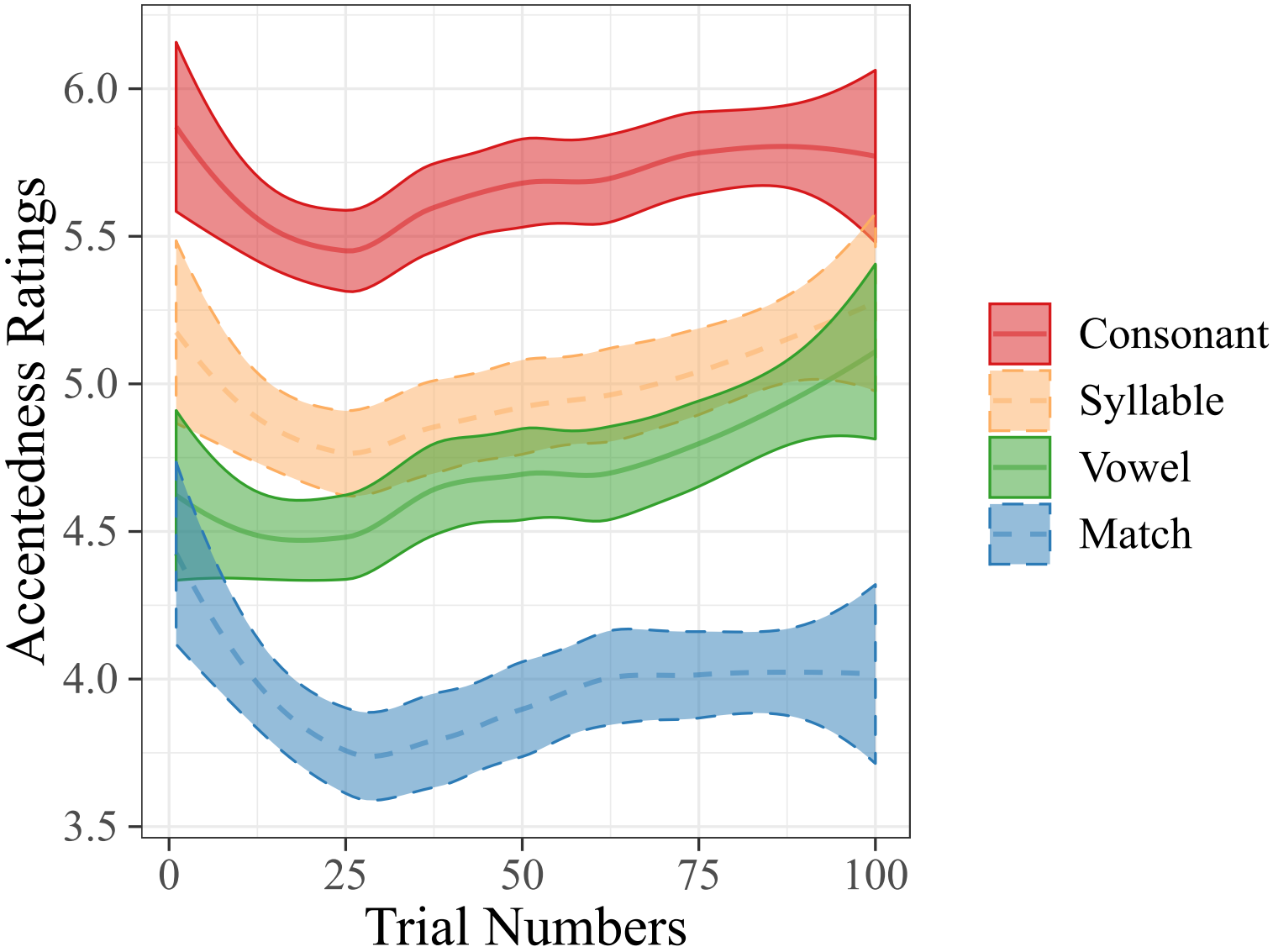
- 108 Participants (L1 American English Speakers)
- Male:61, Female:45, 2 did not report
- Age: range 20-66 (M=33.50, SD=12.51)
- Completion Time: M=12.33 min, SD=3.2 min;
  Maximum time allowed:30 min

Experiment 1: Results

Meaning Ratings by Type



Experiment 1: Ratings across Time



Experiment 1: General Findings

Mixed-effects linear model:

Fixed effects: Types of stimuli (contrast-coded), DTW, Trial Number;

Random effects: (Type of stimuli) Subjects, Stimuli

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4. Ratings increased over time. (χ^2=46.80, p <.001)

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

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- No training phase
- Intelligibility/Comprehensibility (e.g., six spoons vs. seeks spoons)
- Chances for a "mismatch" to exist in L1 speech (e.g., "thick" /tɪk/ vs. /stɪk/)

Experiment 2: Research Design

Aim: fix methodological problems in Experiment 1

- No training phase –> add a training phase with 10 stimuli

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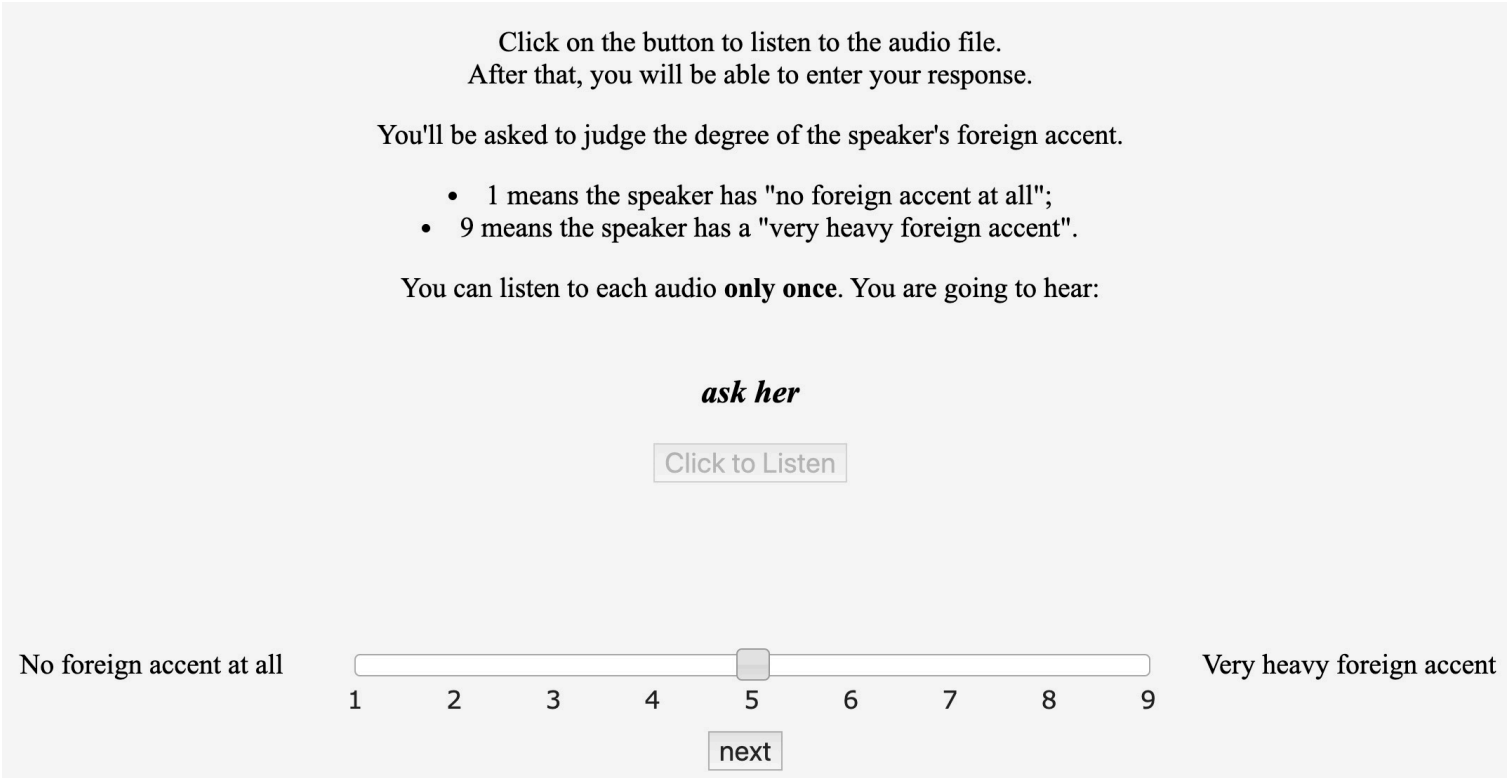
- Chances for a "mismatch" to exist in L1 speech—> deal with this in **Experiment 3**

Experiment 2: Procedure



Experiment 2: Rater Demographics

- 133 participants (L1 American English speakers)
- Male:68, Female:58, 7 did not report
- 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

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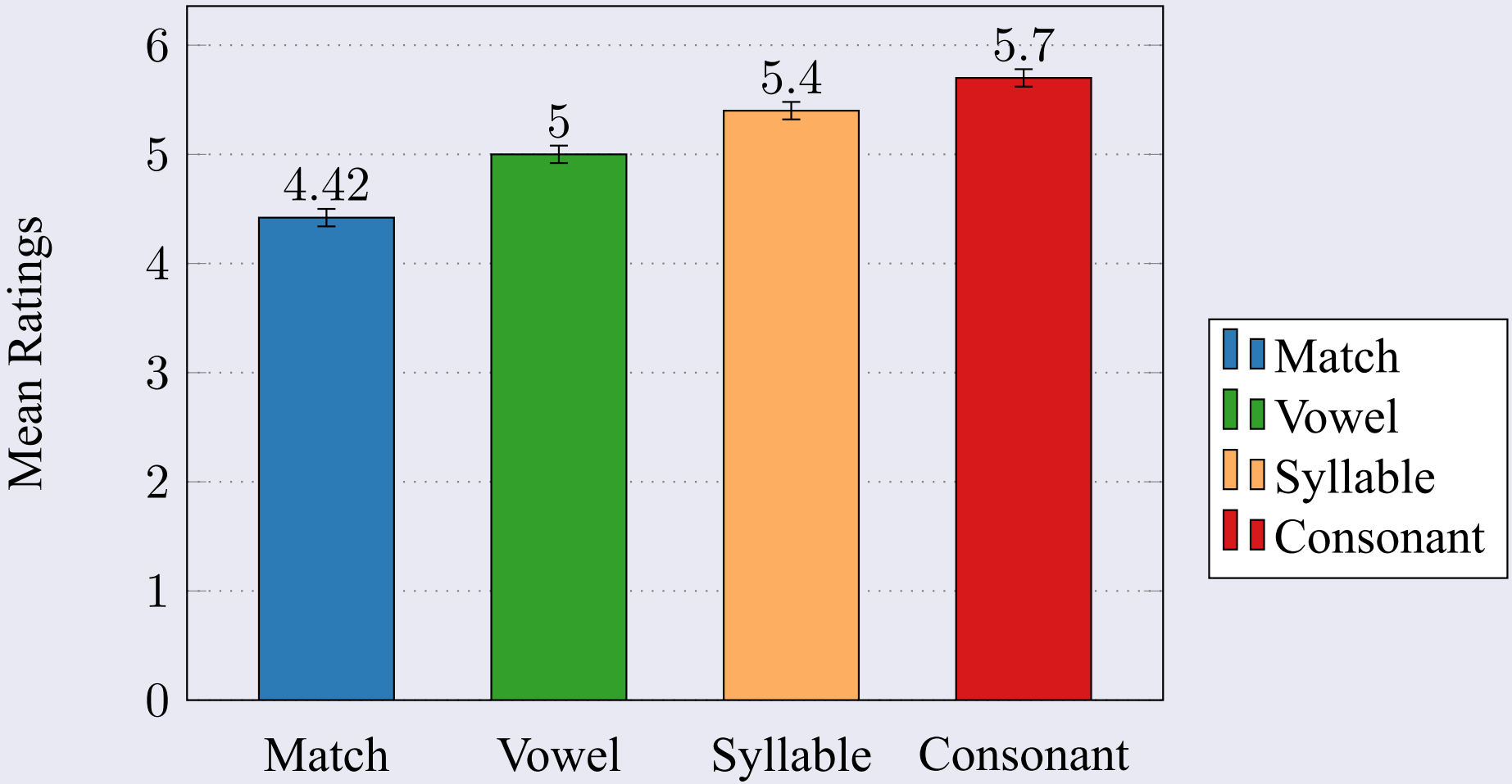
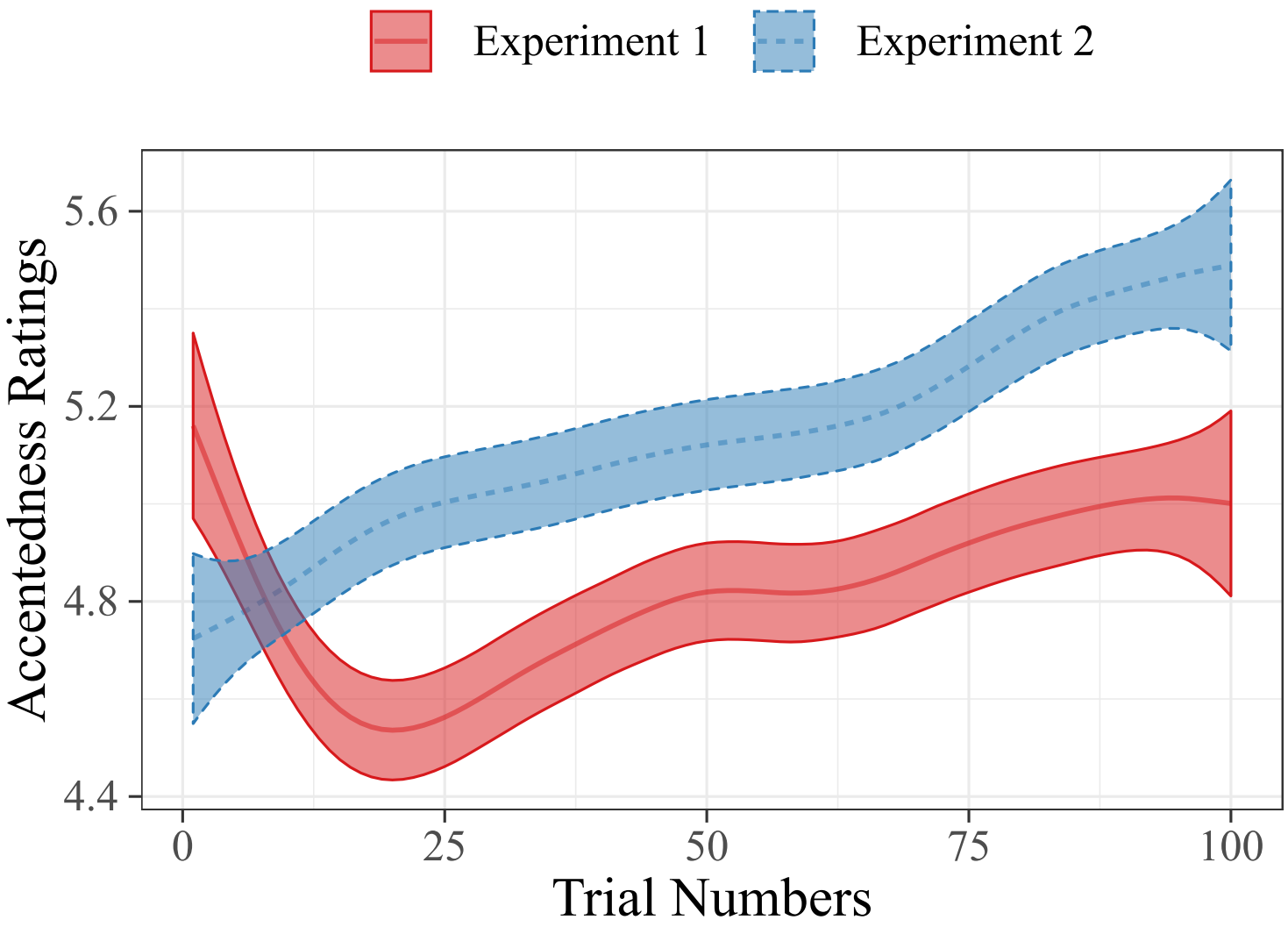


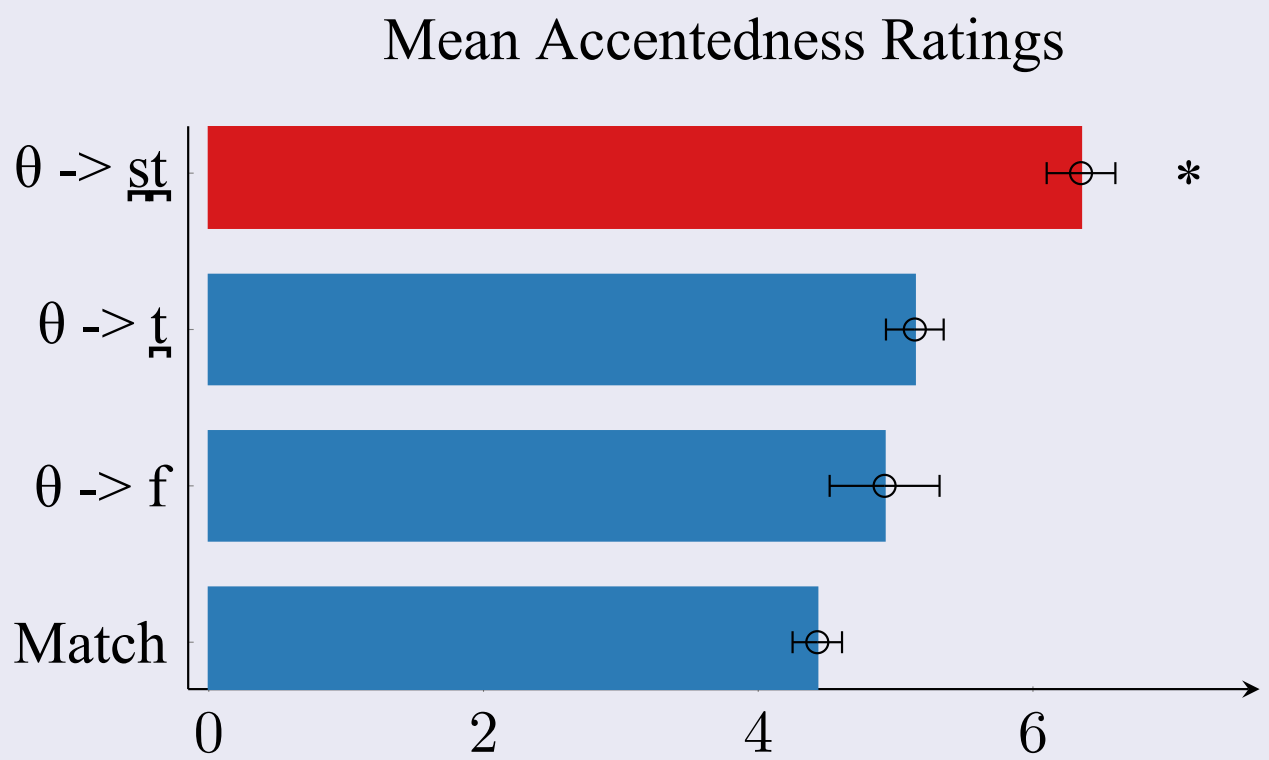
Experiment 2: Ratings across Time (SSANOVA)



Experiment 2: L1 Dialectal vs. Non-dialectal

θ→st is more accented than **θ→t** and **θ→f**

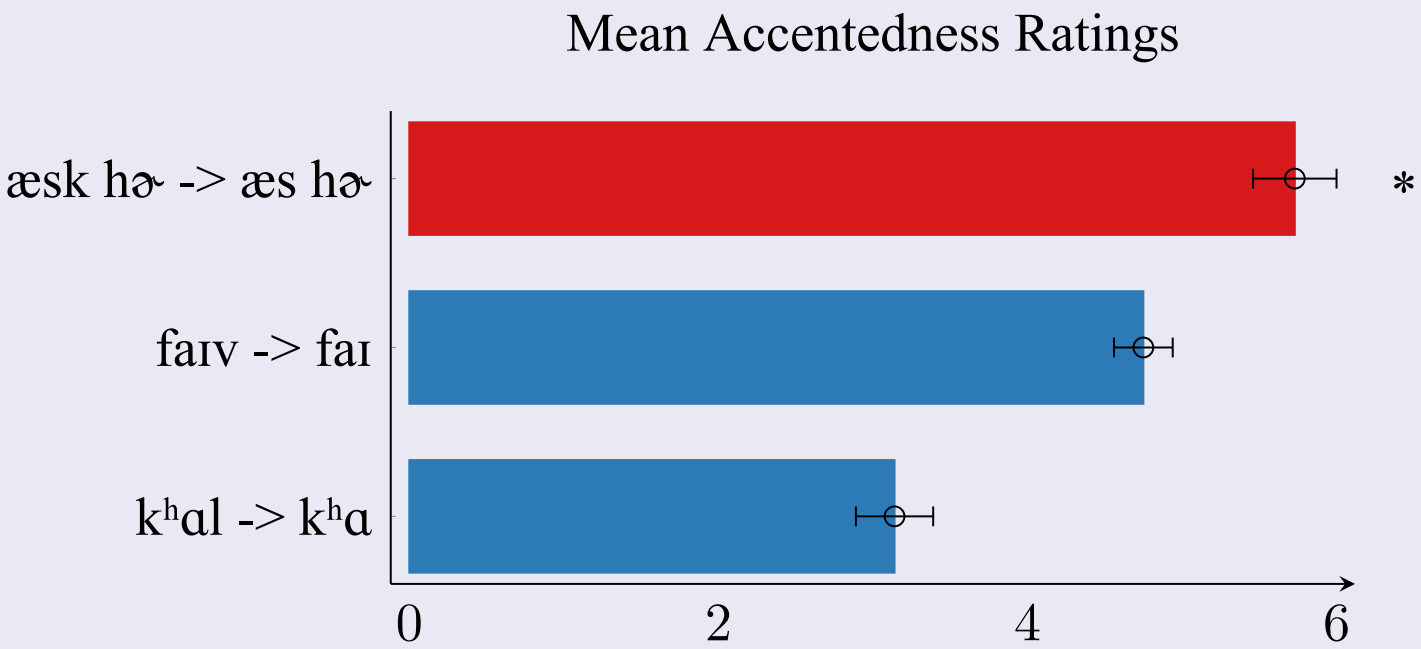
/θ/ changes in "five thick"



Experiment 2: Phonological Environment

/k/-deletion in “ask her” vs. other coda deletions

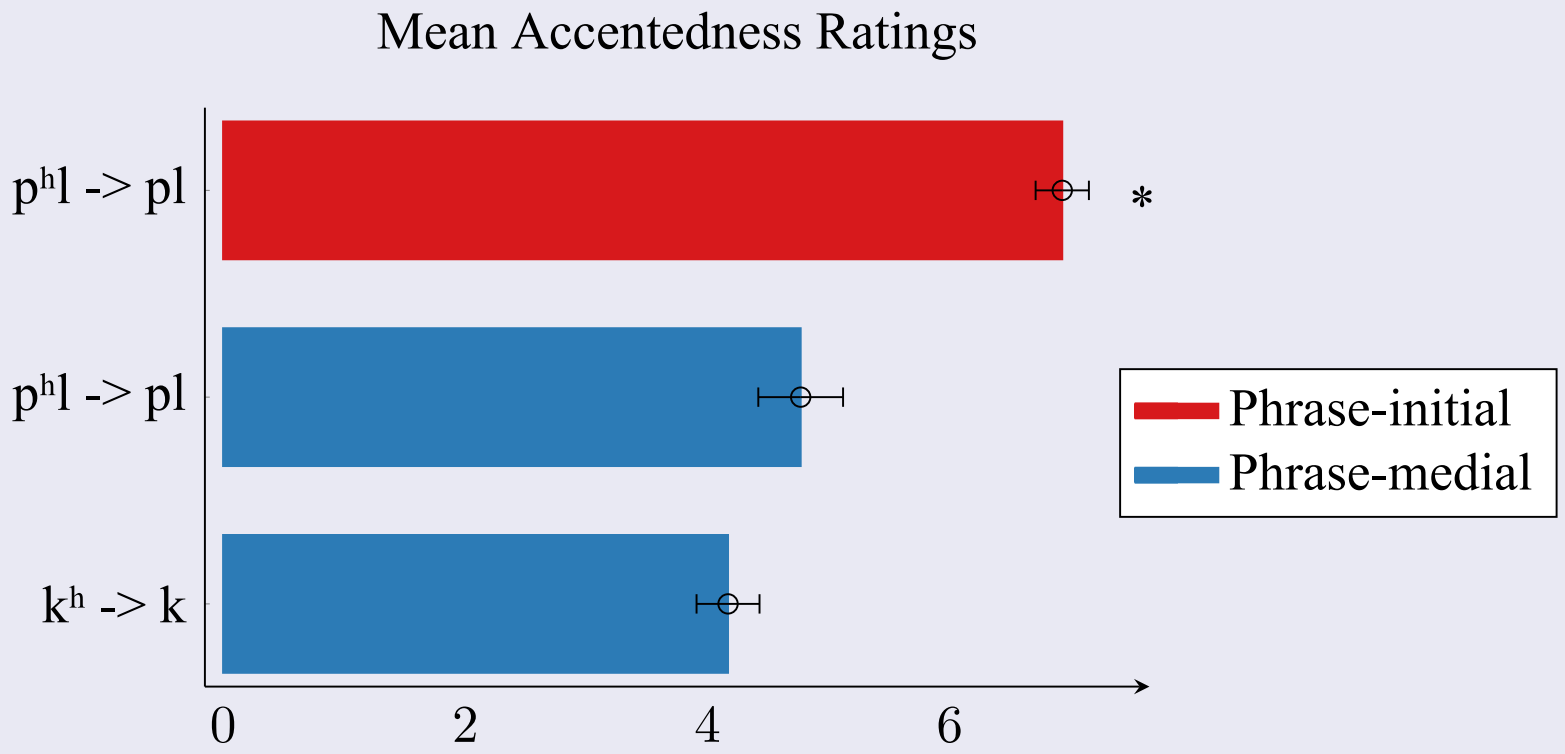
Coda Deletions



Experiment 2: Phonological Environment

Phrase-Initial vs. Phrase-Medial VOT-shortening

VOT-shortenings



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3. **Phonological environment**
   e.g., /k/-deletion in "ask her",
   Phrase-initial vs. phrase-medial VOT-shortening

Experiment 3: Introduction

Hypothesis:

(1) Lexical information
(2) Occurrences in L1 speech
(3) Phonological environment

} L1 Knowledge –> Accent judgment

Aim:

Build a computational model to verify that L1 knowledge affects accentedness judgment.

Experiment 3: Method

The Naïve Discriminative Learning Model (**NDL Model**)

(Wieling et al. 2014; Bayaan, 2011)

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

Cue: Four-legged
Outcomes: Puppy, Kitten, Table, Chair etc.
Association Strength (Weight):
How probably the cue "Four-legged" can predict outcome "Puppy".

Experiment 3: Method

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

Table 4: Association Strengths

Cues	Outcomes	Association Strengths
#æs	ask	0.166
æsk	ask	0.167
sk#	ask	0.667
#æ̱s	ask	0.147
æ̱sk	ask	0.147
#ɚ#	her	1.000
#hɚ	her	0.500
hɚ#	her	0.500

Experiment 3: Method

Reasons for using Trigram cues:

1. **Three-member sequence**: English phonotactics, sound changes in continuous speech
2. **Include diacritics**: Sub-phonemic information ([æ] and [a̟] are two independent segments)
3. **Lexical outcomes**: Lexical information

Experiment 3: Method

Pronunciation	Association Strength	NDL-distance
[æsk.ɚ]	$(0.166 + 0.167 + 0.667 + 1.000) \div 2 = 1.000$	$1 - 1.000 = 0.000$
[æ̣sk.ɚ]	$(0.147 + 0.147 + 0.667 + 1.000) \div 2 = 0.980$	$1 - 0.980 = 0.020$
[ask.hɚ]	$(0 + 0 + 0.667 + 0.500 + 0.500) \div 2 = 0.834$	$1 - 0.834 = 0.166$

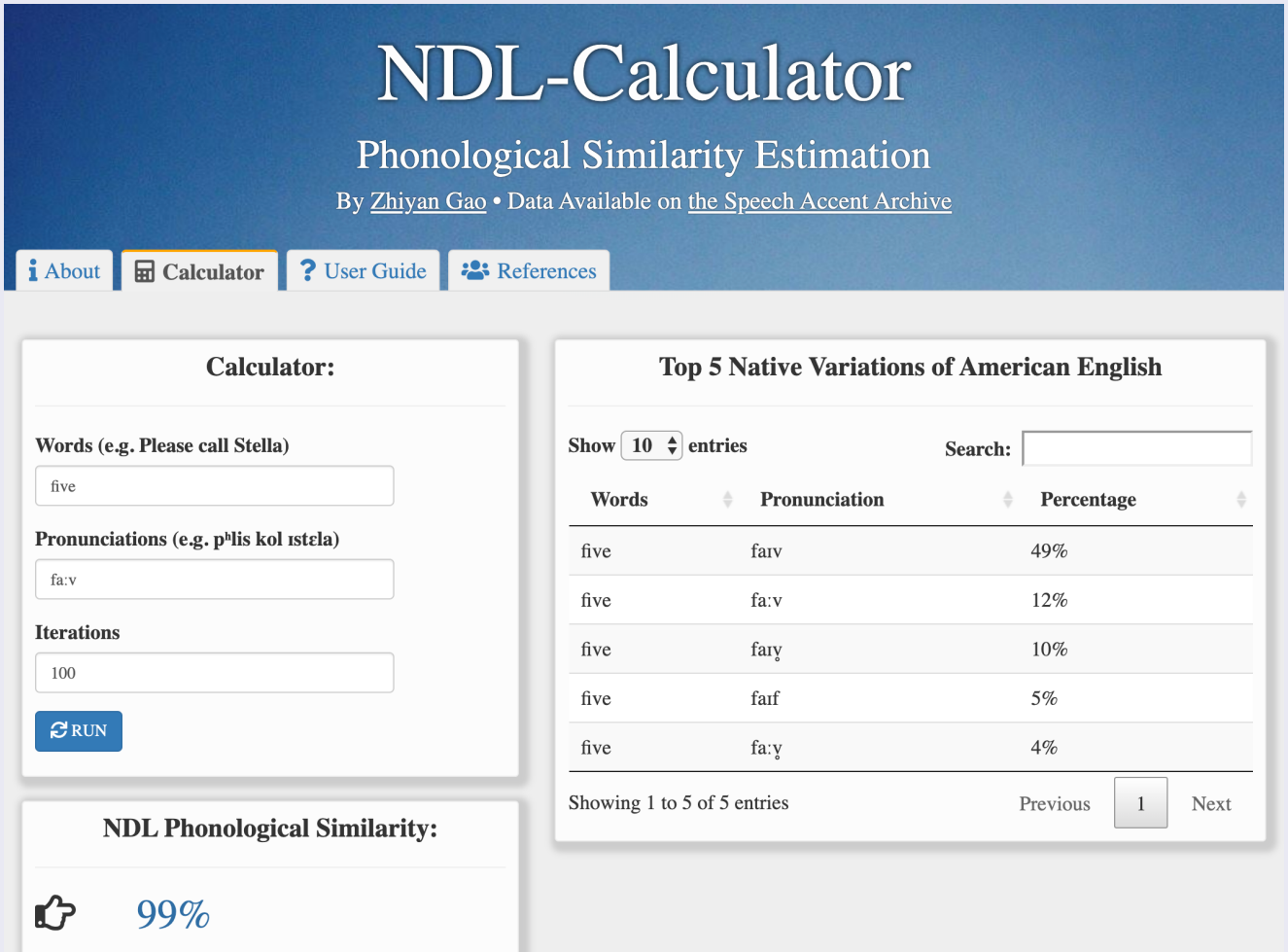
Table 4: Association Strengths

Cues	Outcomes	Association Strengths
#æs	ask	0.166
æsk	ask	0.167
sk#	ask	0.667
#æ̣s	ask	0.147
æ̣sk	ask	0.147
#ɚ#	her	1.000
#hɚ	her	0.500
hɚ#	her	0.500

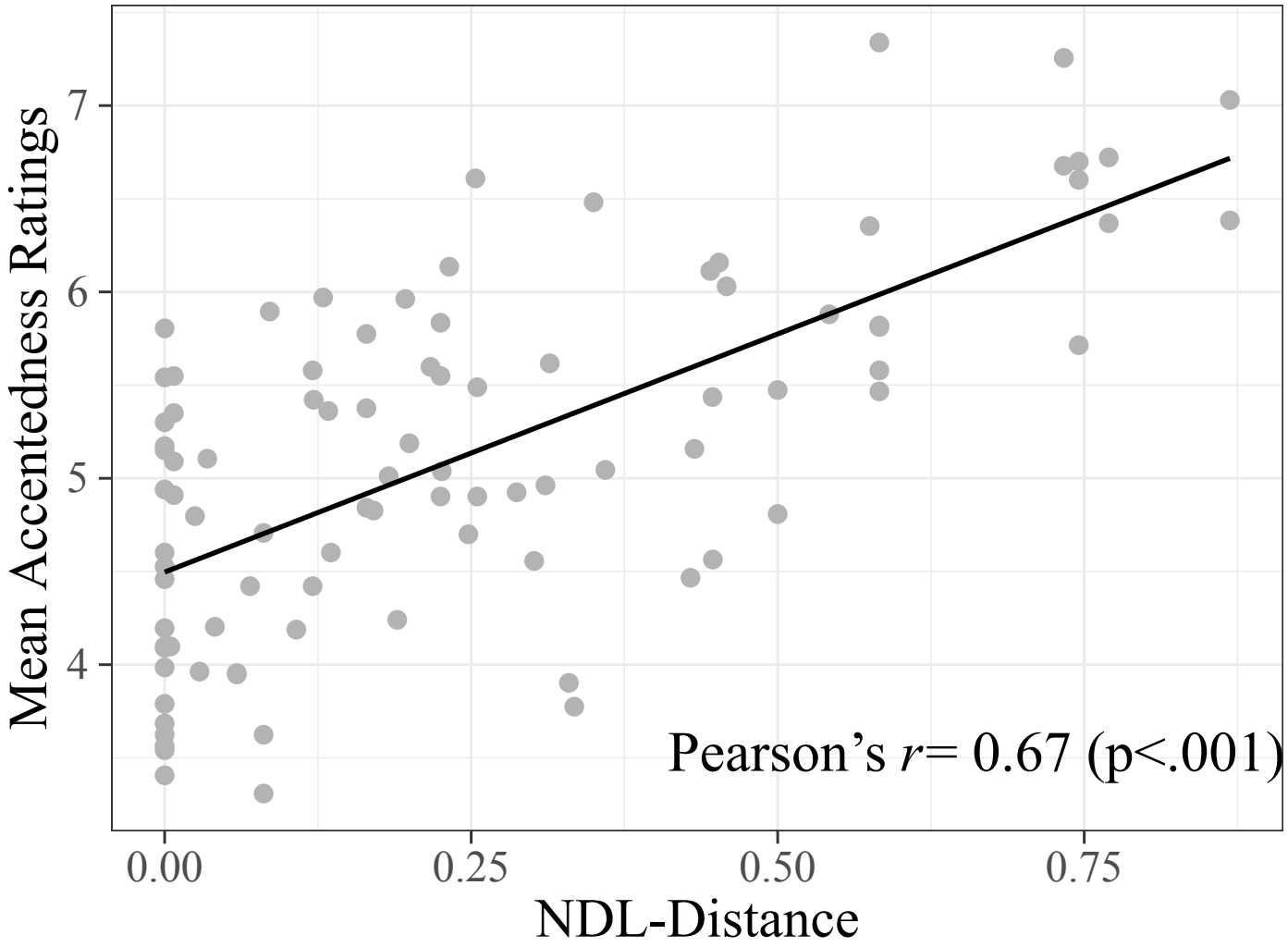
Experiment 3: The NDL model

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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Linear Mixed-effects model:

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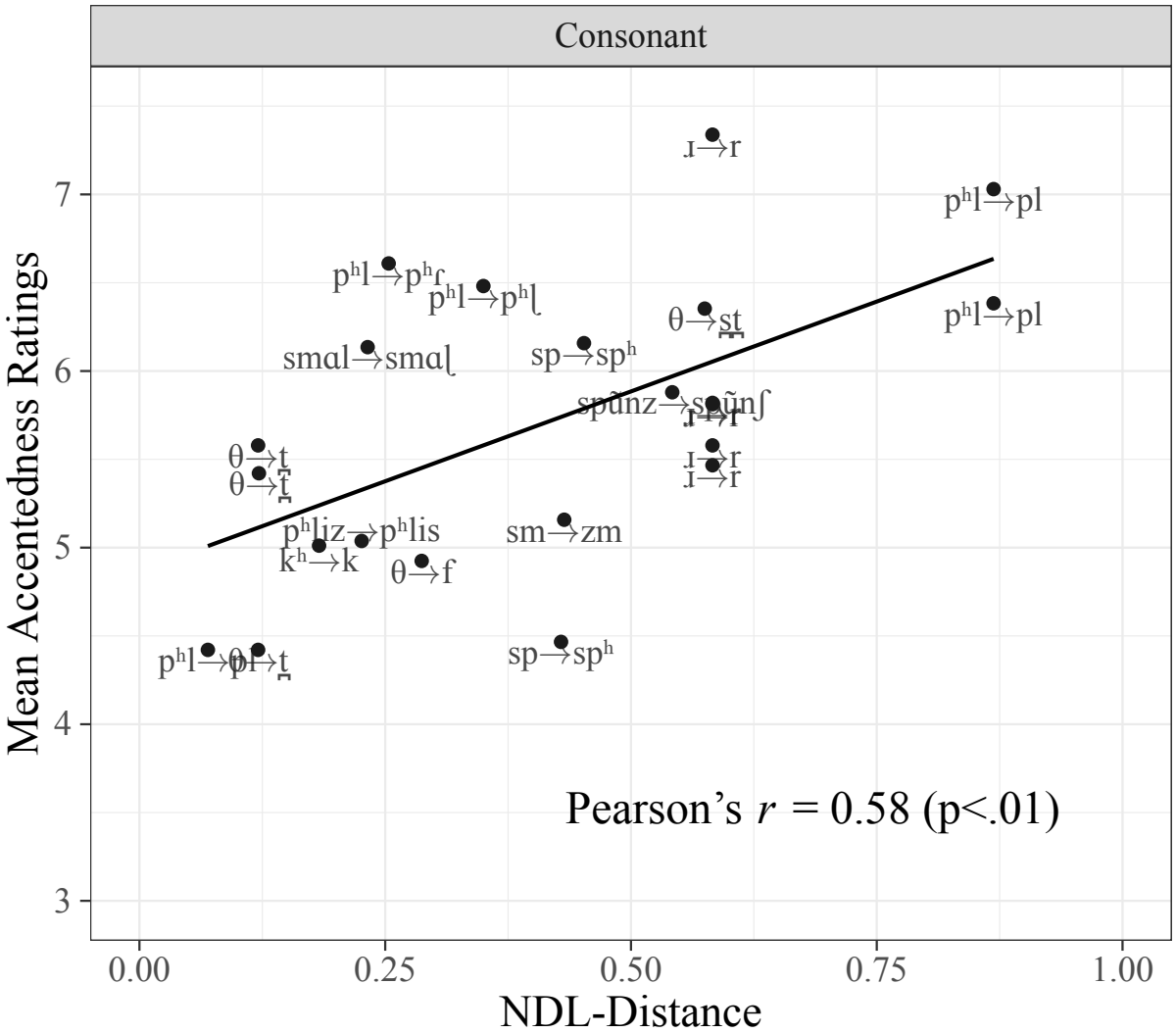
Results:

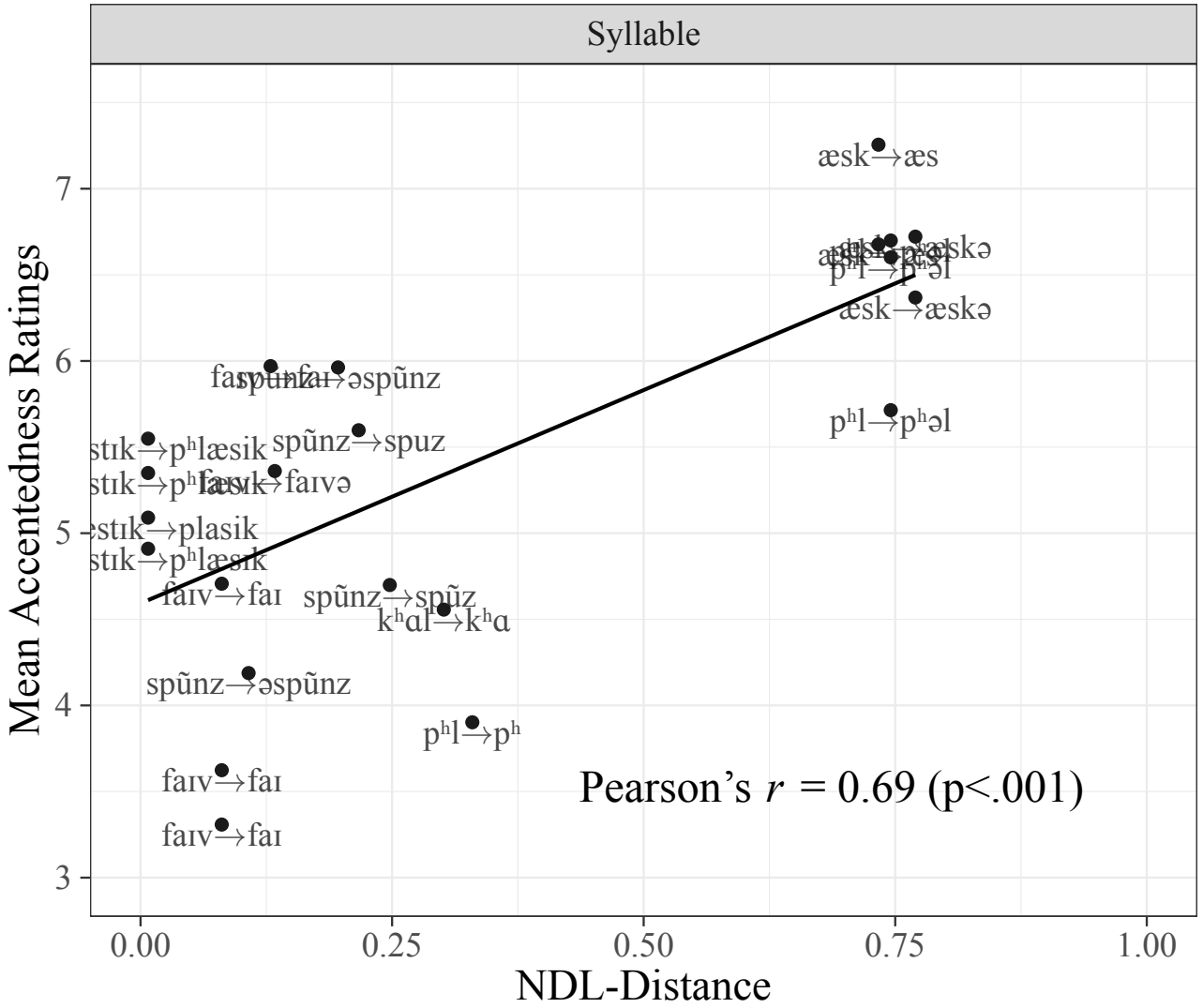
- NDL-distances significantly contributed to model fit ($\beta = 1.74$, $\chi 2 = 8.79$, $p<.01$)
- The three stimuli contrasts did not contribute significantly to model fit.
- Trial number contributed significantly to model fit ($\beta = 0.6$, $\chi 2 = 72.24$, $p<.001$),

Experiment 3: Consonants & Syllable



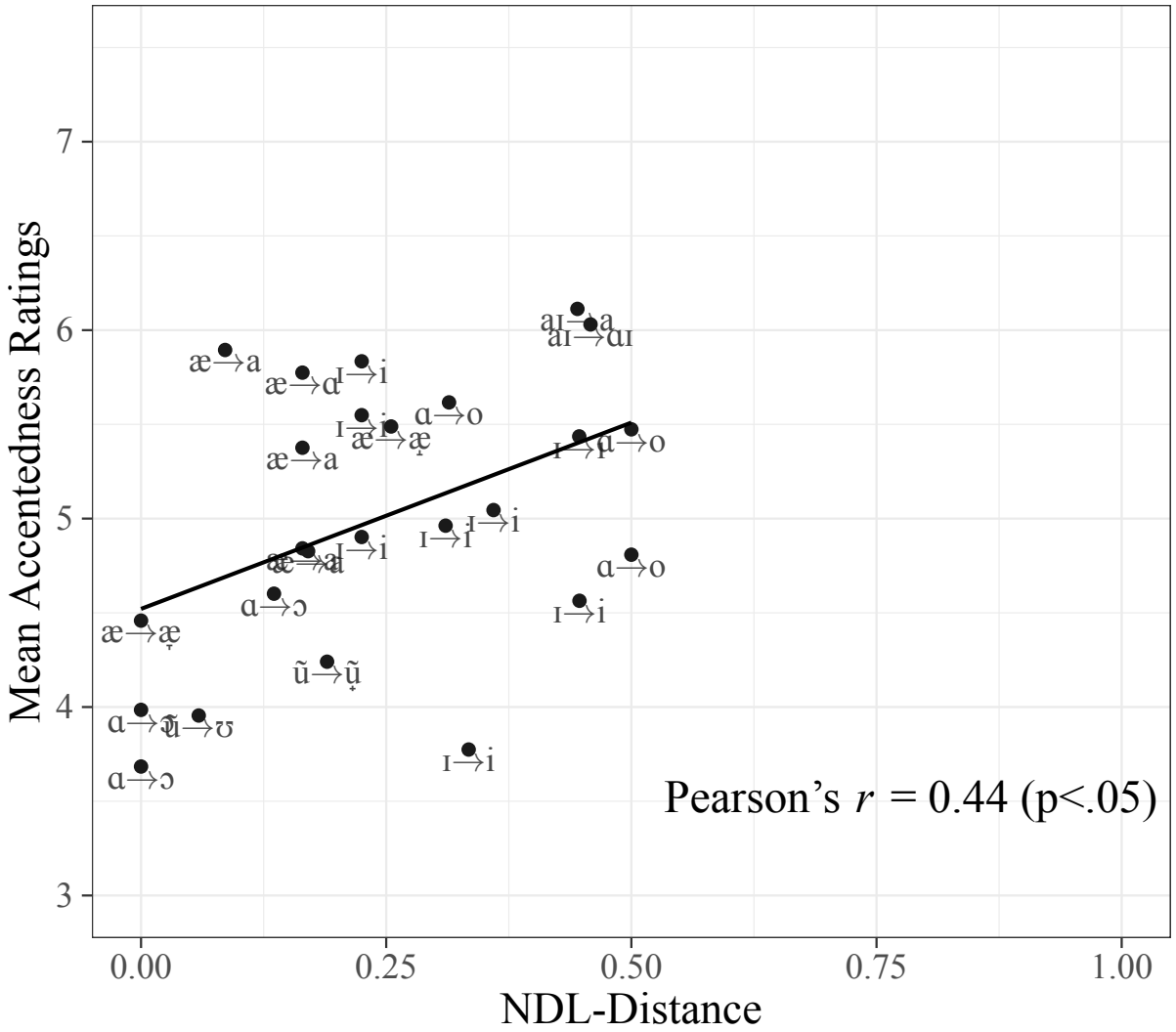
Clear positive correlation.
Not that good for non-English sounds (e.g., retroflex [ɭ])

Experiment 3: Consonants & Syllable



clear positive correlation

Experiment 3: Vowels



Positive correlation.
Restricted Range

Experiment 3: Variability of Segments

Words	Pronunciations	Frequency
small	[smɑlˠ]	41%
small	[smɔl]	16%
small	[smɔlˠ]	14%
small	[smaʊl]	4%
small	[smɑːlˠ]	4%

Outcomes	Cues	Strengths
small	#sm	0.712
small	smɑ	0.078
small	mɑlˠ	0.094
small	ɑlˠ#	0.094

- Vowels are more variable in L1 speech than consonants
- Trigrams involving vowels have smaller association strengths

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

Research Questions:

1. Do some phonetic/phonological patterns contribute more to accent than others?

2. Why are some phonetic/phonological patterns more accented than others?

The Current Study: Conclusions

Experiment 1 & 2:

1. Do some phonetic/phonological patterns contribute more to accent than others? YES!

2. Why some phonetic/phonological patterns are more accented than others?

- (1) Lexical information
- (2) Occurrences in L1 speech
- (3) Phonological environment

} L1 Knowledge

The Current Study: Conclusions

Experiment 3:
Modeled L1 knowledge based on

1. **lexical outcome**:

   (lexical information)

2. **Trigram cues**:

   (occurrences & phonological/phonetic constraints)

3. **Diacritics**:

   (sub-phonemic information)

Conclusion:

L1 knowledge, as modeled by the NDL model, potentially governs foreign accent perception.

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 sub-phonemic acoustic information on accentedness

   (We conducted some analyses, results are not conclusive)

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Sociolinguistic issues

4. Raters' own L1 dialects and familiarity of certain L2 accents
5. Other factors: age, gender, educational attainment, etc
6. Reliability of online experiments.

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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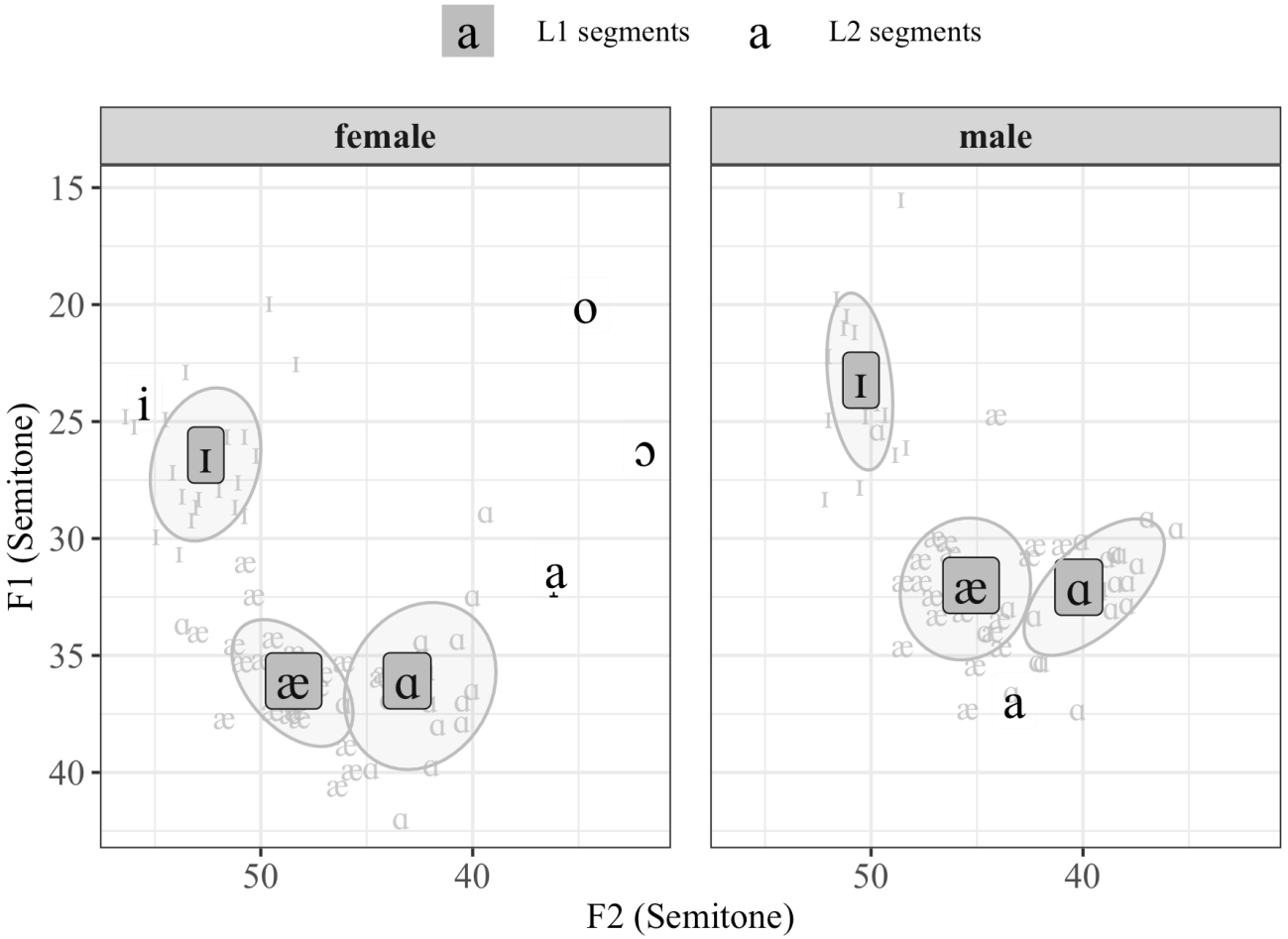
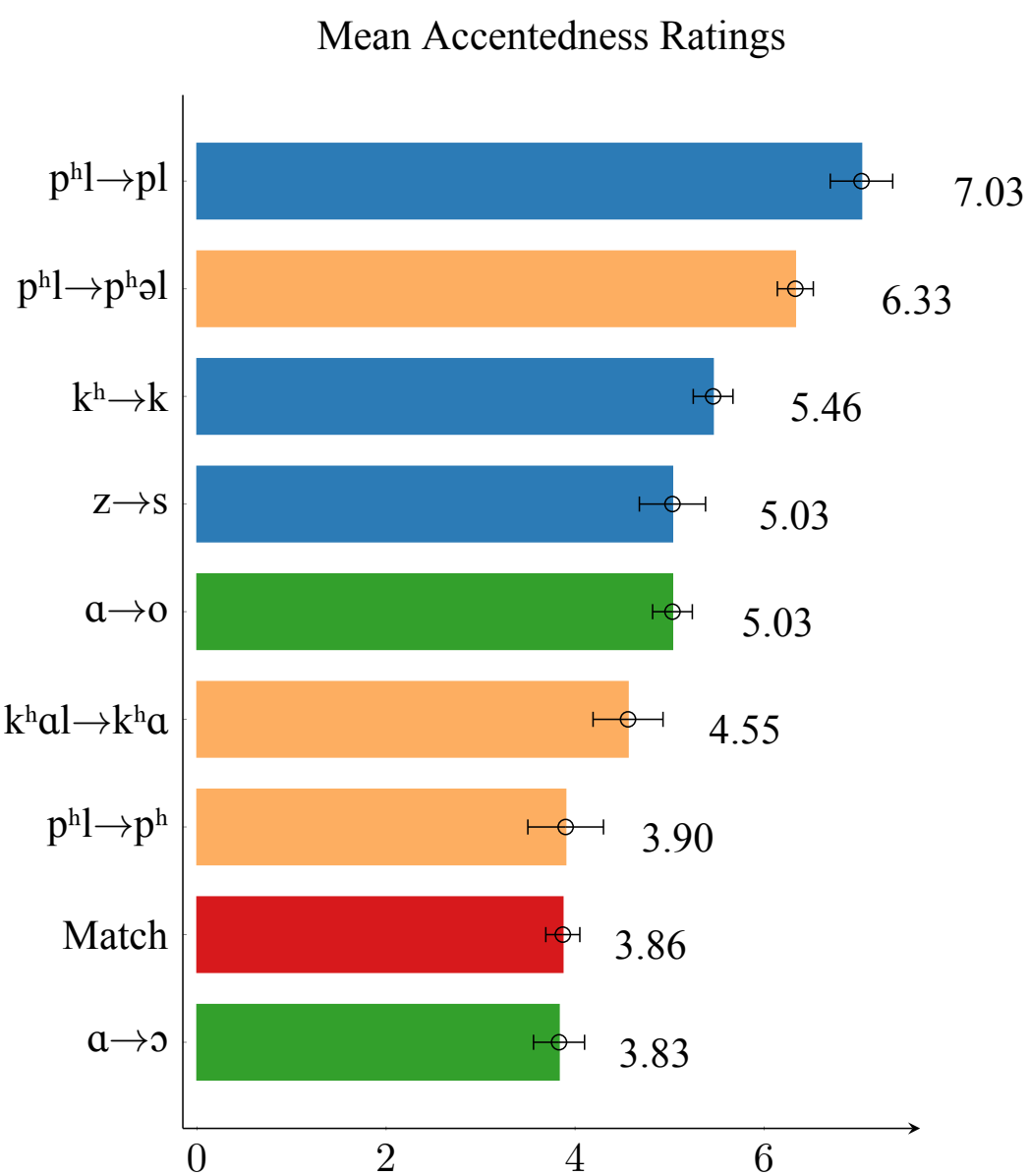
Thank You!

Acoustic Verification



Experiment 2: Rankings (Please call)



Ranking 1:

pʰl→pl; pʰl→pʰəl
⇓
z→s; ɑ→o
⇓
ɑ→ɔ; Match

Ranking 2:

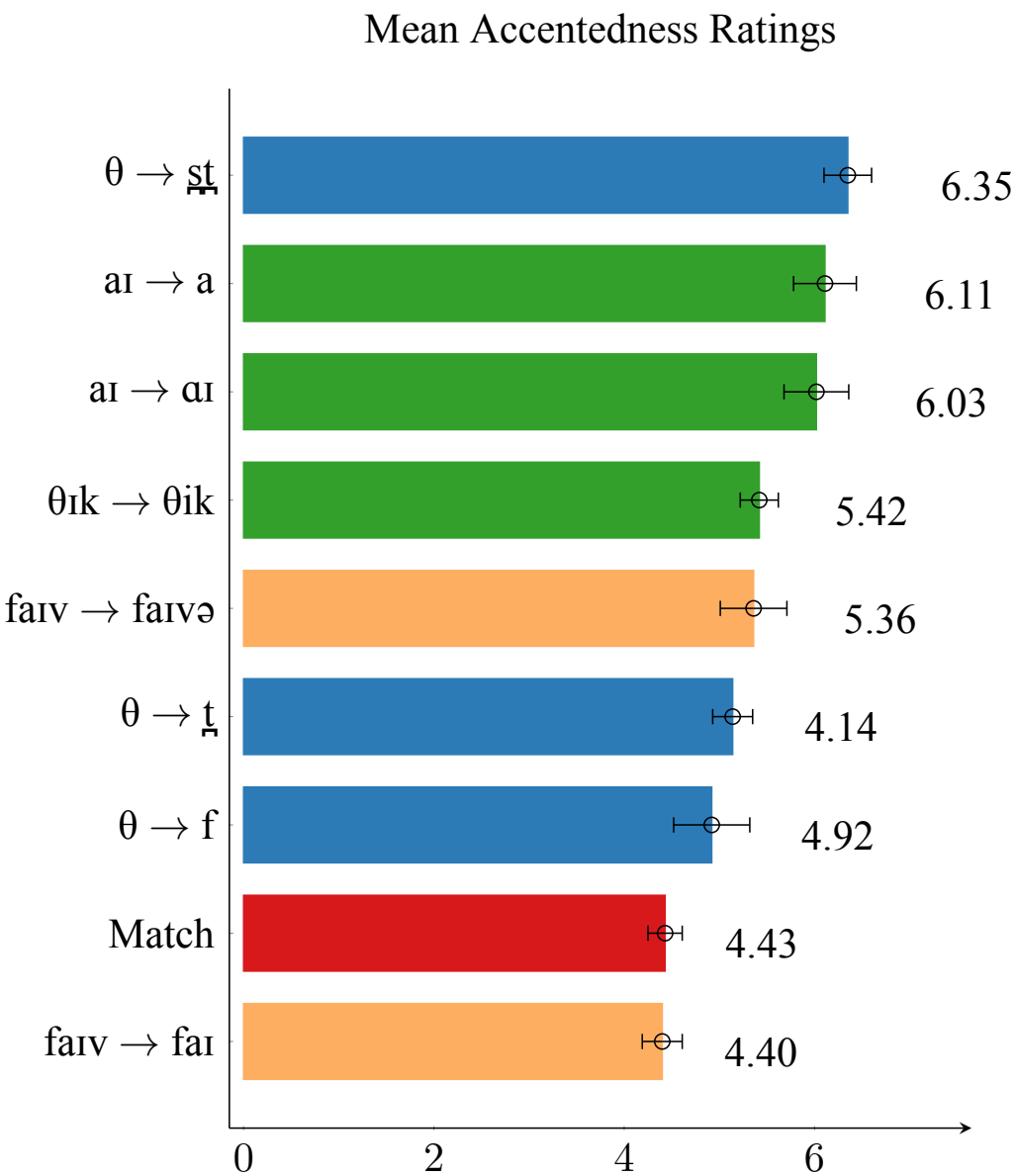
pʰl→pl
⇓
kʰ→k
⇓
ɑ→ɔ; Match;pʰl→pʰ; kʰɑl→kʰɑ

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 (Five Thick)



Ranking 1:

θ-> st̪

⇓

faɪv→faɪvə; θɪk→θik

⇓

faɪv→faɪ; Match

Ranking 2:

θ-> st̪

⇓

faɪv→faɪ; Match; θ→f; θ→t̪

Ranking 3:

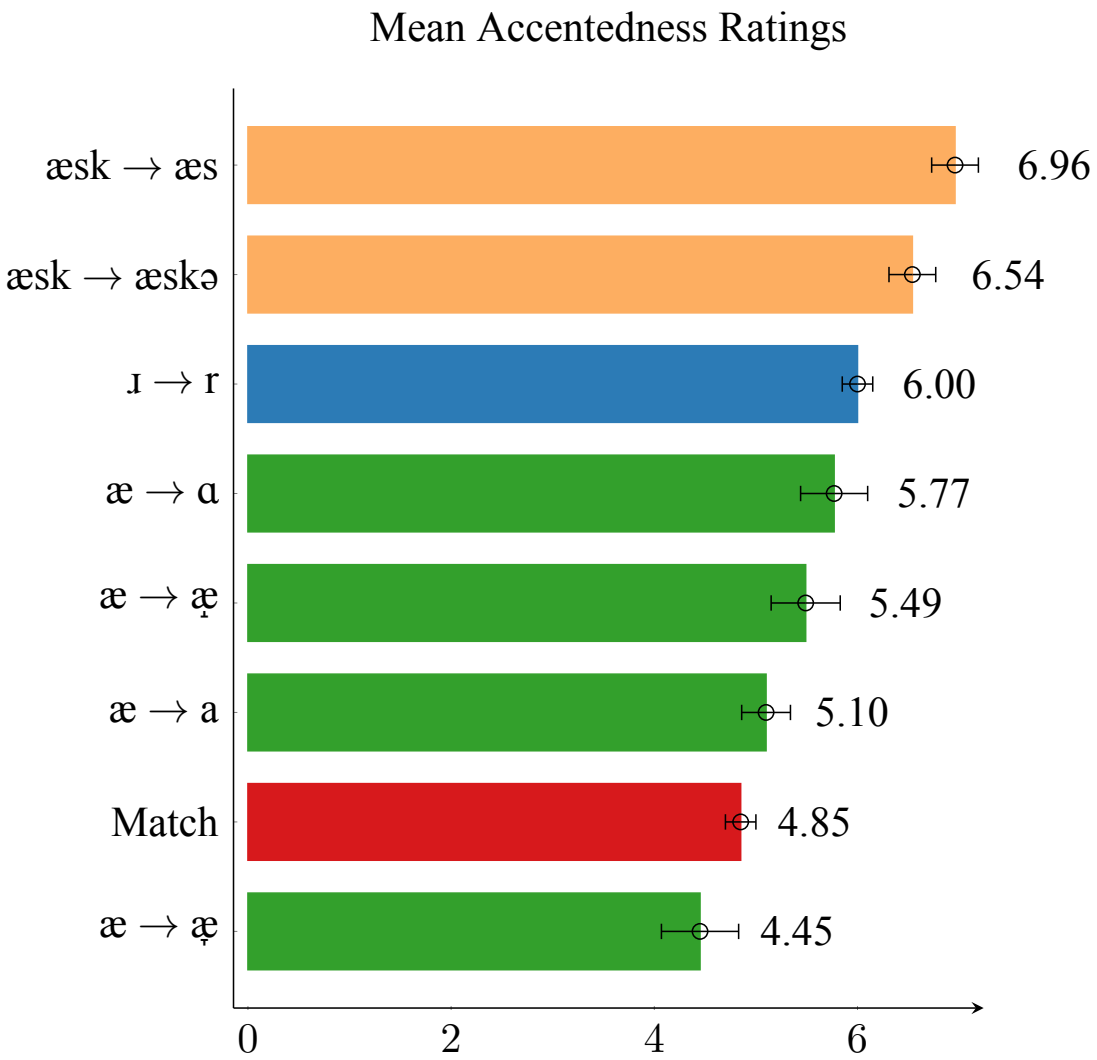
aɪ→ɑɪ; aɪ→a

⇓

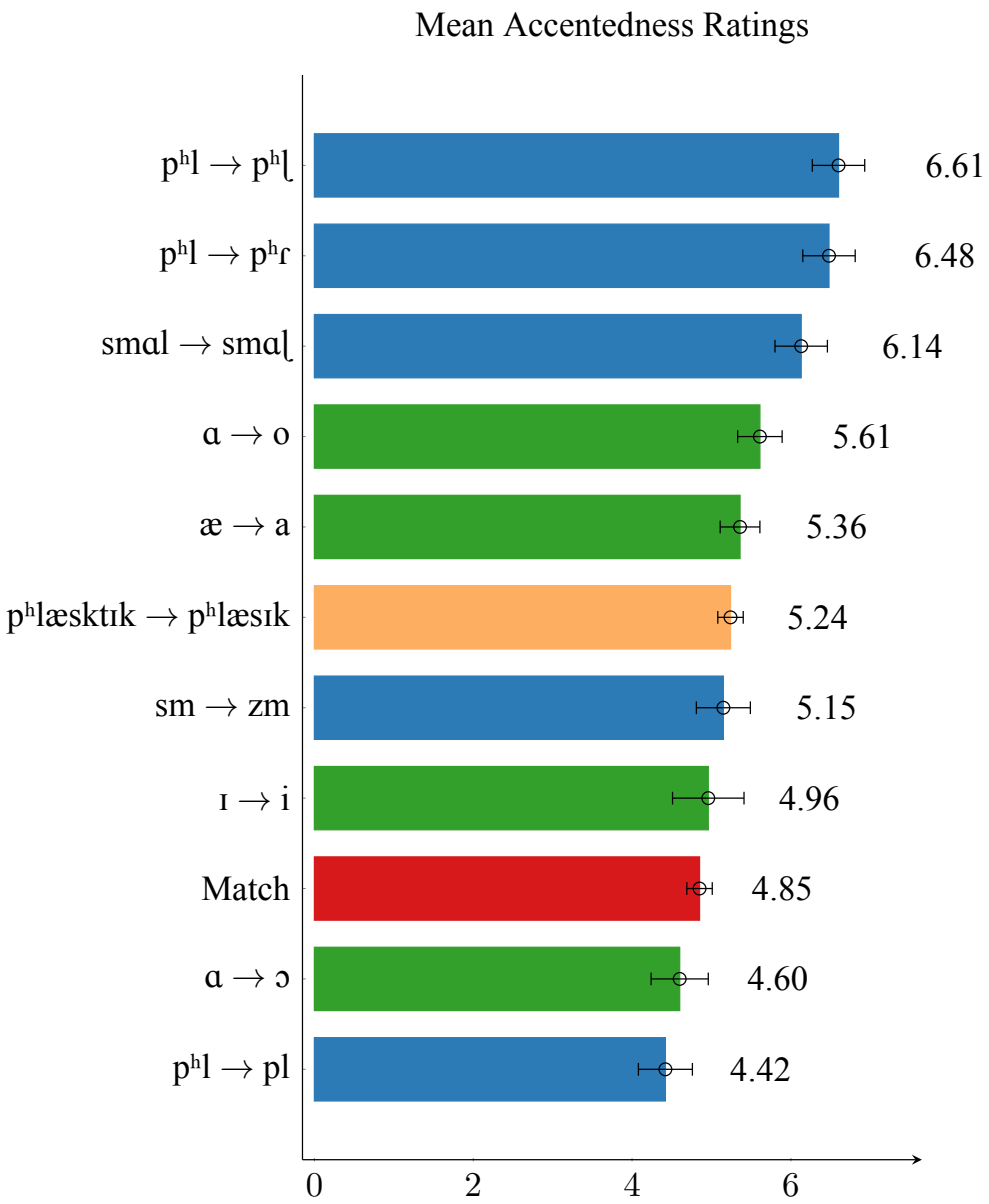
faɪv→faɪ; Match; θ→f

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

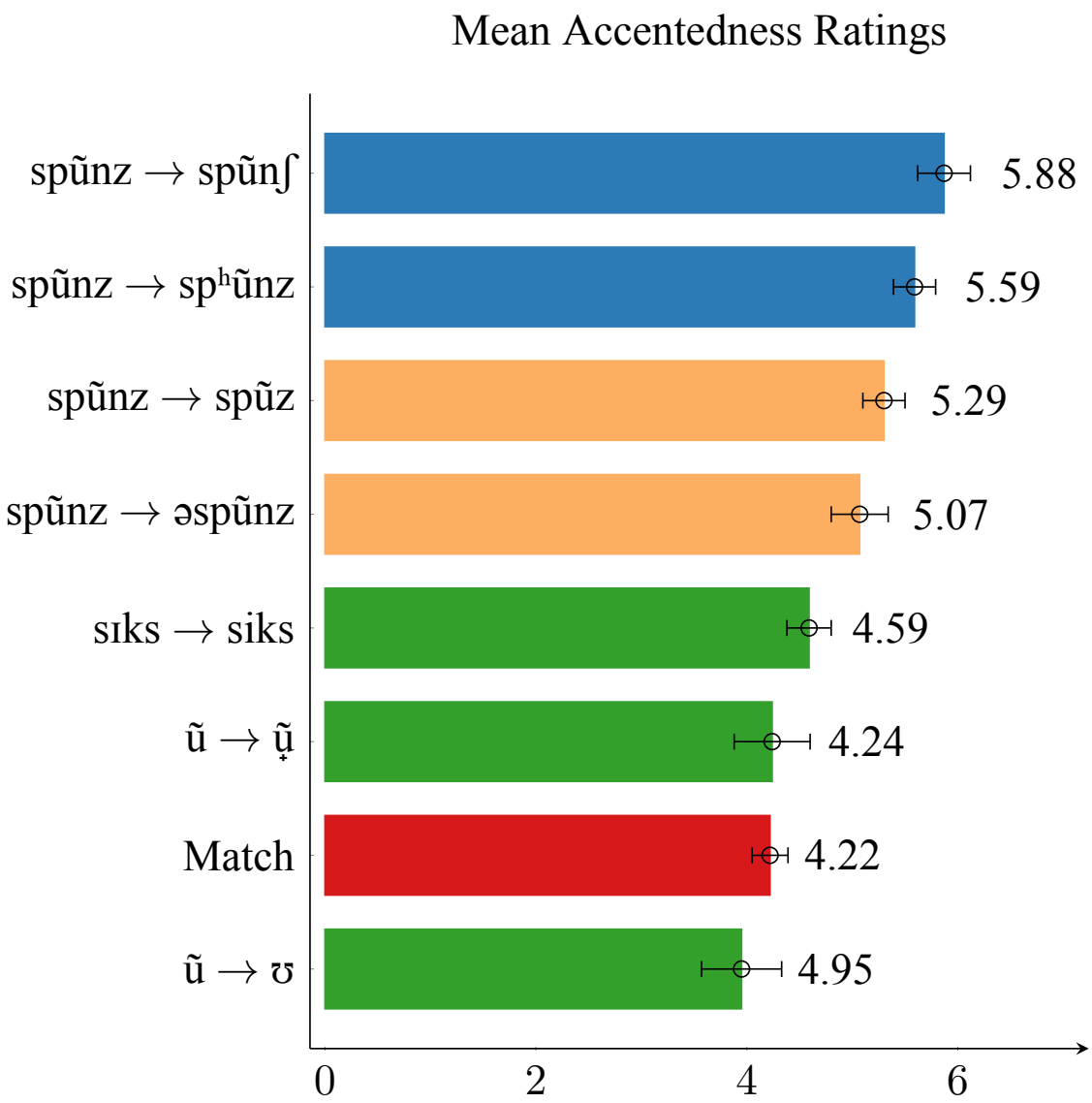
Experiment 2: Rankings (Ask her)



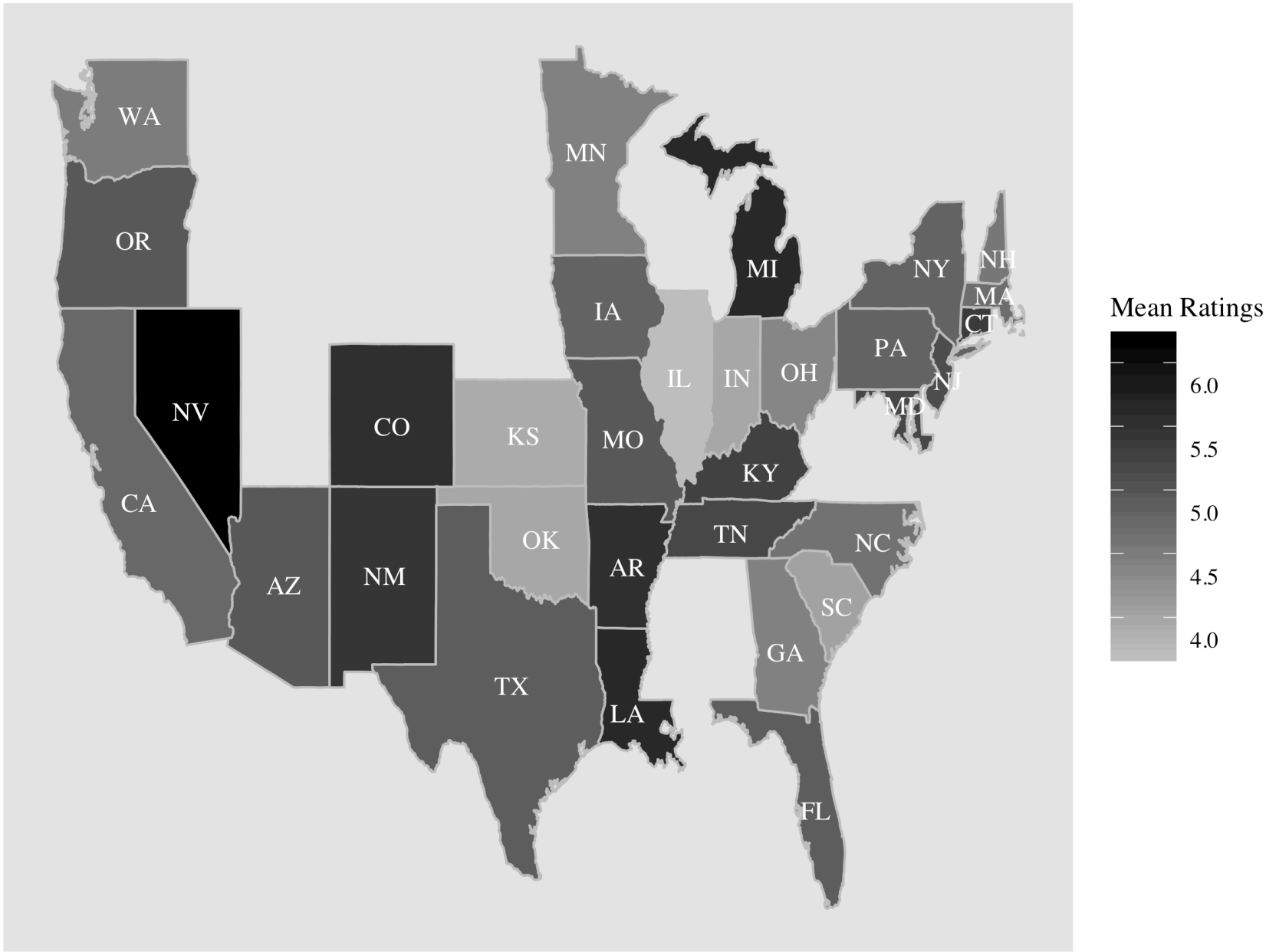
Experiment 2: Rankings (Small plastic)



Experiment 2: Rankings (Six spoons)



Ratings across the US: Experiment 1



Ratings across the US: Experiment 2