



GRADIENT MORPHOPHONOLOGY

Evidence from Uyghur
vowel harmony

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PHONOLOGY AND PHONETICS

- Phonology is often conceptualized as categorical sound patterns
 - For segments, this is typically defined in terms of discrete binary features over relatively abstract units (e.g. vowel, syllable, word)
- In contrast, phonetics is often regarded as the domain of gradient sound patterns
 - This involves translation of abstract symbols into continuous space and time

PHONOLOGY AND PHONETICS

- Gradience doesn't seem to be the essential dividing line between phonology and phonetics, though.
 - A number of putatively phonological processes have been shown to exhibit subphonemic gradience
 - word-final devoicing
 - nasal place assimilation
 - flapping
 - All of these have been analyzed as post-lexical

Morphophonemic alternations are at the very core of what most phonologists think of as phonology If these sorts of cases are shown to involve gradience, this would strike at the core of our understanding of the phonology, since these are the least disputable candidates for ‘being phonology’ (Cohn 2006:36)

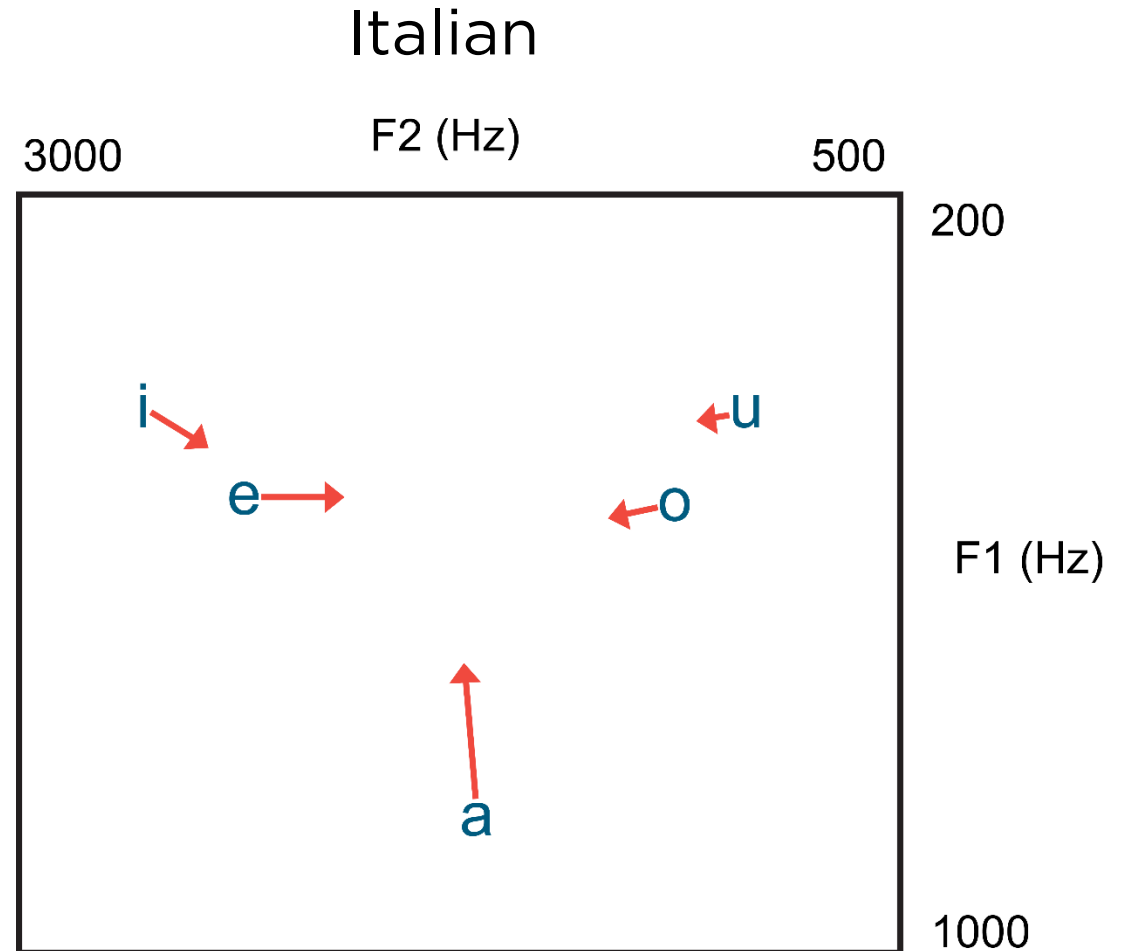
THE CLAIM

Uyghur vowel harmony exhibits morphophonological gradience that is not reducible to phonetic reduction or interpolation.

- As a result, morphophonological alternations may be gradient.

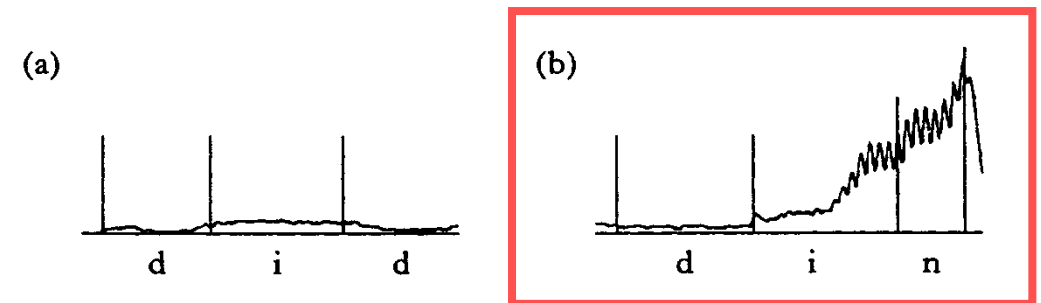
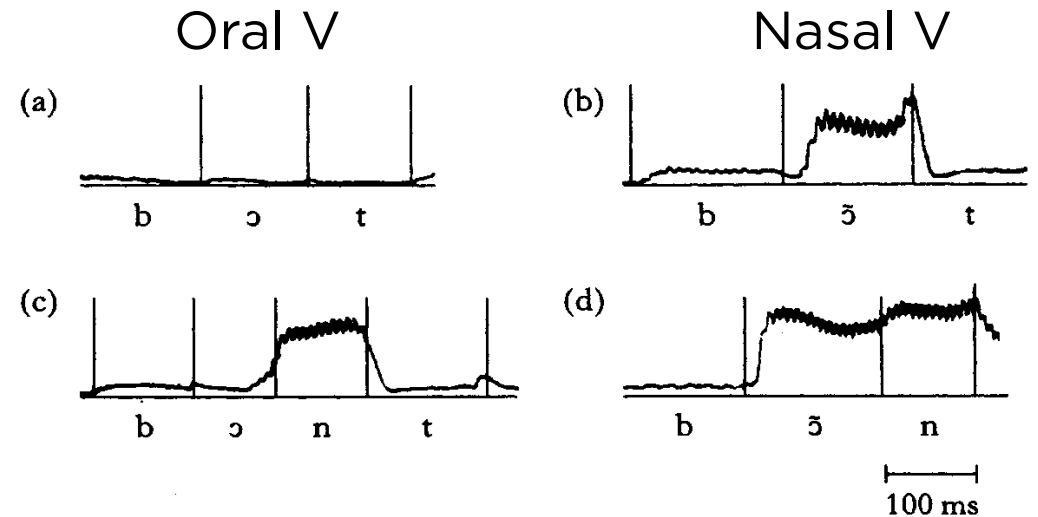
PHONETIC REDUCTION

- Phonetic reduction involves a gradient/incomplete neutralization of contrasts.
 - For vowels, this typically means **centralization**
 - Reduction of unstressed vowels in Italian



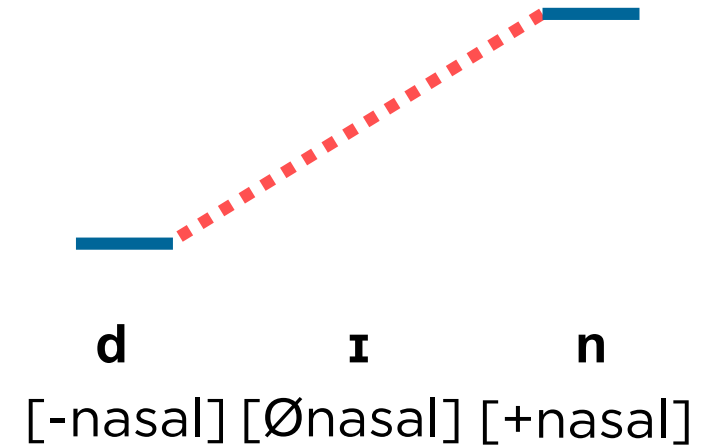
PHONETIC INTERPOLATION

- In French, vowel nasality is contrastive
 - Cohn (1993) finds that nasal airflow during vowels is characterized by **plateaus**.
- In English, vowel nasality is not contrastive
 - Nasal airflow during vowels is marked by gradient **clines**.



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UYGHUR VOWEL HARMONY

- Uyghur has a 9-vowel inventory: /ɑ æ (e) o ø u i u y/
- Uyghur exhibits two progressive vowel harmonies
 - backness harmony targets all non-initial vowels
 - rounding harmony targets non-final high vowels

Domain	Alternation	word	gloss	word	gloss
Root-internal	æ-ɑ	sællæ	'turban'	palta	'axe'
	y-u	jyɜym	'grape'	qurum	'soot'
Suffixal	æ-ɑ	bæl-lær	'waist-PL'	bal-lar	'honey-PL'
	i-u	bæl-din	'waist-ABL'	bal-dun	'honey-ABL'
	y-u	køl-ym	'lake-POSS.1S'	jol-um	'road-POSS.1S'

POSITIONAL EFFECTS ON VOWEL BACKNESS

- If Uyghur exhibits gradience, in acoustic terms, F2 should be significantly affected by position in the word (syllable #, counting from the left).

POSITIONAL EFFECTS ON VOWEL BACKNESS

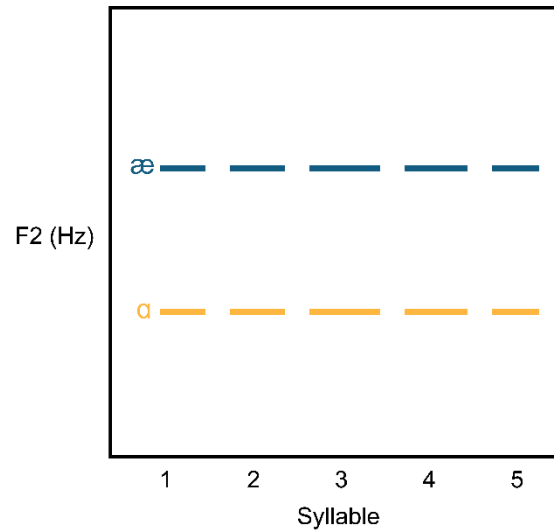
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ʃwɪwɪm-lwɪr-w-dwɪn ‘paste-PL-POSS.3-ABL’

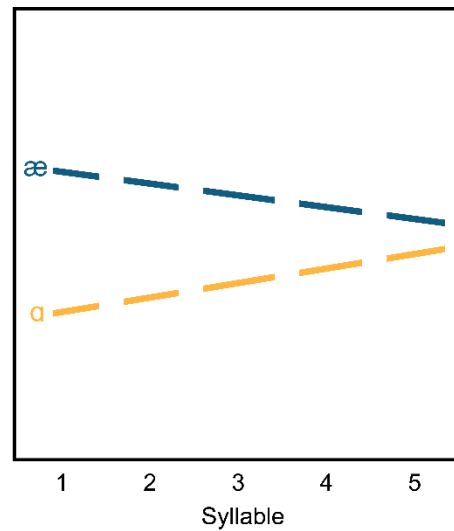
- If harmony is gradient, then F2 of [w] should vary by position
- If F2 does not differ by position, then harmony is categorical

POSITIONAL EFFECTS ON VOWEL BACKNESS

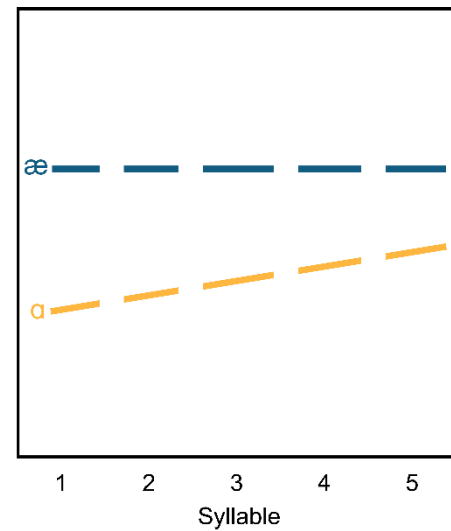
Categorical phonology



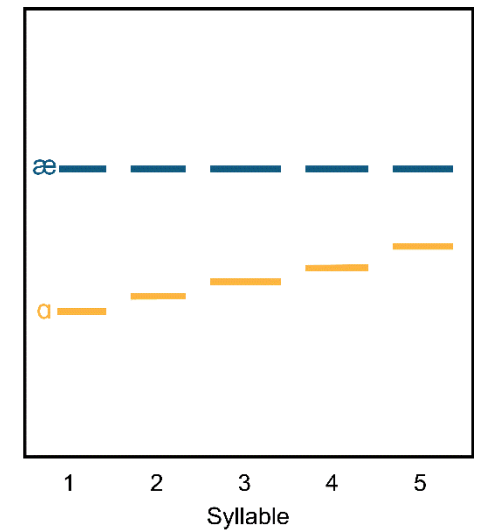
Phonetic centralization



Phonetic interpolation

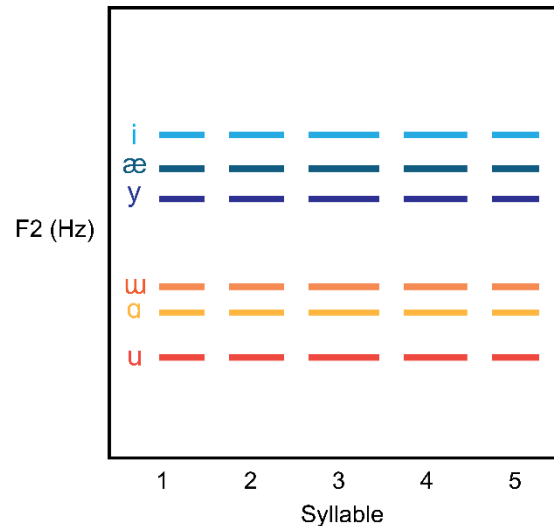


Gradient phonology



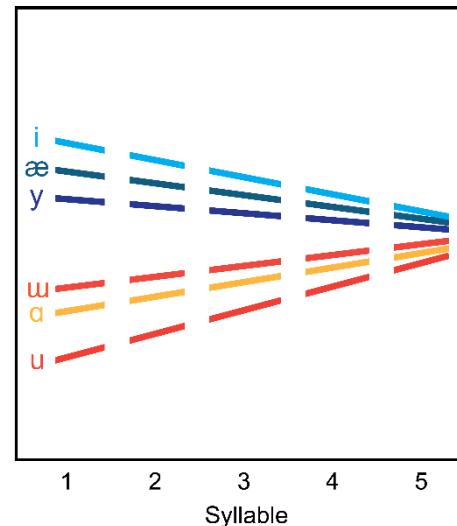
POSITIONAL EFFECTS ON VOWEL BACKNESS

Categorical phonology



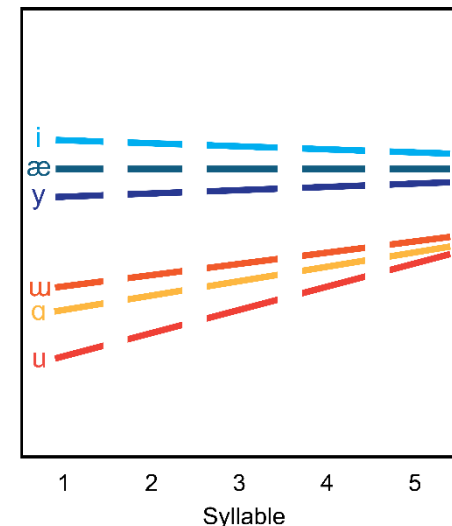
Turkish

Phonetic centralization



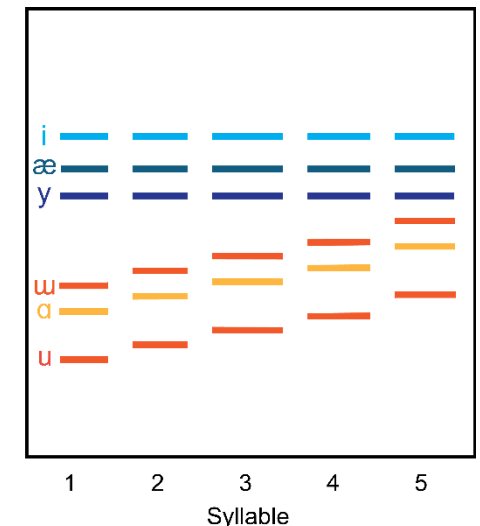
Italian,
Crimean Tatar

Phonetic interpolation



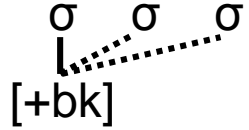
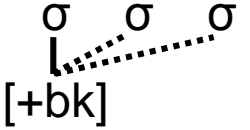
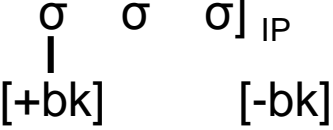
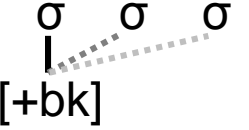

French,
English

Gradient phonology

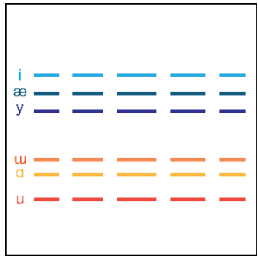
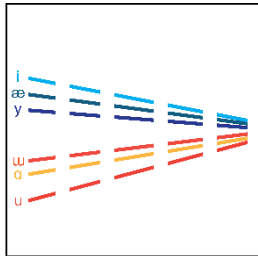
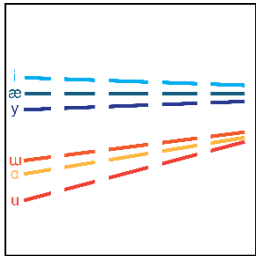
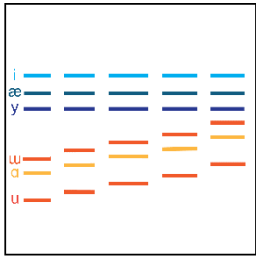


Uyghur

POSITIONAL EFFECTS ON VOWEL BACKNESS

	Categorical phonology	Phonetic centralization	Phonetic interpolation	Gradient phonology
PHONOLOGY	 <p>σ σ σ ••••• [+bk]</p>	 <p>σ σ σ ••••• [+bk]</p>	 <p>σ σ σ]_{IP} ••••• [+bk] [-bk]</p>	<p>[1] [0.7] [0.5]</p>  <p>σ σ σ ••••• [+bk]</p>
PHONETICS	no phonetic effects	gradient centralization	 <p>σ σ σ]_{IP} ••••• [+bk] [-bk]</p>	no phonetic effects

PREDICTIONS

	Categorical phonology	Phonetic centralization	Phonetic interpolation	Gradient phonology
				
Across-syllable effects	x	✓	✓	✓
Symmetrical	✓	✓	x	x
Converges on single target	x	✓	✓	x
Non-initial backness dictated by phonology	✓	✓	x	✓

METHODS

- Data was collected from 9 speakers (6 females; age range 19-63, mean 44.4) from Shonzhy, Kazakhstan
- Stimuli were shown as randomly ordered pictorial prompts
- Speakers were taught to associate certain visual cues with grammatical categories to produce paradigms
 - words varied in length between 1 and 5 syllables
 - PL, LOC, ABL, ACC, POSS.1, POSS.3 suffixes elicited
- Target words were produced in isolation as responses to pictorial prompts
- F1-F3 were measured at three points (25, 50, and 75%)
 - 6,751 vowel tokens were measured

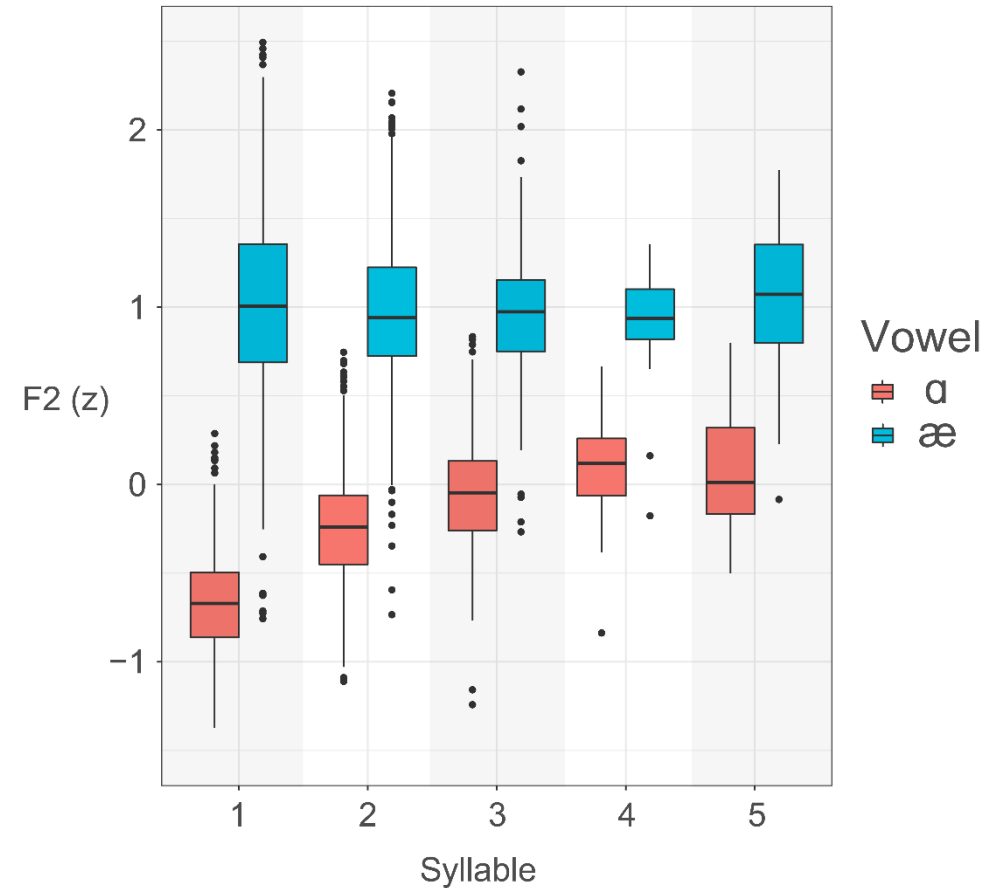
METHODS

- Results were analyzed using a linear mixed effects model

Dependent variable	Normalized F2 (at midpoint)	
Fixed effects	V1 backness Syllable Target height Preceding C place Following C place	V1 backness : V1 roundness V1 backness : Syllable V1 backness : Target height Target Height : Preceding C Place Target Height : Following C Place V1 backness : Syllable : Target Height
Random effects	Speaker Target vowel	

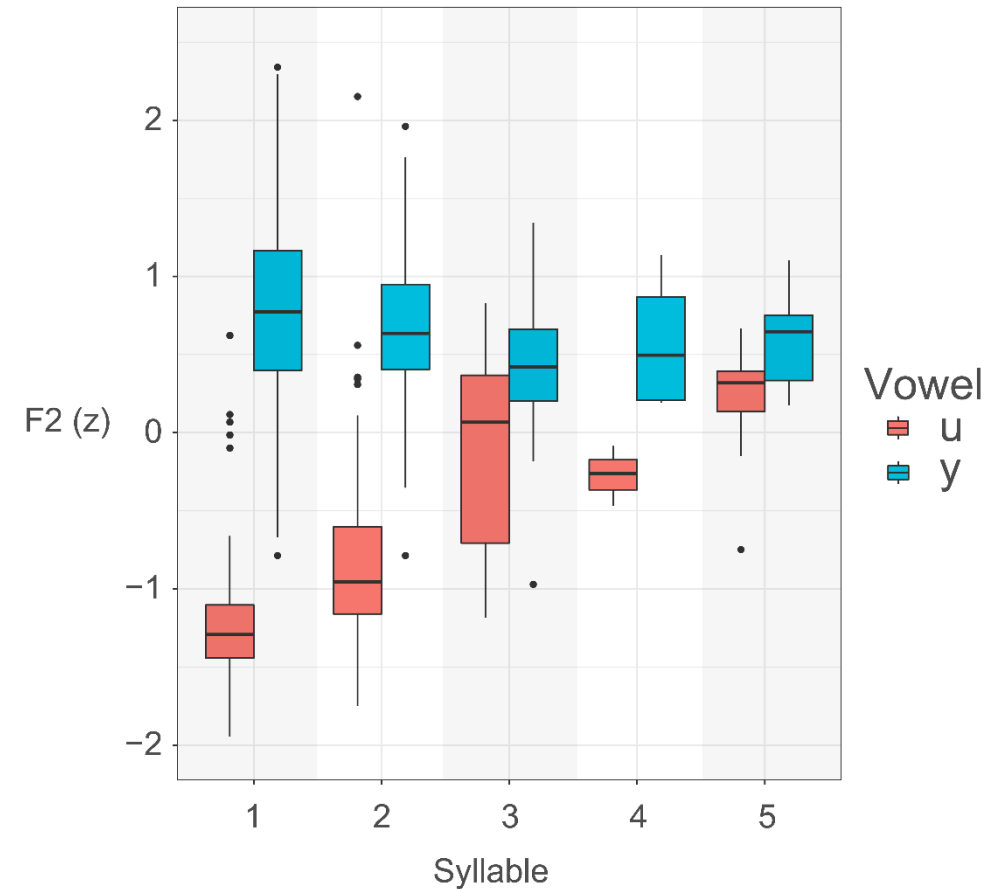
RESULTS

- F2 exhibits positional effects; specifically, F2 of back vowels shifts by position
 - Significant main effect of position, $\beta = -0.07$, $t(6,723) = -3.60$, $p < .001$
 - Significant interaction between position and vowel backness, $\beta = 0.23$, $t(6,721) = 11.04$, $p < .0001$



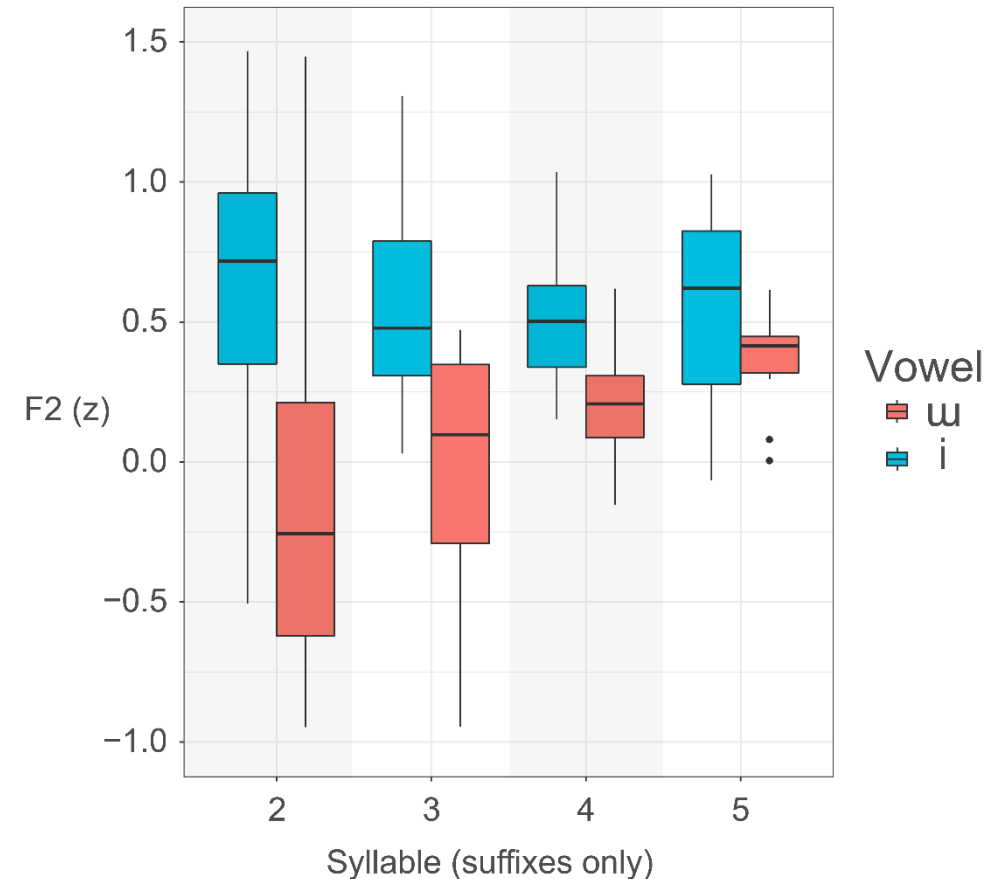
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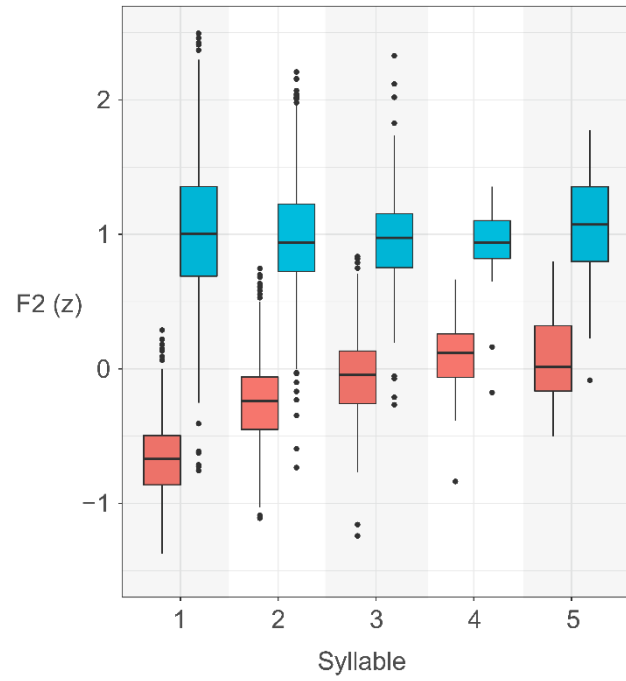
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 - *Root-internal /i/ and /u/ were not included due to other phonological factors

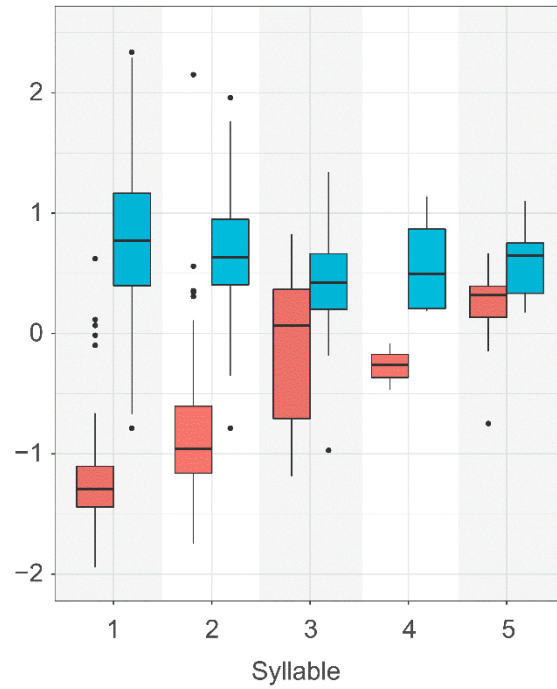


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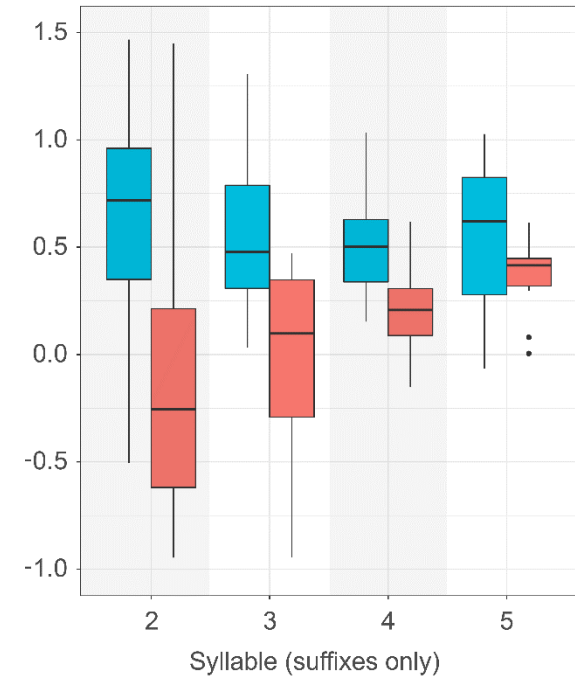
ɑ - æ




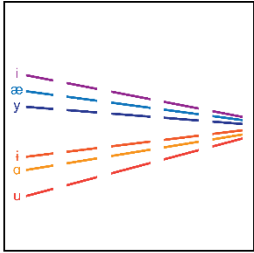
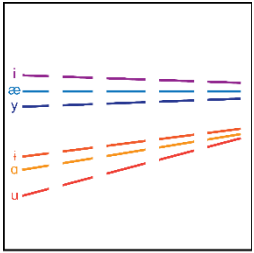
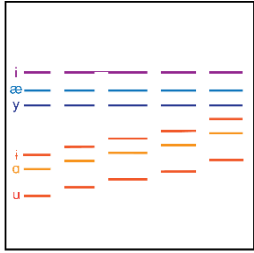
u - y



ω - i

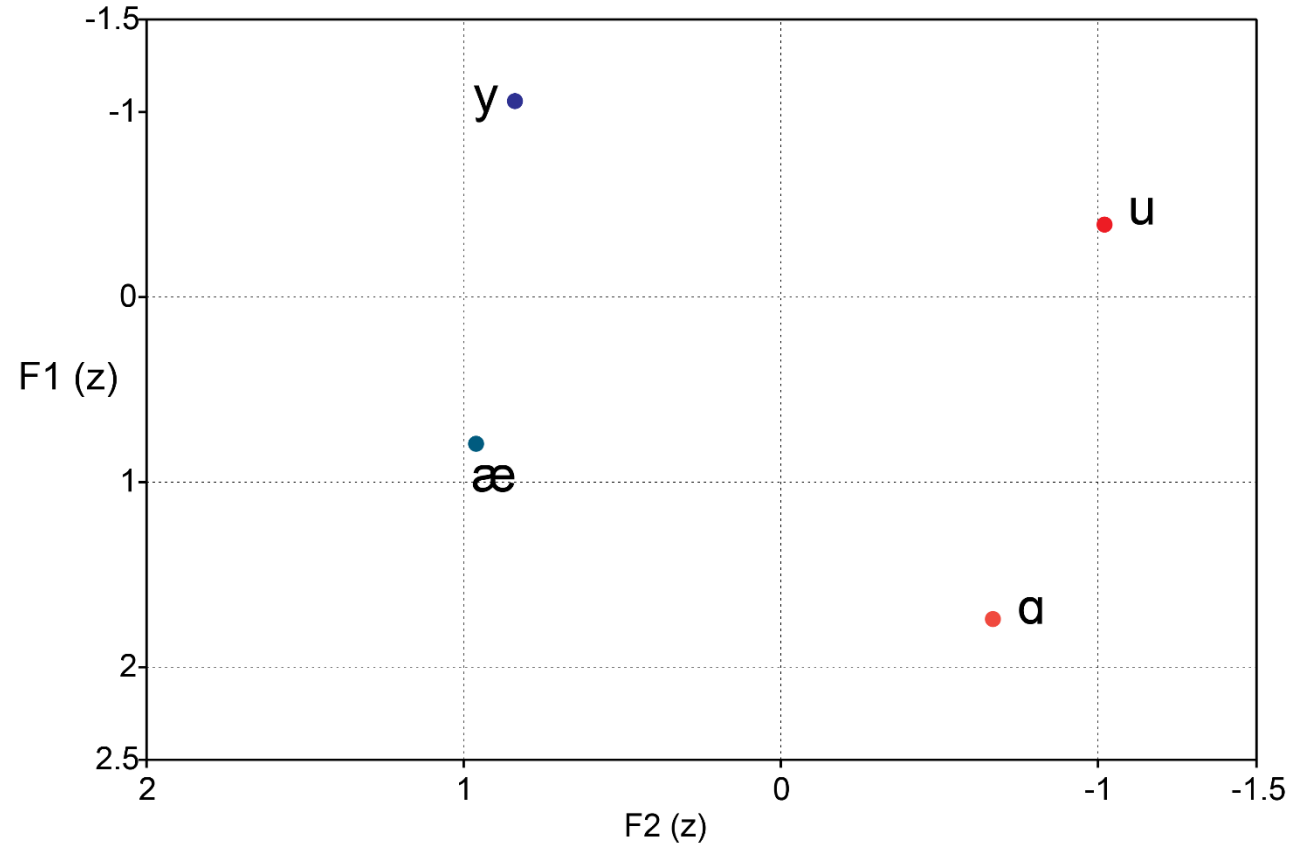


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Across-syllable effects	x	✓	✓	✓	✓
Symmetrical	✓	✓	x	x	x
Converges on a single target	x	✓	✓	x	
Non-initial backness dictated by phonology	✓	✓	x	✓	

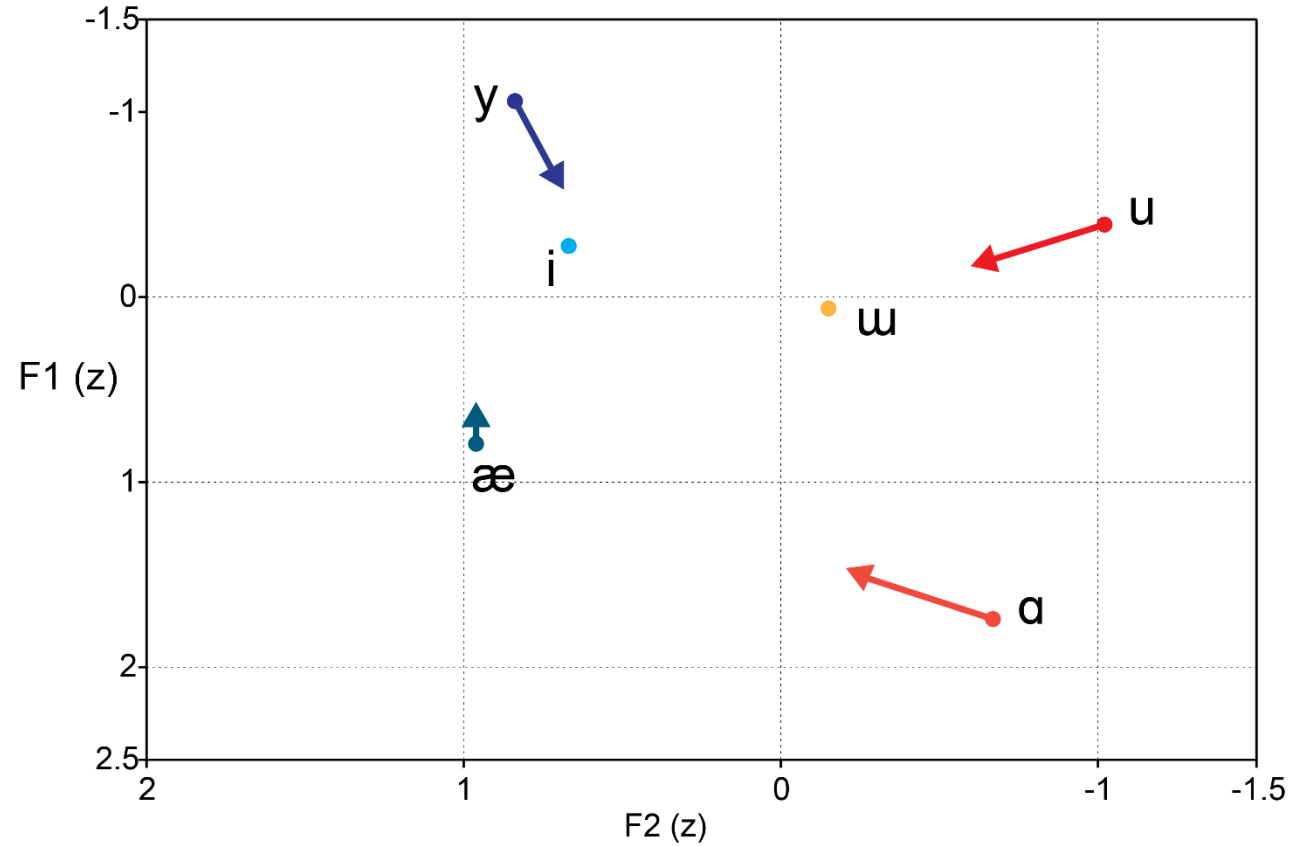
PHONOLOGY OR PHONETICS?

- Centralization or interpolation?
 - If this is centralization or interpolation to a default articulatory setting, the trajectory of each vowel's positional shift should converge on a single target.



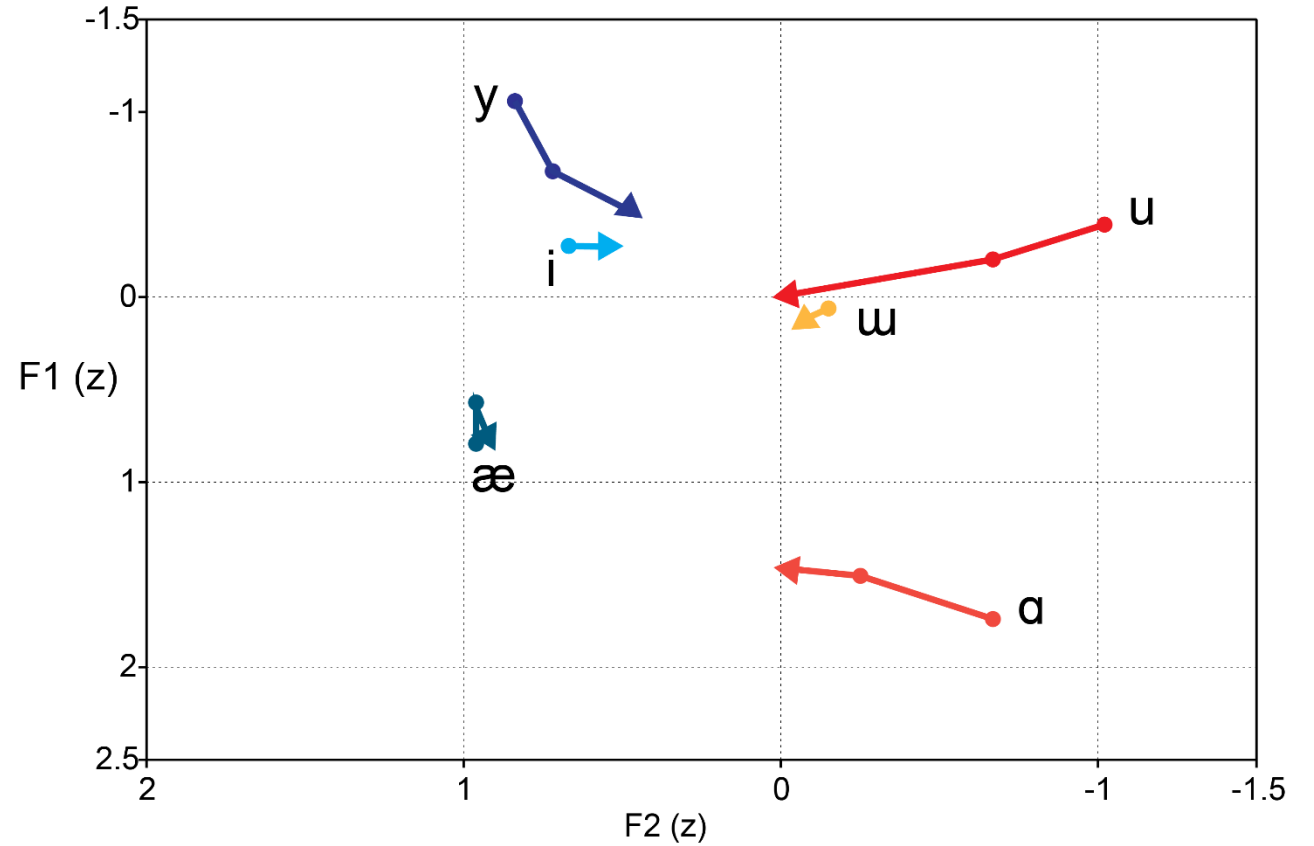
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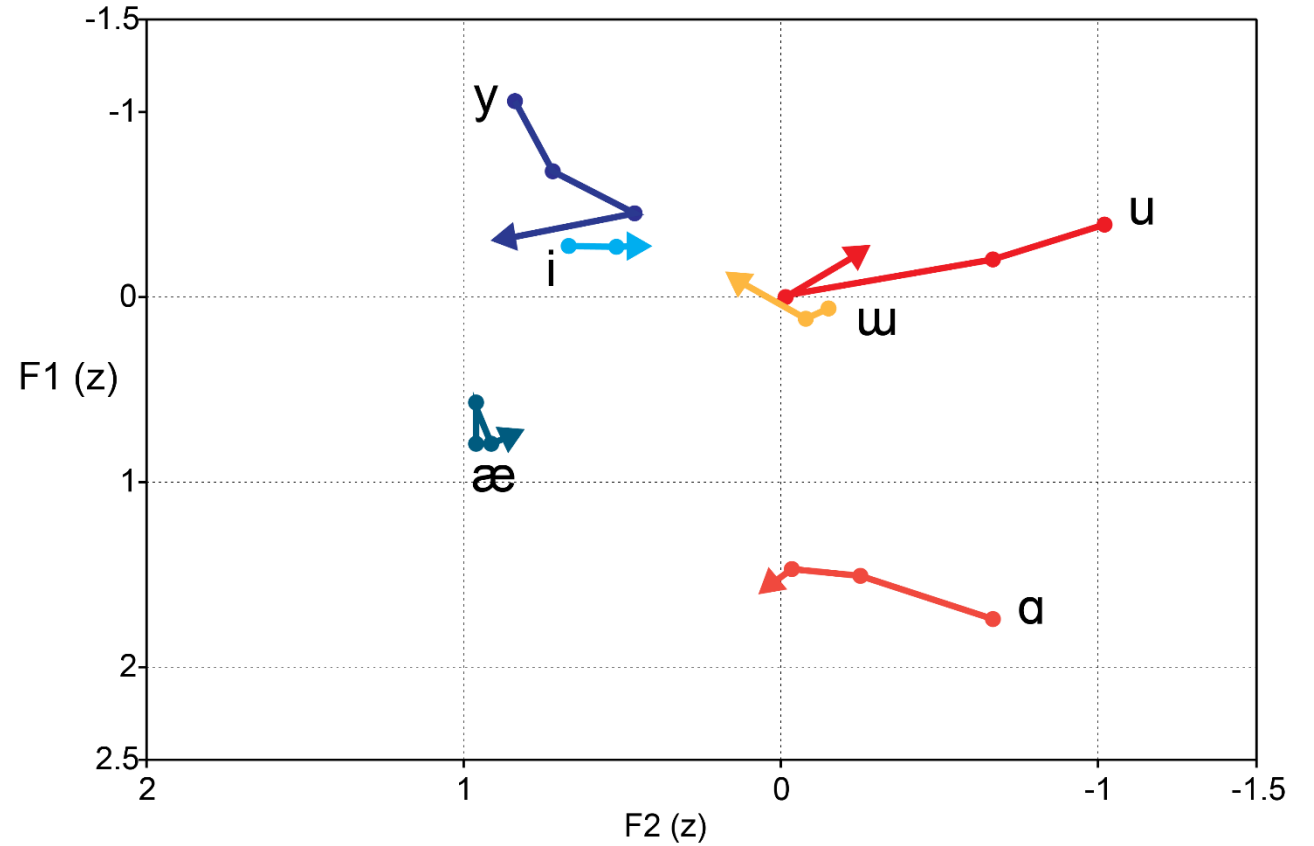
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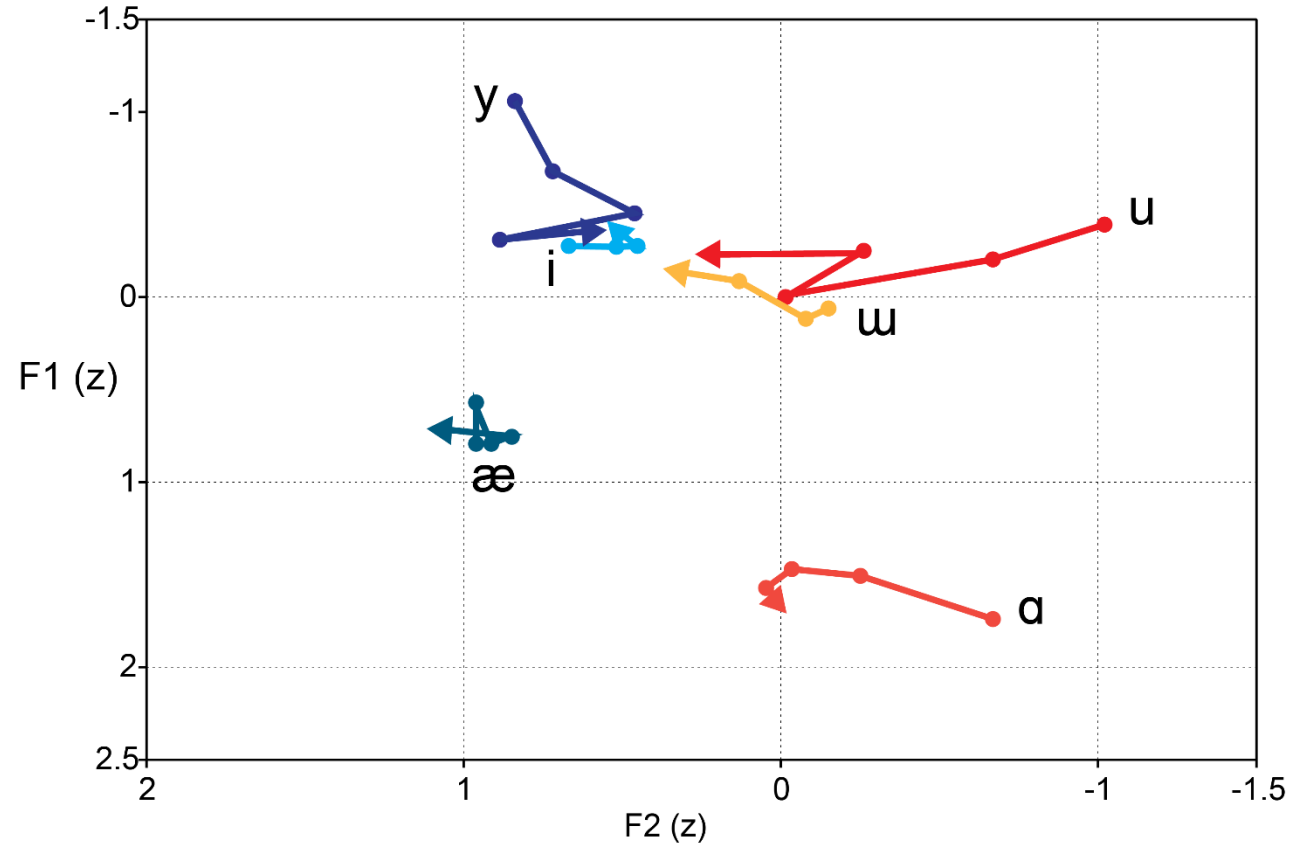
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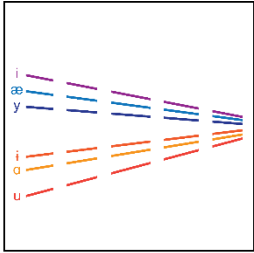
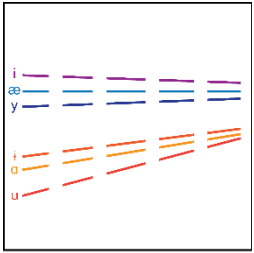
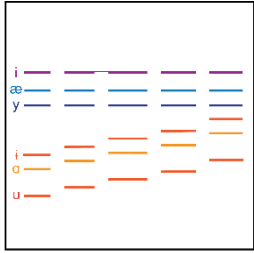


PHONOLOGY OR PHONETICS?

- Centralization or interpolation?
 - If this is centralization or interpolation to a default articulatory setting, the trajectory of each vowel's positional shift should converge on a single target.
- There is no clear target that all vowels converge on.
 - Note especially the low vowels.



PREDICTIONS

	Categorical phonology	Phonetic centralization	Phonetic interpolation	Gradient phonology	Uyghur
					
Across-syllable effects	x	✓	✓	✓	✓
Symmetrical	✓	✓	x	x	x
Converges on a single target	x	✓	✓	x	x
Non-initial backness dictated by phonology	✓	✓	x	✓	

PHONOLOGY OR PHONETICS?

- If these positional effects are due to phonetic interpolation, then all non-initial vowels lack a [back] specification during phonology
- There are two pieces of evidence that argue against this-consonant alternations and word-final high vowels
 - Non-initial vowels, just like initial vowels, trigger alternations (e.g. g-ɤ, and l-ɫ)

bæɫ-gæ

‘waist-DAT’

baɫ-ɤa

‘honey-DAT’

bæɫ-læɫ-gæ

‘waist-PL-DAT’

baɫ-ɫaɫ-ɤa

‘honey-PL-DAT’

PHONOLOGY OR PHONETICS?

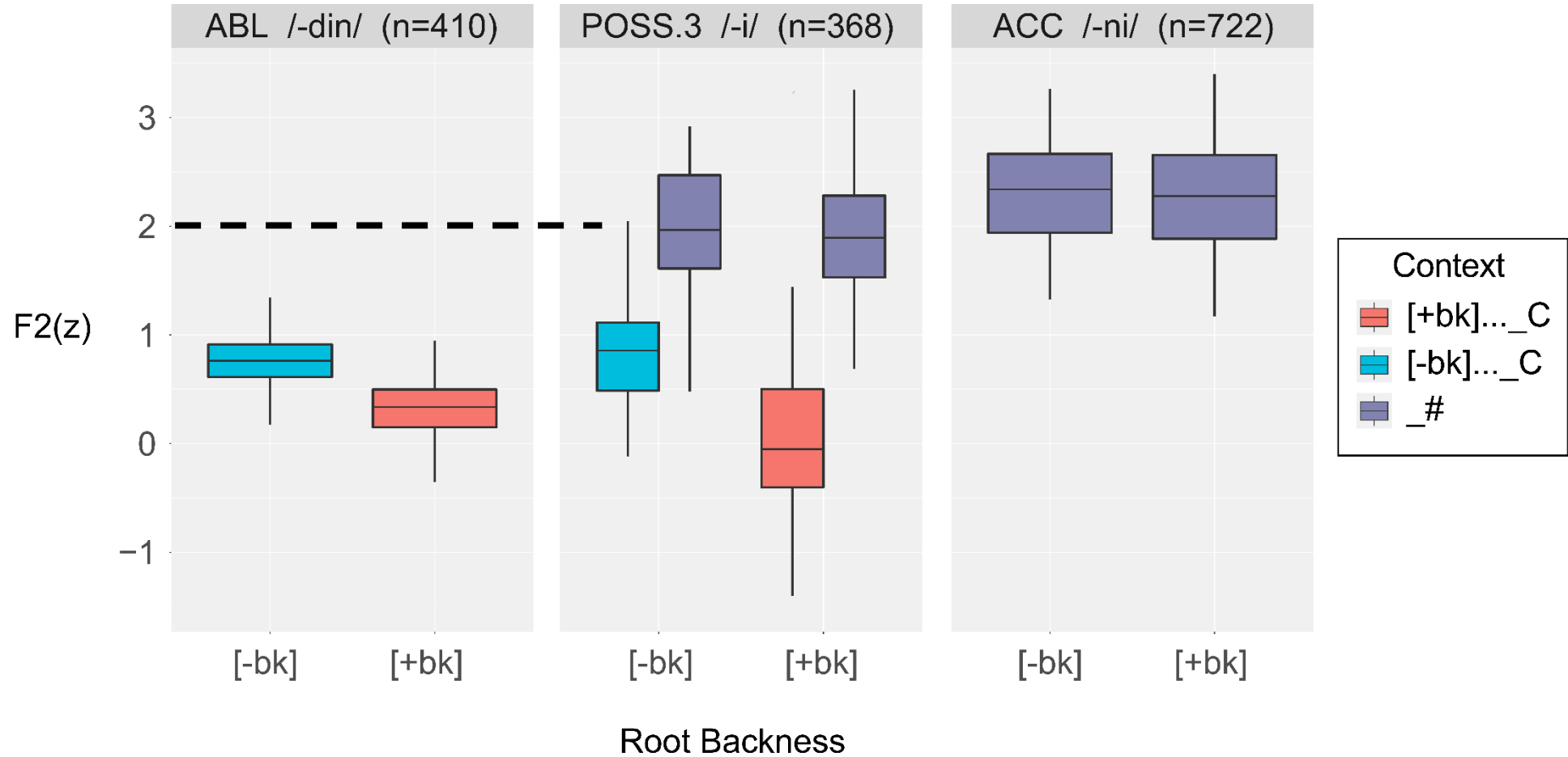
- High vowels alternate for both backness and rounding when they are word-medial.

bæɫ-i-dæ	‘waist-POSS.3-LOC’	bal-w-da	‘honey-POSS.3-LOC’
køɫ-y-dæ	‘lake-POSS.3-LOC’	jol-u-da	‘road-POSS.3-LOC’

- But word-finally, high vowels surface as a very peripheral [i] regardless of root backness and roundness

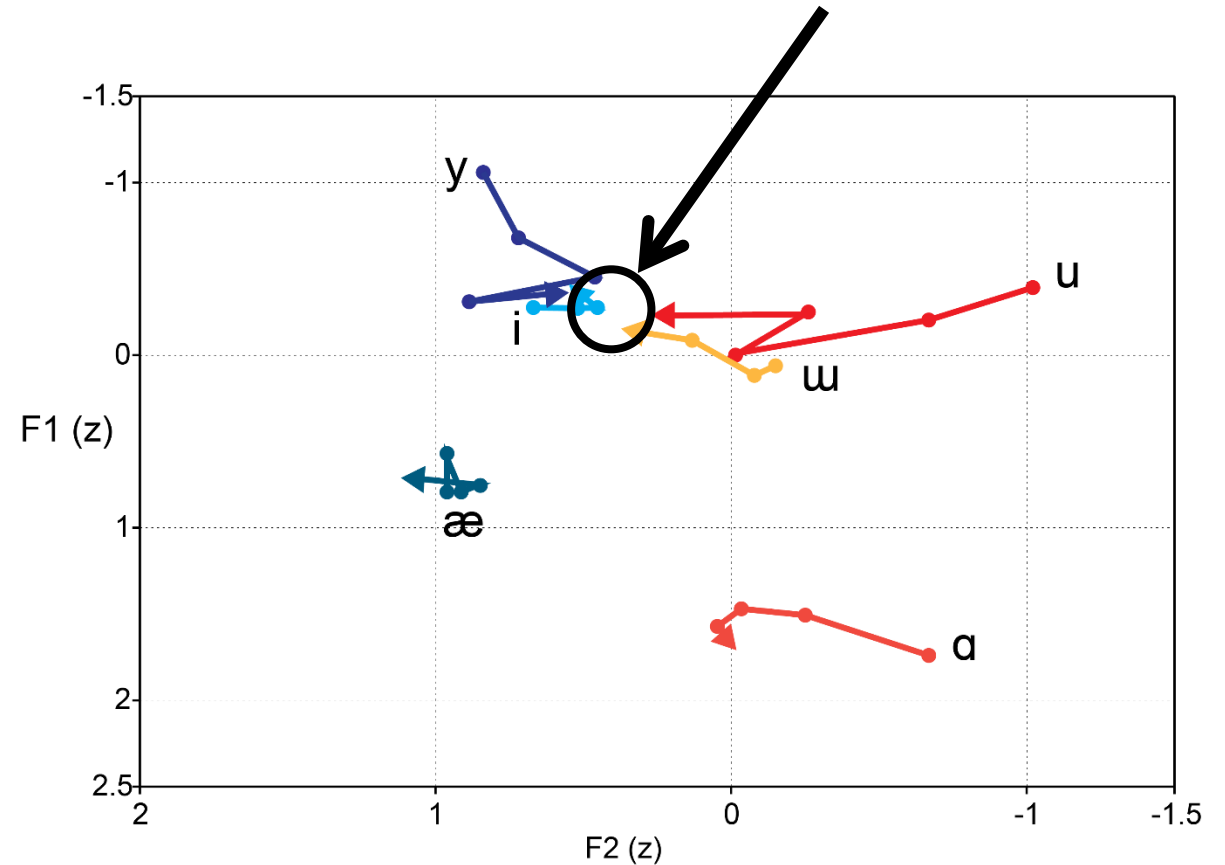
bæɫ-i		‘waist-POSS.3’	bal-i	*bal-w	‘honey-POSS.3’
køɫ-i	*køɫ-y	‘lake-POSS.3’	jol-i	*jol-u	‘road-POSS.3’

PHONOLOGY OR PHONETICS?



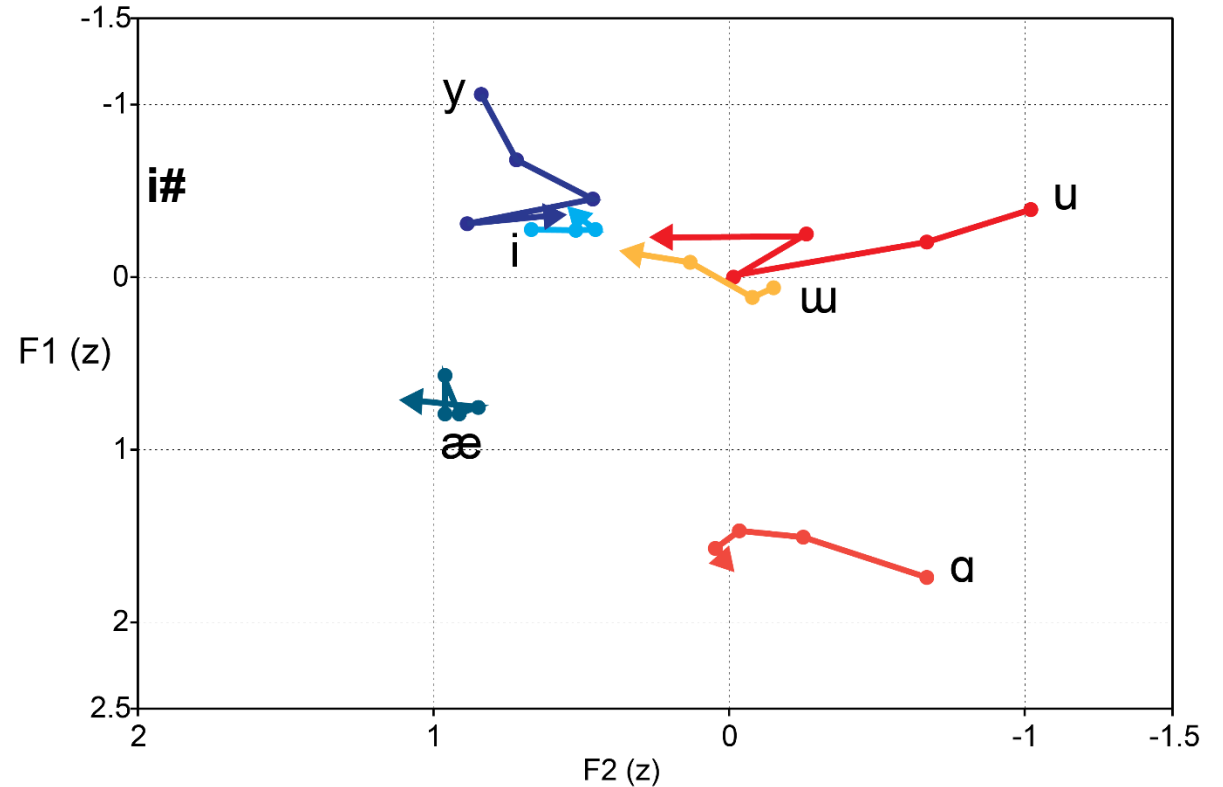
PHONOLOGY OR PHONETICS?

- Phonetic interpolation?
 - If these effects are due to interpolation, a word-final high vowel should approximate F1-F2 of the target articulatory rest position.
 - We would probably predict it to be somewhere around between [i] and [ɯ].



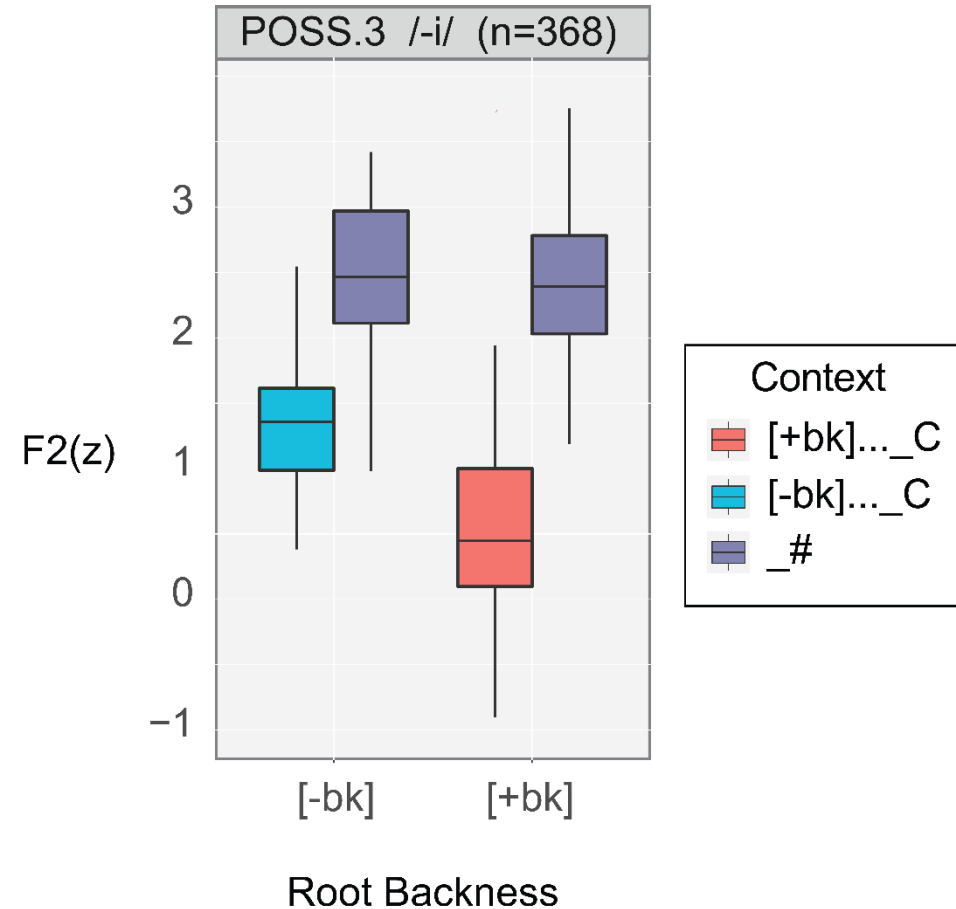
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 - We would probably predict it to be somewhere around between [i] and [ɯ].
- But this is not how i# surfaces.


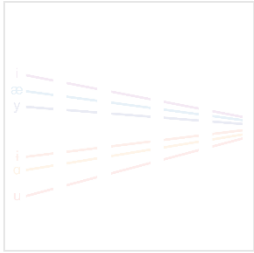

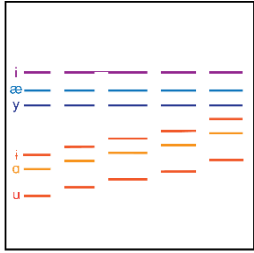


PHONOLOGY OR PHONETICS?

- If the realization of POSS.3 in word-final position is not due to interpolation, its realization word-medially is not either
- If the behavior of POSS.3 word-medially is not due to interpolation, and its behavior is mirrored by all other harmonic vowels, then there is no clear evidence for interpolation



PREDICTIONS

	Categorical phonology	Phonetic centralization	Phonetic interpolation	Gradient phonology	Uyghur
					
Across-syllable effects	x	✓	✓	✓	✓
Symmetrical	✓	✓	x	x	x
Converges on a single target	x	✓	✓	x	x
Non-initial backness dictated by phonology	✓	✓	x	✓	✓

GRADIENT PHONOLOGY

- Acoustic evidence suggests that [+back] is the active feature value, and it spreads gradiently.
- In addition, the behavior of word-final high vowels further suggests that [-back] is the unmarked or underlying feature value.
- Backness harmony in Uyghur is gradient.

GRADIENT PHONOLOGY

- Is this result an artefact of recording words in isolation?
 - That is what a gradient interpolation account would predict.
 - This same gradient vowel harmony has been found in neighboring Kazakh, and has been replicated in three different phrasal contexts.

IS THIS PATTERN ATTESTED ELSEWHERE?

- Data from Hungarian shows the same pattern
 - It has also been argued that in Hungarian [+back] is the active feature value.
- Gradient vowel harmonies are described in at least three Bantu languages
 - Ikoma ATR harmony
 - Kirangi ATR harmony
 - Yeyi labial harmony
- Gradient vowel-consonant harmony is attested in Papantla Totonac

RAMIFICATIONS OF GRADIENT PHONOLOGY

- If morphophonological alternations can be gradient, what impact does this have on our conception of phonology?
 - Representations, potentially both underlying and surface, may be continuous rather than discrete.
 - Gradient representations can easily be incorporated into formalisms like HG and GSC.

RAMIFICATIONS OF GRADIENT PHONOLOGY

- If morphophonological alternations can be gradient, what impact does this have on our conception of phonology?
 - By incorporating gradience into our formalisms, we can account for problematic cases of incomplete neutralization and differentiate between epenthetic and intrusive vowels.
 - This should guide new work examining the role of phonological gradience from acoustic, articulatory, psycholinguistic, and formal perspectives.

THANK YOU!

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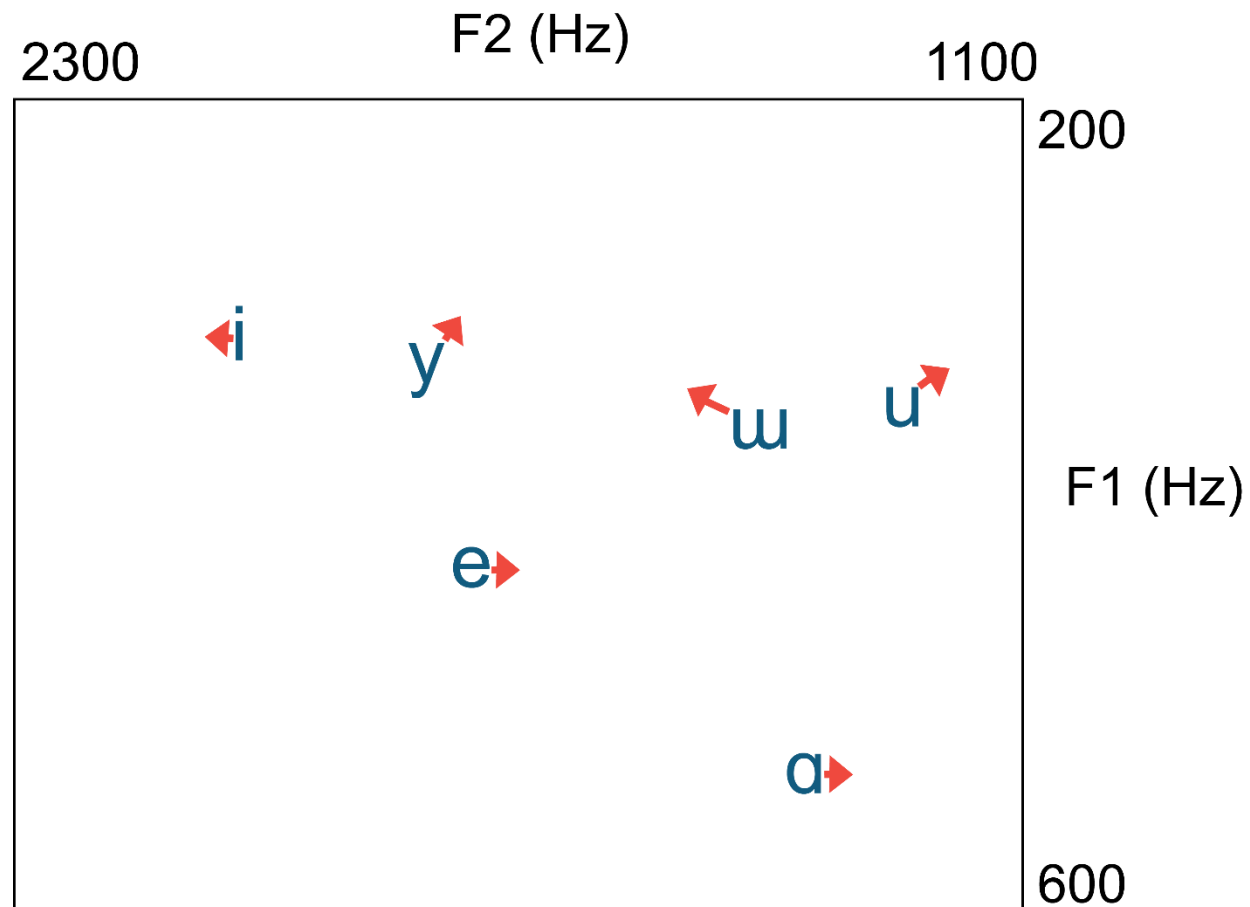
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APPENDIX

1. Turkish vowel plots
2. Crimean Tatar vowel plots
3. Potential within-syllable differences between interpolation and gradient phonology

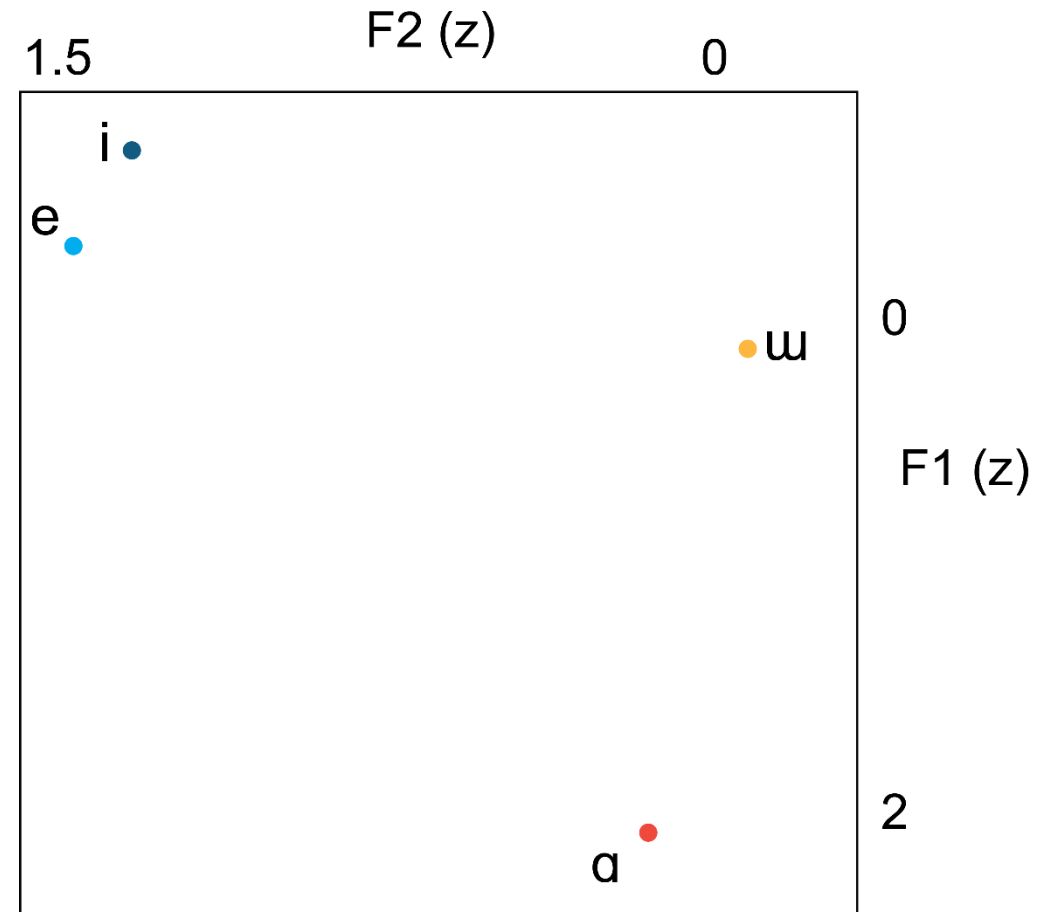
TURKISH VOWEL HARMONY

- Turkish vowels exhibit no obvious positional shifts by position.



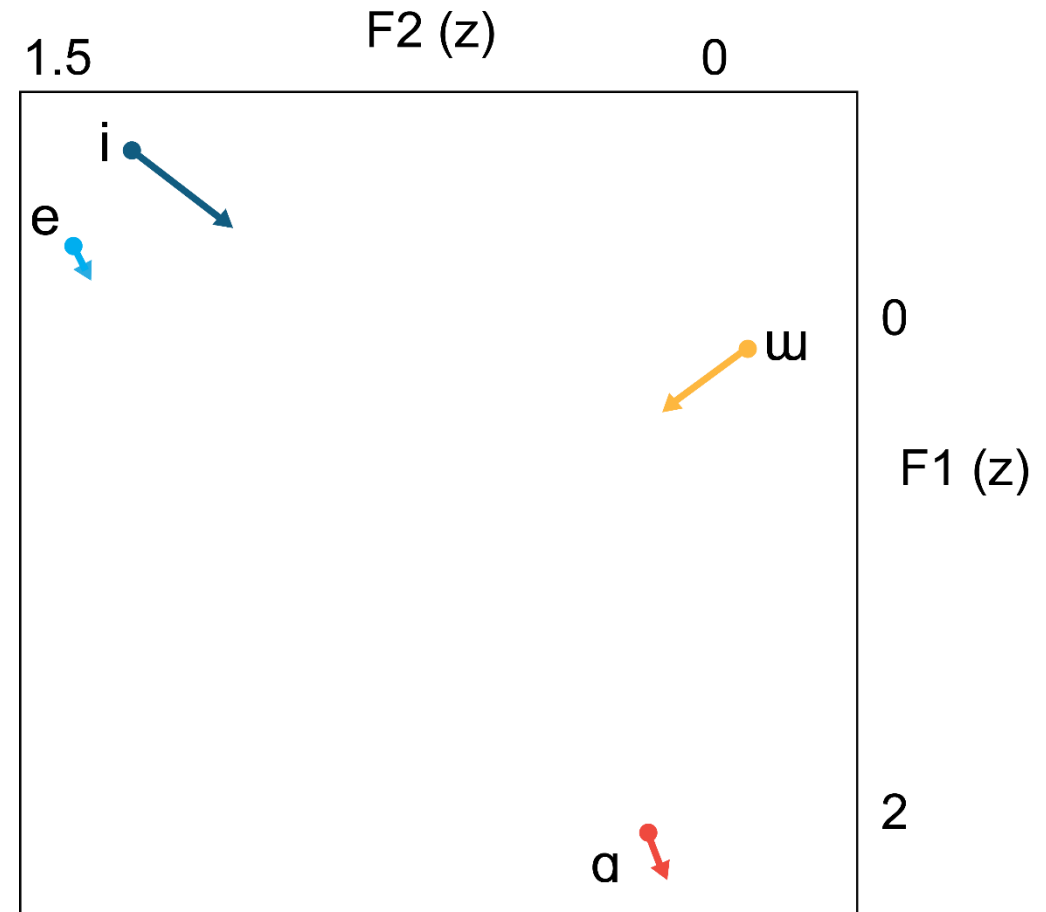
CRIMEAN TATAR VOWEL HARMONY

- Crimean Tatar vowels exhibit centralization by-position.



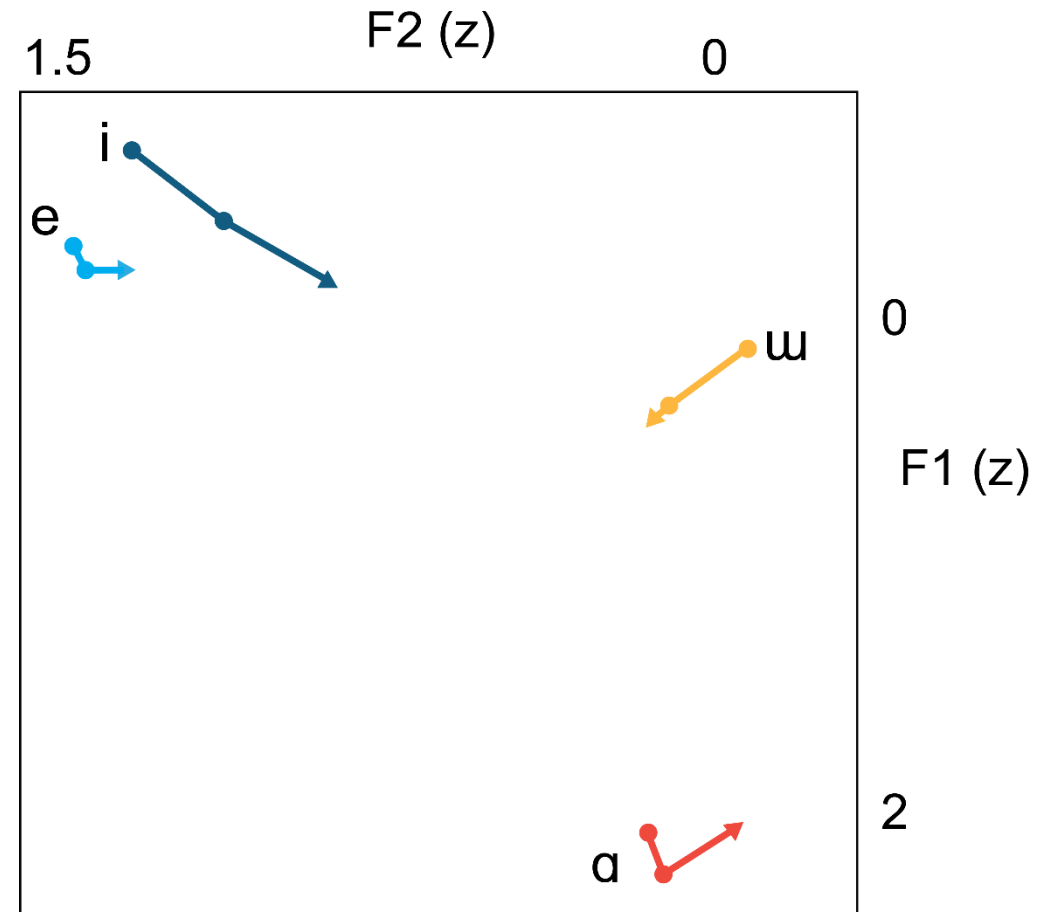
CRIMEAN TATAR VOWEL HARMONY

- Crimean Tatar vowels exhibit centralization by-position.



CRIMEAN TATAR VOWEL HARMONY

- Crimean Tatar vowels exhibit centralization by-position.

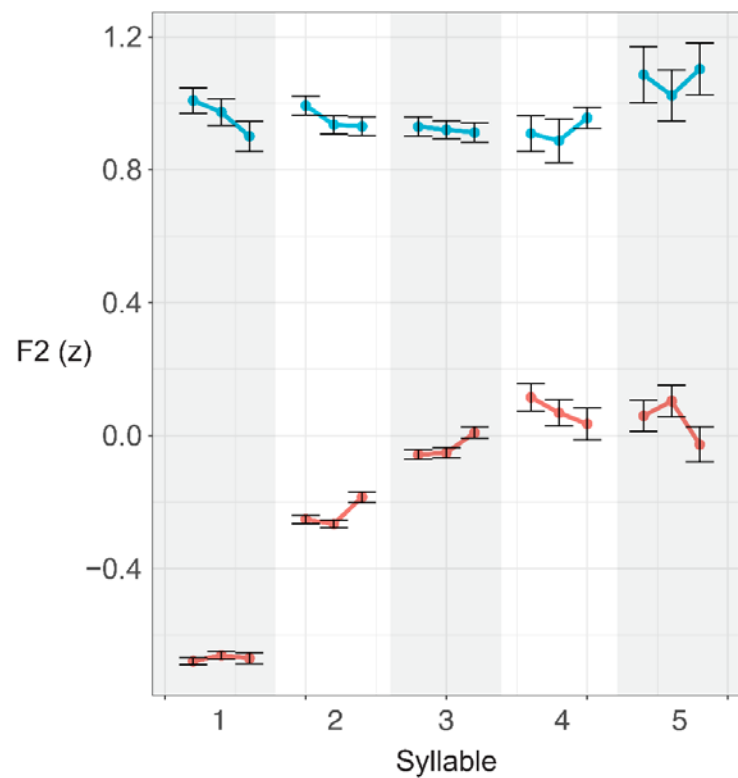


PHONOLOGY OR PHONETICS?

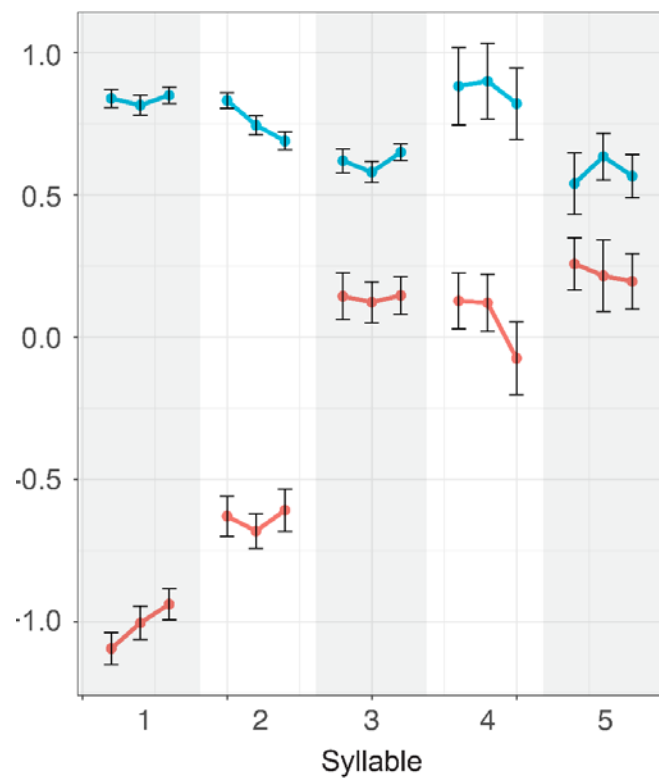
- Phonetic interpolation?
 - If this is interpolation, we might also expect that F2 should shift both within- and across-syllables (**clines**).
- Gradient phonology?
 - If this is phonological, we might expect to find across-syllable shifts in F2, but **plateaus** within-syllables.

PHONOLOGY OR PHONETICS?

ɑ - æ



u - y



ω - i

