What can vowel formant trajectories tell us about language change?

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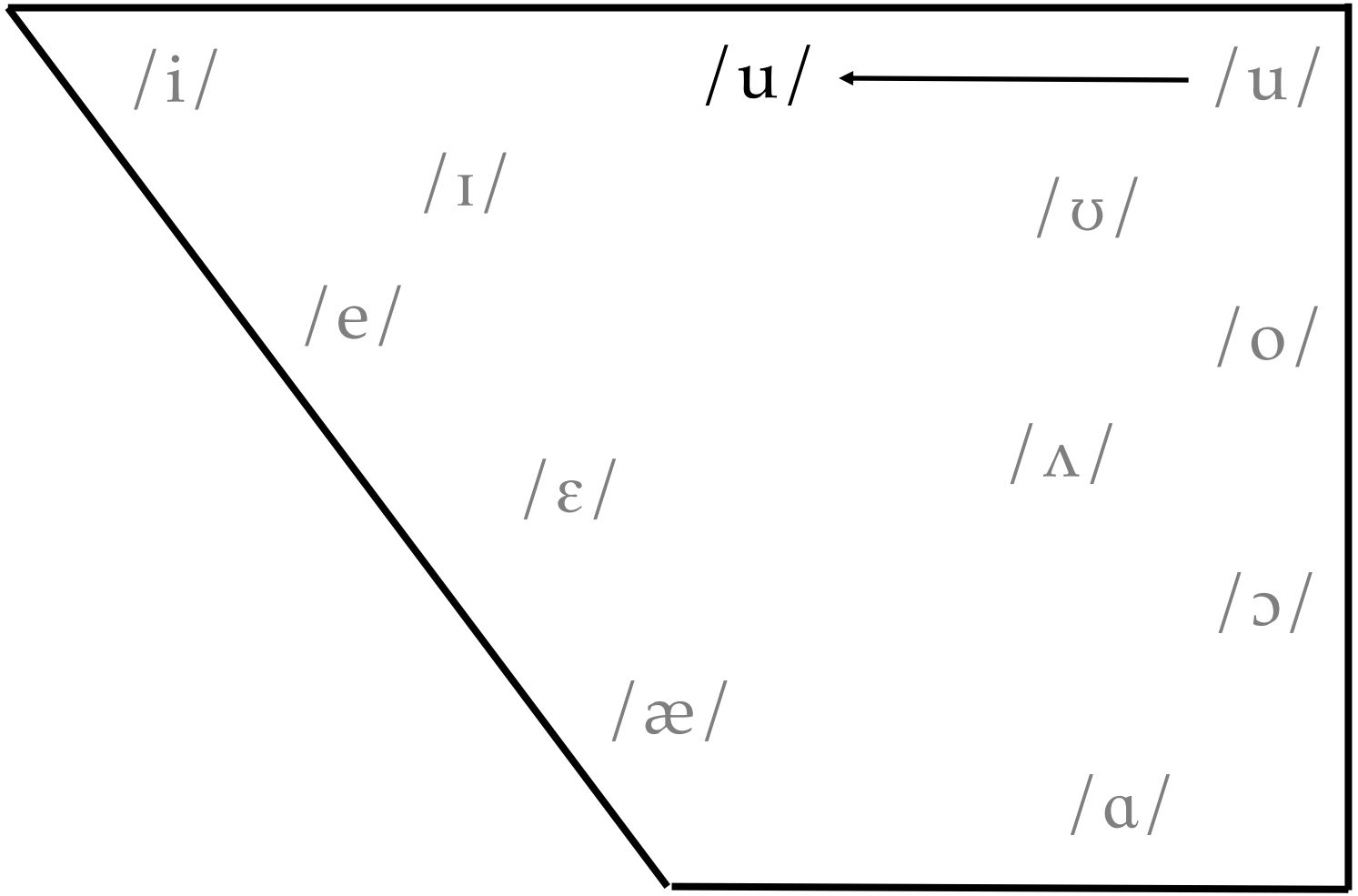
Vowels, Vowels, Vowels

- American English vowels are variable in pronunciation.

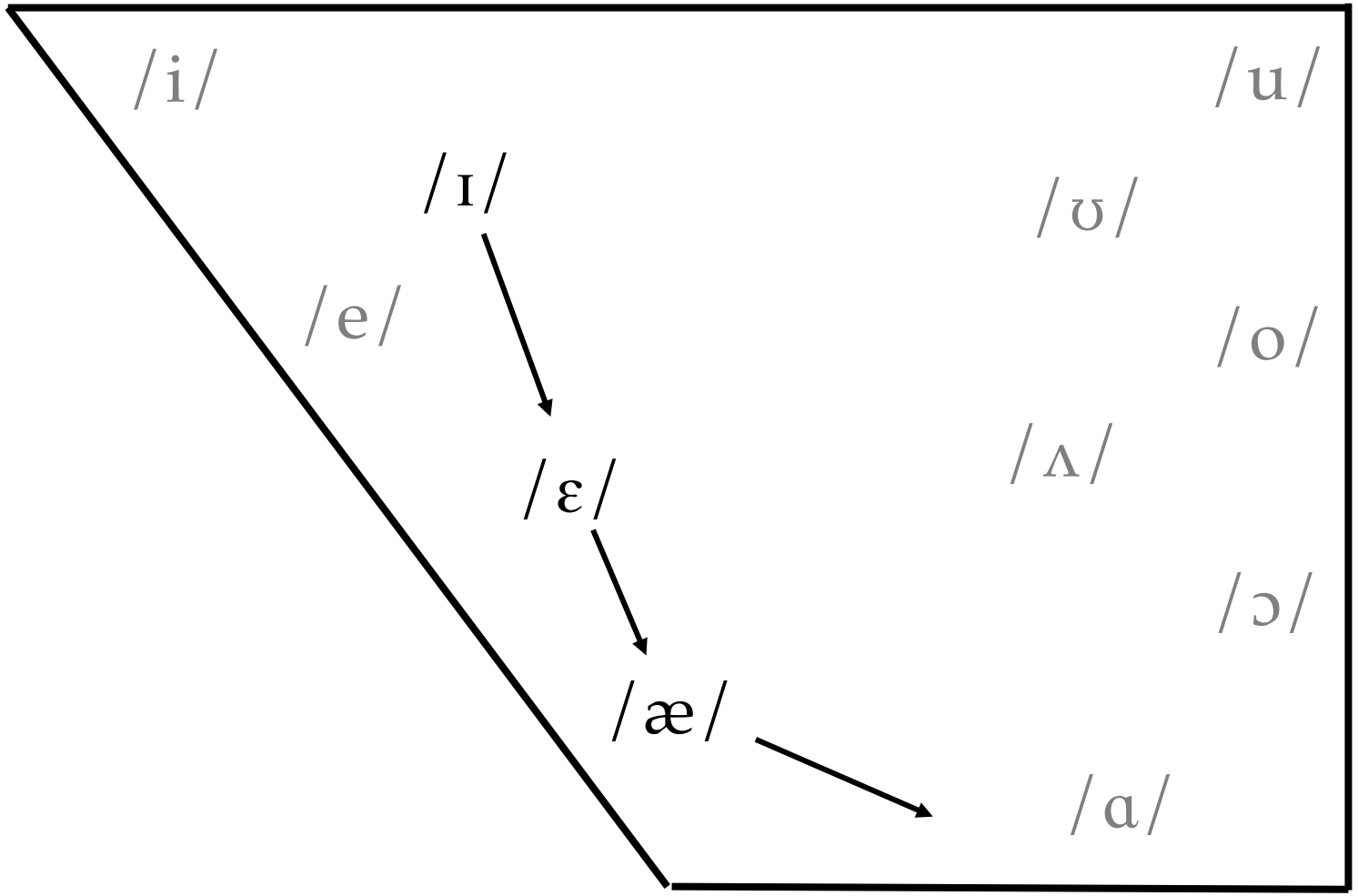
- We can categorize these differences:
  - Shifts
    - My students pronounce /æ/ as lower and more centralized than I do
    - I pronounce /u/ fronter than my grandparents do.
  - Mergers
    - For me, *cot* and *caught* are distinct; for 95% of my students, they're homophones
    - In Utah, *feel* and *fill* are often pronounced the same

- Language change happens as some variants spread to more and more people.

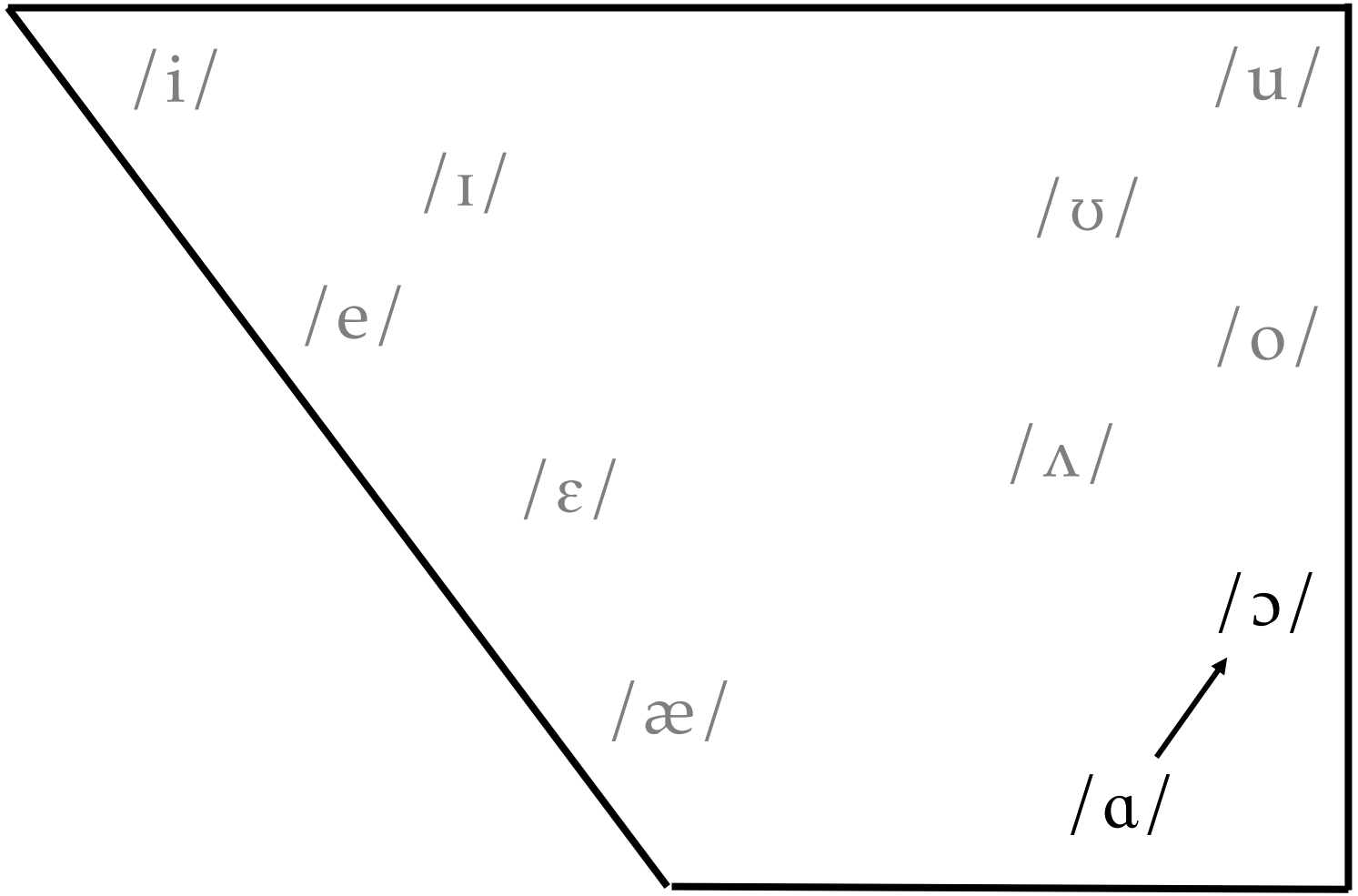
Vowel Shifts

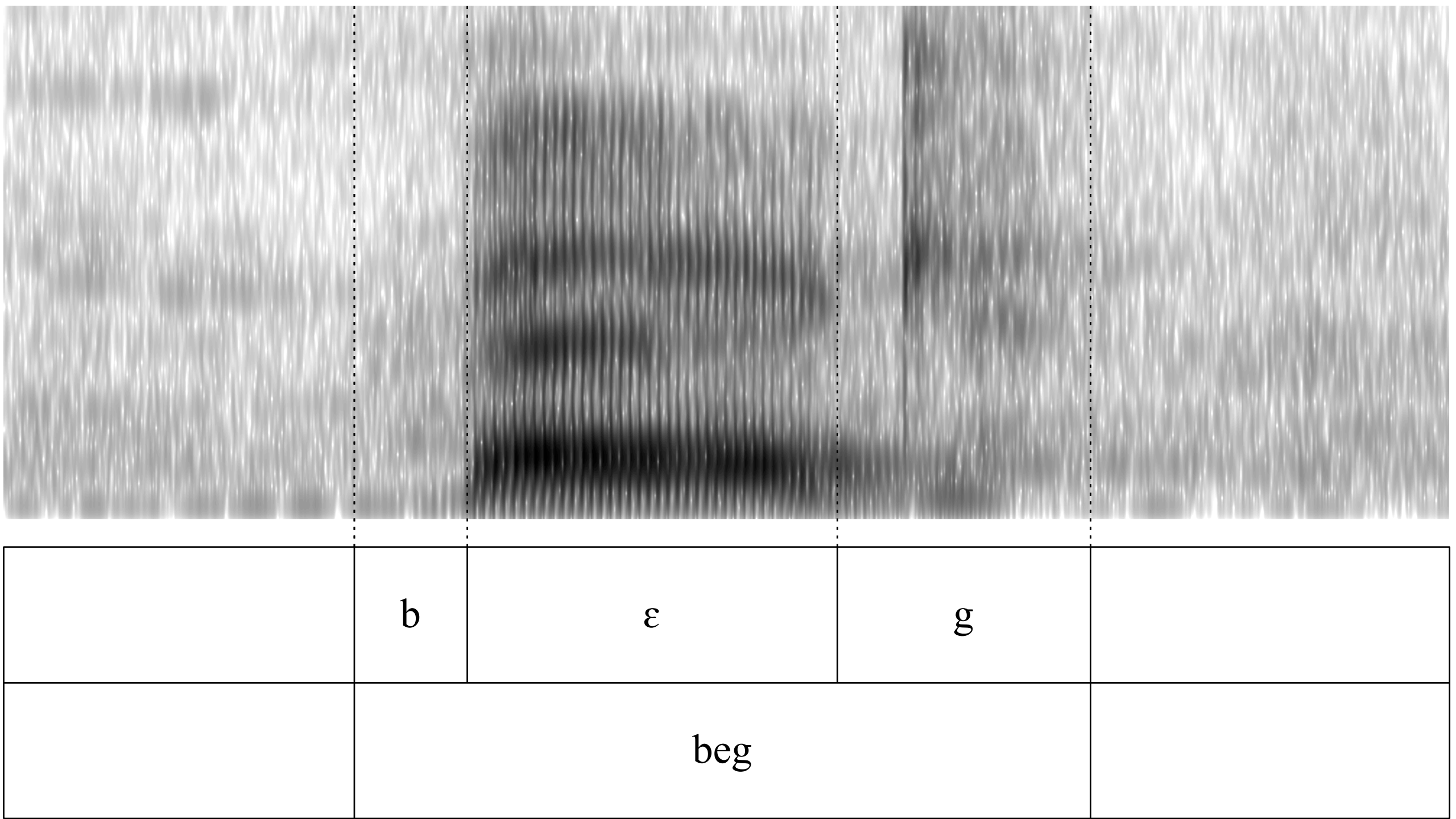


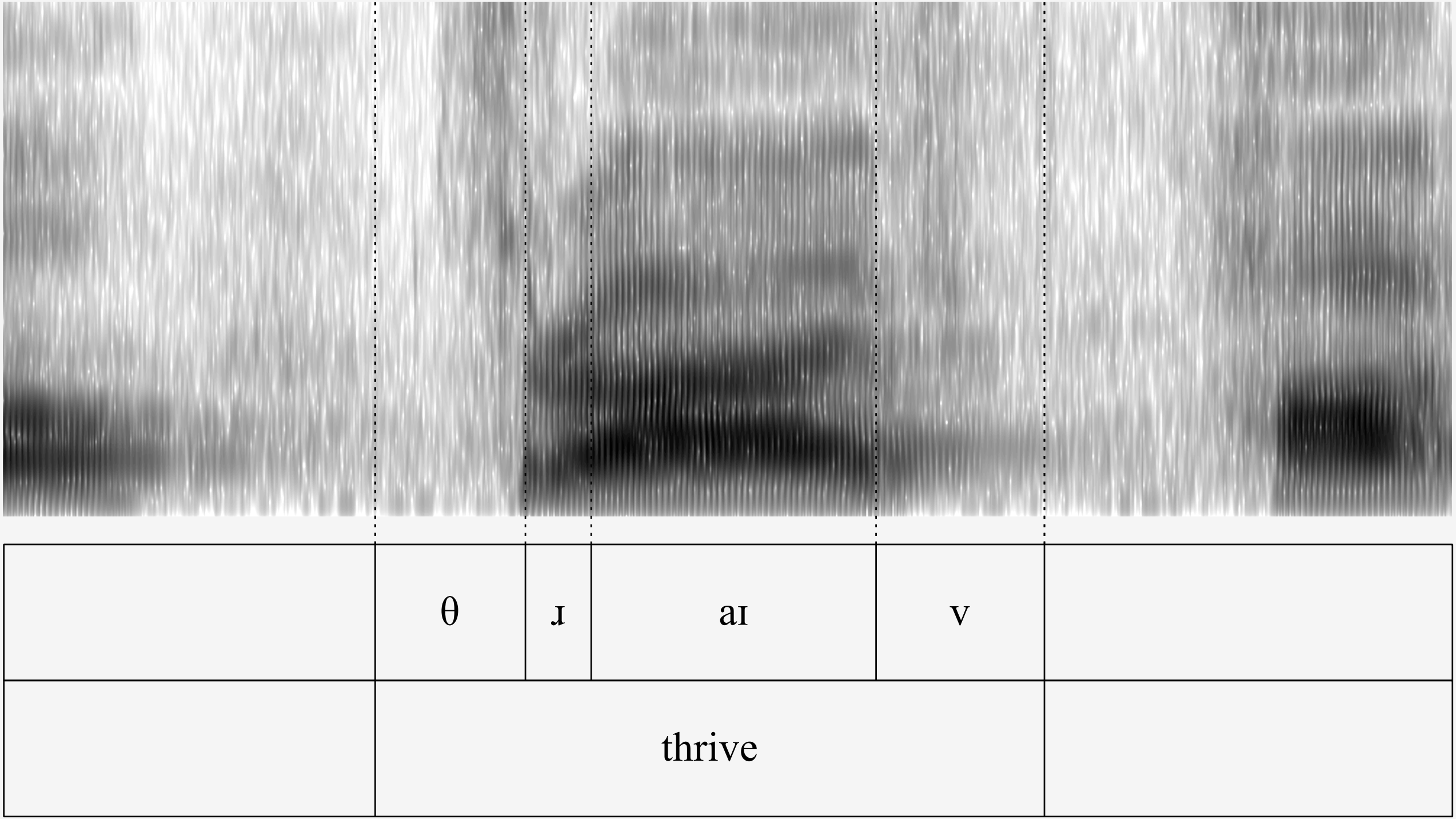
Chain Shifts



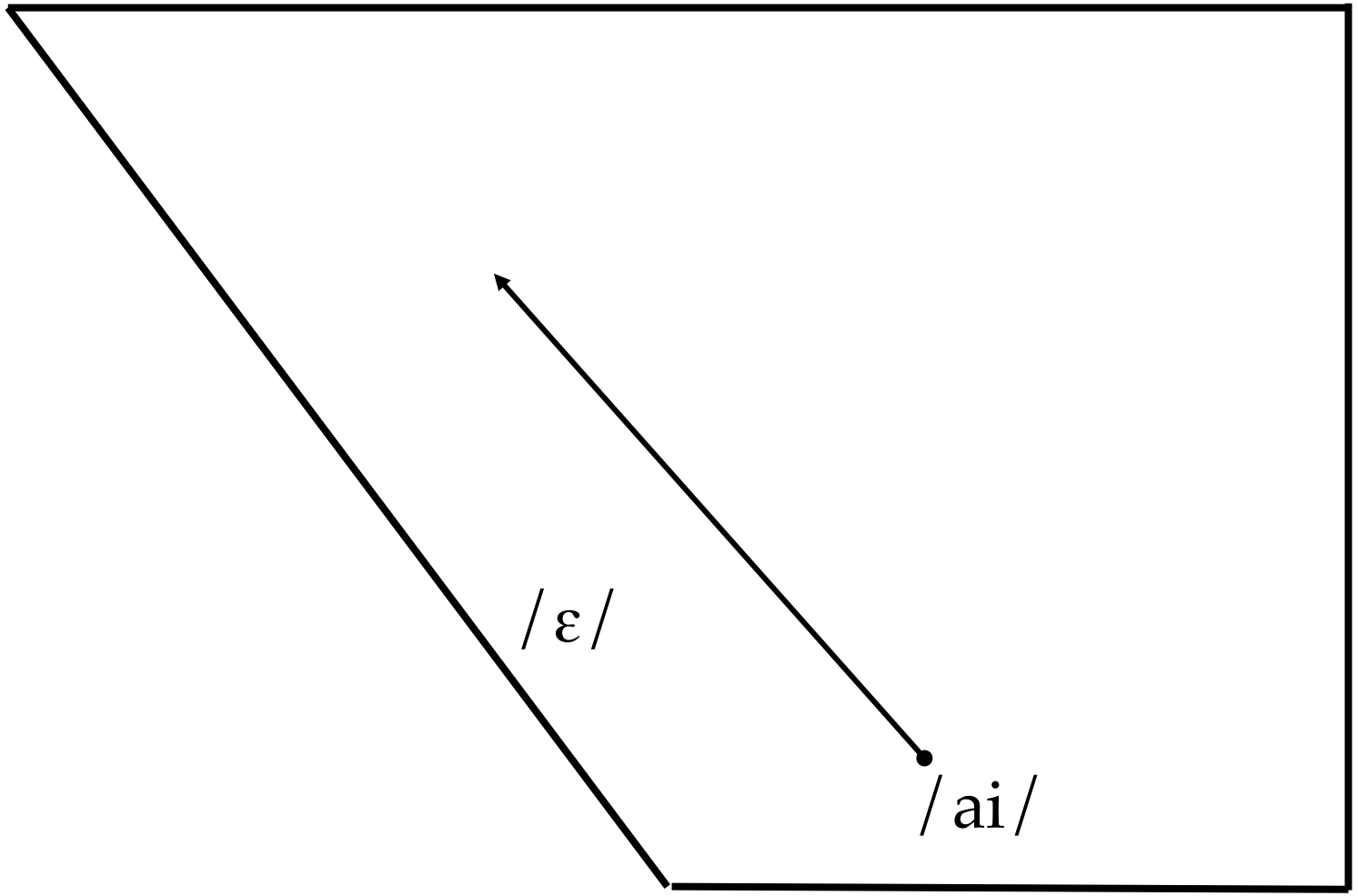
Mergers



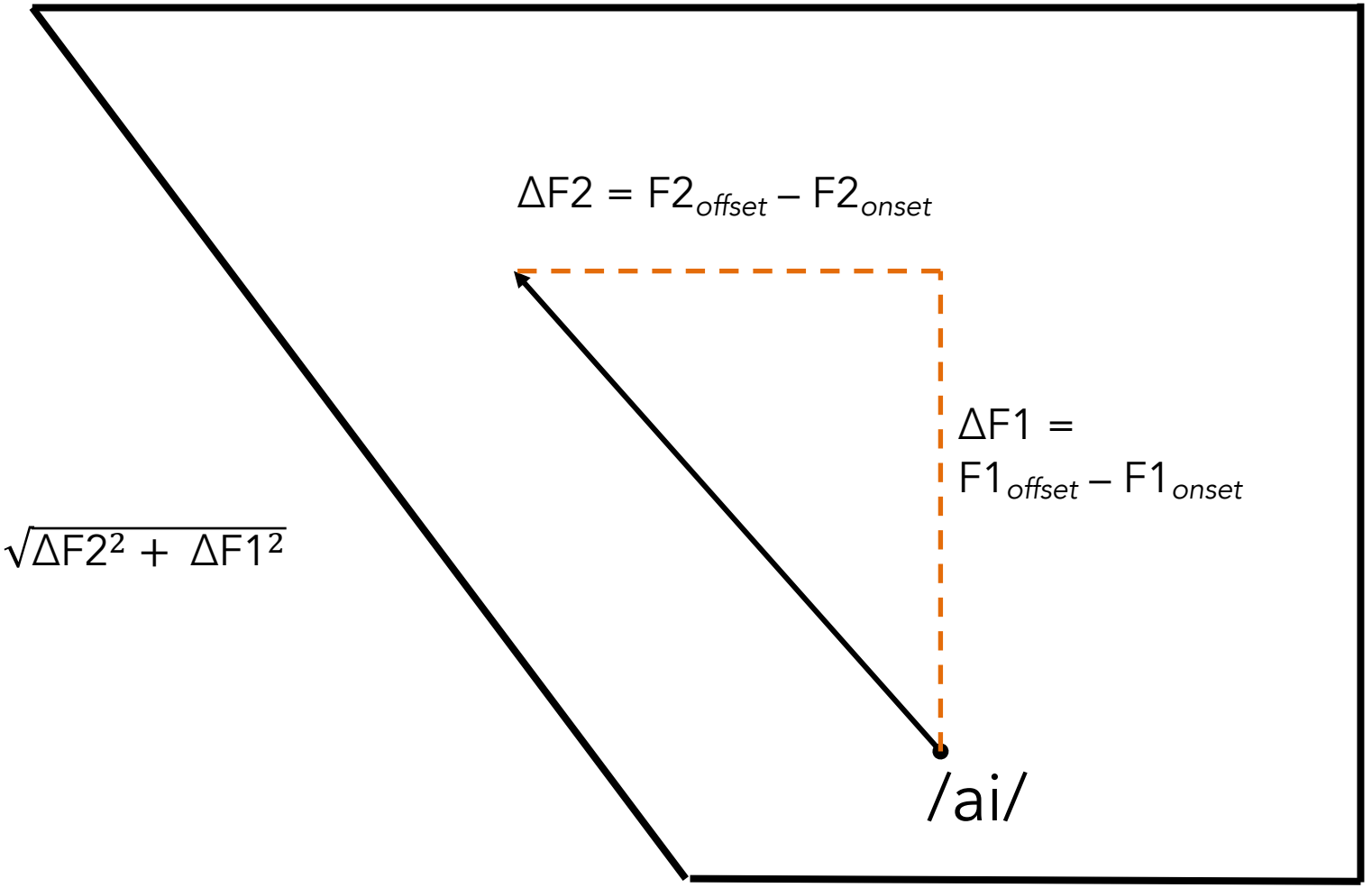

b
ɛ
g
beg


θ
ɹ
aɪ
v
thrive

Monophthongs vs. Diphthongs



Studying Diphthongs



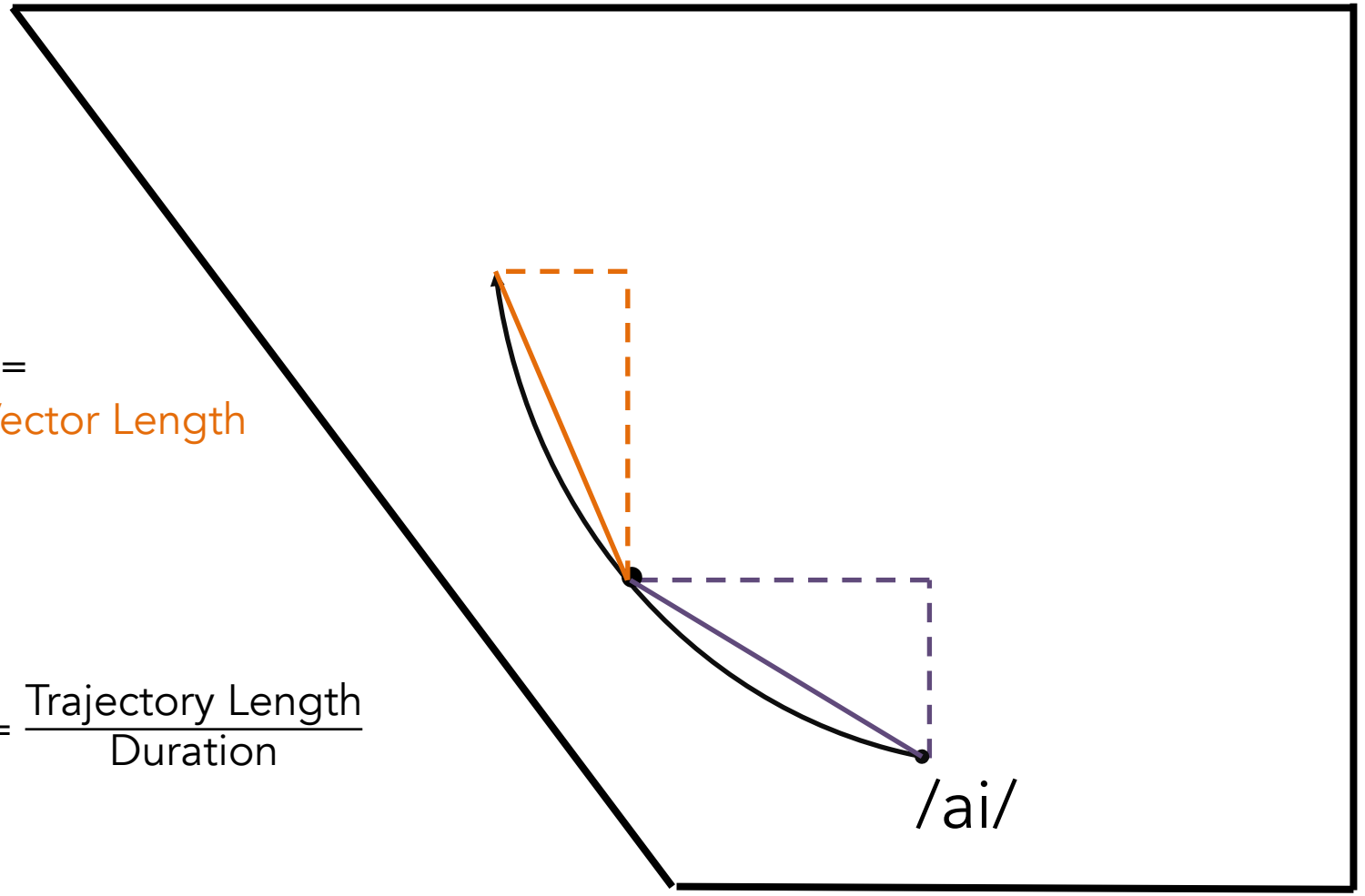
Vector Length = $\sqrt{\Delta F2^2 + \Delta F1^2}$

Farrington et al. (2018),
Fox & Jacewicz (2009)

Studying Diphthongs

Trajectory Length =
Vector Length + Vector Length

$$\text{Rate of Change} = \frac{\text{Trajectory Length}}{\text{Duration}}$$

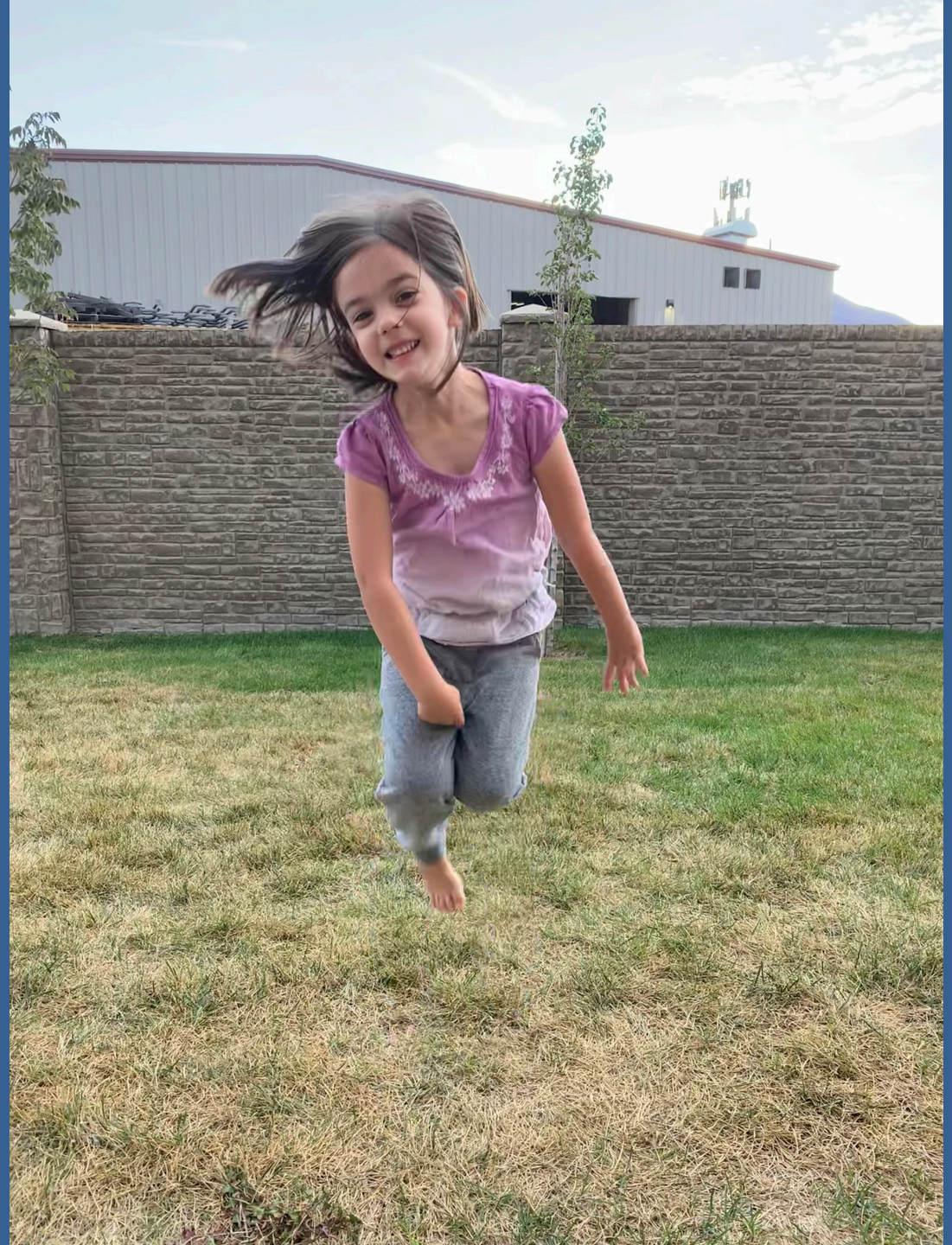


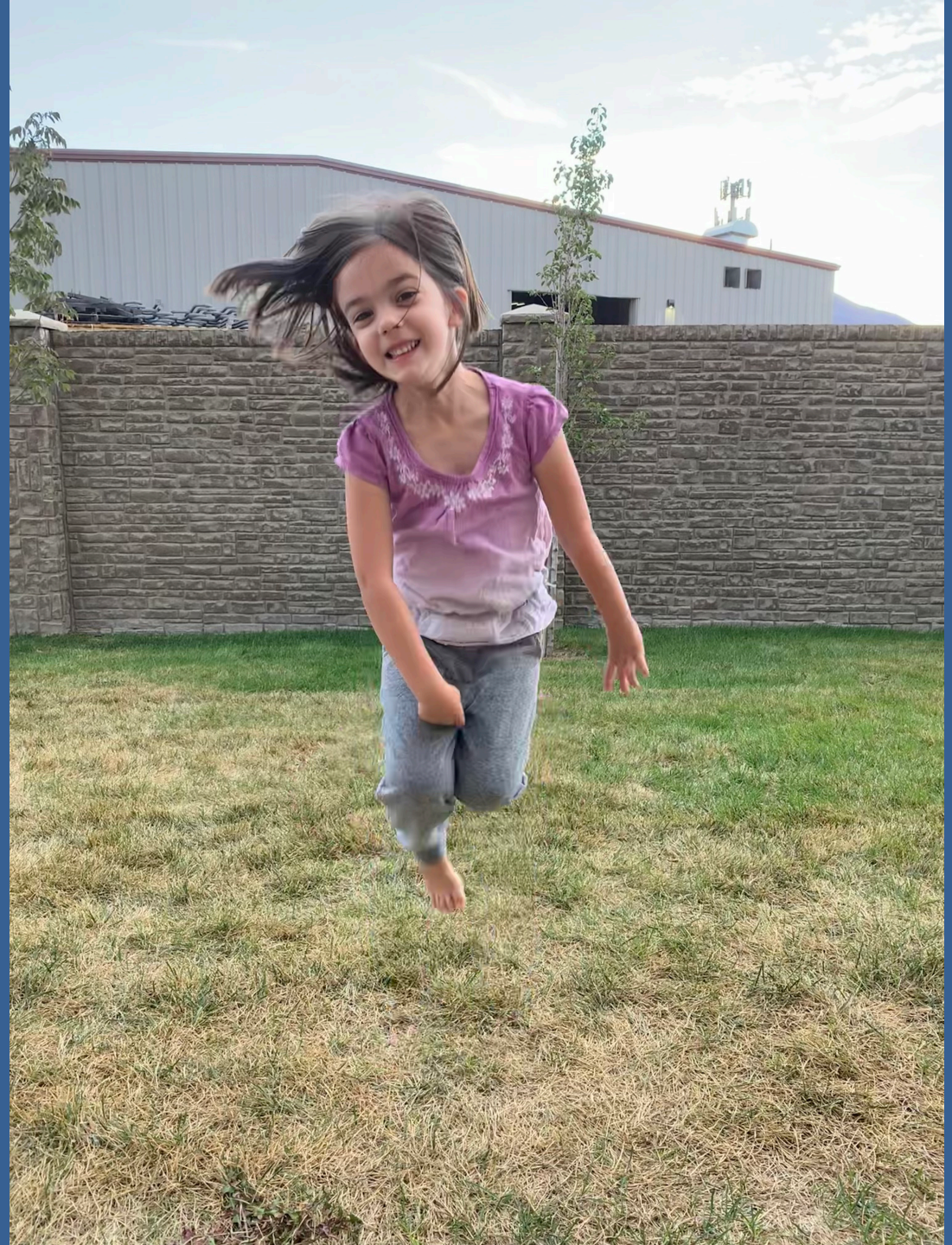
Farrington et al. (2018),
Fox & Jacewicz (2009)

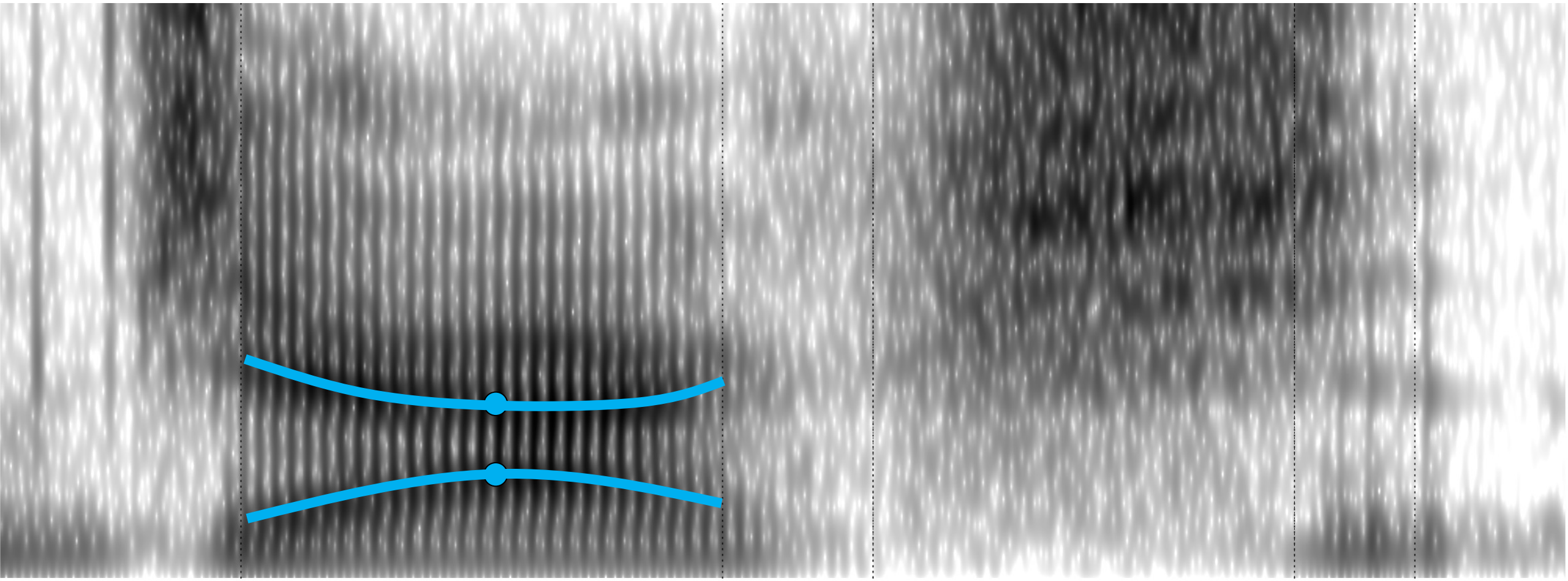
Issues

- A false dichotomy between monophthongs and diphthongs
  - Diphthongal methods only applied to canonical diphthongs
  - Are trajectories in monophthongs not important?

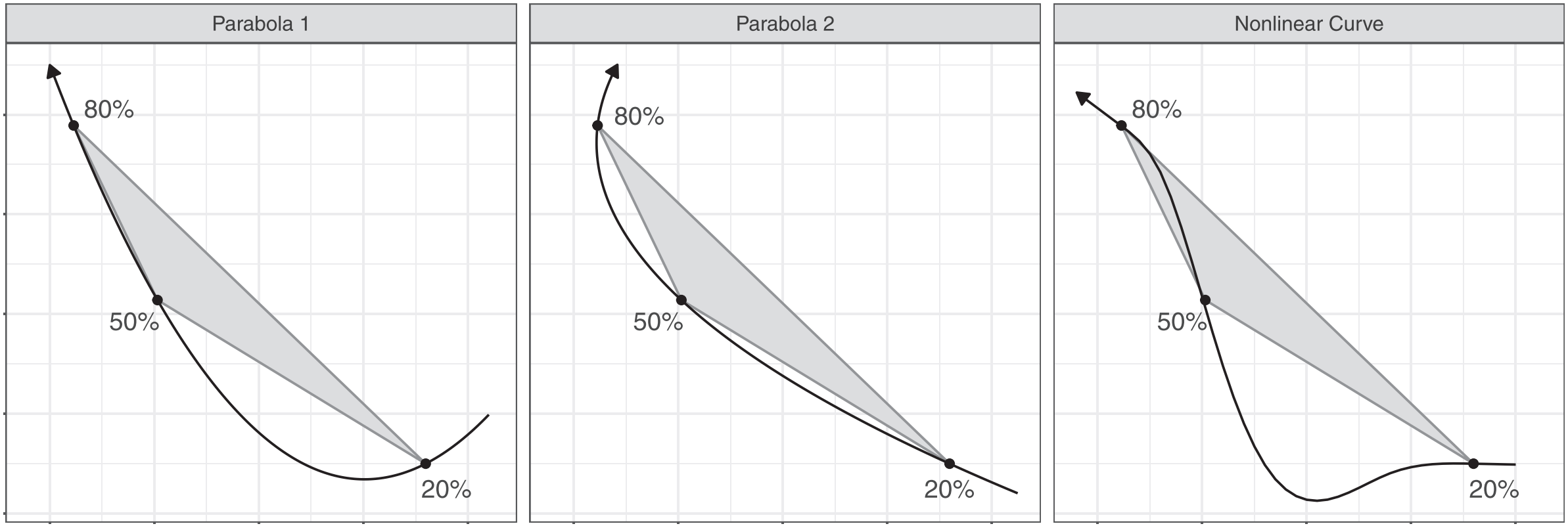
- Missing gradience in studying trajectory
  - VL, TL, ROC, etc. are only *properties* of trajectories
  - Are we missing nuance in the trajectory itself?







dʒ	æ	k	s	ə	n
jackson					



From Renwick & Stanley (2020:582)

Recent Developments

- Easier to extract trajectory data
  - FAVE is good, but only returns 5 points, English-only
  - Fast Track has more gradience, cleaner, any language.

- Easier to analyze trajectory data
  - Generalized additive mixed effects models
  - ”Difference smooths” can tells us where along the trajectory we see statistical significance between two curves.

- We can analyze the trajectories *themselves*, rather than *properties* about them.

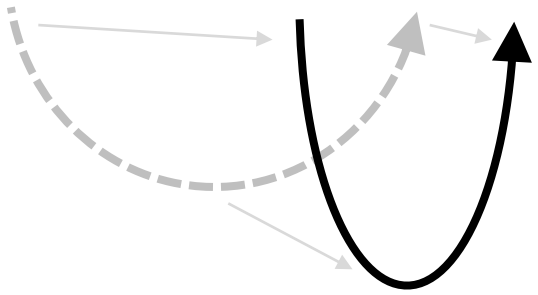
Overview

1. Vowel shifts may involve changes in trajectory
   - Data: sociolinguistic interviews in Washington State
   - Phenomenon: The “Elsewhere Shift”

2. Vowel shift might night involve changes in trajectory
   - Data: Legacy linguistic atlas interviews in the South
   - Phenomenon: Southern Vowel Shift

3. Enrich our understanding of merger
   - Data: Wordlists in Heber City, Utah
   - Phenomenon: The *feel-fill* merger

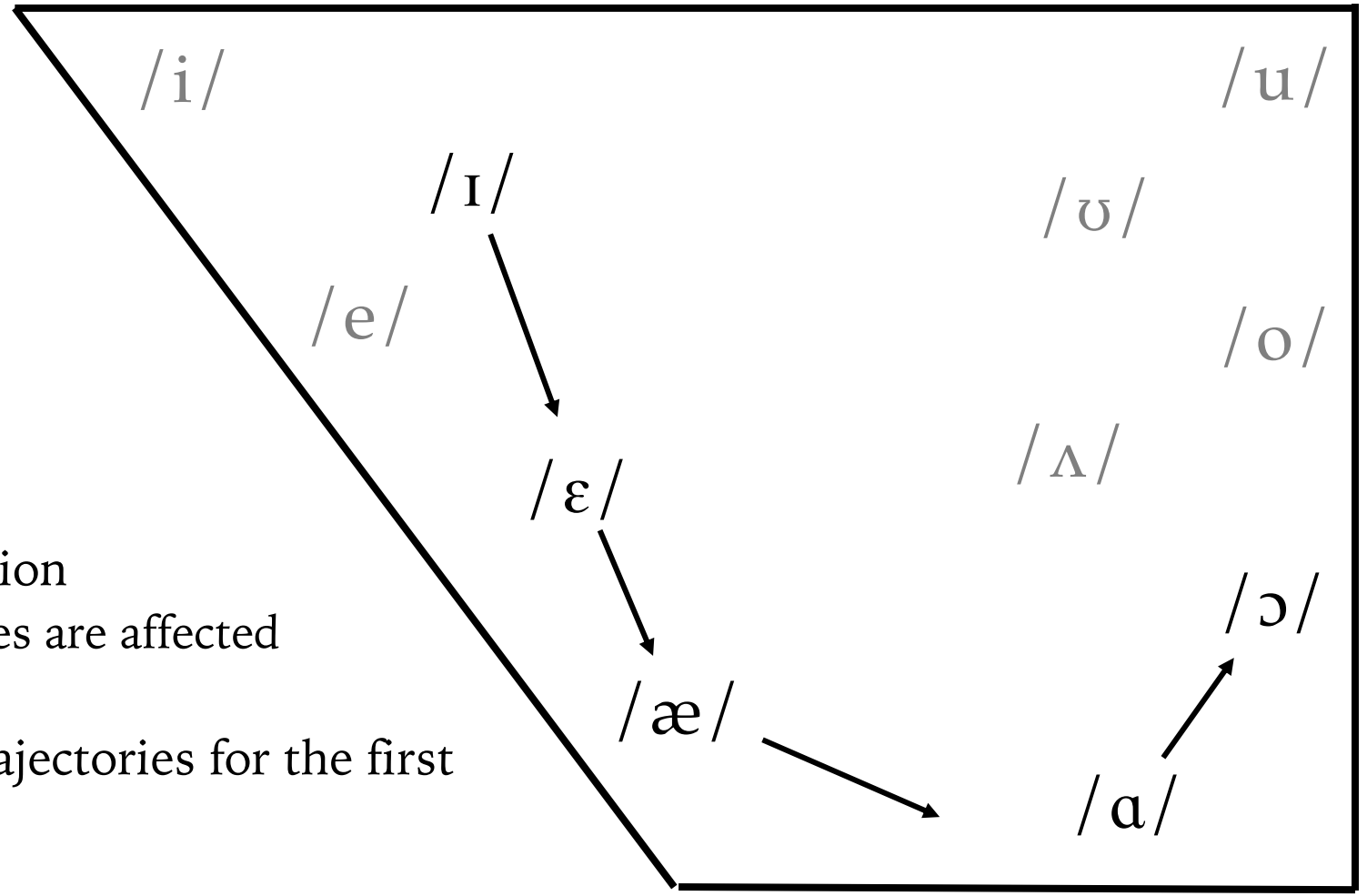
Vowel Shifts with Trajectory Changes



Joseph A. Stanley. 2020. *Vowel Dynamics of the Elsewhere Shift: A Sociophonetic Analysis of English in Cowlitz County, Washington*. Ph.D. Dissertation. University of Georgia: Athens, Georgia.

The "Elsewhere" Shift

- "Elsewhere" describes its geographic distribution.
  - California (Hinton et al. 1987)
  - Canada (Clarke et al. 1995)
  - Colorado (Holland & Brandenburg 2017)
  - Ohio (Durian 2012)
  - Massachusetts (Stanford et al. 2019)
  - Michigan (Mason 2018)
  - Georgia (Stanley & Renwick 2021)
- Also its phonological distribution
  - Only preobstruent allophones are affected
- Stanley (2020) describes its trajectories for the first time.

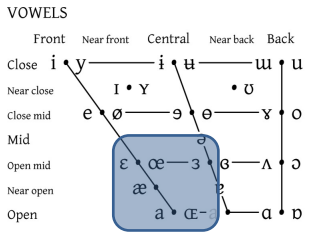


Data Collection

When	Summer 2016
Field site	Cowlitz County in southwestern Washington
Recruitment	face-to-face, business cards, snowball, family
Method	Traditional sociolinguistic interviews (Labov 1984)
Speakers	54
Audio	45h 16m
Corpus size	~350,000 words
Vowels analyzed	128,370

Data Processing

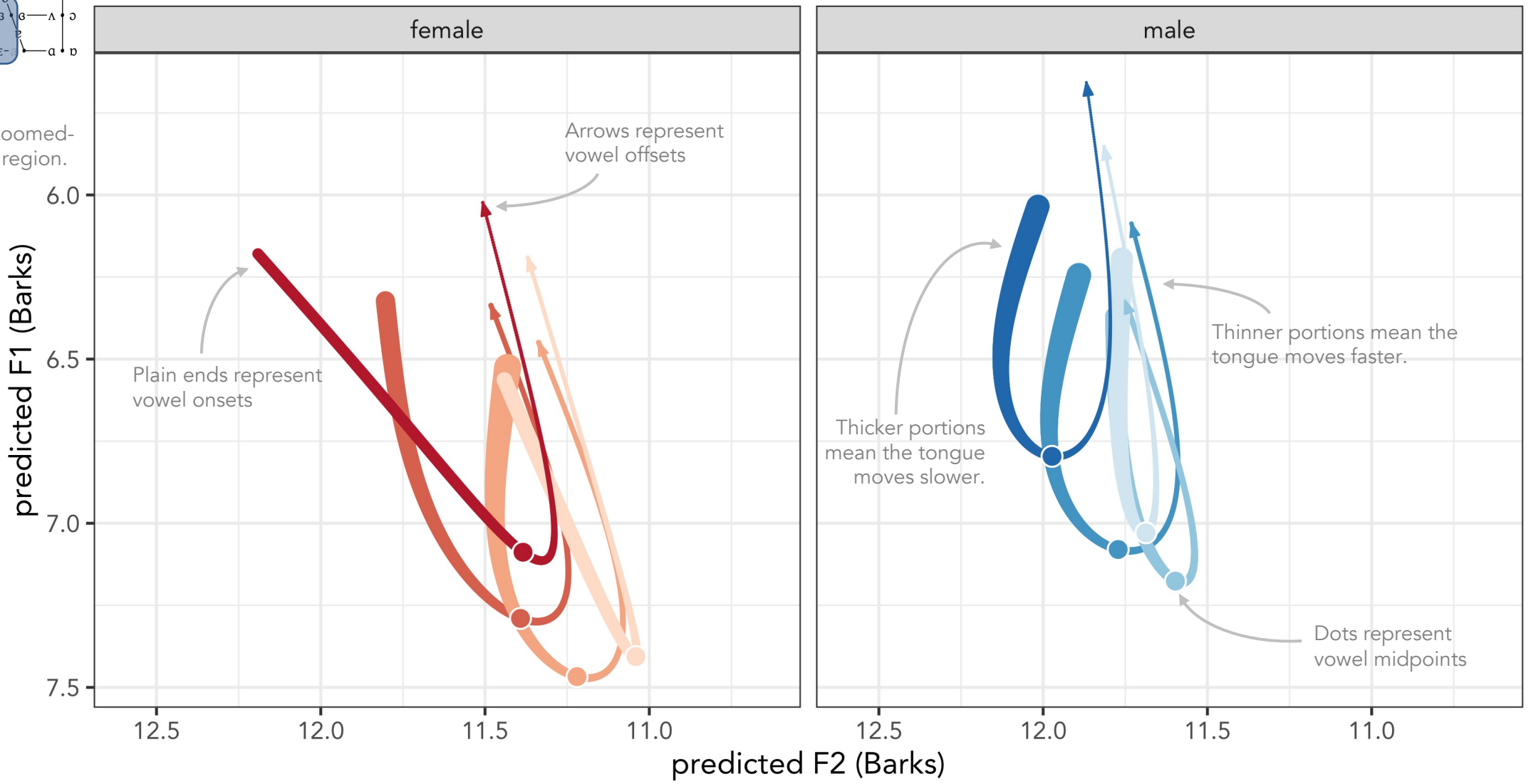
Transcription	Manual
Forced-Alignment	Montreal Forced Aligner (McAuliffe et al. 2017)
Formant Extraction	Praat (Boersma & Weenink 2018) at 11 points per vowel
Filtering	Mahalanobis distance (Mahalanobis 1936)
Normalization	ANAE method (Labov, Ash, Boberg 2006; cf. Nearey 1978)
Transformation	Barks (Zwicker 1961, Traunmüller 1990)
Statistical Modeling	Generalized additive mixed-effects models (Wood 2017)
Software	R (R Core Team 2018), tidyverse (Wickham 2018)
Visuals	ggplot2 (Wickham 2015)



This plot is a zoomed-in view of this region.

Predicted vowel trajectories for /æ/ in Cowlitz County, WA, by gender and generation

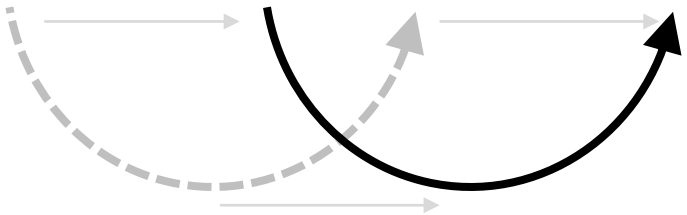
What you should see: Trajectories change shape as the midpoints shift.



generation and gender

- silent F
- boomer F
- genX F
- millennial F
- silent M
- boomer M
- genX M
- millennial M

Vowel Shifts without Trajectory Changes



Joey Stanley

Peggy Renwick

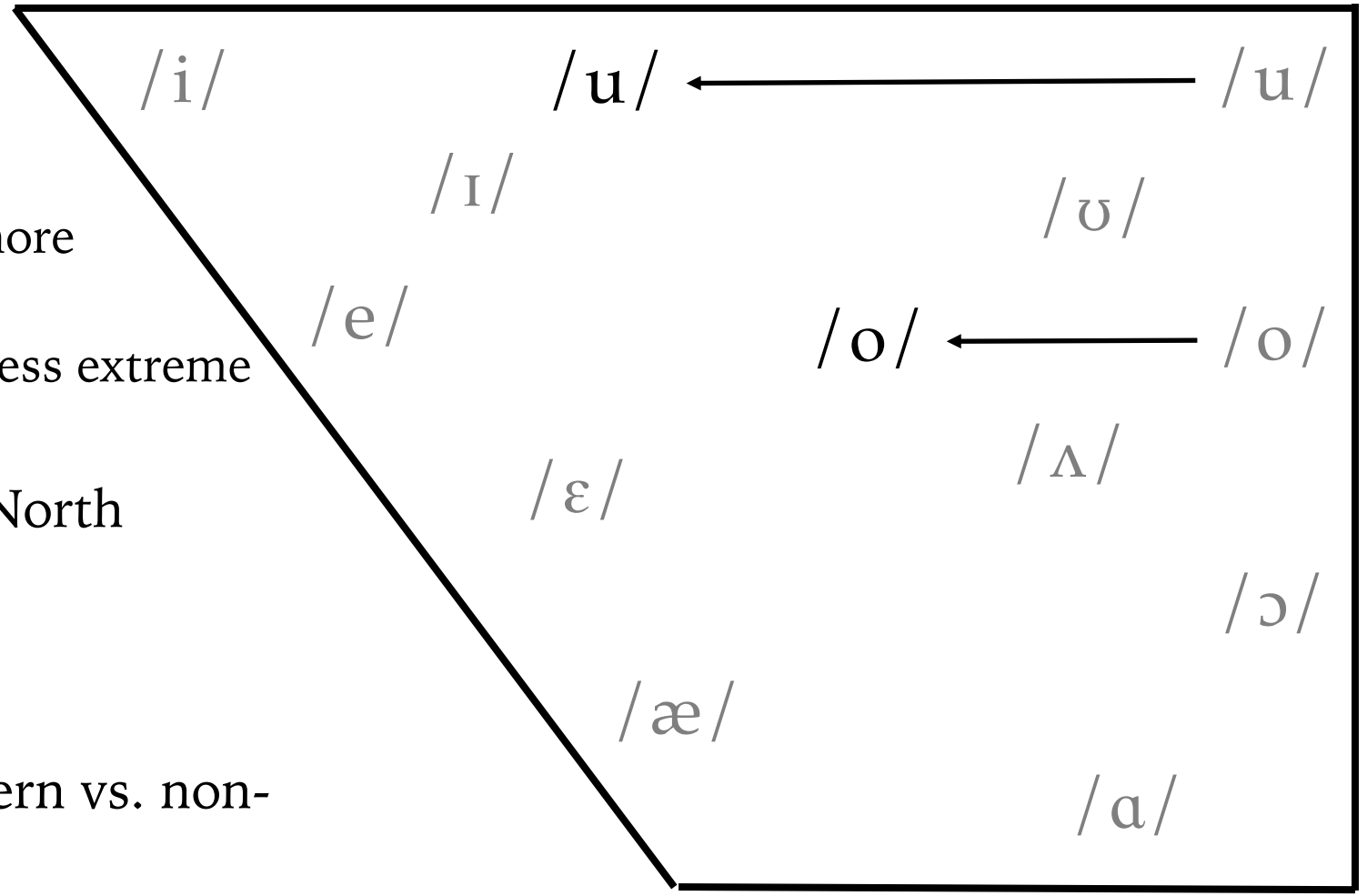
Rachel Olsen

Katie Kuiper

Joseph A. Stanley, Margaret E. L. Renwick, Katie Ireland Kuiper, & Rachel Miller Olsen (accepted). "Back vowel dynamics and distinctions in Southern American English." *Journal of English Linguistics*.

Back Vowel Fronting

- Canonical back vowels are becoming phonetically central or even front
  - /u/-fronting is older and more extreme
  - /o/-fronting is newer and less extreme
- Found in most varieties of North American English
  - Today's focus: The South
- Koops (2010) describes southern vs. non-southern trajectory shapes



Data "Collection"

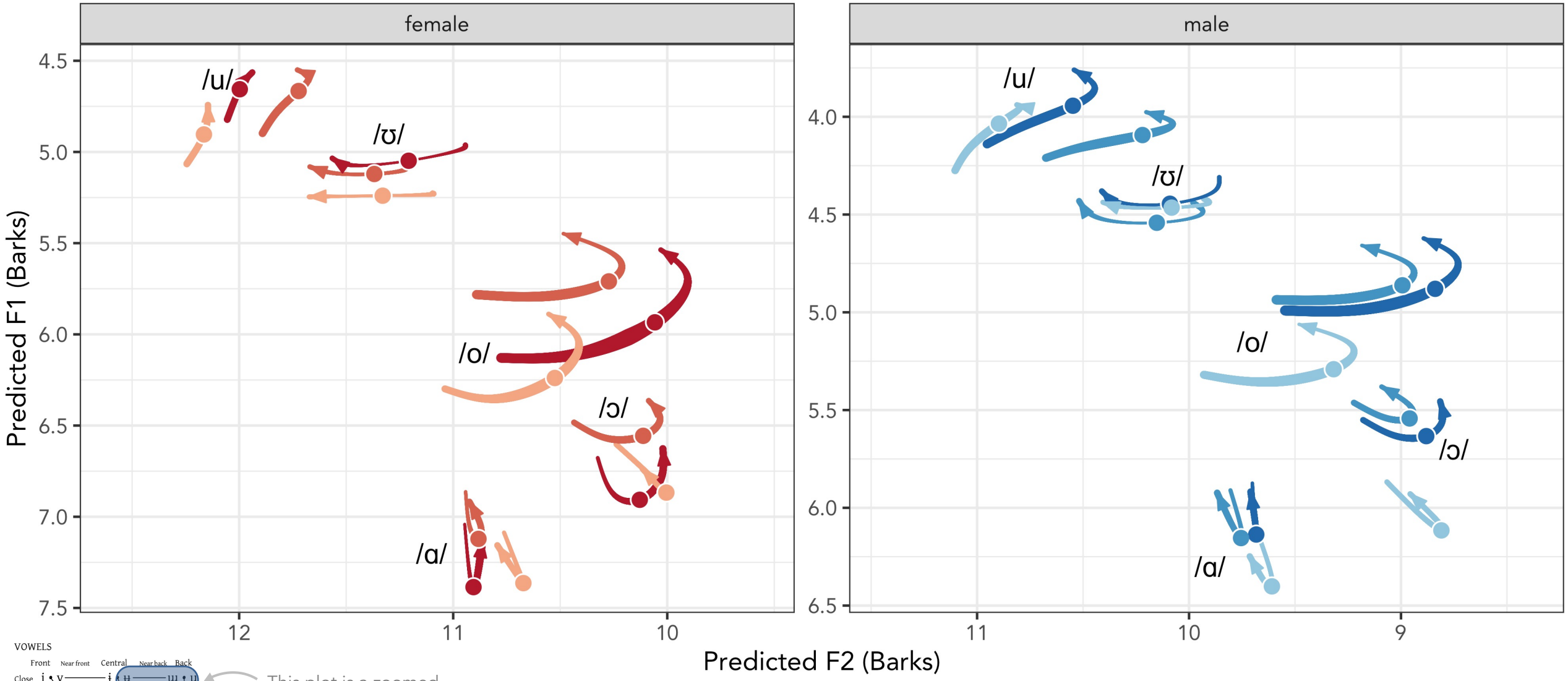
Dataset	Linguistic Atlas of the Gulf States (Pedersen et al. 1986)
Field site	Texas, Arkansas, Oklahoma, Tennessee, Mississippi, Alabama, Georgia, Florida
When	1968–1983
Method	Linguistic Atlas interviews
Format	Reel-to-reel; digitized
Speakers	48
Audio	290 hours
Vowel tokens	89,367

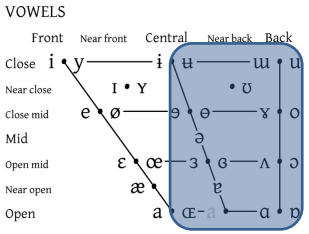
Data Analysis

Transcription	manual (Olsen et al. 2017)
Forced-Alignment	Montreal Forced-Aligner (McAuliffe et al. 2017)
Formant Extraction	FAVE (Rosenfelder et al. 2014) at 20%, 35%, 50%, 65%, 80% into vowels' durations
Exclusions	stopwords, pre-liquids, pre-nasals, non-primary lexical stress
Outlier detection	Mahalanobis Distance (Mahalanobis 1936); furthest 5% removed
Transformation	Barks (Zwicker 1961, Traunmüller 1990)
Statistics	generalized additive mixed-effects models (Wood 2017; cf. Sóskuthy 2017, Gahl & Baayen 2019, Renwick & Stanley 2020)
Modeling	Five separate models: /aɪ/, /eɪ/, /ɛ/, /u/, /oʊ/
Software	R (R Core Team 2018), tidyverse (Wickham 2018); mgcv (Wood 2011); itsadug (van Rij et al. 2020)
Visuals	ggplot2 (Wickham 2015)

Predicted vowel trajectories for /o/ in the South, by gender and generation

What you should see: Trajectories don't change even though midpoints shift





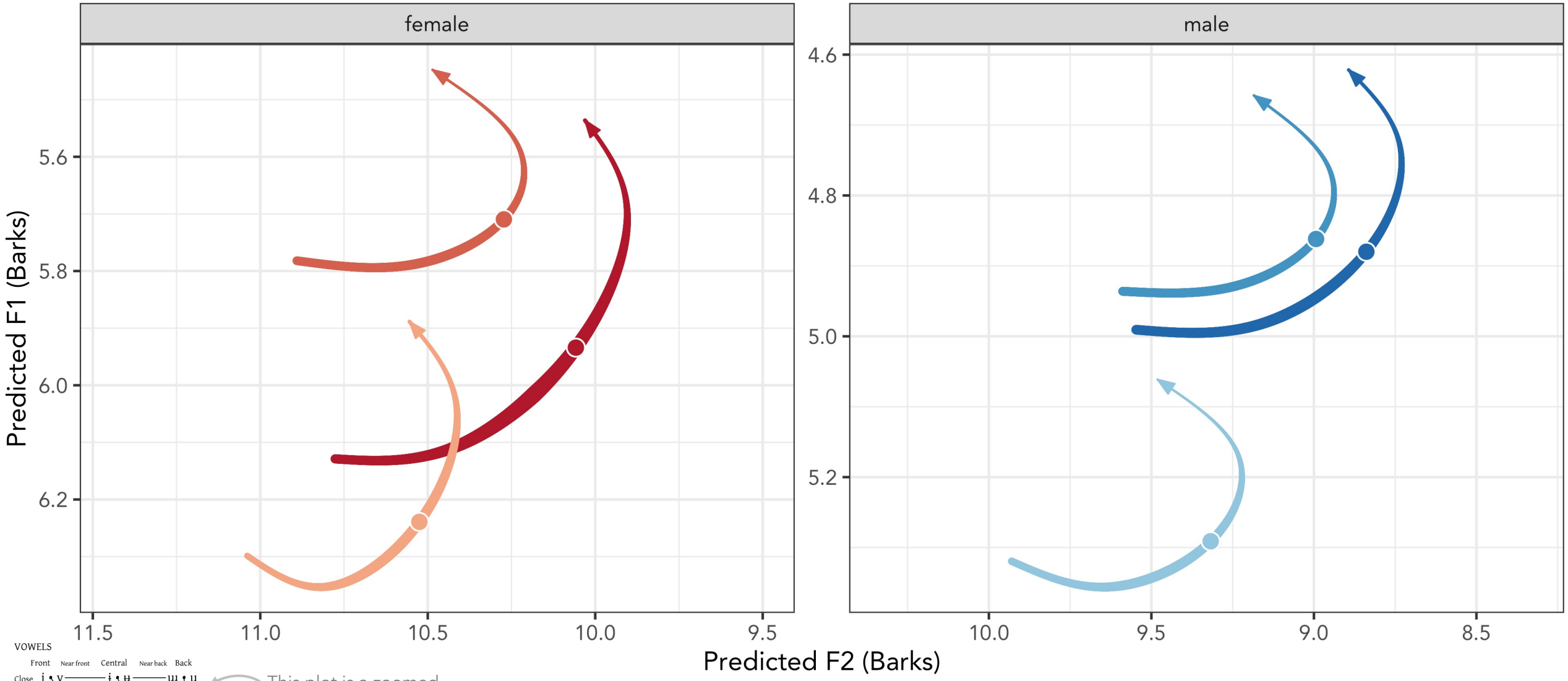
This plot is a zoomed-in view of this region.

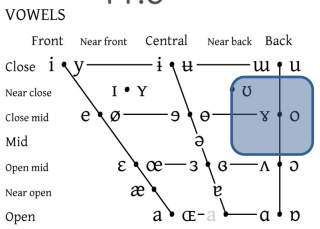
generation and gender

- G.I. Generation female
- Lost Generation female
- Silent/Boomer female
- G.I. Generation male
- Lost Generation male
- Silent/Boomer male

Predicted vowel trajectories for /o/ in the South, by gender and generation

What you should see: Trajectories don't change (much) even though midpoints shift





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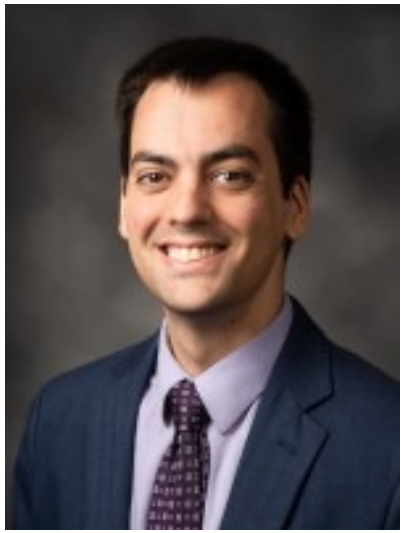
generation and gender

- G.I. Generation female
- Lost Generation female
- Silent/Boomer female
- G.I. Generation male
- Lost Generation male
- Silent/Boomer male

Trajectories' Role in Vowel Merger

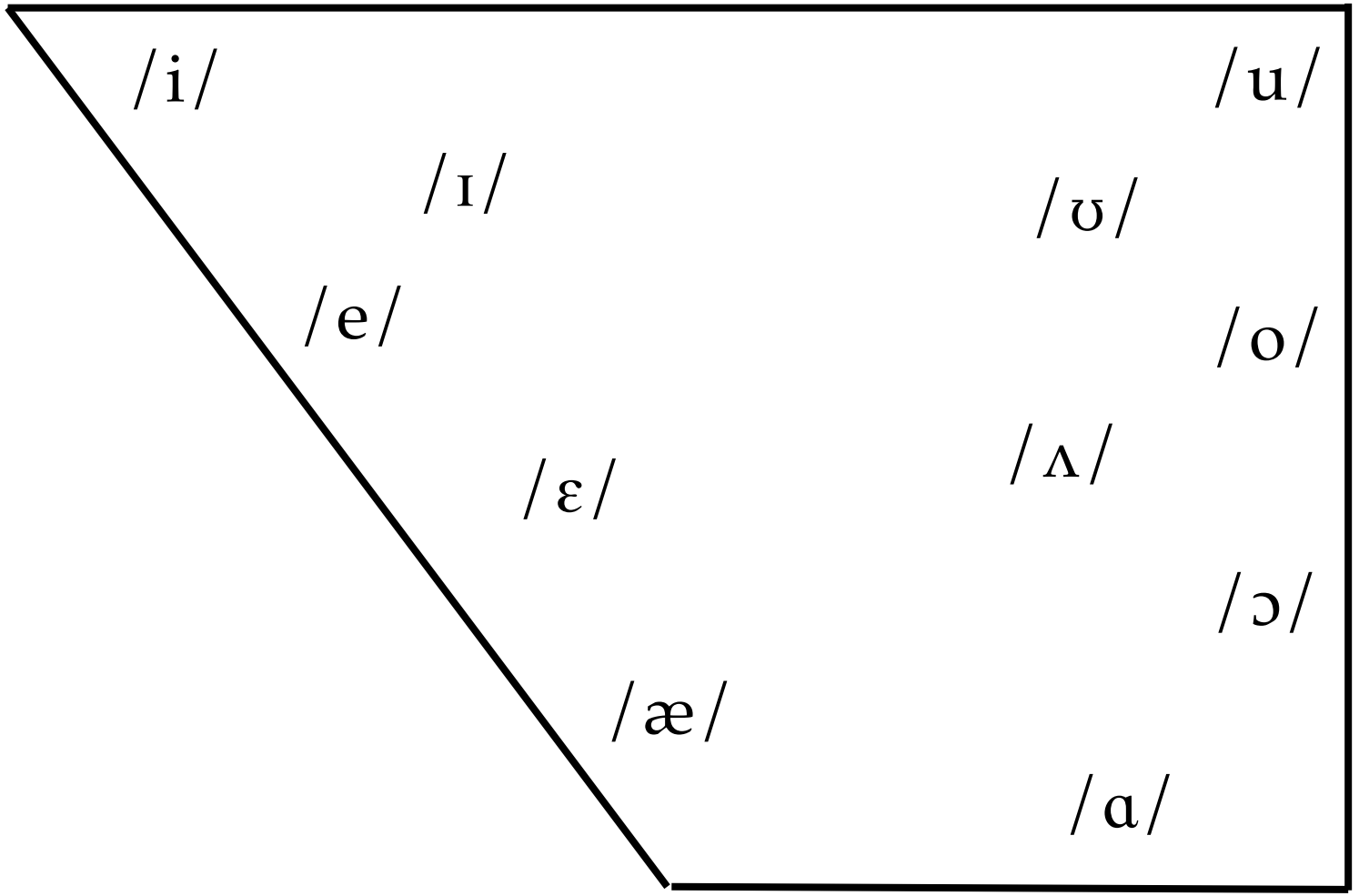


Joey Stanley

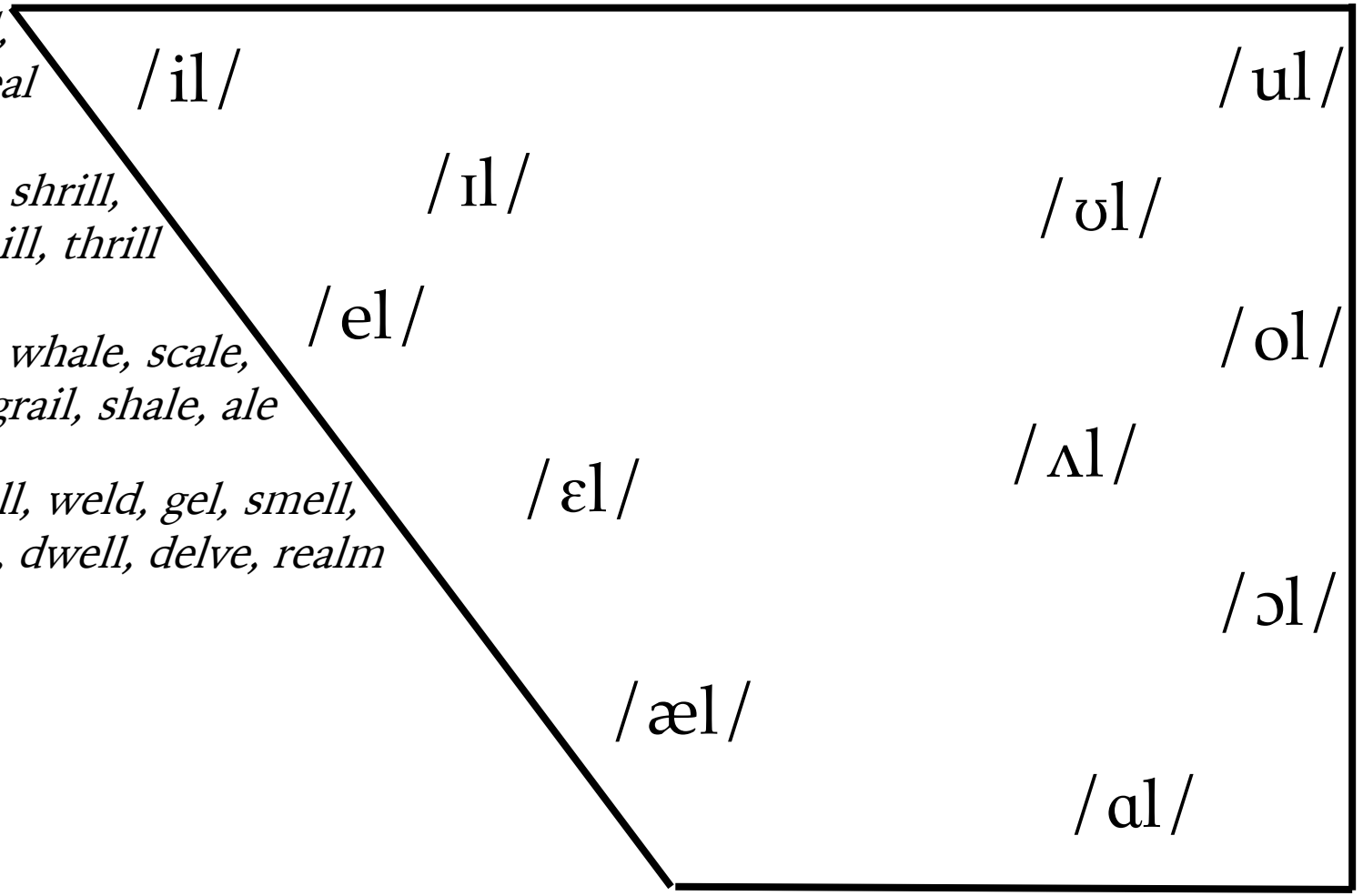
Lisa Johnson

Joseph A. Stanley & Lisa Morgan Johnson. Vowels can merge because of changes in trajectory: Prelaterals in rural Utah English. The 96th Annual Meeting of the Linguistic Society of America. Washington, D.C. January 6–9, 2022

Prelateral Mergers



Prelateral Mergers



feel, peel, deal, kneel, meal, seal

ill, pill, dill, gill, shrill, drill, kilt, quill, thrill

fail, tail, whale, scale, jail, trail, grail, shale, ale

fell, bell, weld, gel, smell, swell, dwell, delve, realm

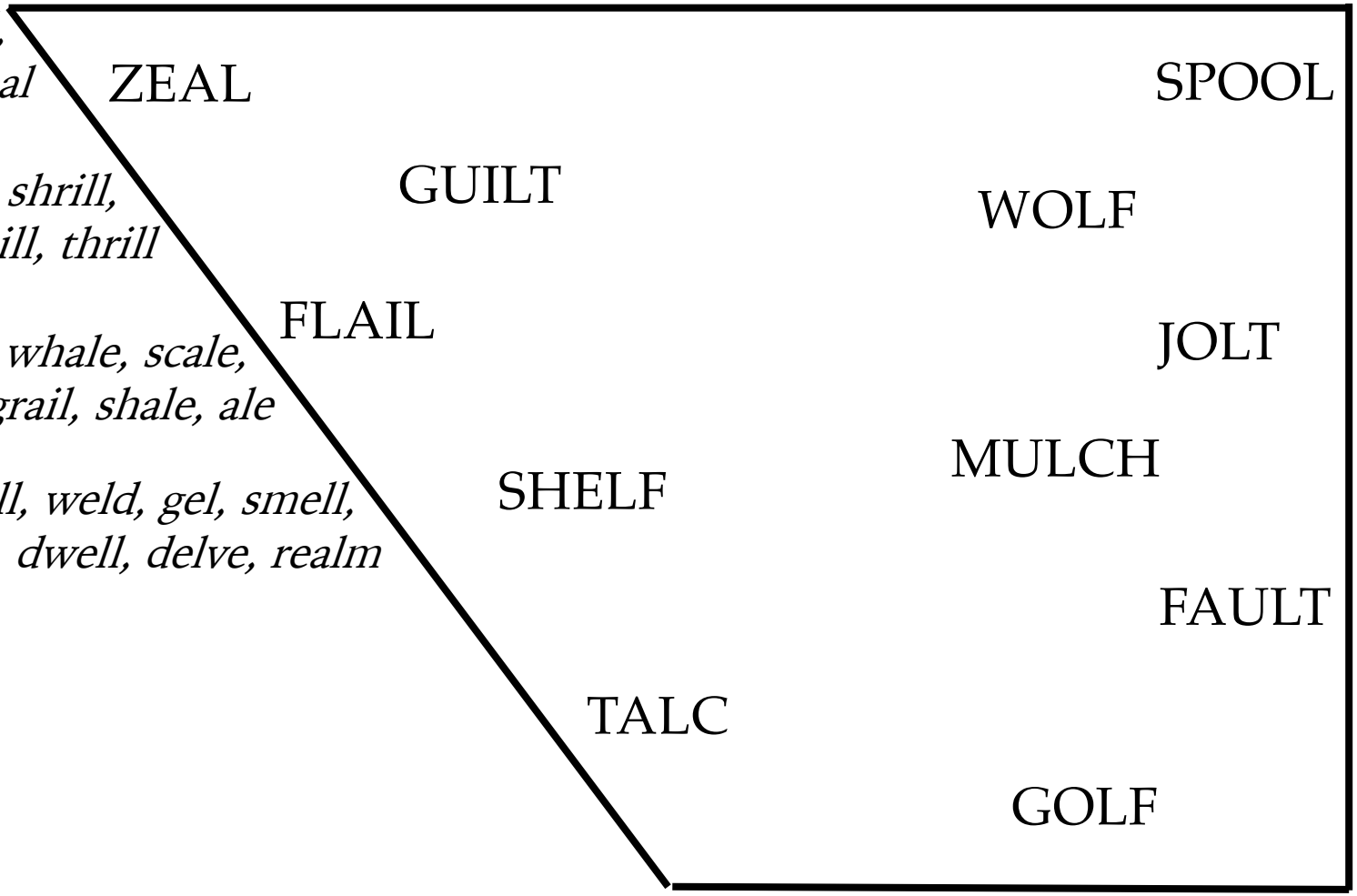
fool, cool, tool, ghoul, stool, school, drool, cruel, Yule

full, pull, bull, wool, wolf

hole, coal, bowl, goal, cold, scold, troll, molt, gold

hull, dull, gull, pulse, skull, cult, gulf, lull, sulk, sculpt

Prelateral Mergers



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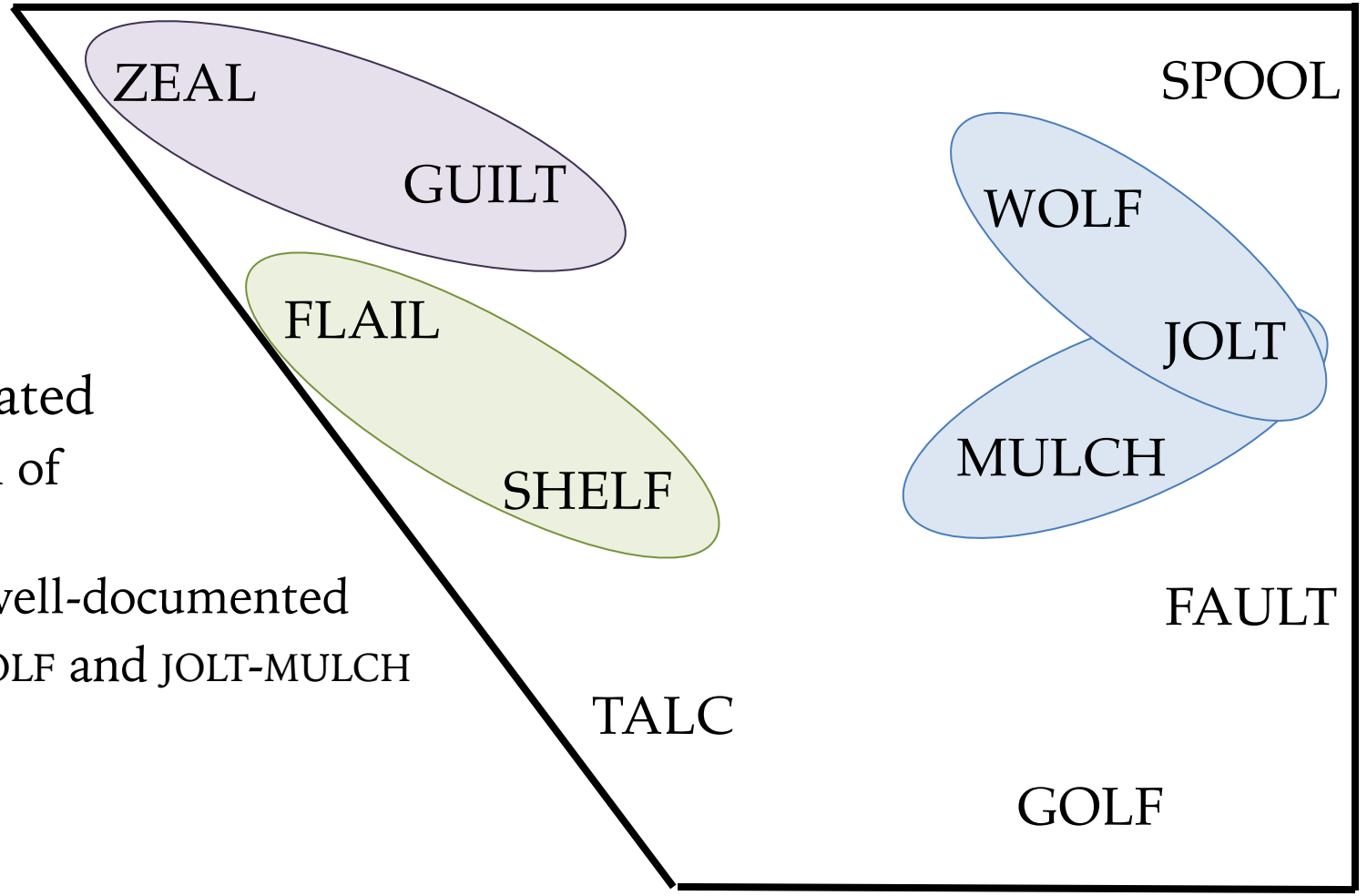
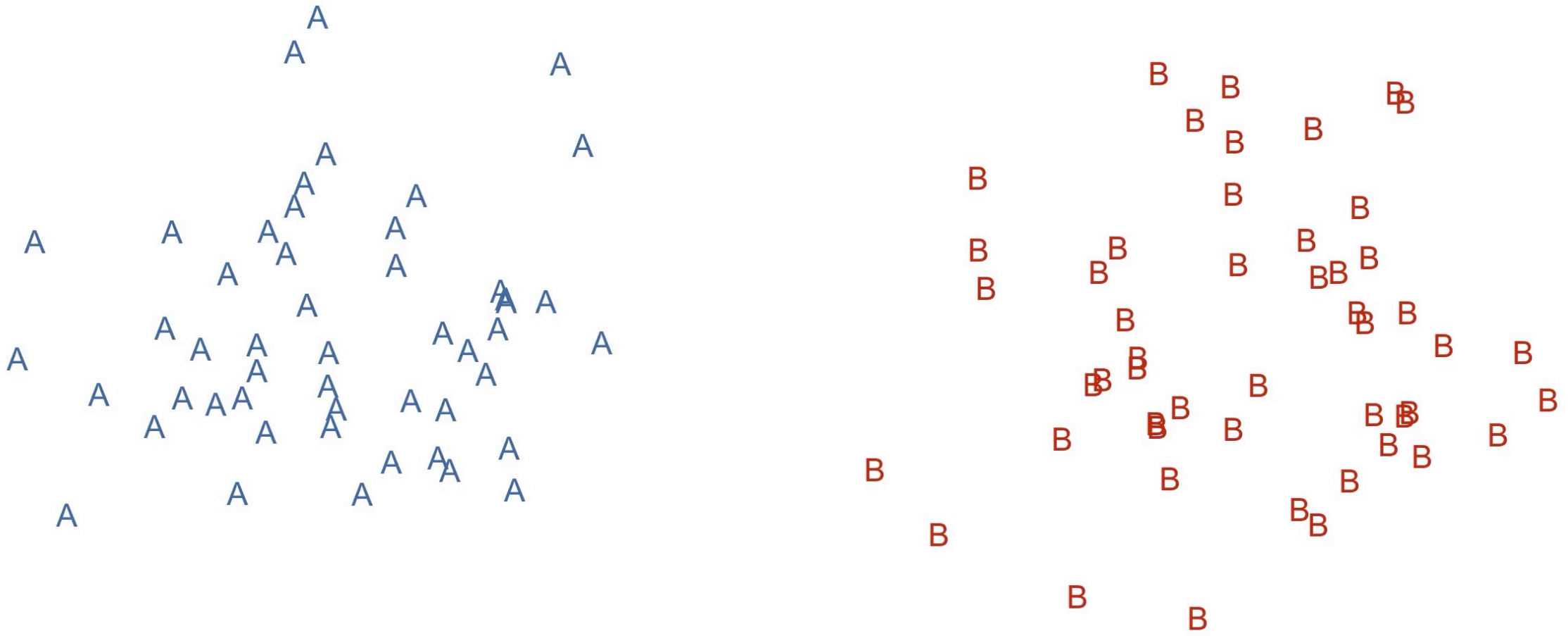
Prelateral Mergers

- In front vowels, tense-lax distinction is lost before /l/
  - Found in Utah, Texas, and scattered elsewhere
- In back vowels, it's complicated
  - Basically, any configuration of mergers has been attested.
  - Regional distribution not well-documented
  - Today's focus is on JOLT-WOLF and JOLT-MULCH



Merger by Approximation (Trudgill & Foxcroft 1978)

Based on 100 randomly generated data points



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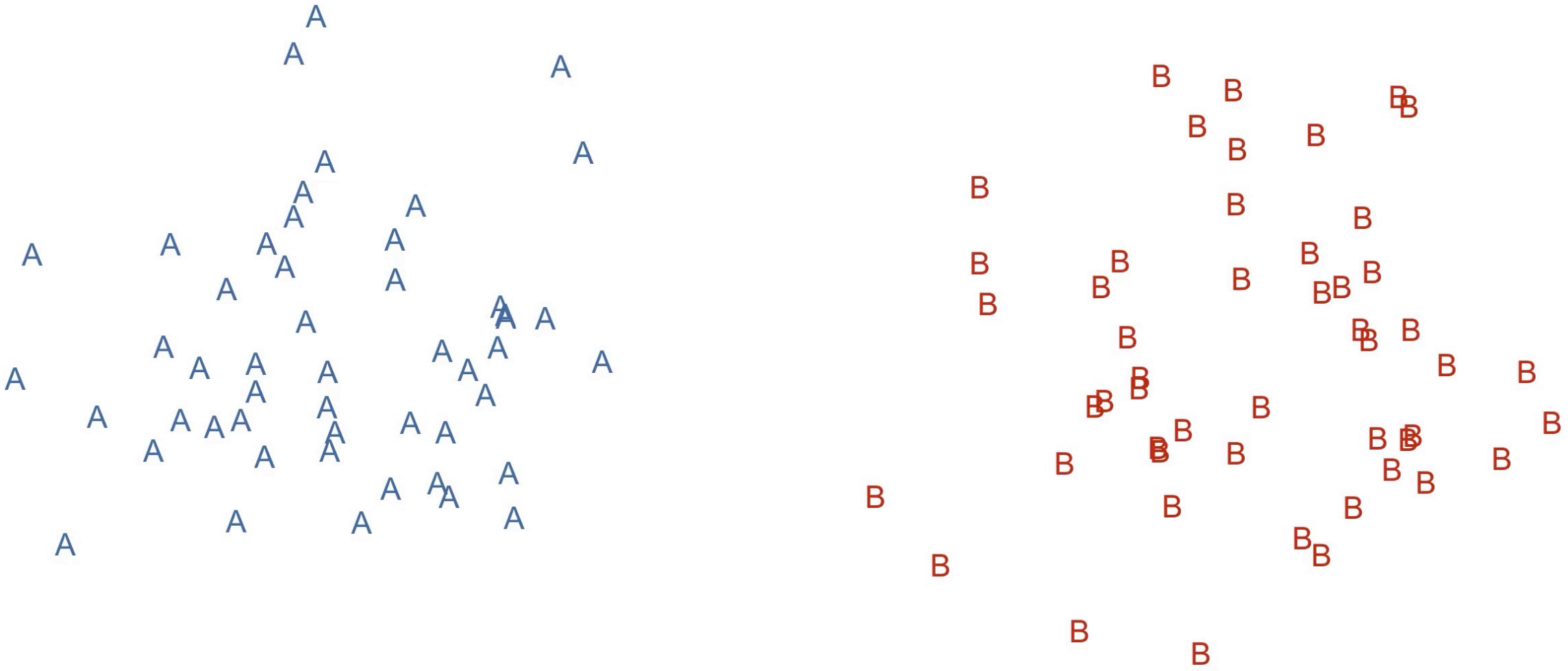
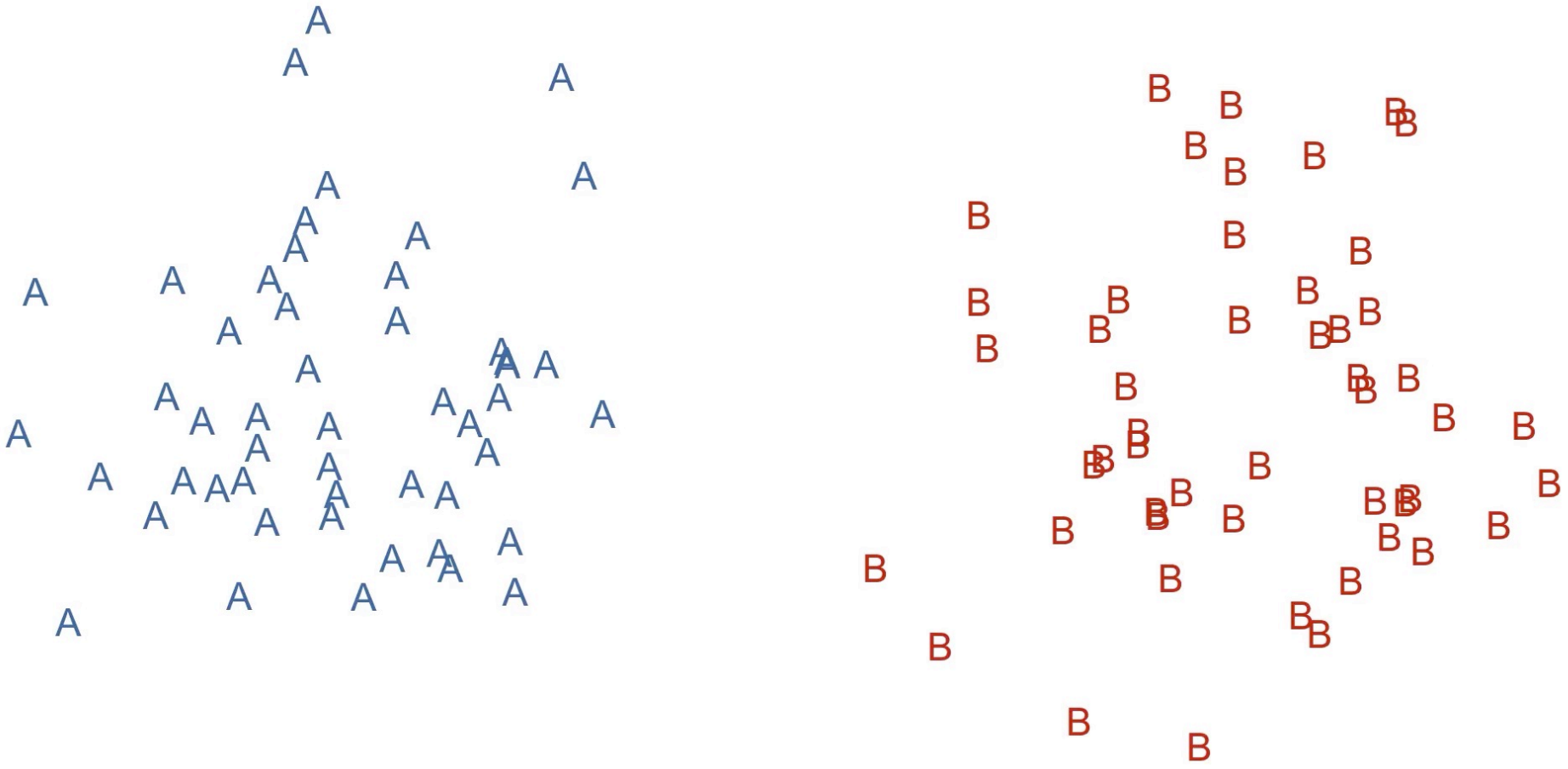
Merger by Transfer (Foxcroft & Trudgill 1978)

Based on 100 randomly generated data points



Merger by Expansion (Herold 1990)

Based on 100 randomly generated data points



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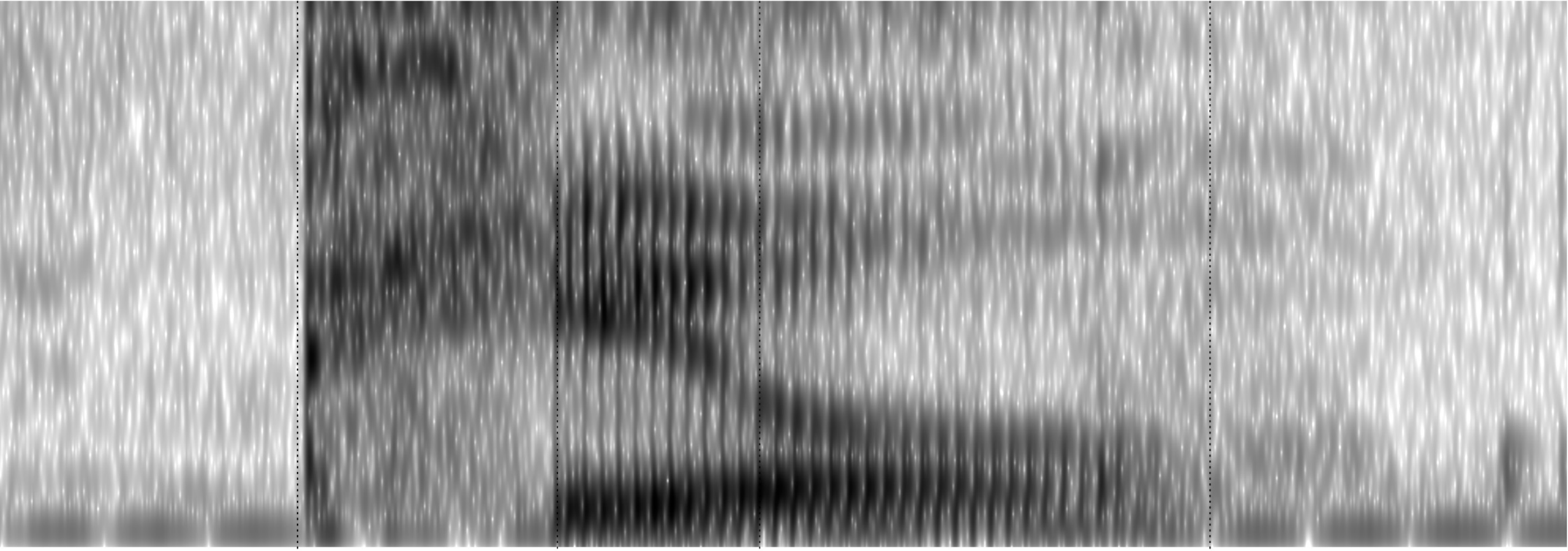
Mechanisms of Merger

- Several have been proposed
  - Merger by approximation (Foxcroft & Trudgill 1978)
  - Merger by transfer (Foxcroft & Trudgill 1978)
  - Merger by expansion (Herold 1990)
  - Merger by phonological transfer (Dinkin 2016)
  - Merger by glide loss (Irons 2007)

- Trajectories and merger?
  - Other than merger by glide loss, trajectories have not been considered



	p	i	l	
	peel			

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  - Merger by expansion (Herold 1990)
  - Merger by phonological transfer (Dinkin 2016)
  - Merger by glide loss (Irons 2007)

- Trajectories and merger
  - Other than merger by glide loss, trajectories are not considered
  - What role to trajectories play in merger?

Data Collection

When	January 2018
Field Site	Wasatch County, Utah
Recruitment	face-to-face, business cards, snowball, family
Method	Wordlist
Speakers	28
Vowels analyzed	4,514 prelateral vowel tokens

Data Processing

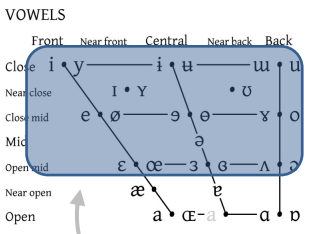
Transcription	Manual
Forced-Alignment	Manual
Formant Extraction	Fast Track (Barreda 2021), binned at 11 points per vowel
Filtering	Mahalanobis distance (Mahalanobis 1936)
Normalization	ΔF (Johnson 2020)
Statistical Modeling	Generalized additive mixed-effects models (Wood 2017)
Software	R (R Core Team 2018), tidyverse (Wickham 2018); mgcv (Wood 2011); itsadug (van Rij et al. 2020)
Visuals	ggplot2 (Wickham 2015)

I can make some sweet plots.

Birth year modeled as a continuous, nonlinear variable.

Predicted prelateral vowel trajectories in Heber City, UT

What you should see: Lots of change!



This plot is a zoomed-in view of this region.

No indication of SPOOL merging with WOLF (*i.e.*, no *pool-pull* merger)

ZEAL distinct but moving towards GUILT.

ZEAL

SPOOL

WOLF

JOLT

Lots of merging happening here.

GUILT

FLAIL

Massive amount of raising

MULCH

SHELF

Lines represent the 10%–50% into the vowel + lateral segment

Predicted F1 (normalized)

0.4

0.5

0.6

2.0

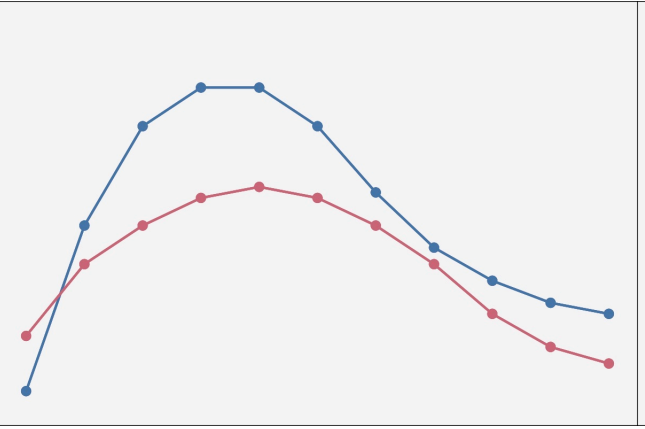
1.6

1.2

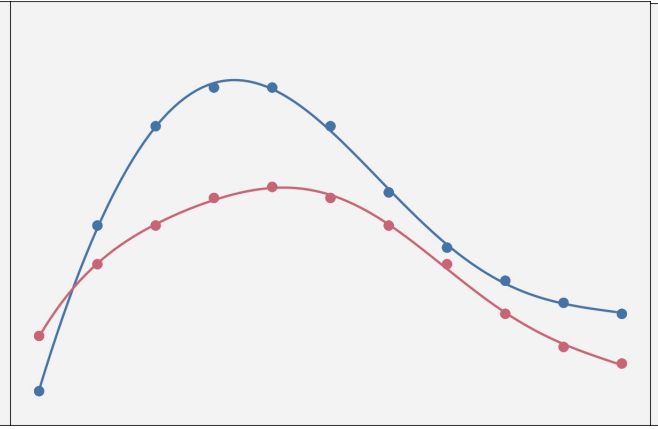
0.8

Predicted F2 (normalized)

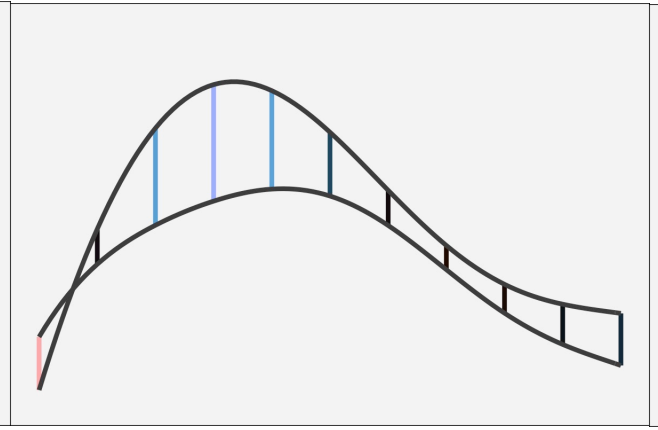
1930 1950 1970 1990 2010



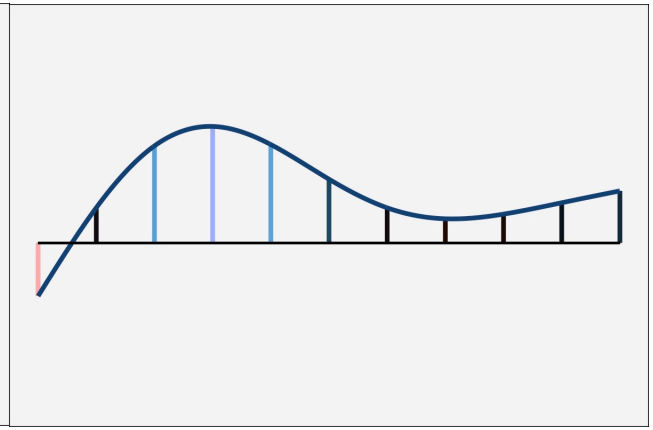
The raw data



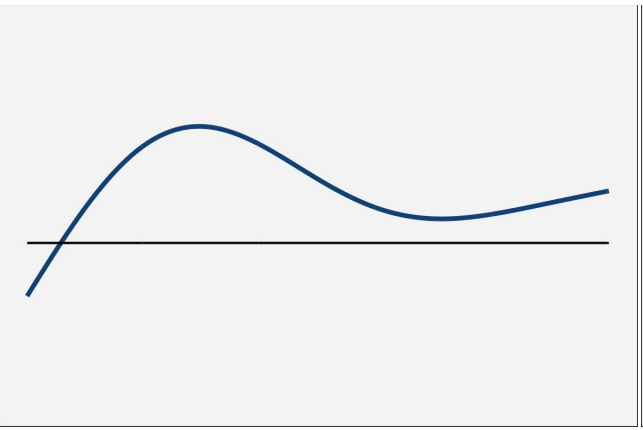
Raw data connected smoothly via GAMM.



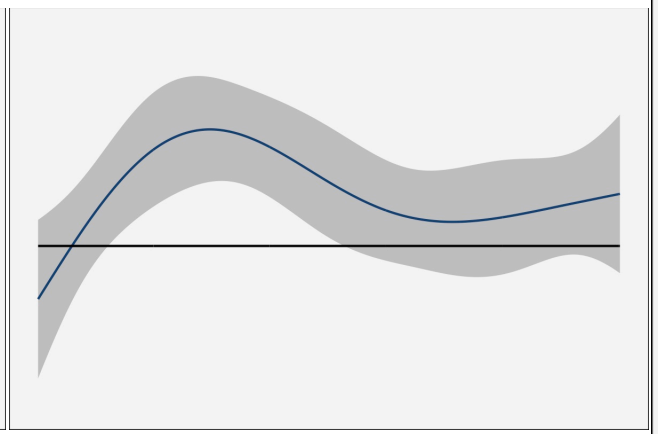
Difference between the smooths. Larger = bluer.



Flatten one of them; keep vertical lines consistent.

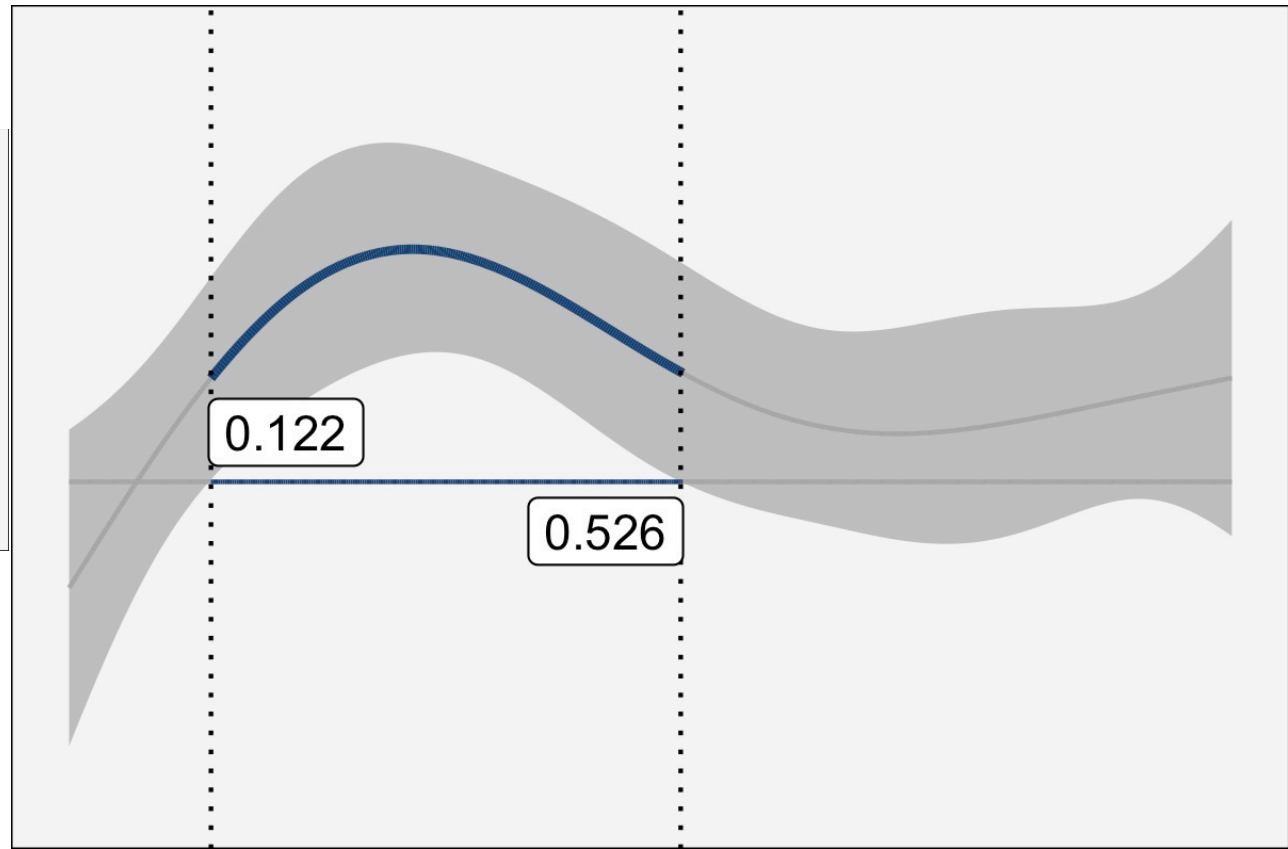


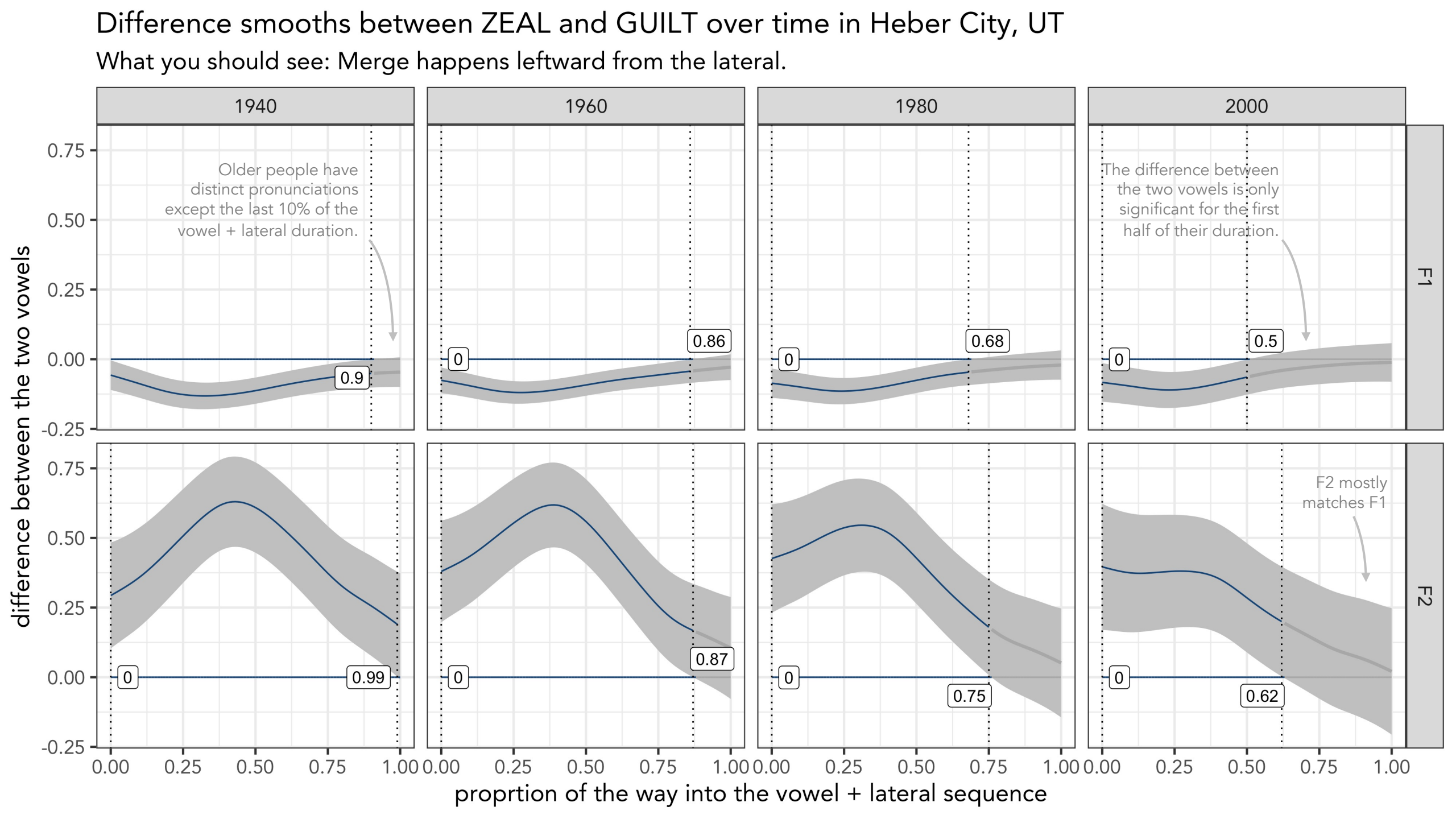
Extract just the top line. This is the **difference smooth.**

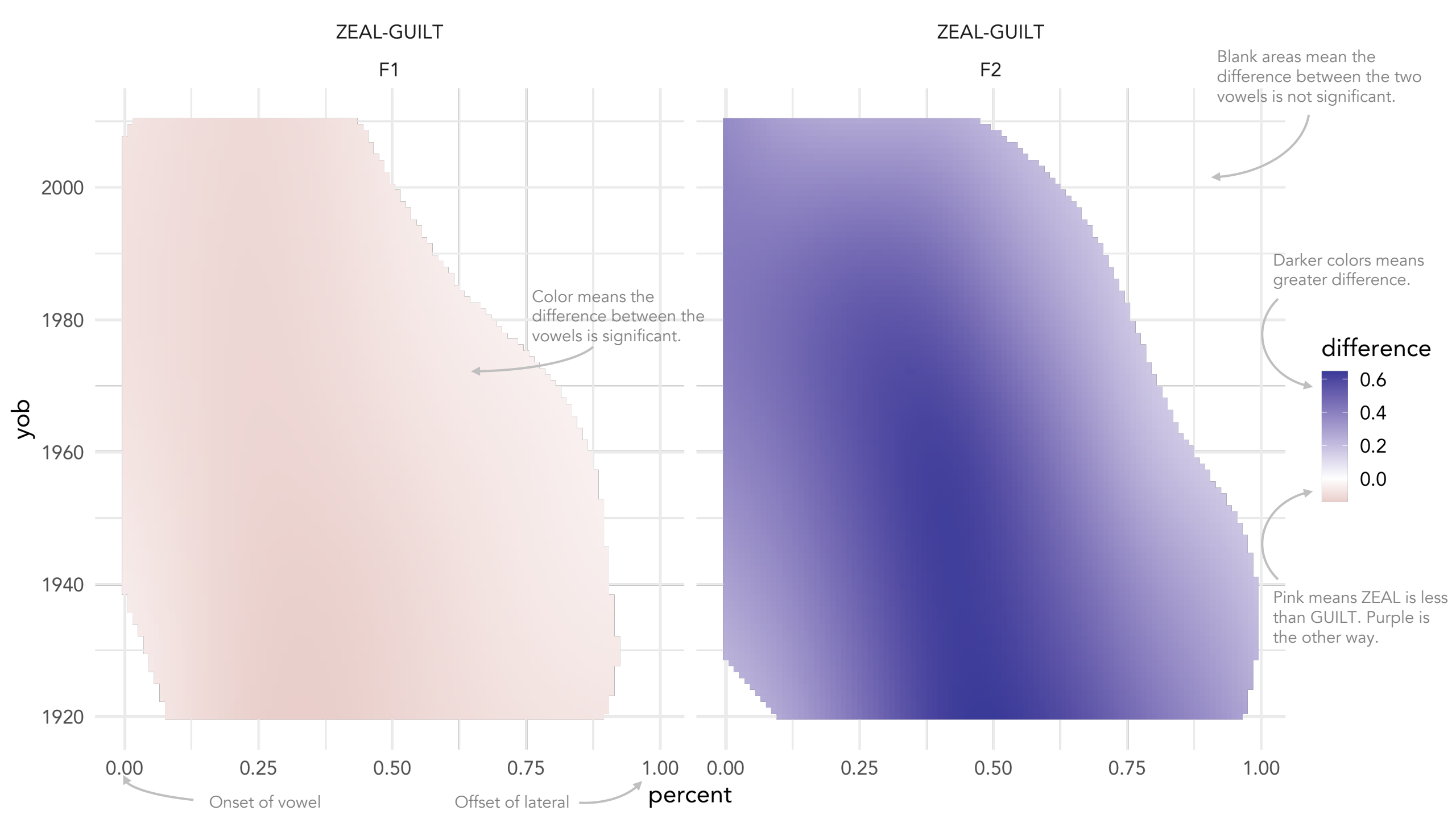


Add confidence intervals.

Indicate where confidence intervals do not include 0. ▶




Difference smooths between ZEAL and GUILT over time in Heber City, UT
What you should see: Merge happens leftward from the lateral.
1940
1960
1980
2000
F1
F2
Older people have distinct pronunciations except the last 10% of the vowel + lateral duration.
The difference between the two vowels is only significant for the first half of their duration.
F2 mostly matches F1
0.9
0.86
0.68
0.5
0.87
0.99
0.75
0.62
0
0.75
0.50
0.25
0.00
-0.25
0.00
0.25
0.50
0.75
1.00
difference between the two vowels
proprtion of the way into the vowel + lateral sequence


ZEAL-GUILT
F1
ZEAL-GUILT
F2
Blank areas mean the difference between the two vowels is not significant.
Color means the difference between the vowels is significant.
Darker colors means greater difference.
difference
0.6
0.4
0.2
0.0
Pink means ZEAL is less than GUILT. Purple is the other way.
yob
2000
1980
1960
1940
1920
0.00
0.25
0.50
0.75
1.00
percent
Onset of vowel
Offset of lateral

So what?

- The vowel plot suggests a merger by approximation
  - ZEAL and GUILT are gradually getting closer in apparent time.
  - … at least based on the midpoints.

- Expanding to trajectories gives greater insight into this type of merger.
  - In this sample, offsets are ahead of the curve than midpoints.
  - Kinda like a zipper.

Conclusion

Summary

- Changes in trajectory may accompany vowel shifts
  - With BAT in Washington, trajectories changed as the vowel lowered.
  - With GOAT in the South, trajectories were more stable as the vowel fronted.

- Trajectories are involved in vowel mergers.
  - With ZEAL and GUILT in Utah, the lateral has more and more influence on the vowel.

Conclusion

- Trajectories illuminate greater detail in sociophonetic change.

- We now have the ability to analyze trajectories.
  - Let's ditch the (phonetic) monophthong vs. diphthong distinction (at least in methods).
  - Let's reanalyze existing theories about phonetic change.
  - Let's discover new ways that language changes.

- What kind of sociolinguistic meaning is encoded in trajectories?

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