

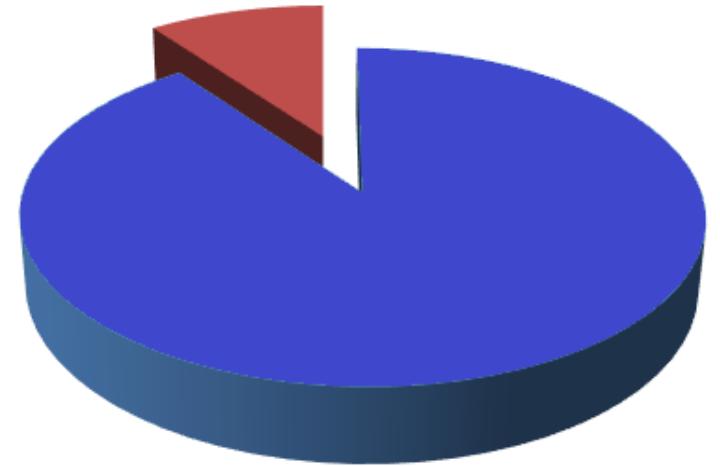
# The effects of language contact on non-native diphthongs in lexical borrowings: The case of Media Lengua

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# Media Lengua



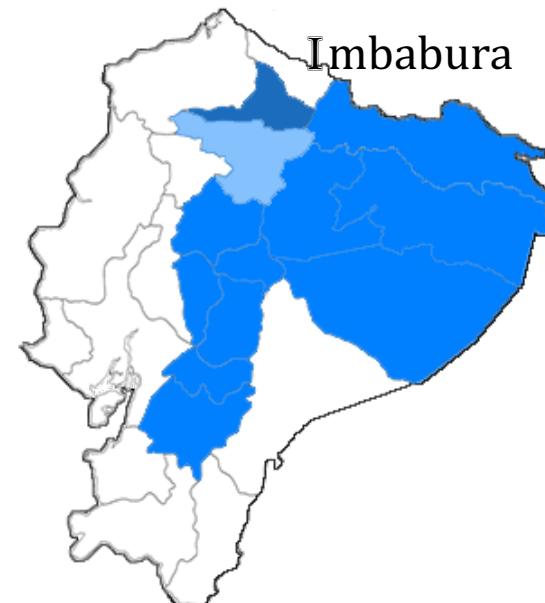
Mixed Language (**Quichua-Spanish**)

Quichua – phonological, morphological, and syntactic system  
Spanish – Lexicon

Si no aceiti-ta ocupa-kpi-ka huevo-ka sarten-pi-mi pega-shpa queda-n.

If not oil-ACC use-DS.COND-TOP egg-TOP pan-LOC-VAL stick-SS remain-3.PRES

*'If you don't use oil, the eggs will stick to the pan.'*



# Mixed language Vowel Systems

## Gurindji

(Jones, Meakins, and Buchan Kriol<sup>2010</sup>)

/æ/ & /e/

/ə:/ &

/o:/

Show more overlap in Gurindji Kriol than in Kriol

## Michif

(Rosen, Stewart, & Sammons 2020)

/ɛ/ & /ɔ/

Merged French and Cree vowels into a Cree-like arrangement with the exception of French origin /ɛ, ɔ/

## Media

(Stewart Lengua<sup>2014</sup>)

/e/ & /i/

/o/ &

/i//u/u/ &

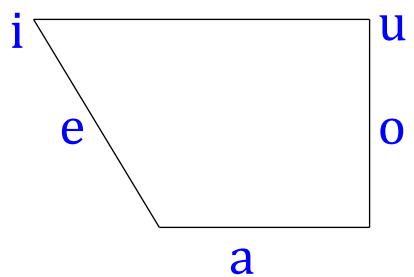
/ə/

Considerable overlap in Quichua/ Spanish high vowels with Spanish mid vowels. Substantial overlap in Spanish and Quichua high and low vowels

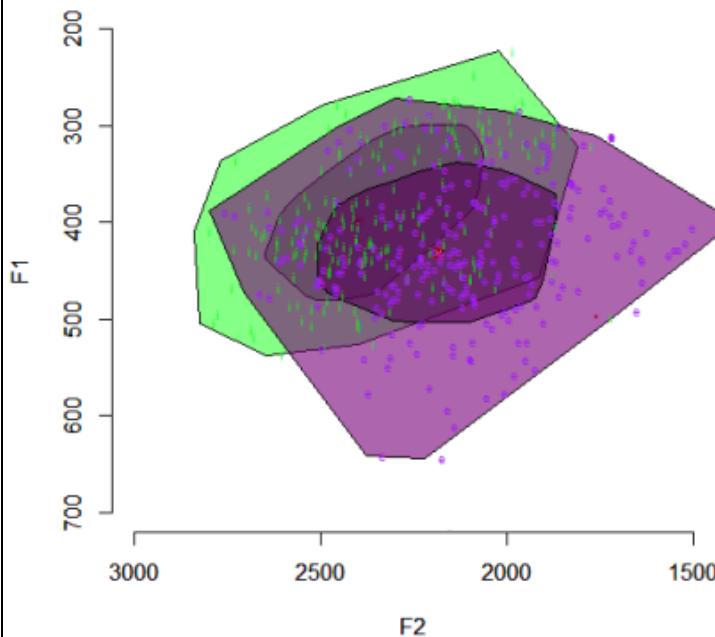
# Media Lengua's Vowel System

## Production

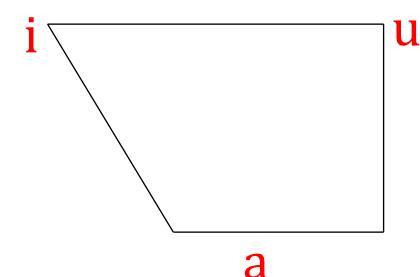
Spanish



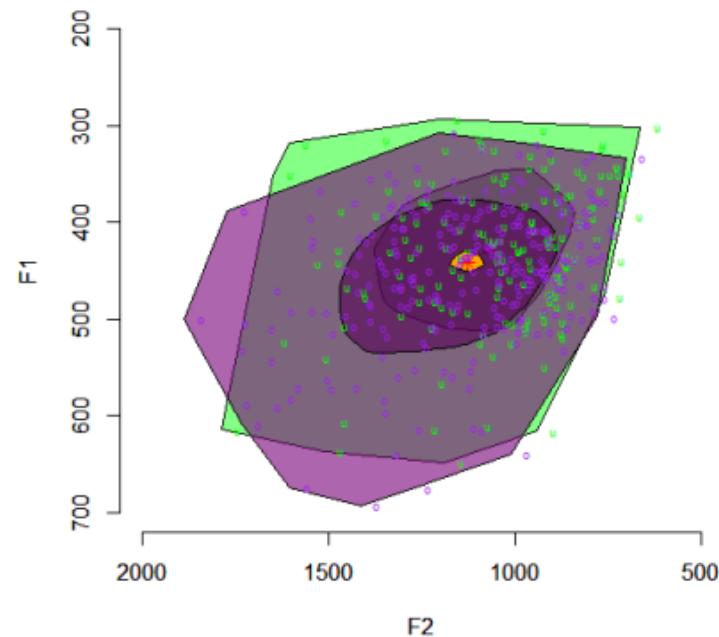
IQ: Spanish-derived /i/ Vs. Spanish-derived /e/



Quichua



IQ: Spanish-derived /u/ Vs. Spanish-derived /o/



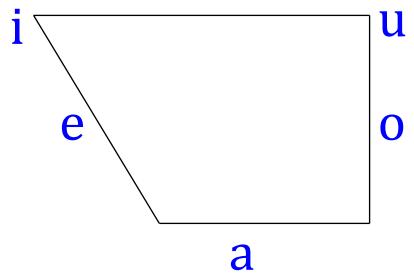
sarten-pimi  
pan-LOC-VAL  
'in the pan'

(Stewart, 2014)

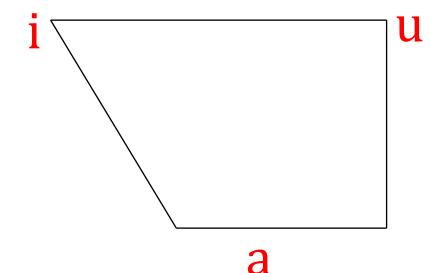
# Media Lengua's Vowel System

*Production*

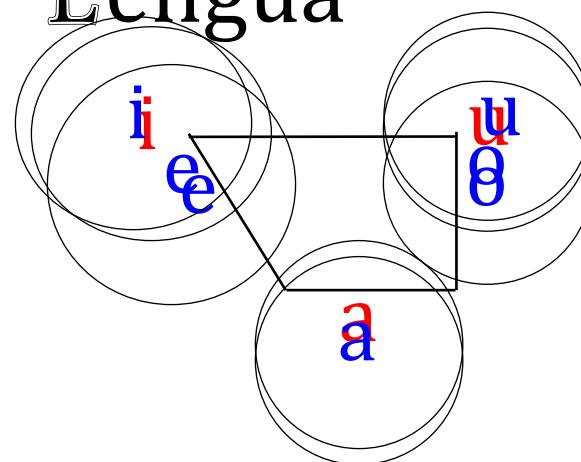
Spanish



Quichua



Media  
Lengua



(Stewart, 2014)

# Media Lengua's Vowel System

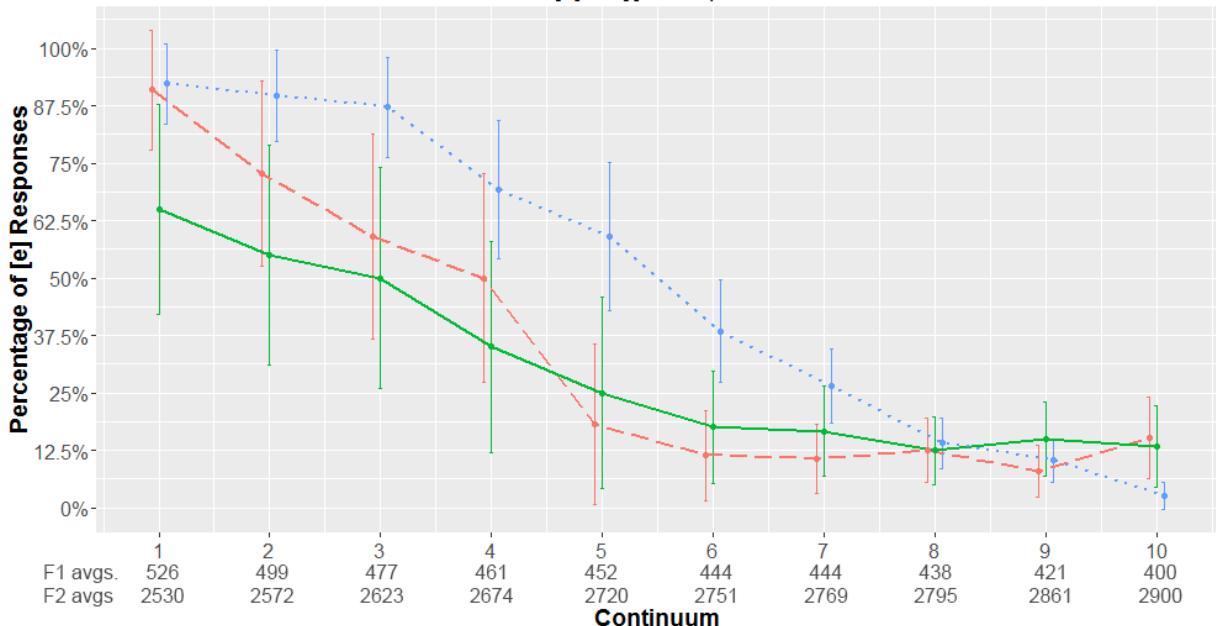
## Perception

2AFC  
Identification  
Task Experiment

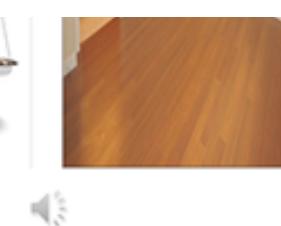
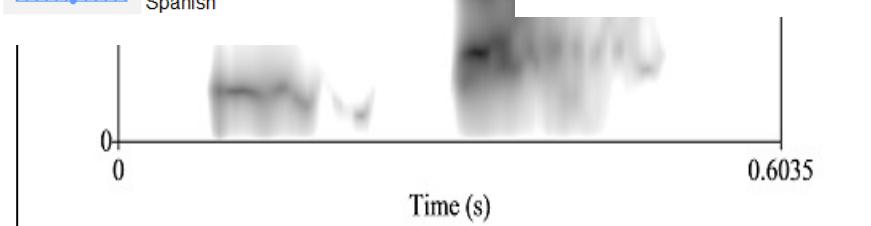
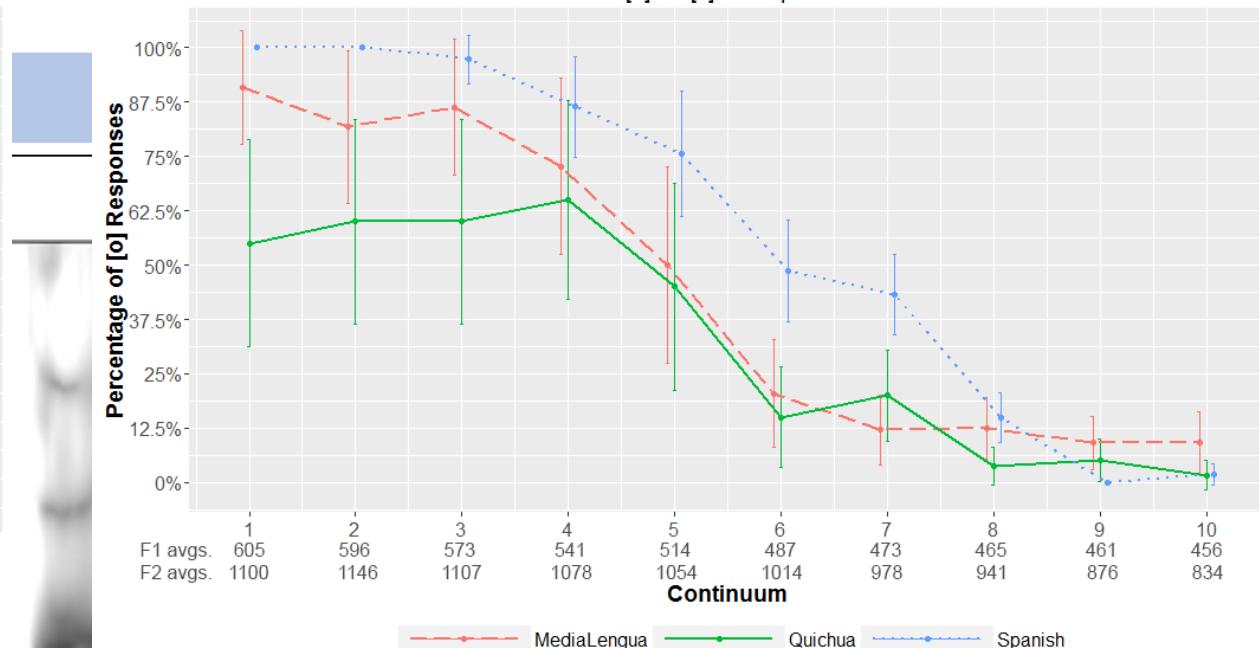
Spanish

|      |      |      |      |      |      |      |      |      |      |                |
|------|------|------|------|------|------|------|------|------|------|----------------|
| 542  | 520  | 486  | 497  | 489  | 484  | 486  | 507  | 470  | 456  | F1 – mid point |
| 2530 | 2572 | 2795 | 2674 | 2720 | 2751 | 2795 | 2623 | 2861 | 2900 | F2 – mid point |
| 3215 | 3254 | 3490 | 3382 | 3422 | 3454 | 3490 | 3306 | 3531 | 3588 | F3 – mid point |

[e] vs. [i] Perception



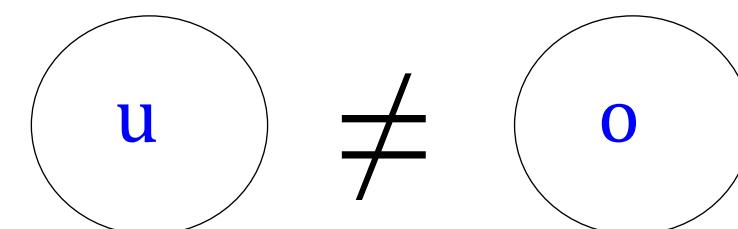
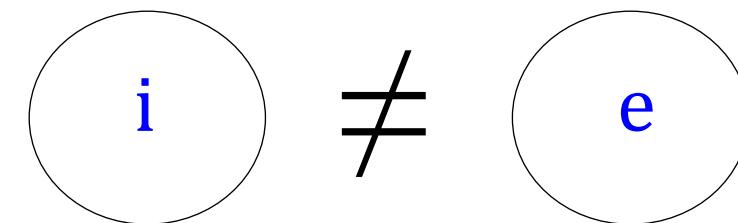
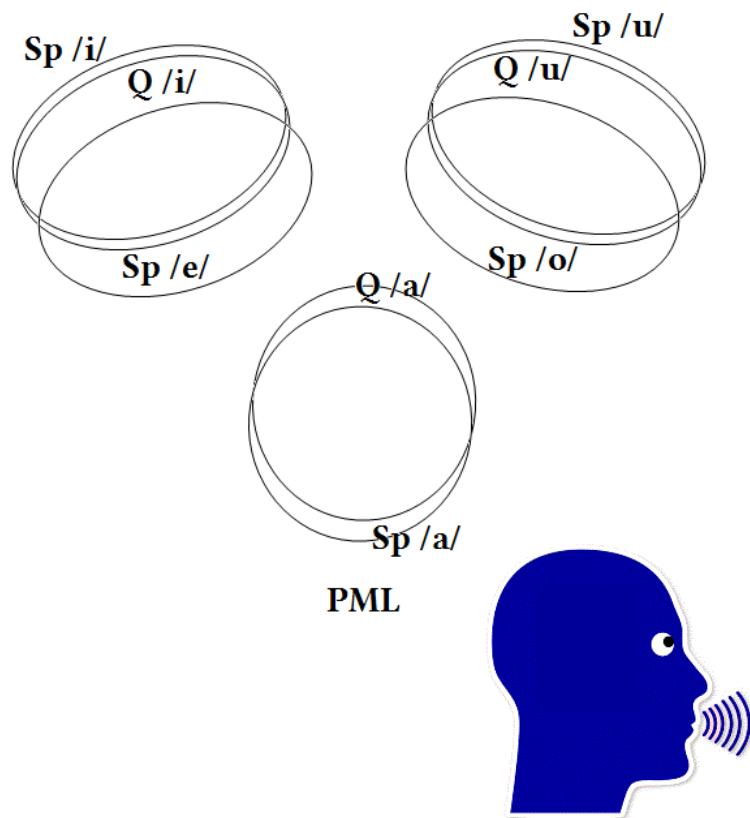
Quichua



# Media Lengua's Vowel System

## *Conclusions*

Media Lengua's vowel system is highly overlapping yet vowels are perceptually distinct.



(Stewart 2014, 2015)

# Media Lengua's Vowel System

*Research question*

How do diphthongs in Spanish origin words adapt to Media Lengua's overlapping vowel space?

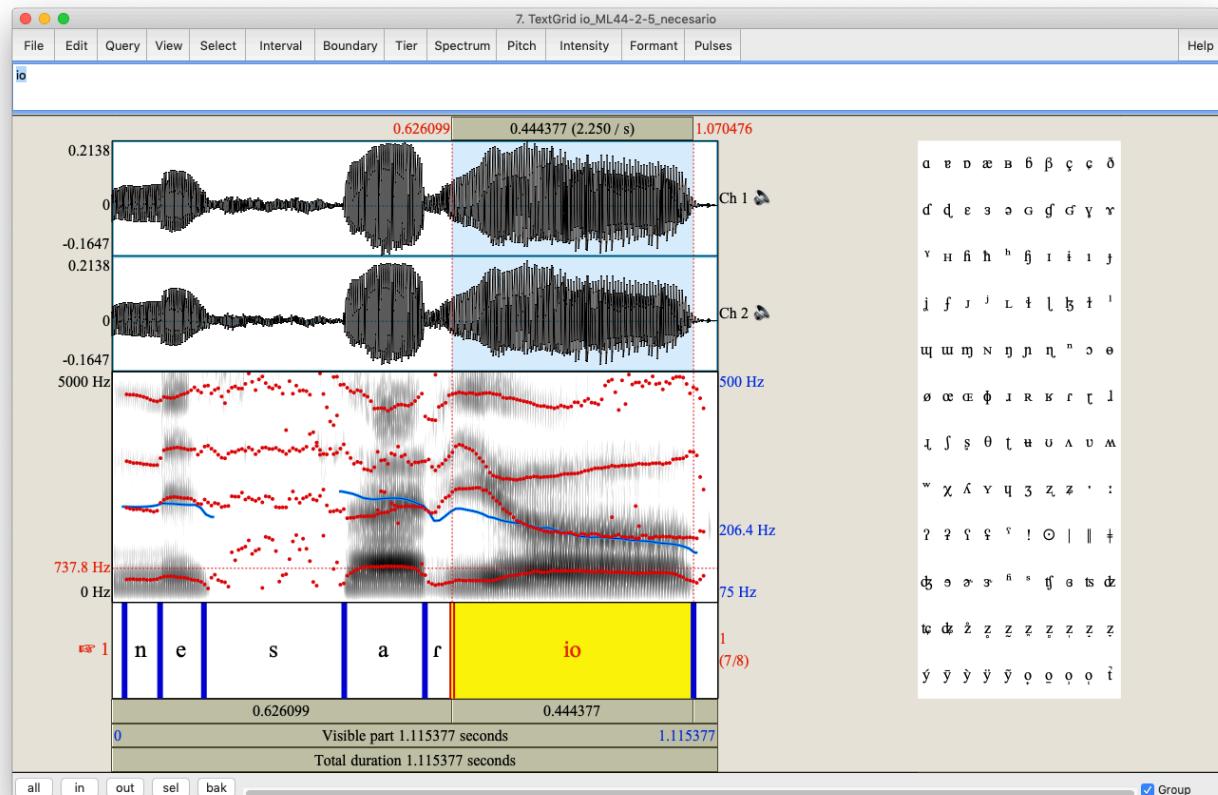
# Media Lengua's Vowel System

*Data*

|                    | Diphthong          | Media Lengua | Quichua    | Spanish    |
|--------------------|--------------------|--------------|------------|------------|
| Media Lengua:      | ae                 | 25           | --         | 26         |
| Quichua:           | ai                 | 27           | 68         | 30         |
| Spanish:           | ao                 | 9            | 0          | 17         |
| Total:             | au                 | 24           | 17         | 31         |
| 2010-2019          | ea                 | 20           | --         | 49         |
| Wordlists          | ei                 | 15           | --         | 23         |
| Elicitations       | eo                 | 11           | --         | 26         |
| Spontaneous speech | eu                 | 13           | --         | 25         |
|                    | ia                 | 32           | 20         | 44         |
|                    | ie                 | 85           | 21         | 73         |
|                    | io                 | 34           | --         | 55         |
|                    | oa                 | 5            | --         | 14         |
|                    | ua                 | 29           | 11         | 23         |
|                    | ue                 | 78           | 12         | 58         |
|                    | ui                 | 13           | 17         | 20         |
|                    | uo                 | 6            | --         | 11         |
|                    | <b>Total: 1117</b> | <b>426</b>   | <b>116</b> | <b>525</b> |

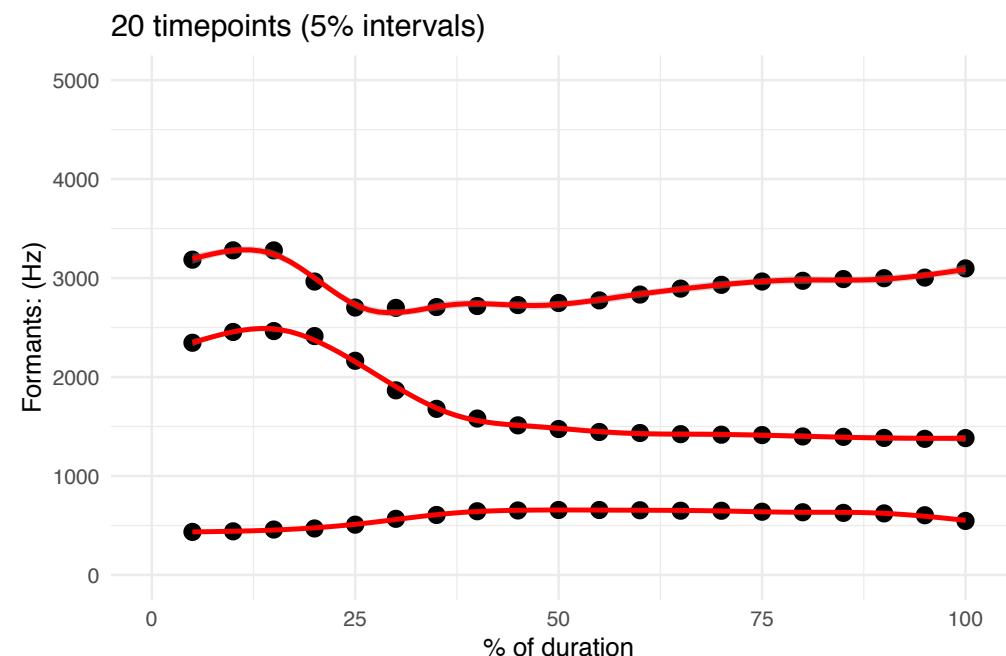
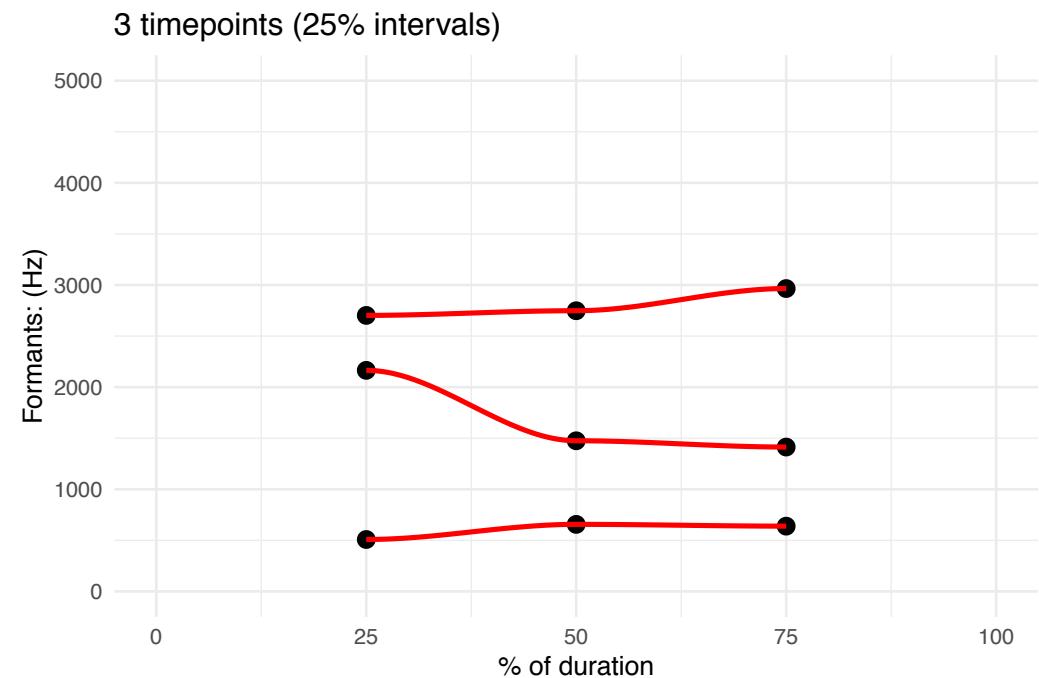
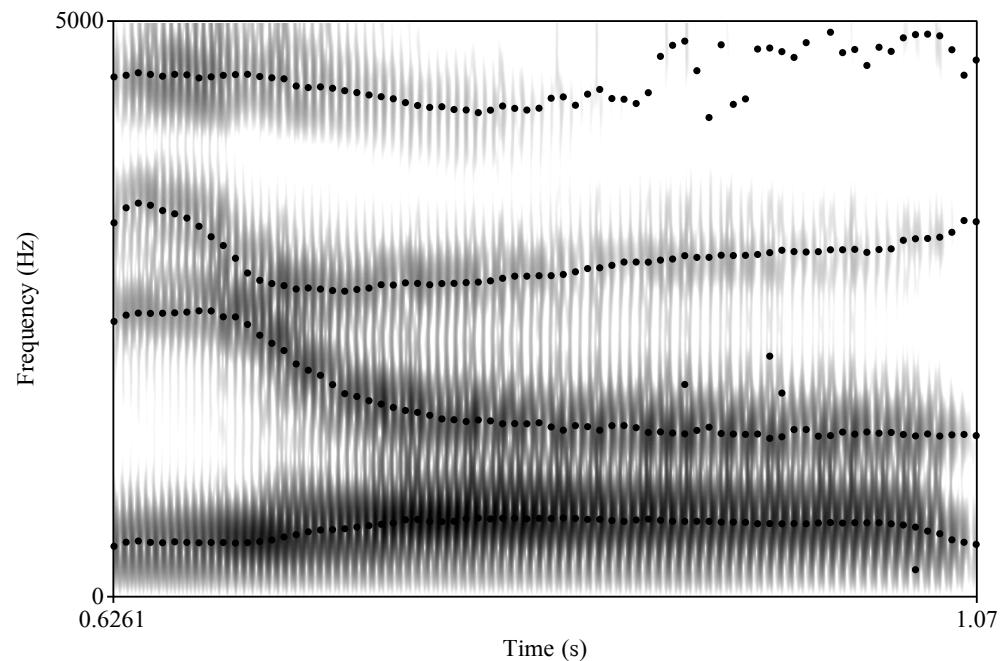
# Acoustic Measurement

- Tokens of diphthong-containing words isolated in Praat and manually segmented
- *FormantPro* script (Xu & Gao, 2018) used to extract formant measurements for F1, F2, F3 at 5% intervals across vowel duration



# Acoustic Analysis

- Formant measurements taken at 5% intervals (20 points) permit high-fidelity replication of original formant contours with minimal errors, versus more commonplace 25% intervals (3 points)

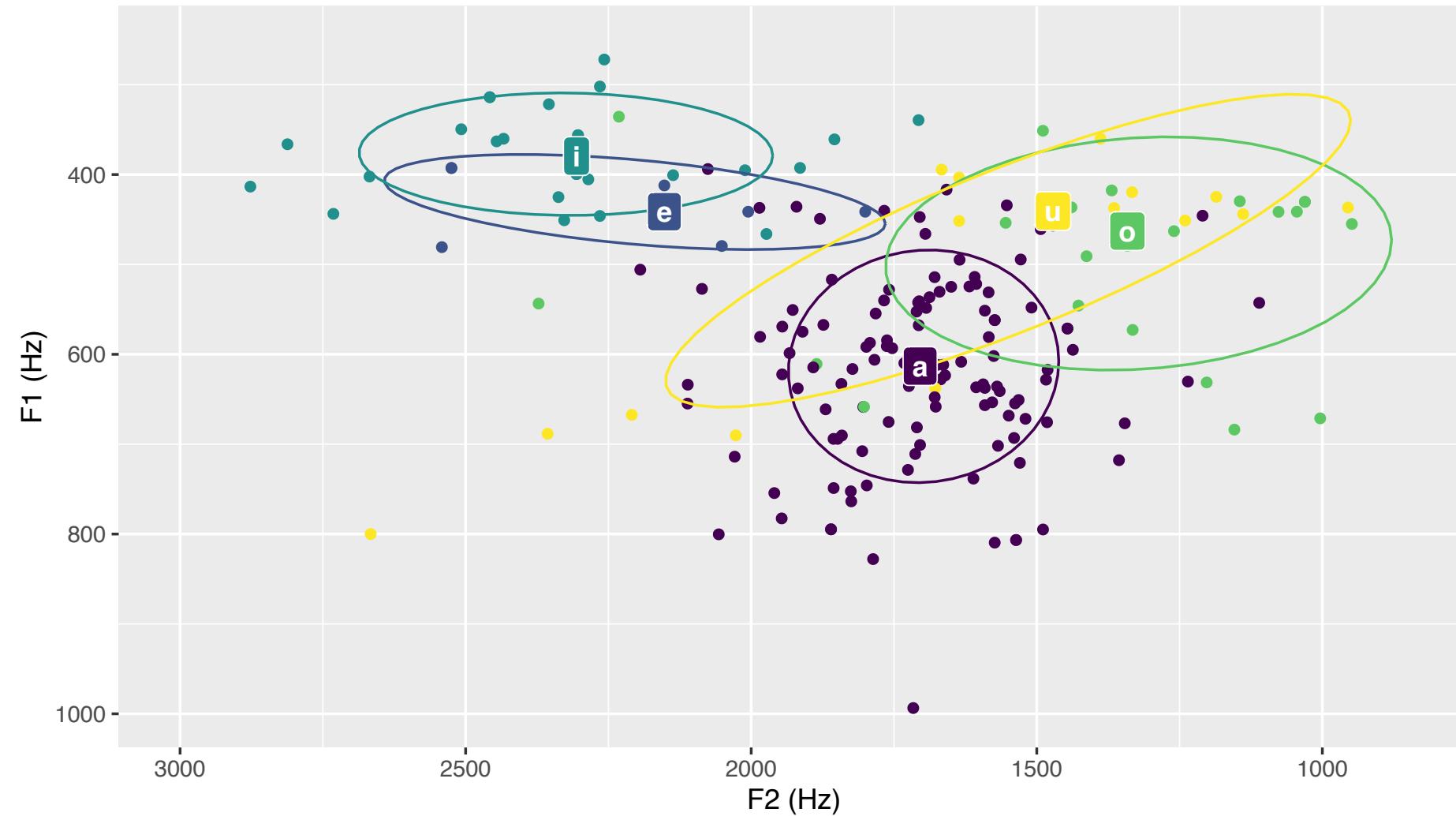


# GAMMs comparisons

- Generalized Additive Mixed Models (GAMMs; Hastie & Tibshirani, 1990; Wood, 2017; Sóskuthy, 2017) for comparison of non-linear data:
  - E.g. comparisons of formant trajectories across different conditions:
    - Vowel A vs. vowel B
    - Vowel A before segment X and segment Y
    - Vowel A by L1 vs. L2 speakers (Onosson & Bird, 2019)
- Applied within our dataset to compare:
  - Production of the same diphthong across Media Lengua, Quichua, and Spanish
  - Production of Quichua- and Spanish-derived diphthongs within Media Lengua

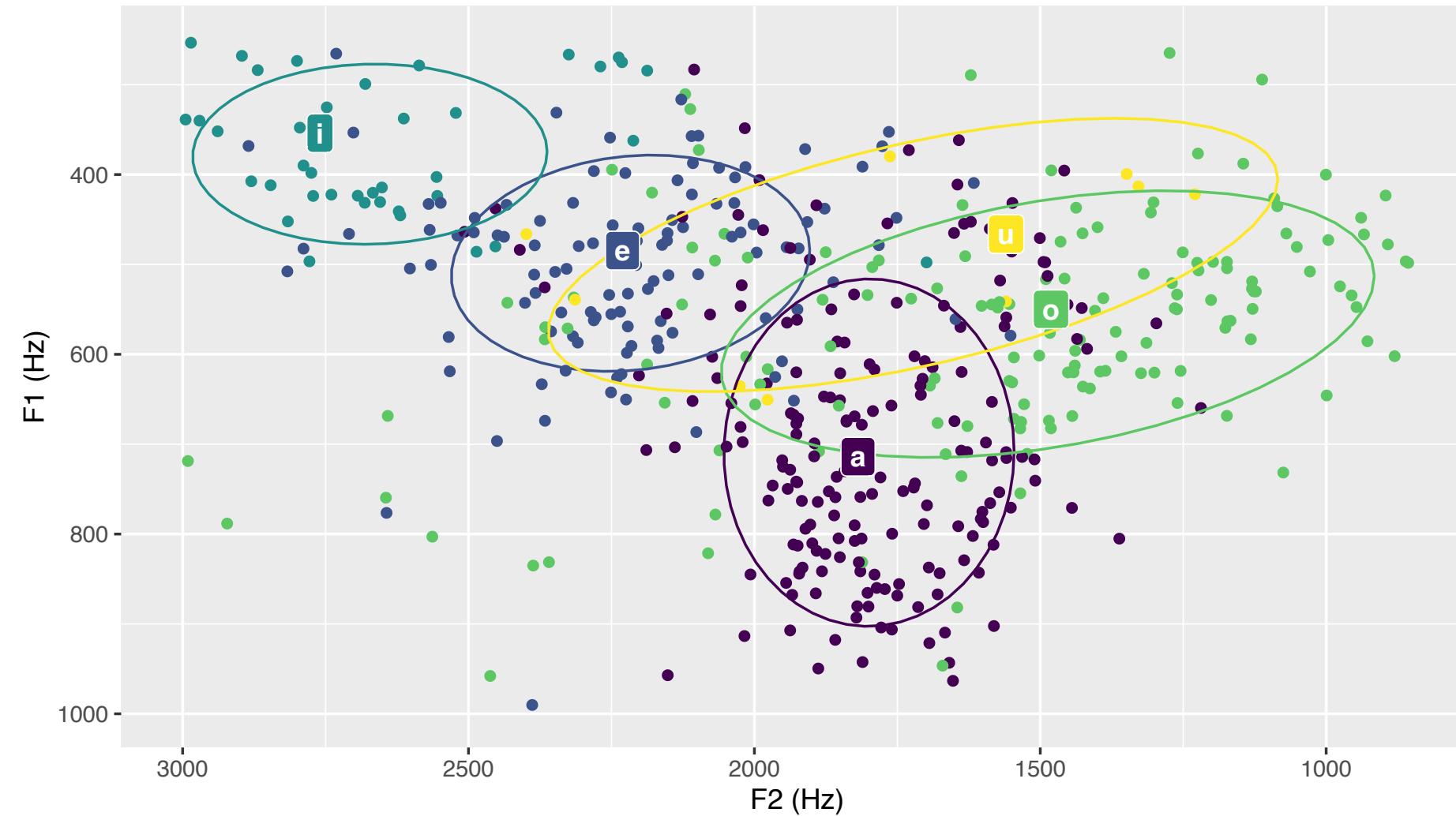
## Quichua vowel space

Ellipses indicate 2 standard deviations; monophthong n = 634



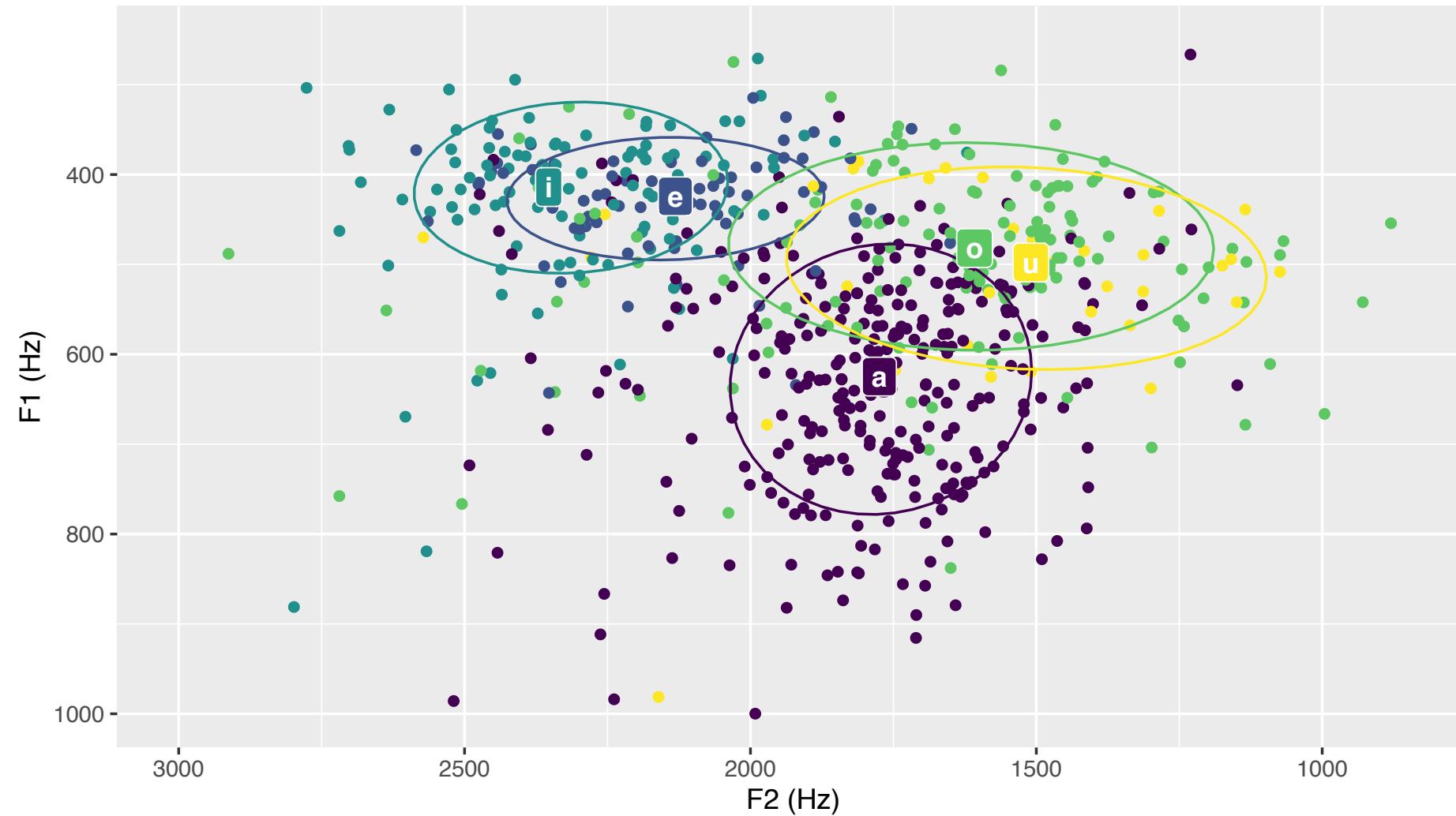
## Spanish vowel space

Ellipses indicate 2 standard deviations; monophthong n = 1929



## Media Lengua vowel space

Ellipses indicate 2 standard deviations; monophthong n = 2040



# Cross-Language Diphthong Comparisons

- Per-diphthong, per-formant GAMMs comparisons:
  - Dependent variable: – F1 or F2
  - Main independent/fixed effect: – Language (M.L. vs. Quichua vs. Spanish)
  - 2 random effects: – Speaker (by Duration)  
– Word (by Duration)

# Cross-Language Diphthong Comparisons

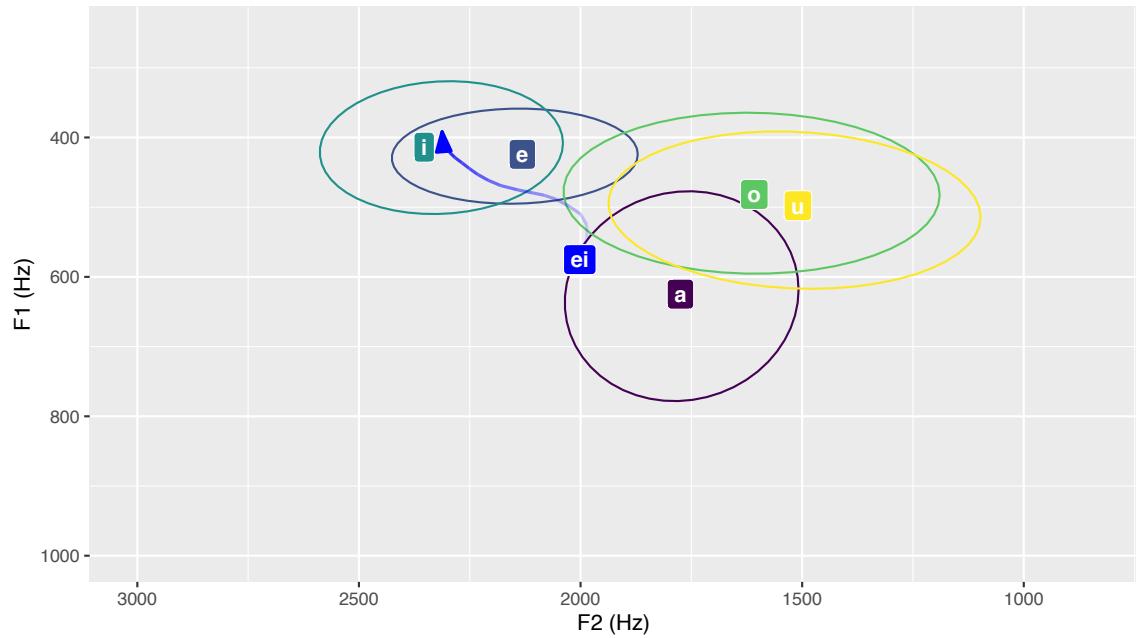
|              | <b>ae</b>         | <b>ai</b>         | <b>ao</b>             | <b>au</b>            | <b>ea</b> | <b>ei</b>             | <b>eo</b> | <b>eu</b>             |
|--------------|-------------------|-------------------|-----------------------|----------------------|-----------|-----------------------|-----------|-----------------------|
| <b>F1</b>    | n.s.              | n.s.              | n.s.                  | <b><i>p=0.02</i></b> | n.s.      | <b><i>p=0.011</i></b> | n.s.      | <b><i>p=0.005</i></b> |
| <b>F2</b>    | n.s.              | n.s.              | n.s.                  | n.s.                 | n.s.      | <b><i>p≈0</i></b>     | n.s.      | <b><i>p=0.006</i></b> |
| <b>Langs</b> | ML, S             | ML, Q, S          | ML, S                 | ML, Q, S             | ML, S     | ML, S                 | ML, Q, S  | ML, S                 |
|              | <b>ia</b>         | <b>ie</b>         | <b>io</b>             | <b>oa</b>            | <b>ua</b> | <b>ue</b>             | <b>ui</b> | <b>uo</b>             |
| <b>F1</b>    | <b><i>p≈0</i></b> | n.s.              | <b><i>p≈0</i></b>     | n.s.                 | n.s.      | n.s.                  | n.s.      | <b><i>p=0.002</i></b> |
| <b>F2</b>    | <b><i>p≈0</i></b> | <b><i>p≈0</i></b> | <b><i>p=0.023</i></b> | n.s.                 | n.s.      | <b><i>p≈0</i></b>     | n.s.      | n.s.                  |
| <b>Langs</b> | ML, Q, S          | ML, Q, S          | ML, S                 | ML, S                | ML, Q, S  | ML, Q, S              | ML, Q, S  | ML, S                 |

# Cross-Language Differences in both E1 and E2

- Media Lengua vs. Spanish: /ei, eu, io/
- Media Lengua vs. Quichua vs. Spanish: /ia/

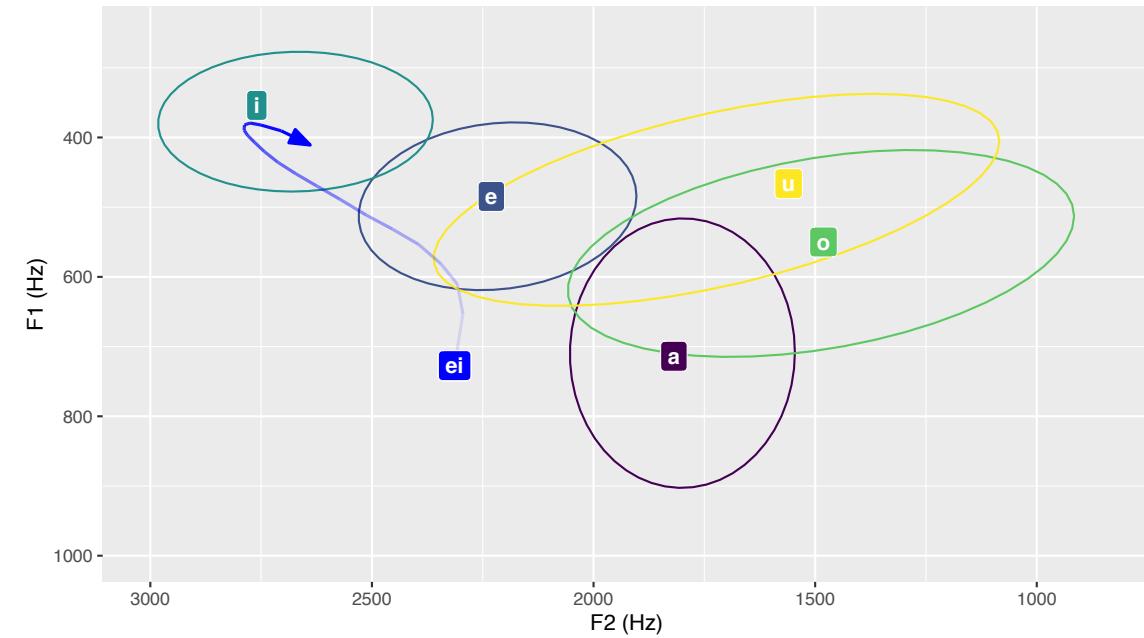
Media Lengua vowel space with /ei/ trajectory

Ellipses indicate 2 standard deviations; monophthong n = 2040

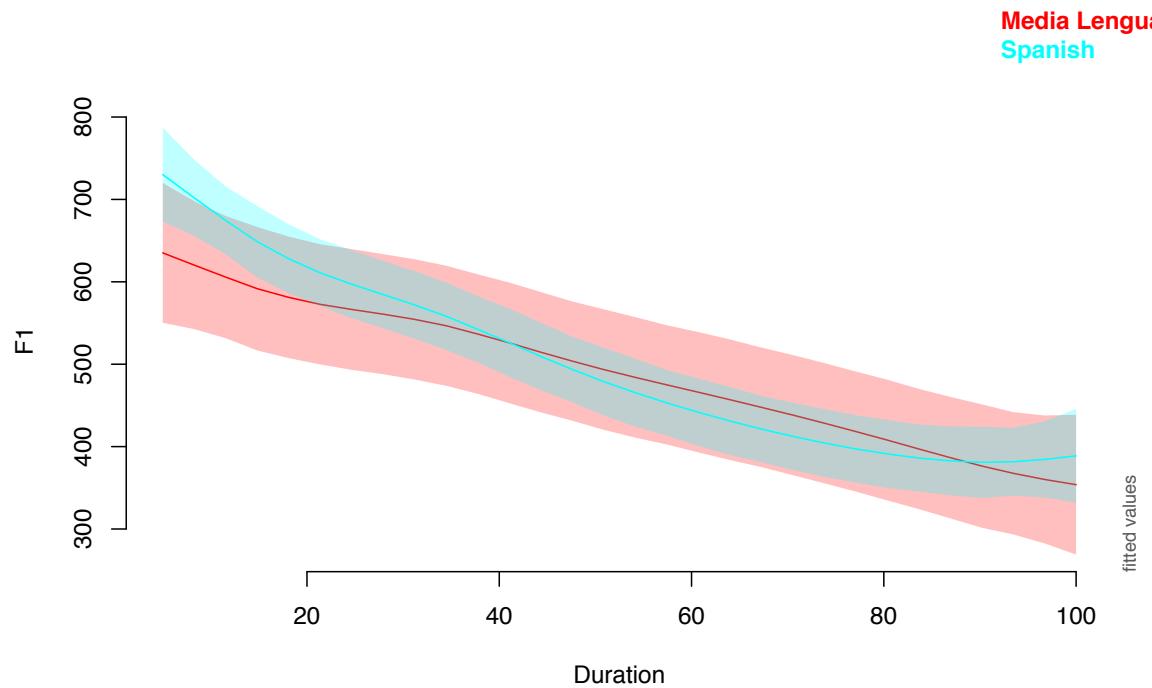


Spanish vowel space with /ei/ trajectory

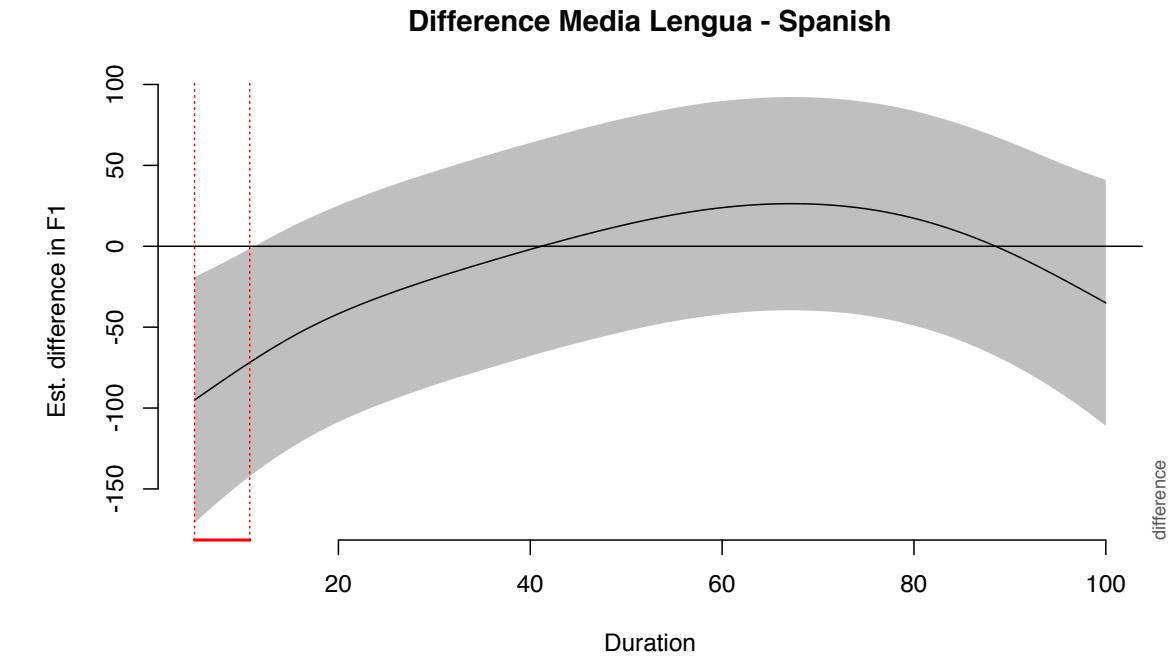
Ellipses indicate 2 standard deviations; monophthong n = 1929



/ei/: F1 & F2



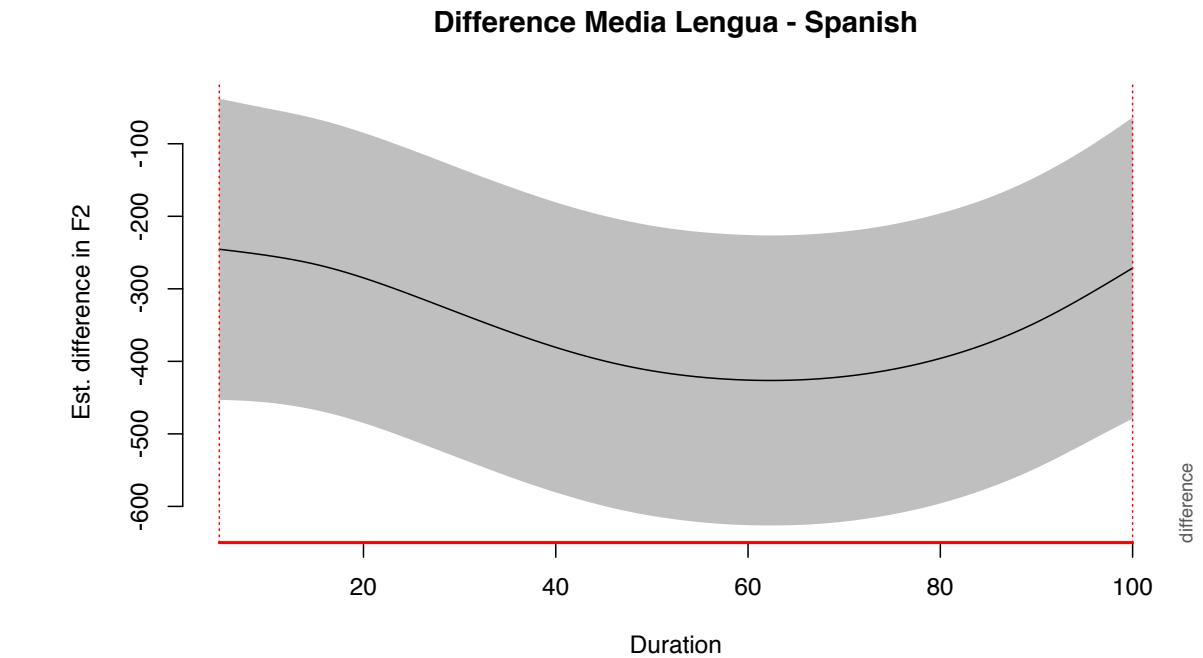
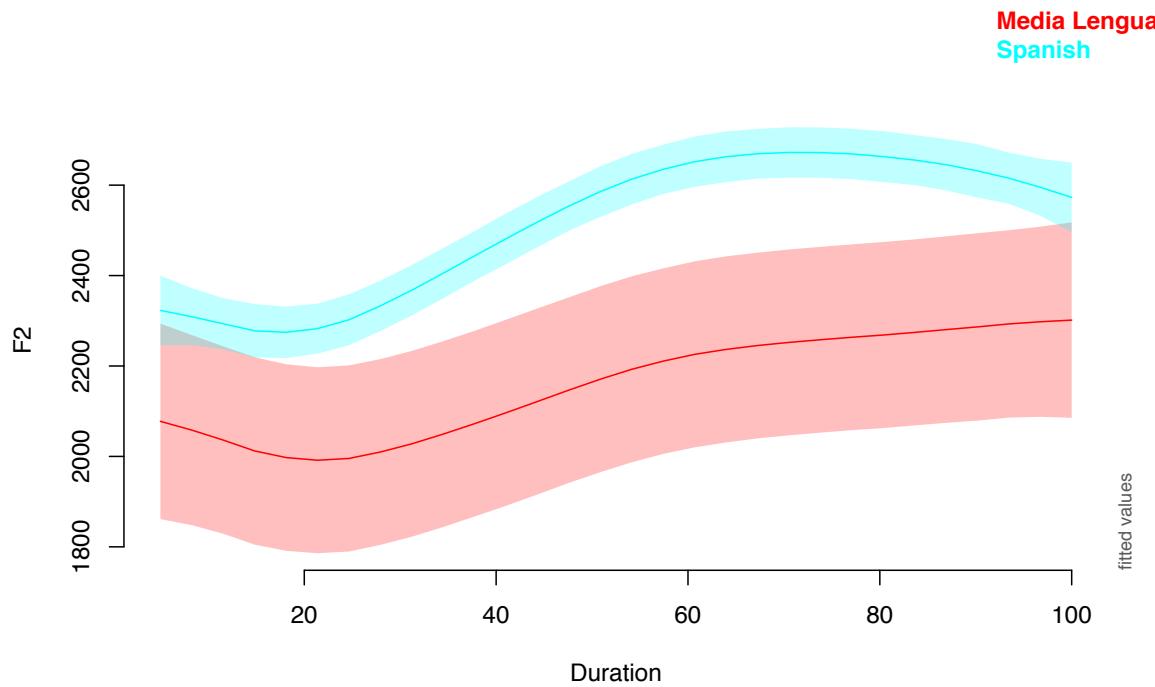
Media Lengua  
Spanish



Difference Media Lengua - Spanish

/eɪ/ F1

- Very small differences, localized to onset
- Media Lengua: lower F1 = higher articulatory position

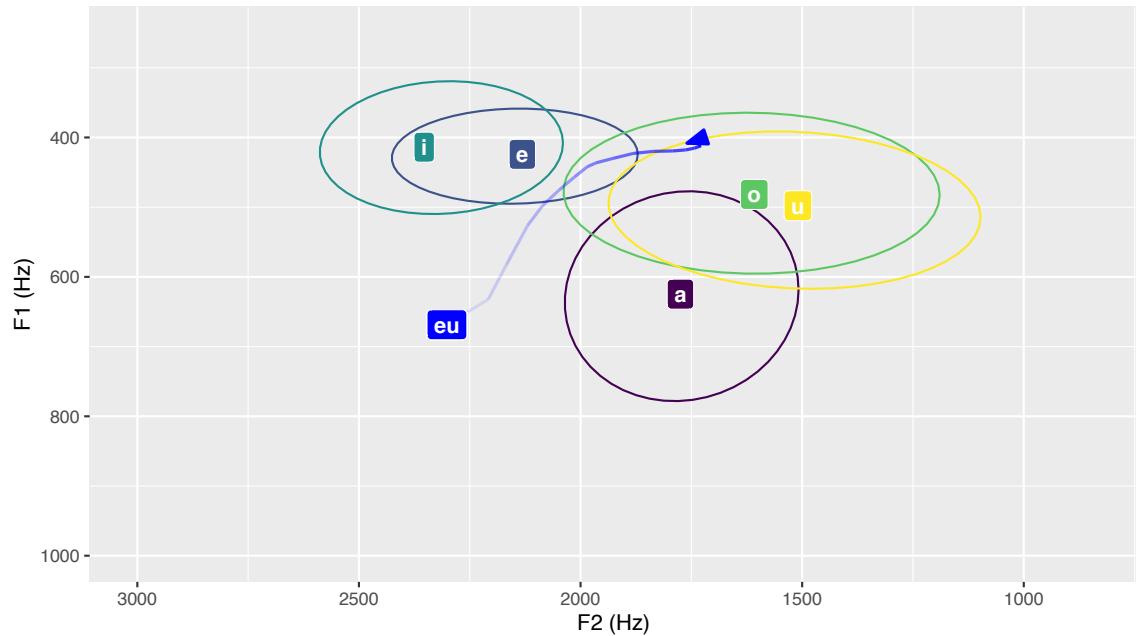


/eɪ/ F2

- Significant differences across full trajectory
- Media Lengua: F2 much lower = retracted position

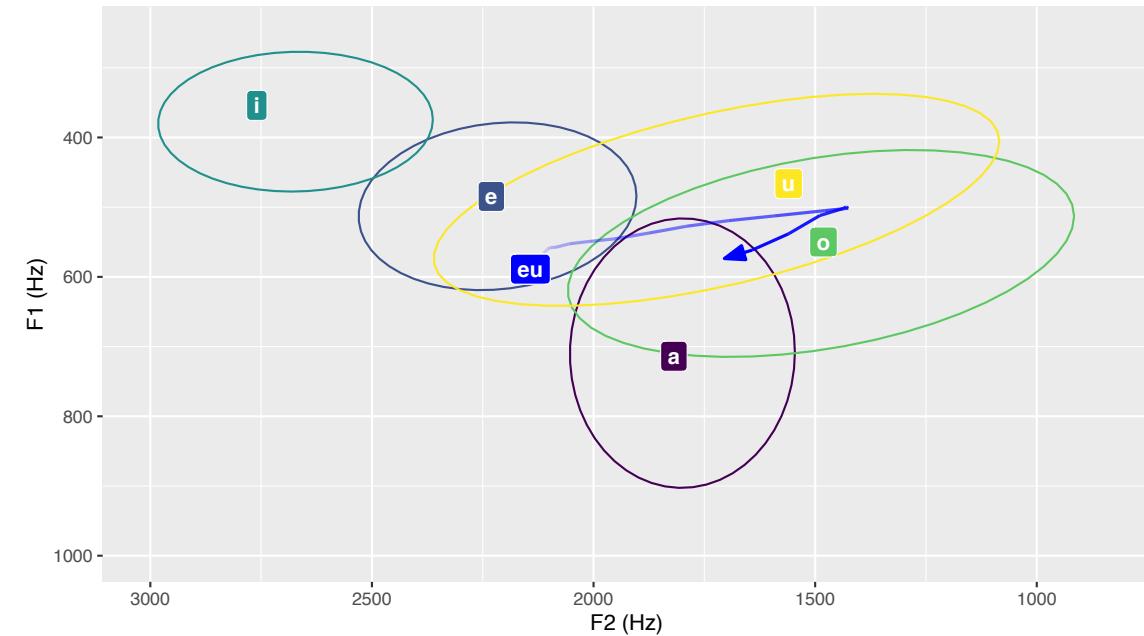
Media Lengua vowel space with /eu/ trajectory

Ellipses indicate 2 standard deviations; monophthong n = 2040

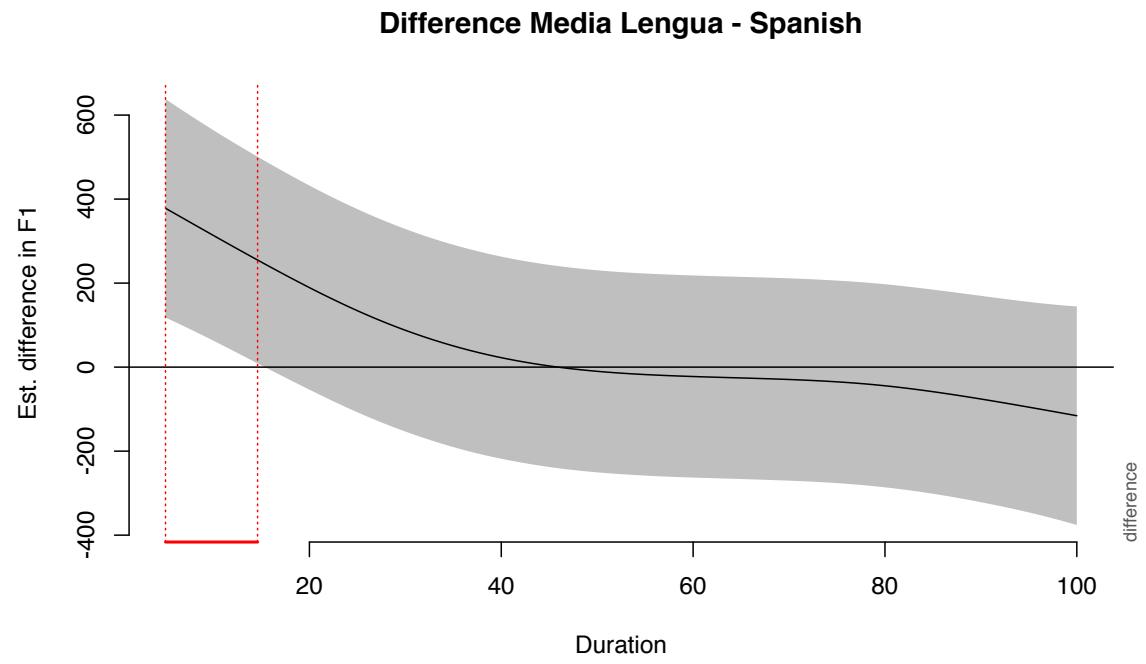
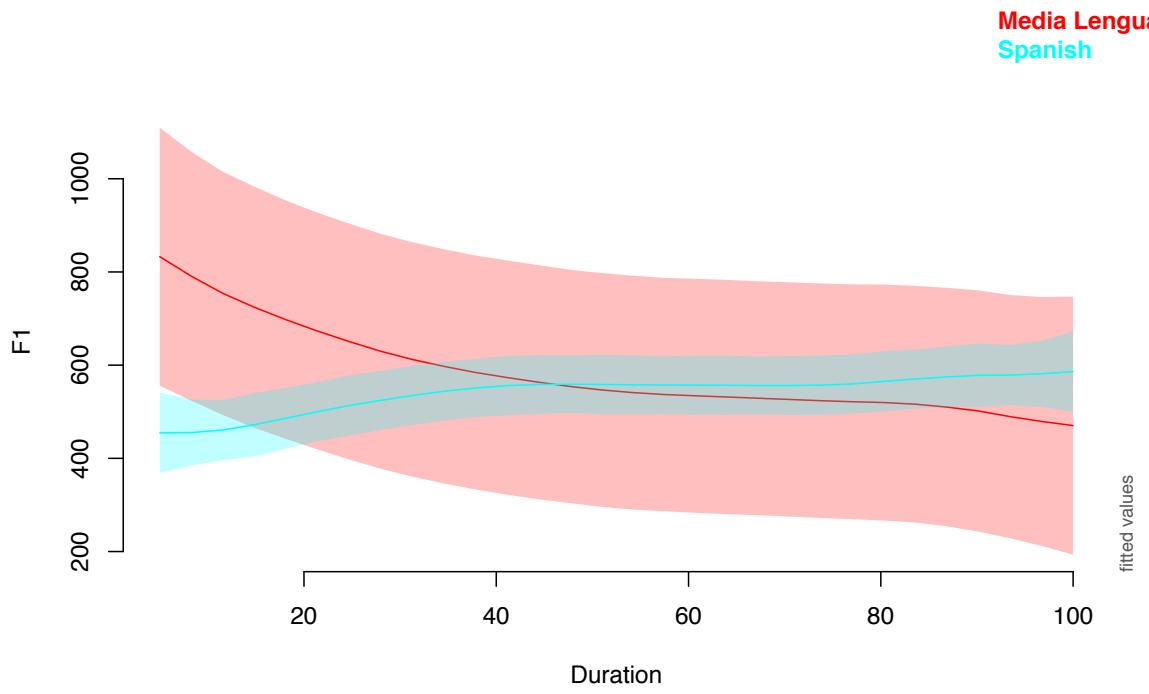


Spanish vowel space with /eu/ trajectory

Ellipses indicate 2 standard deviations; monophthong n = 1929

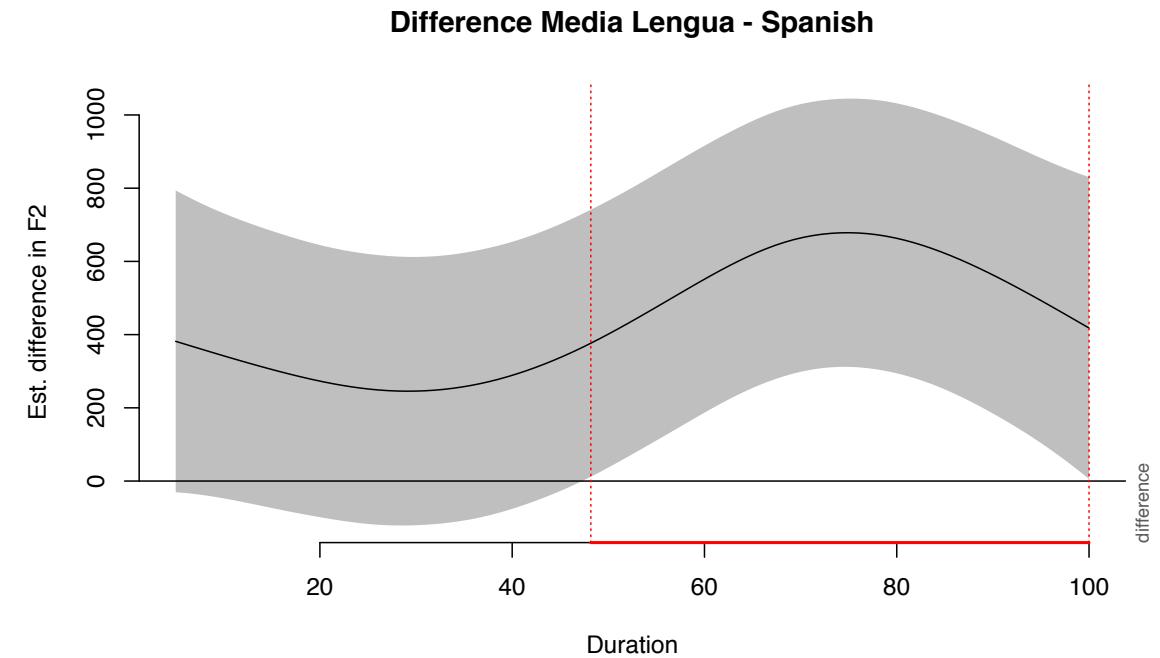
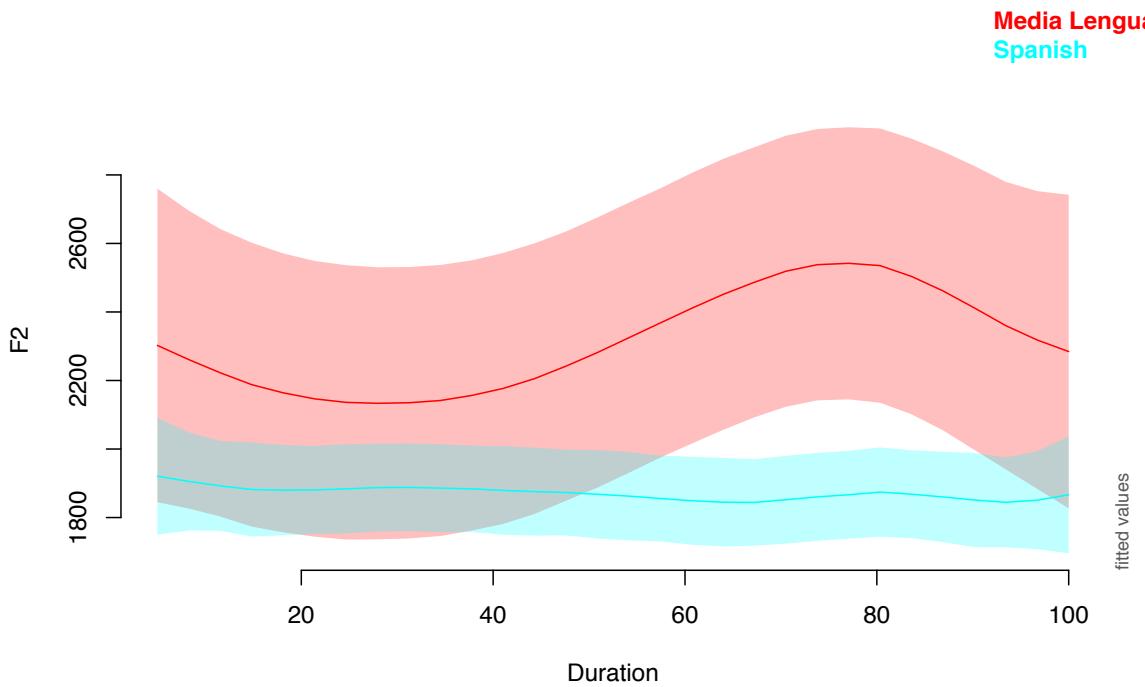


/eu/: F1 & F2



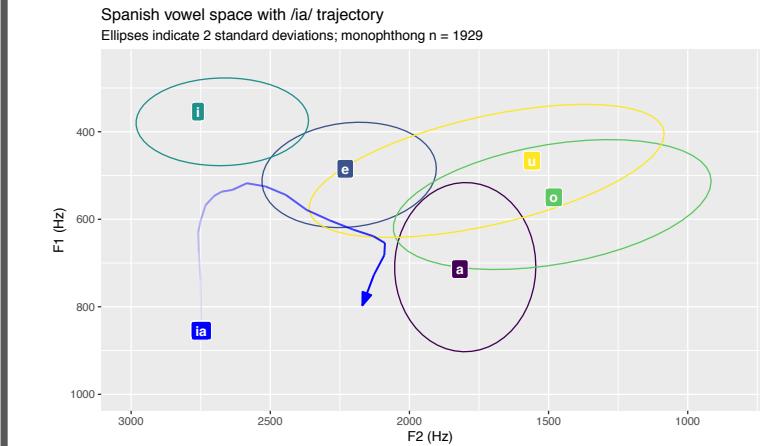
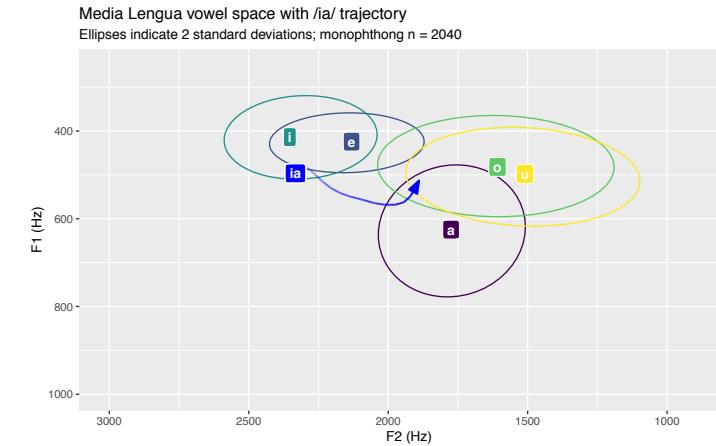
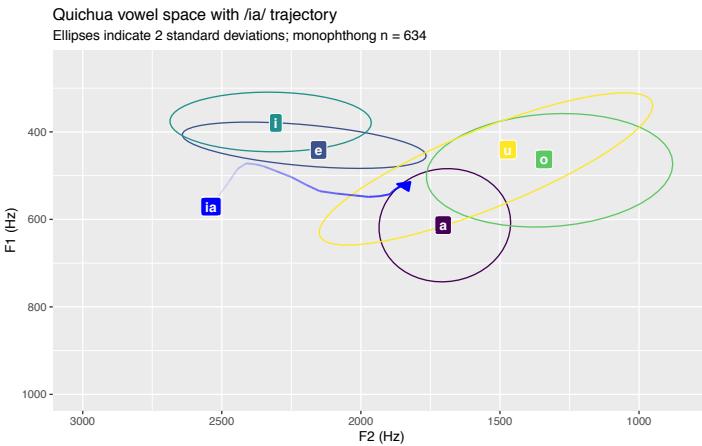
/eu/ F1

- Small, localized difference in onset
- Media Lengua: higher F1 = lower articulation

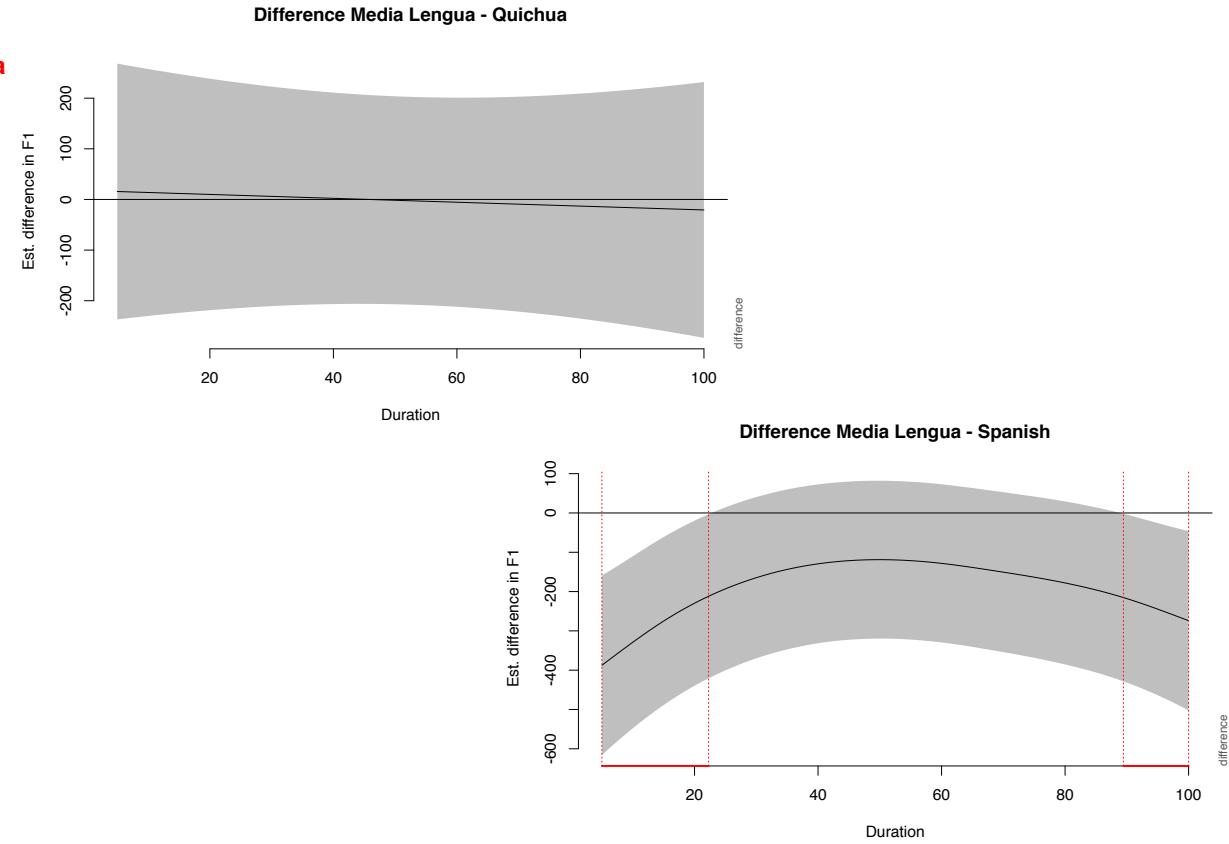
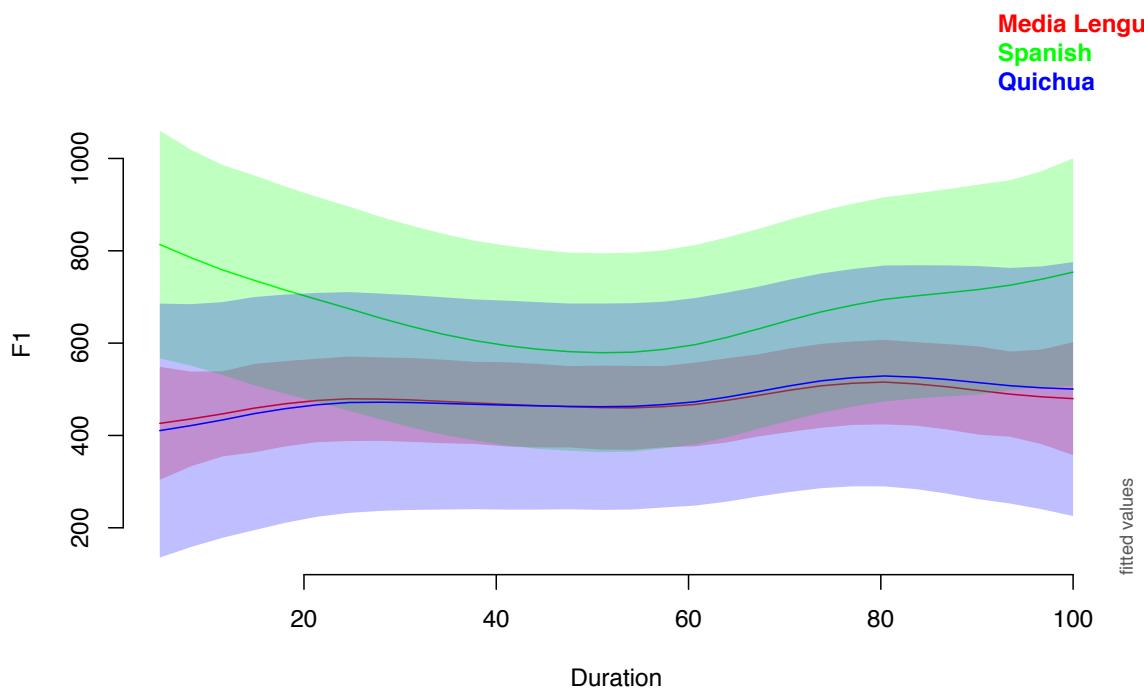


/eu/ F2

- Sig. F2 differences across >50% of trajectory
- Media Lengua: F2 higher (advanced position) and generally more dynamic
- Spanish: F2 very flat, little front-to-back movement

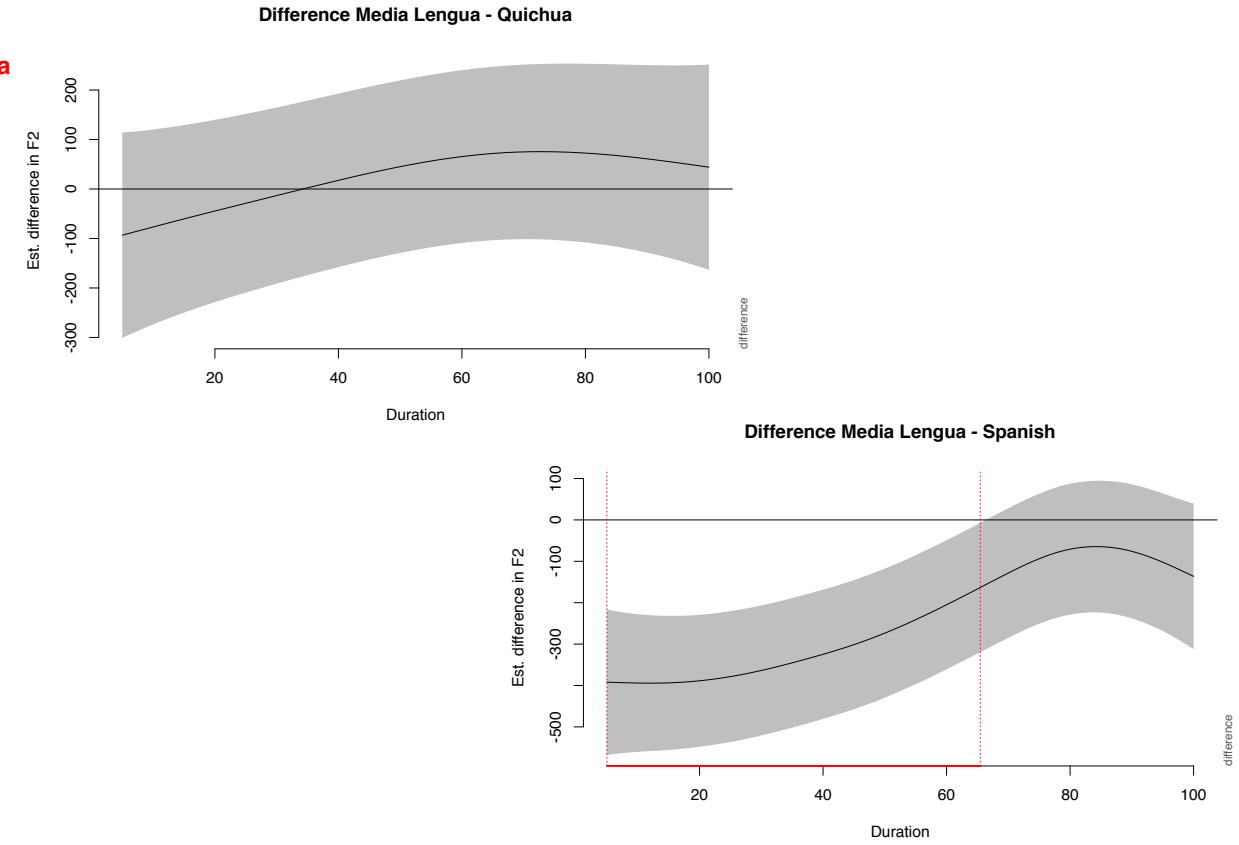
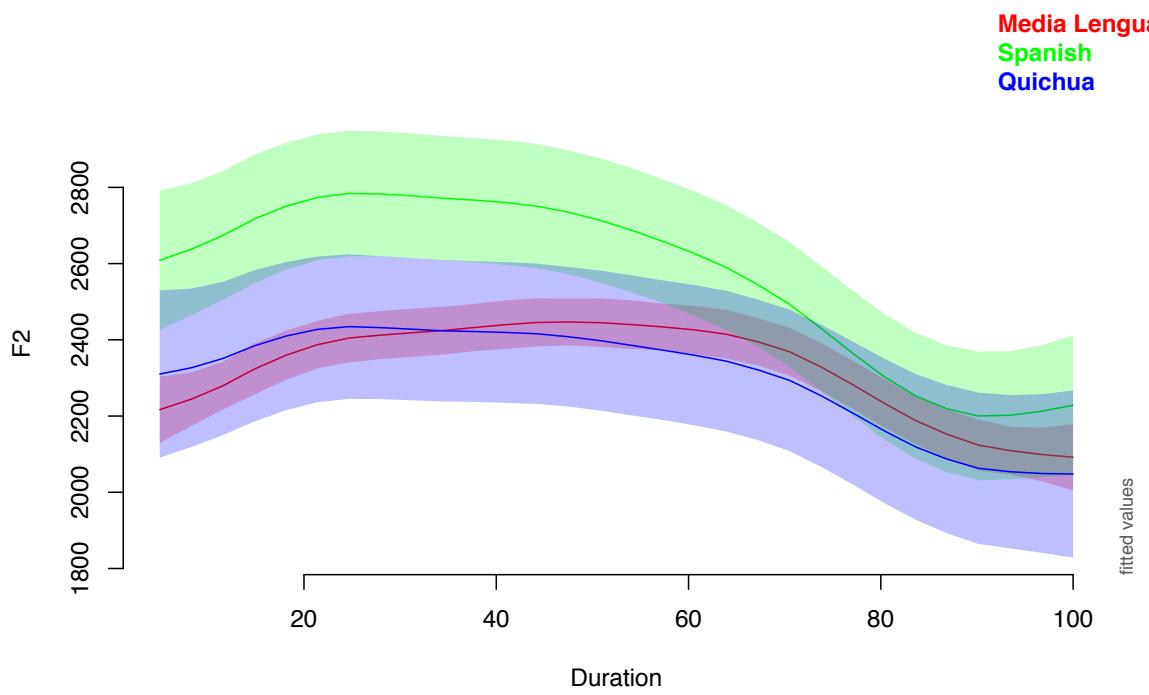


/ia/: F1 & F2



/ia/ F1

- Media Lengua vs. Quichua: no sig. difference
- Spanish: somewhat higher F1 = lower articulation, sig. difference at onset and offset

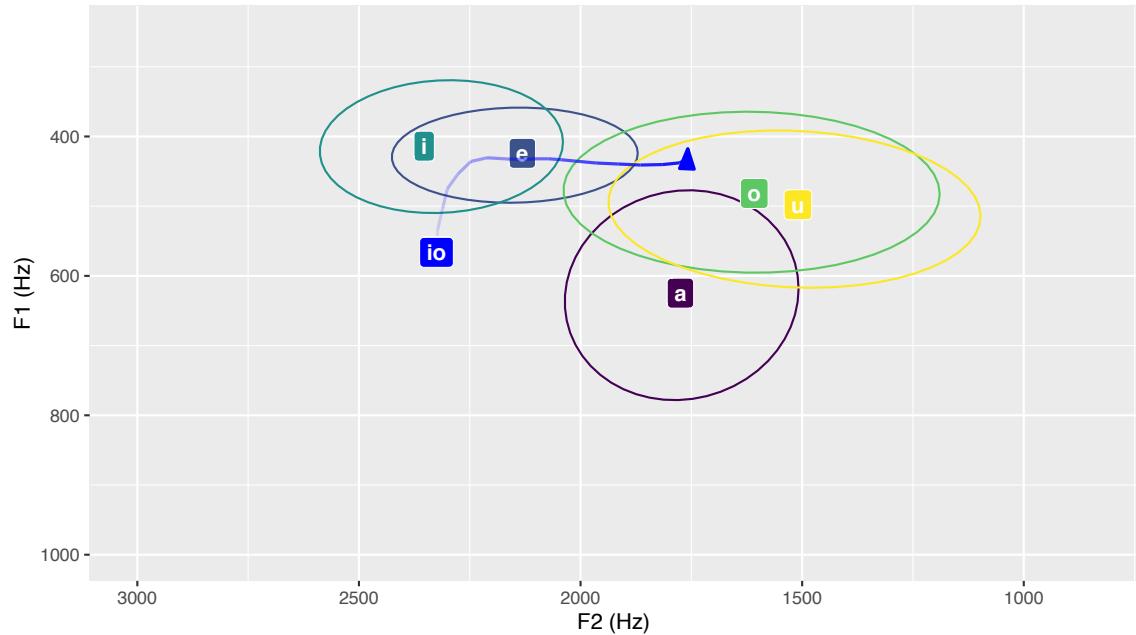


/ia/ F2

- Media Lengua vs. Quichua: no sig. difference
- Spanish: higher F2 = advanced articulation, over initial 2/3 of duration

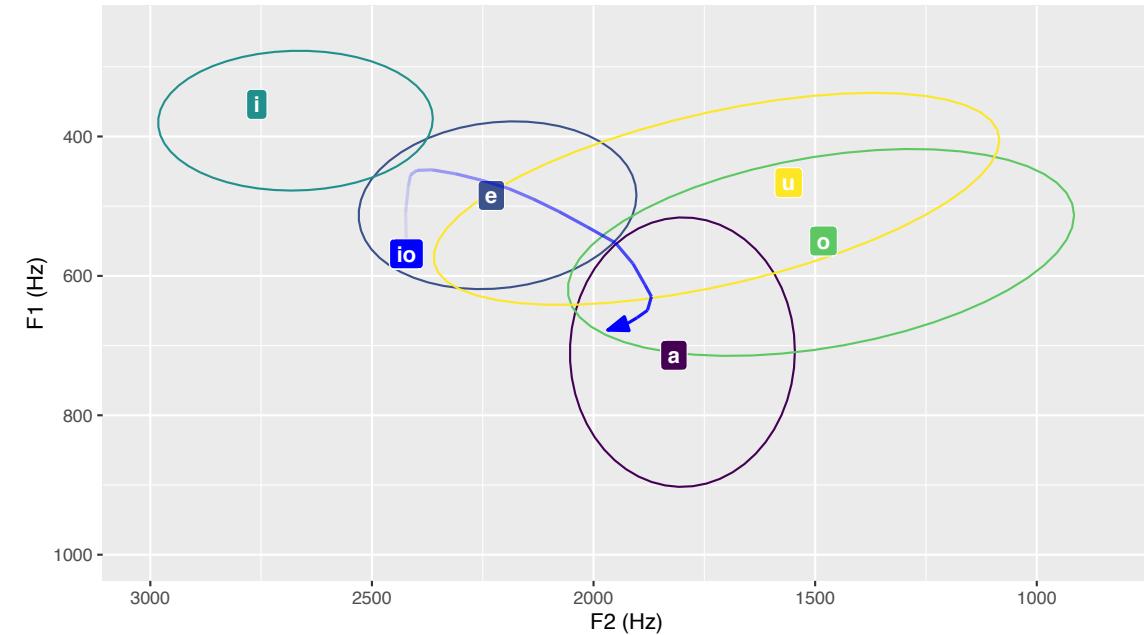
Media Lengua vowel space with /io/ trajectory

Ellipses indicate 2 standard deviations; monophthong n = 2040

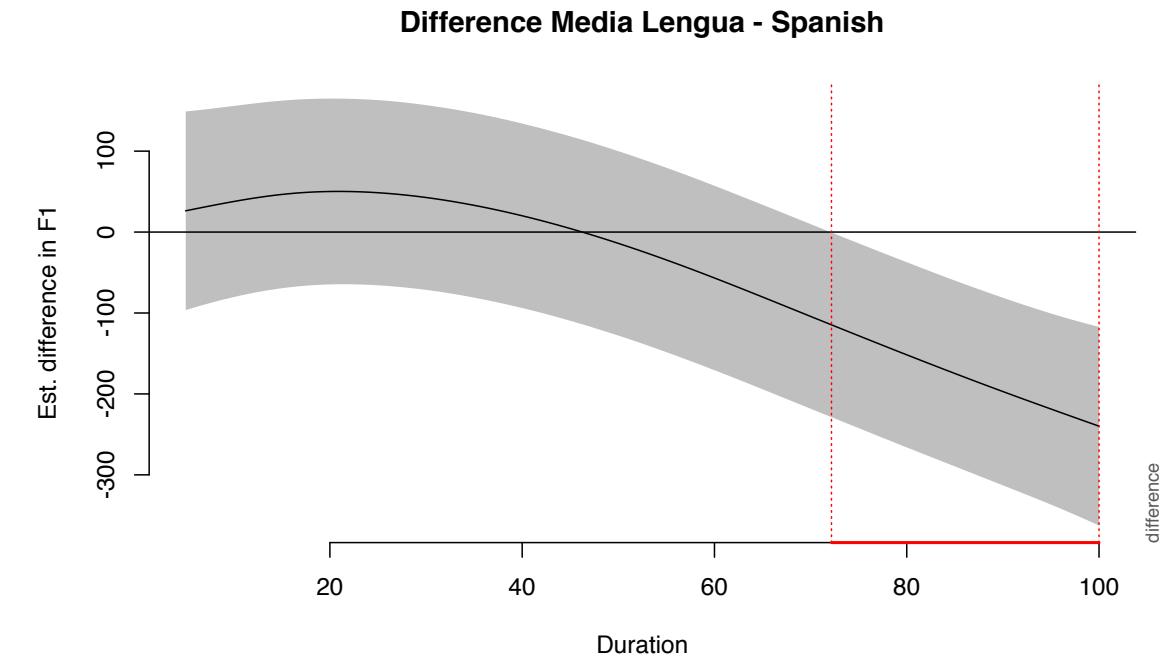
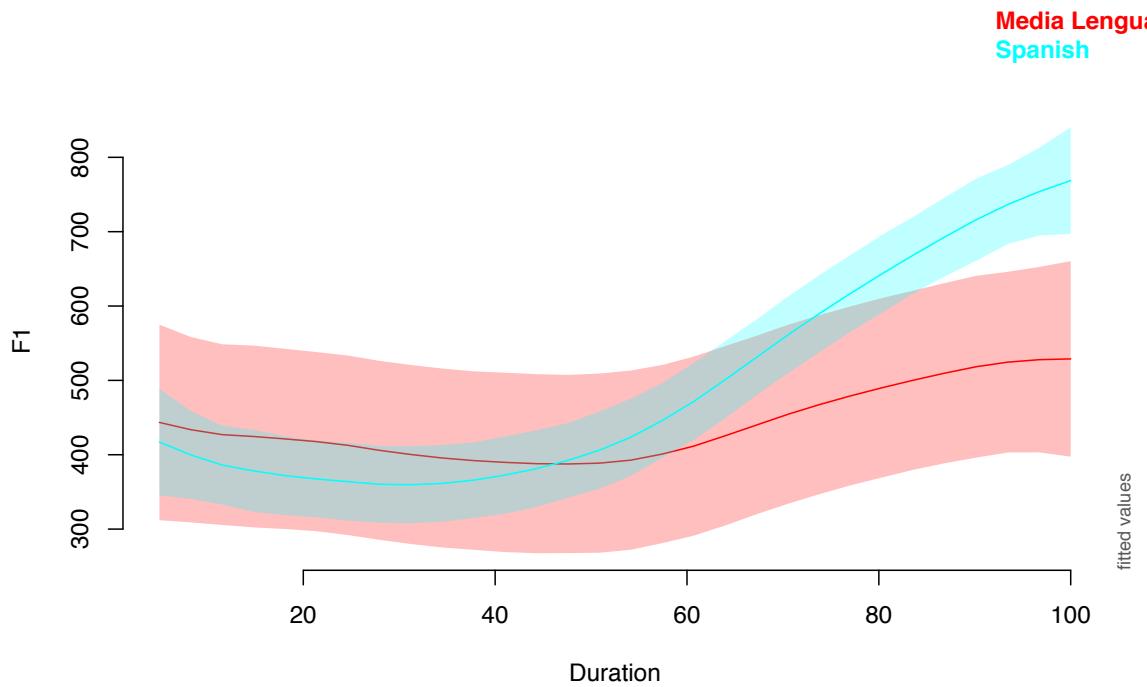


Spanish vowel space with /io/ trajectory

Ellipses indicate 2 standard deviations; monophthong n = 1929

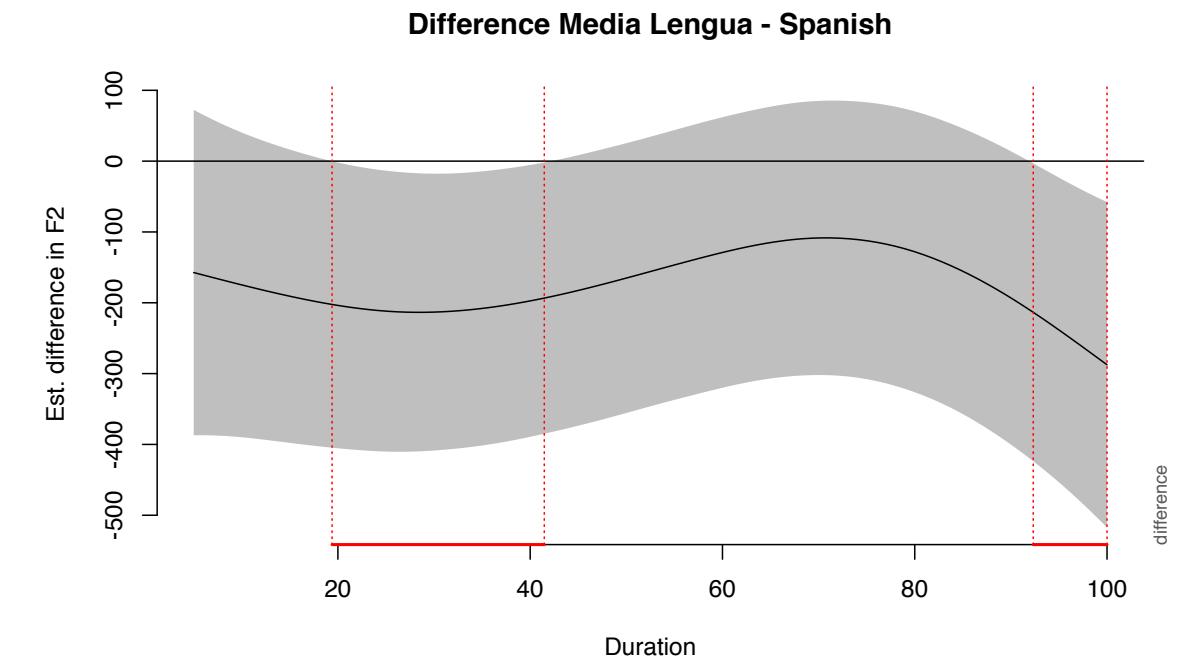
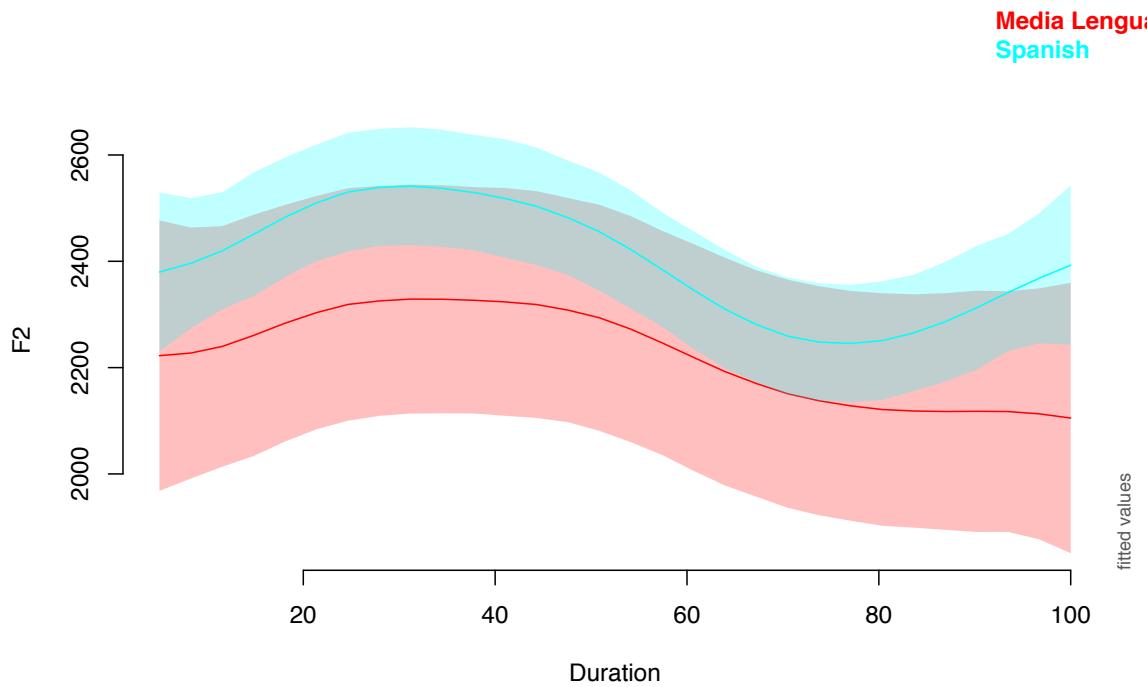


/io/: F<sub>1</sub> & F<sub>2</sub>



/io/ F1

- Media Lengua: F1 lower (higher articulation) during final 25% of duration

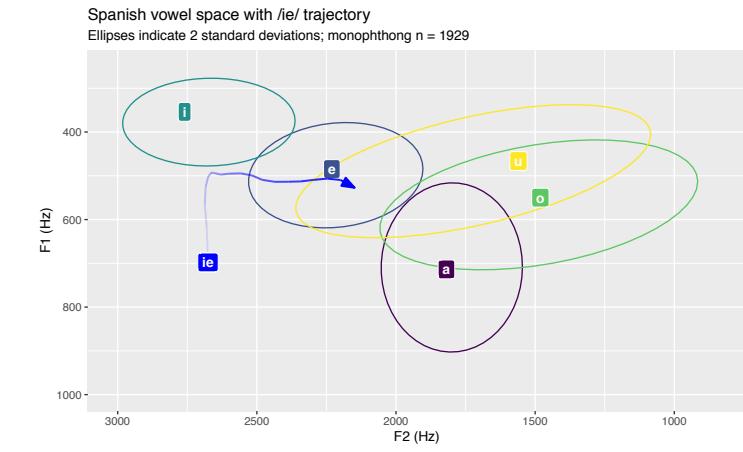
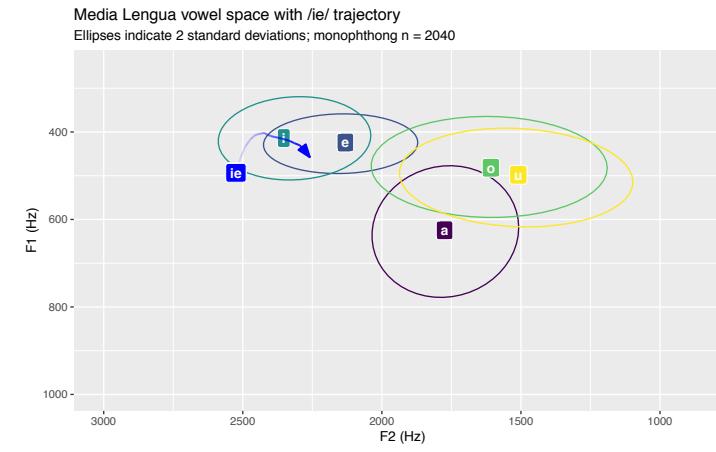
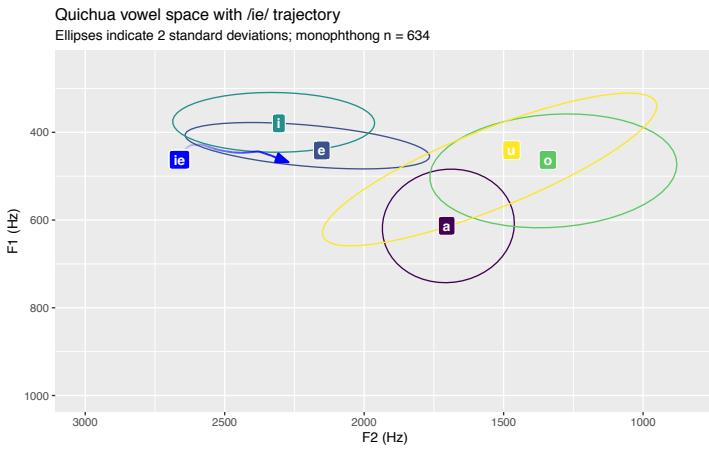


/io/ F2

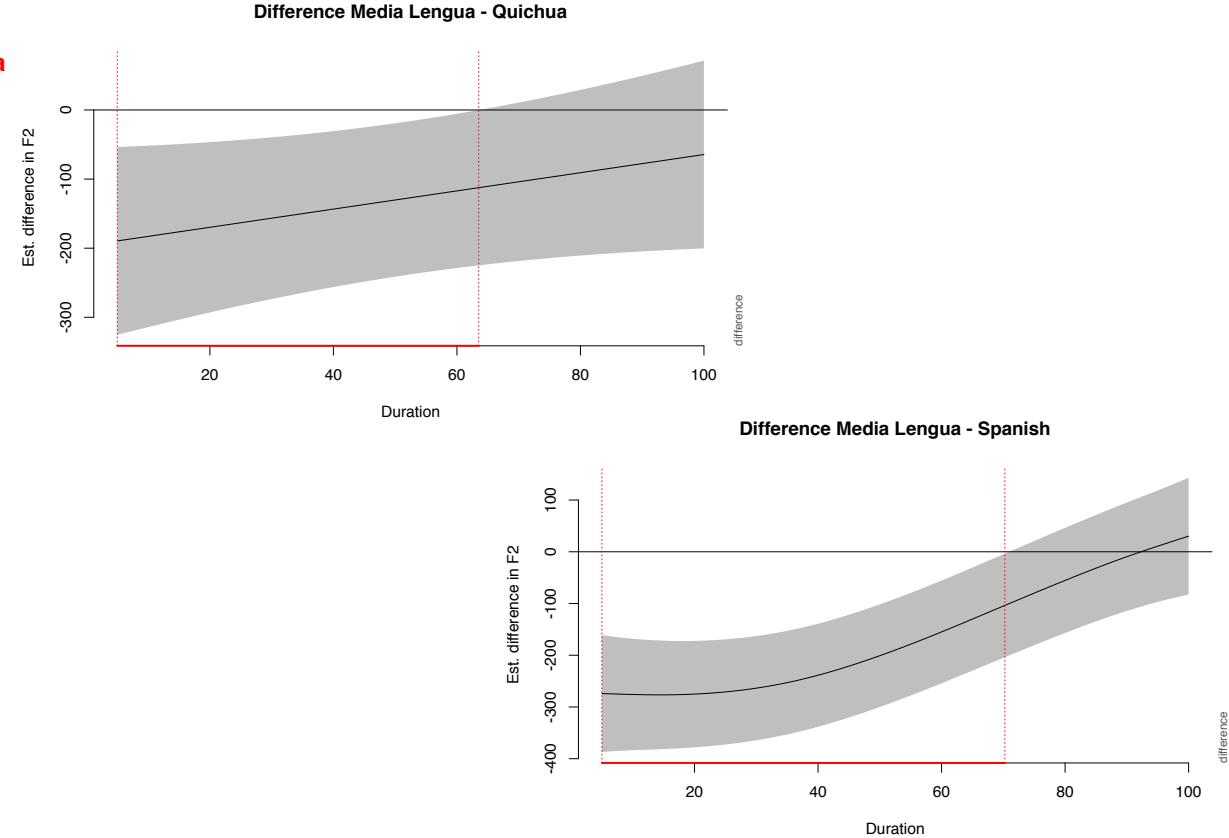
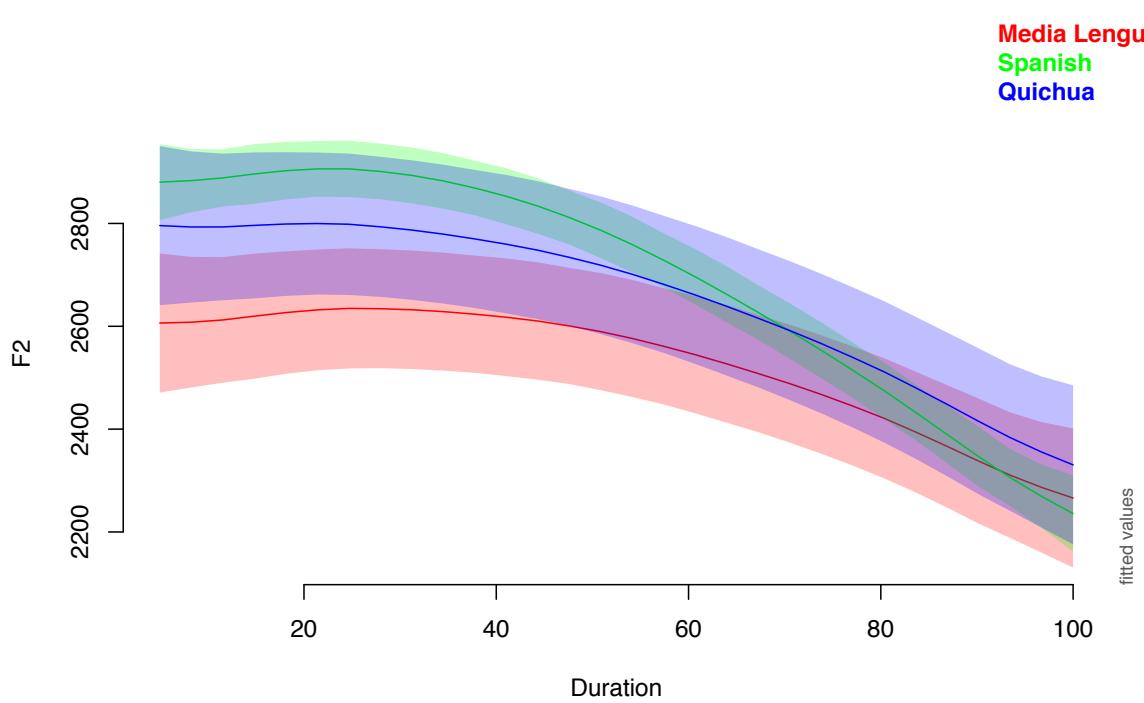
- Spanish: slightly higher F2 = advanced articulation, from 20–40% duration and at offset

# Cross-Language Differences in only F1 or F2

- F1:
  - Media Lengua vs. Spanish: /uo/
  - Media Lengua vs. Quichua vs. Spanish: /au/
- F2:
  - Media Lengua vs. Quichua vs. Spanish: /ie, ue/

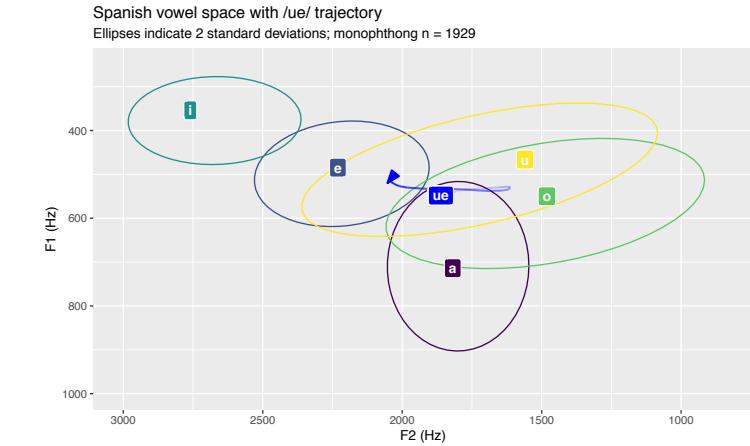
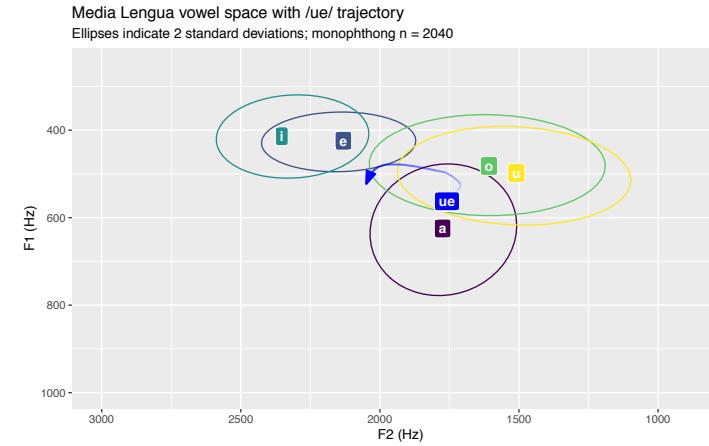
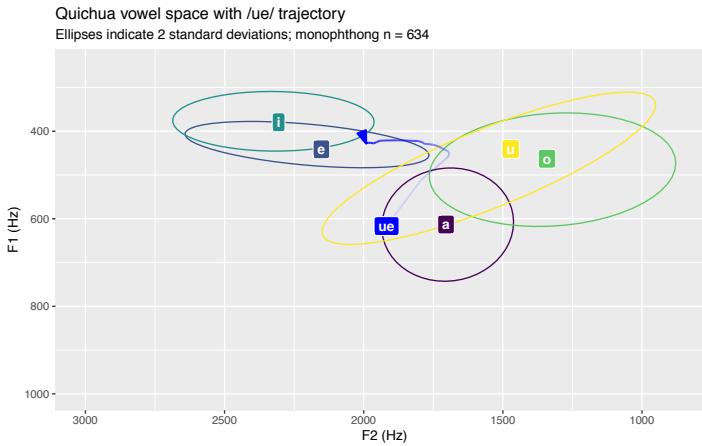


/ie/: F2

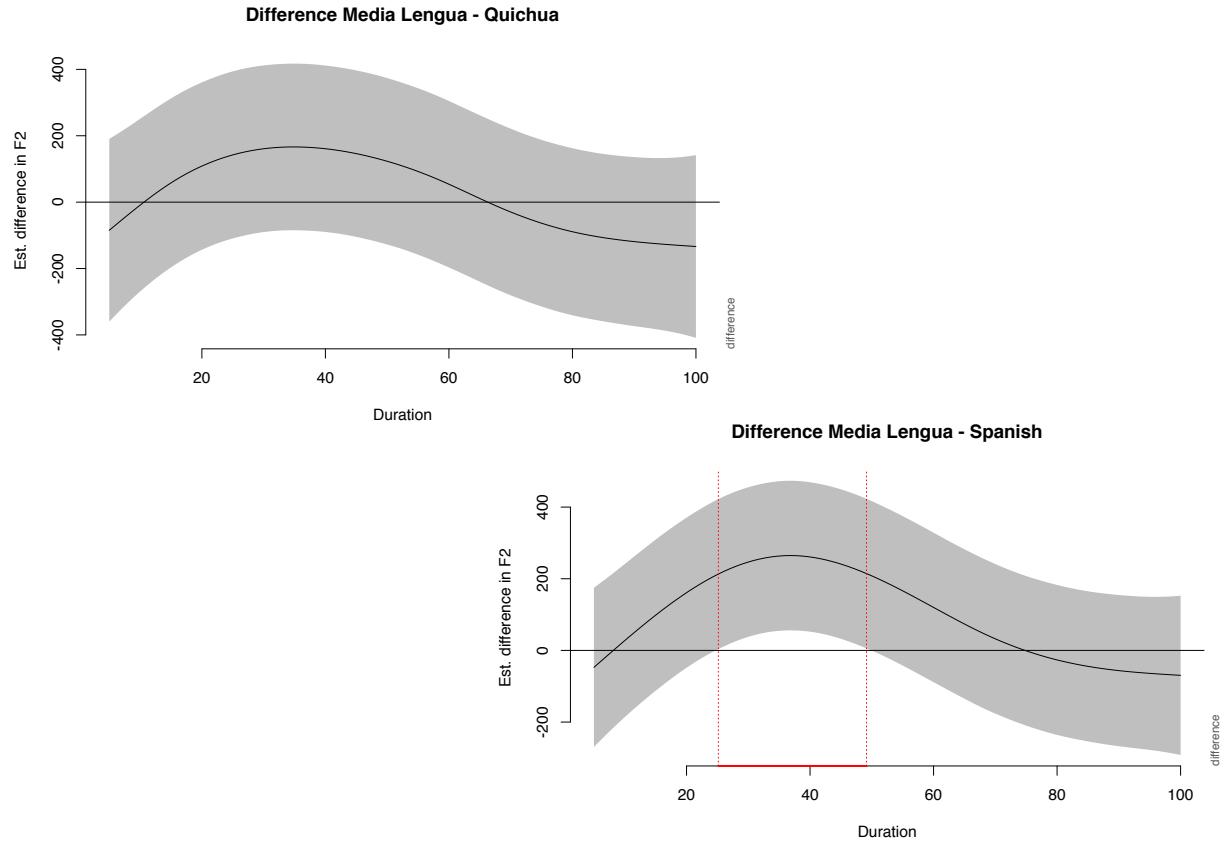
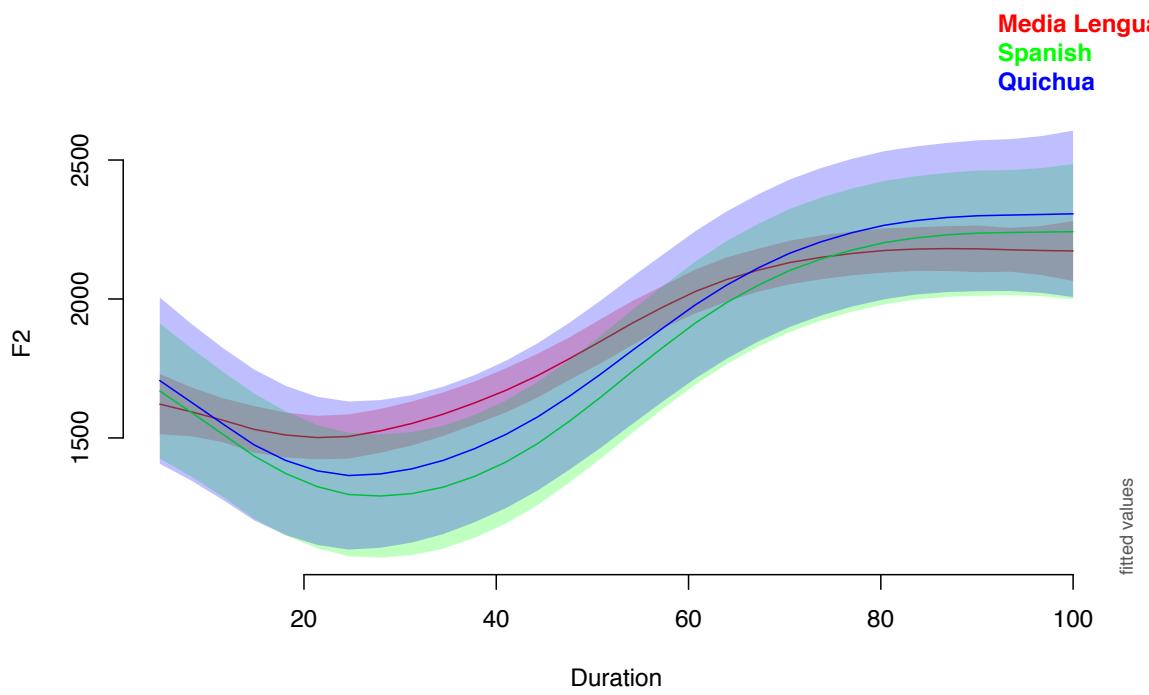


/ie/ F2

- Media Lengua distinct from *both* Quichua & Spanish; lower F2 (retracted) over initial 2/3 duration
- Quichua: F2 slightly higher = advanced position
- Spanish: F2 substantially higher with steeper trajectory



/ue/: F2



/ue/ F2

- Media Lengua vs. Quichua: no sig. diff.
- Spanish: lower F2 = retracted position, during approx. 30-50% of duration

# Cross-Language Comparisons

- Spanish diphthongs generally show less internal variability:
  - Confidence intervals typically much narrower than other languages
  - Lower variation can't be attributed to either speaker  $n$ , which is notably higher than Quichua, nor token  $n$  which is the largest among all three languages
- Media Lengua vs. Quichua typically non-contrasting
  - Single identified contrast between ML~Q is F2 of /ie/; ML~Sp /ie/ F2 difference is even greater
  - *In general, Media Lengua production matches Quichua production*

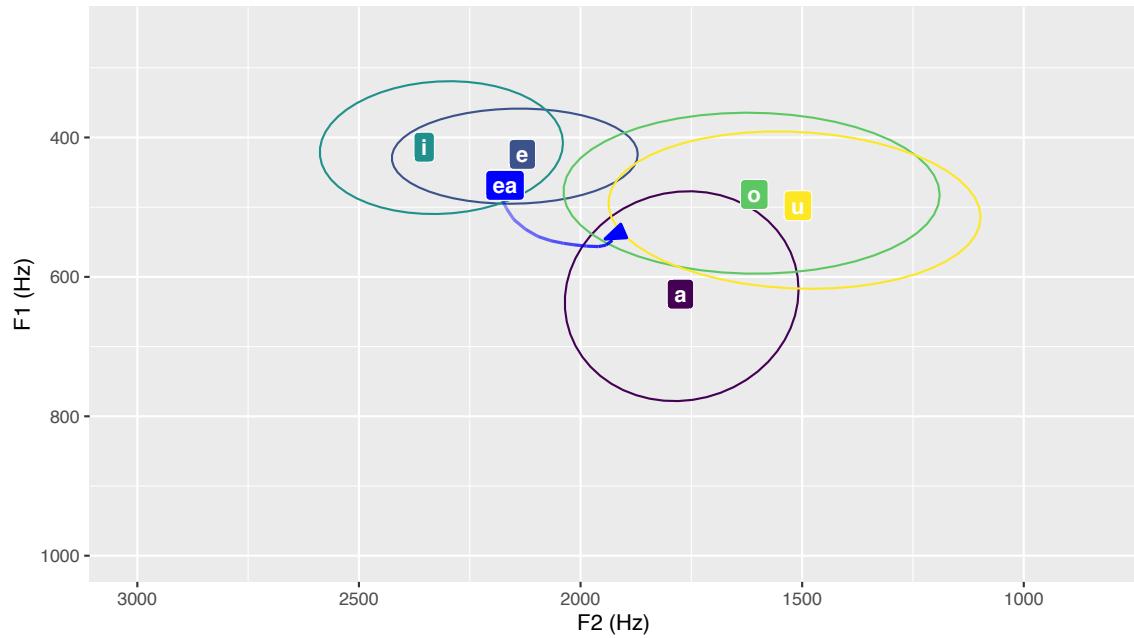
# Media Lengua-Internal Diphthong Comparisons

- Pairs of Media Lengua diphthongs selected for cross-comparison
  - /ai ~ ei/            /ea ~ ia/            /eo ~ eu/            /ue ~ ui/
- GAMMs model uses main fixed effect of Vowel instead of Language
- ANOVA comparison of GAMM *null* vs. *non-null* models identifies where formant trajectories differ significantly between diphthongs

|    | ai vs. ei     | ea vs. ia     | eo vs. eu     | ue vs. ui   |
|----|---------------|---------------|---------------|-------------|
| F1 | $p \approx 0$ | n.s.          | $p \approx 0$ | $p = 0.008$ |
| F2 | $p \approx 0$ | $p \approx 0$ | $p \approx 0$ | $p = 0.002$ |

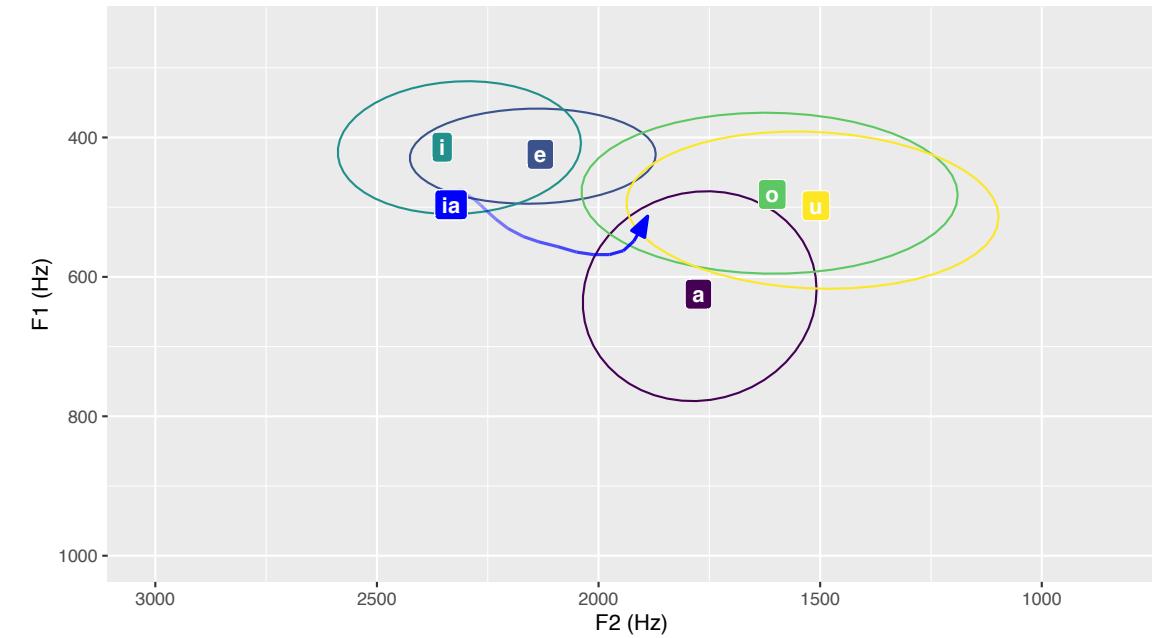
Media Lengua vowel space with /ea/ trajectory

Ellipses indicate 2 standard deviations; monophthong n = 2040

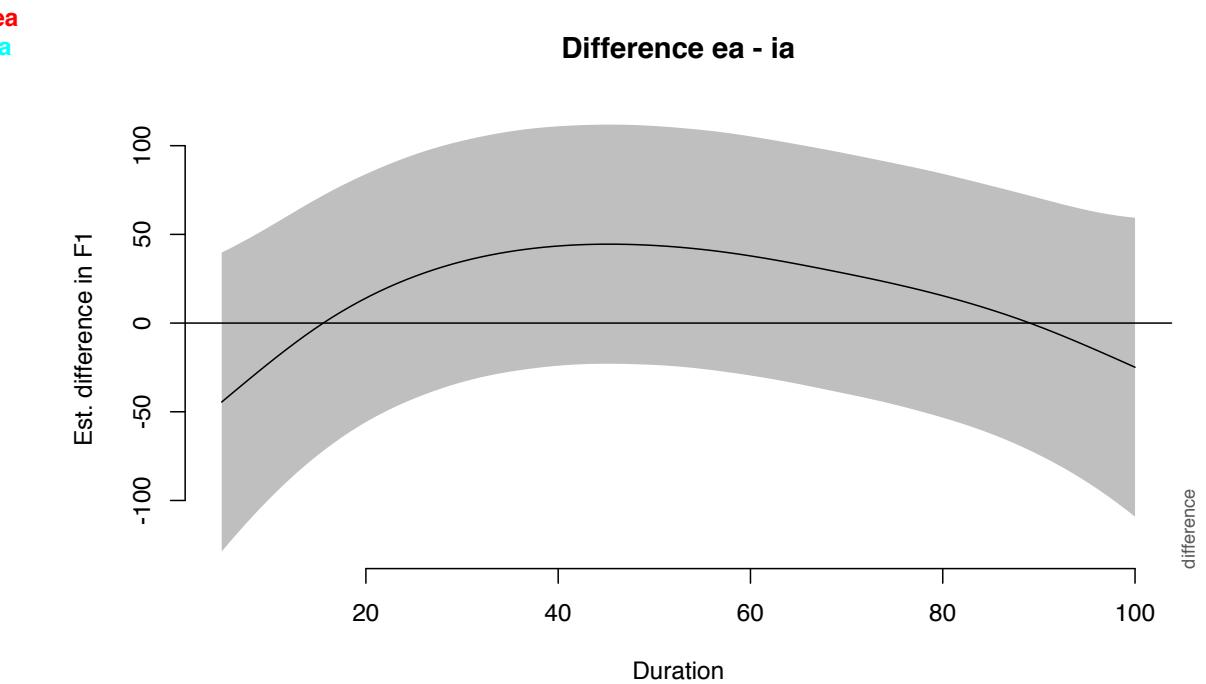
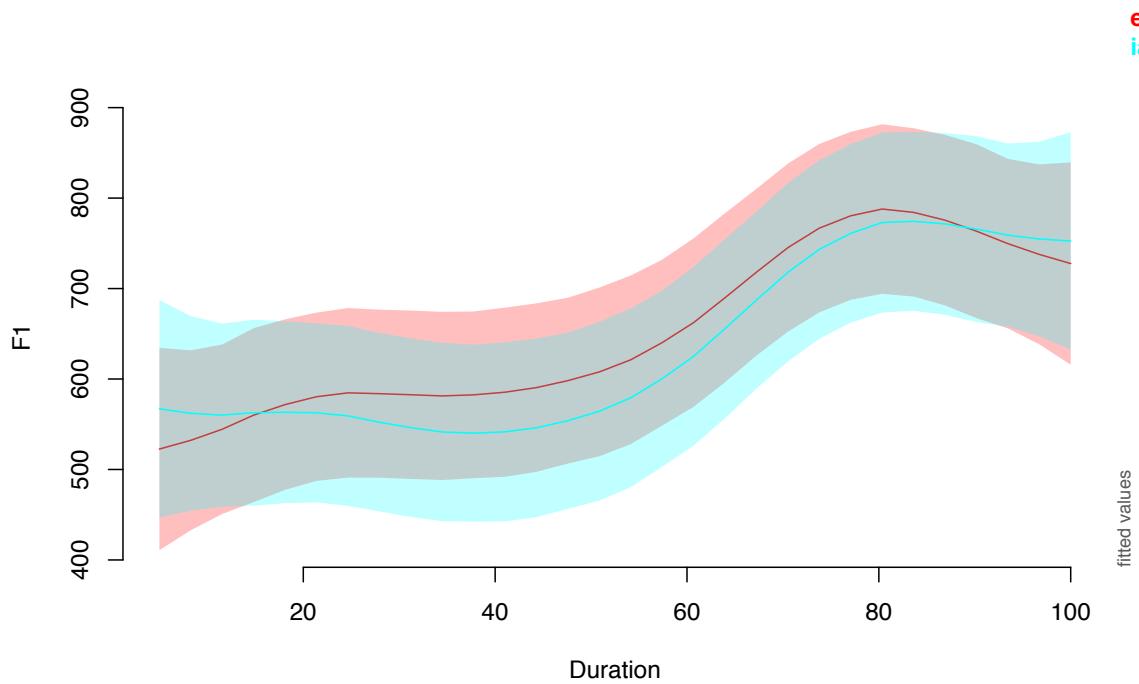


Media Lengua vowel space with /ia/ trajectory

Ellipses indicate 2 standard deviations; monophthong n = 2040

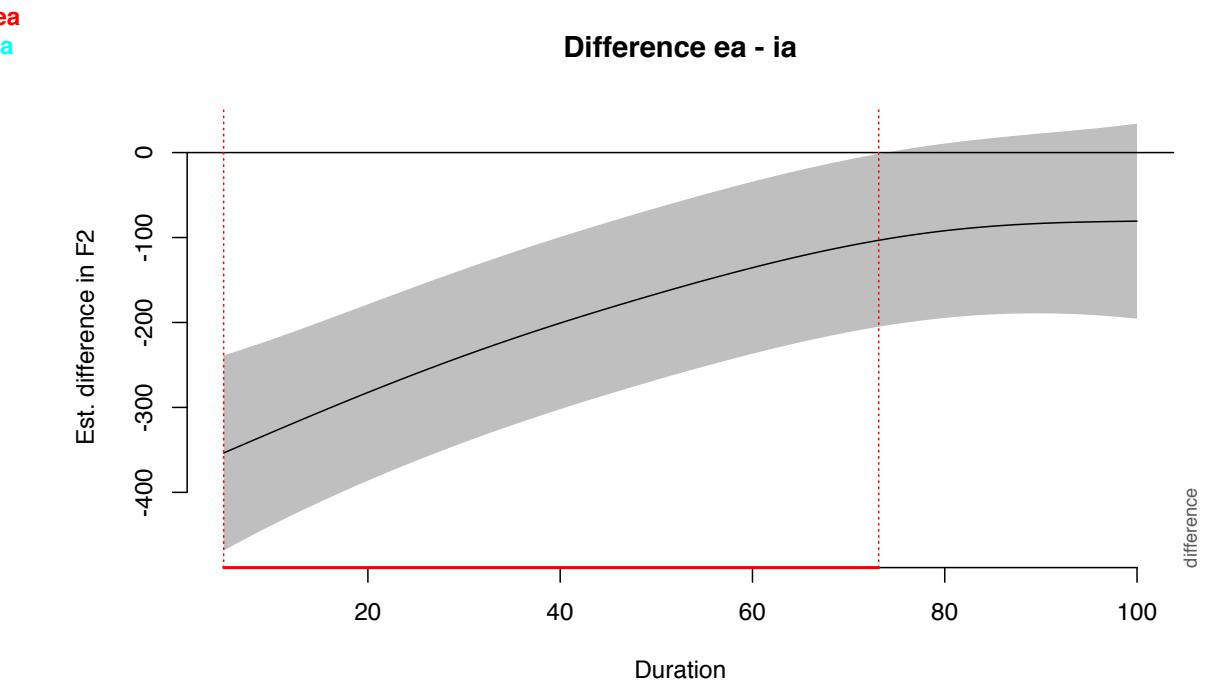
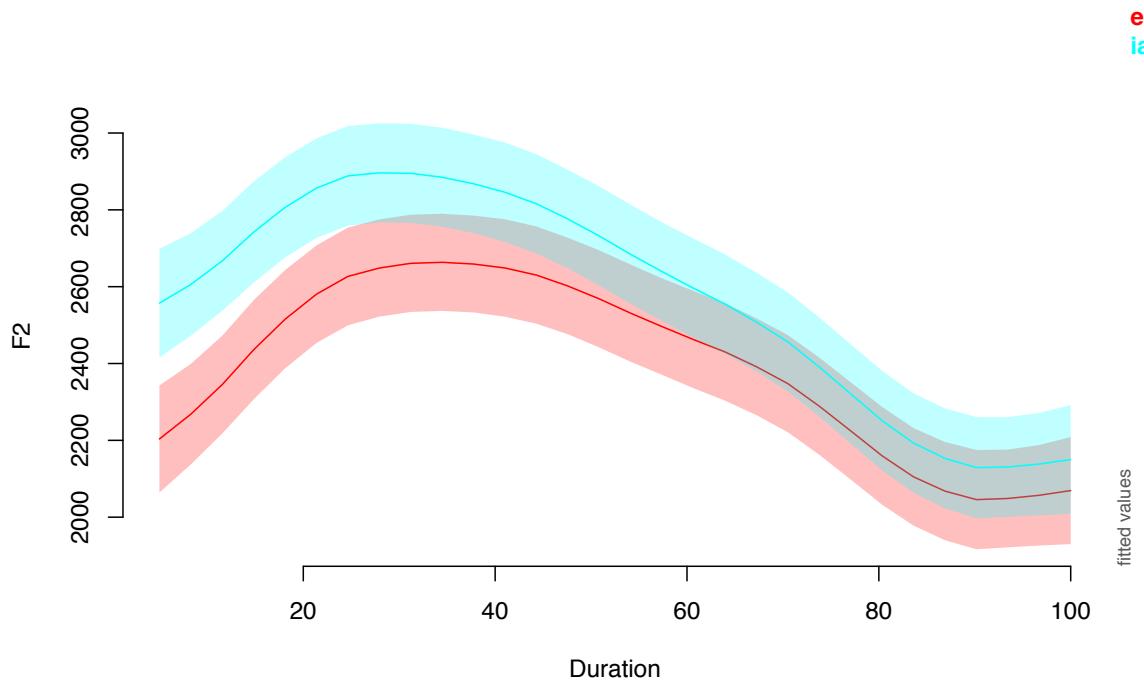


# Media Lengua /ea/ vs. /ia/



**Media Lengua**  
*/ea, ia/ F1*

- Substantial overlap in F1 confidence intervals = no significant difference in vowel height across entire trajectory



**Media Lengua**  
*/ea, ia/ F2*

- /ia/ F2 higher (advanced) until ~70% duration

# Media Lengua-Internal Diphthong Comparisons

- Most diphthong pairs differ significantly across both F1 & F2
  - /ea, ia/ do *not* differ in F1, leaving F2 (i.e. front-back position) as the sole differentiating factor for this pair
  - Some pairs (e.g. /eo, eu/ and /ue, ui/) exhibit only subtle differences, and not always restricted to the expected portion of the trajectory

# Media Lengua Comparisons by Source Language

- Three diphthongs are represented by Media Lengua lexical items of both Quichua and Spanish origin:
  - /ai, au, ui/
- GAMMs comparison conducted for each diphthong using Media Lengua data with a fixed effect of Source Language
- *None* turned out to exhibit significant differences in formant trajectories
  - In other words, different-source-language lexical items are incorporated into a single phonological vowel system (with regards to these particular diphthongs)
  - This aligns with cross-linguistic comparison across diphthong inventory, where vast majority of ML~Q comparisons were non-distinctive

# Discussion: Why?

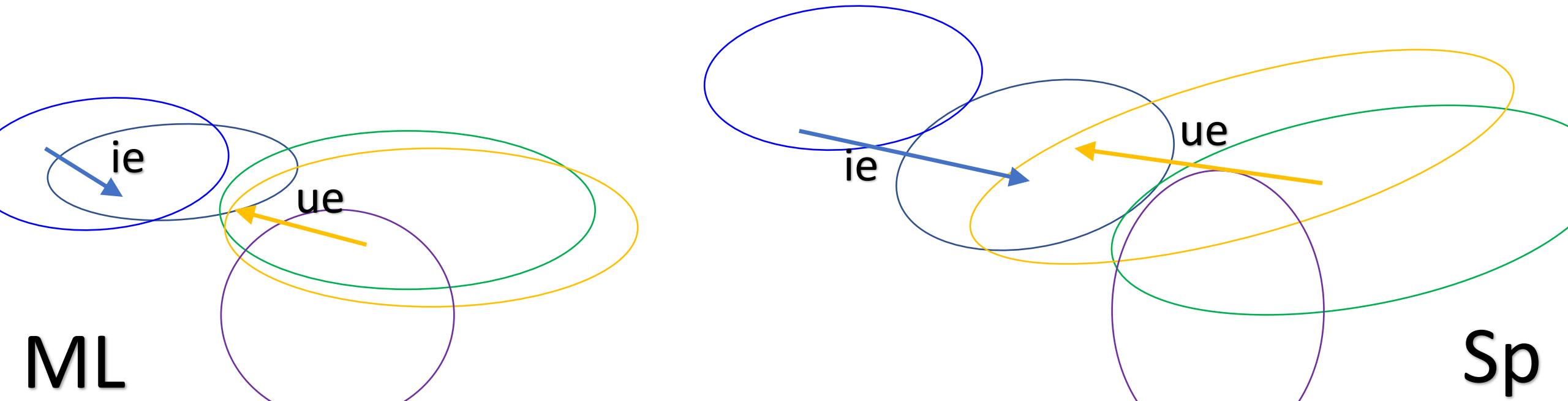
The Media Lengua vowel system reflects that of a late bilingual where interference from their L1 (Quichua) impedes native-like production in their L2 (Spanish).

- Then the vowel system could have been subsequently nativized with the overlaps ‘frozen’ in place.
  - Phonological ‘stresses’ from relexification (e.g., high functional loads of contrastive non-native phonemes) from the mid-vowels may have been driving forces for maintaining/creating contrasts with the high-vowels in the predominately Quichua system.

# 1,415 ML Word Sample

# Discussion: Diphthongs

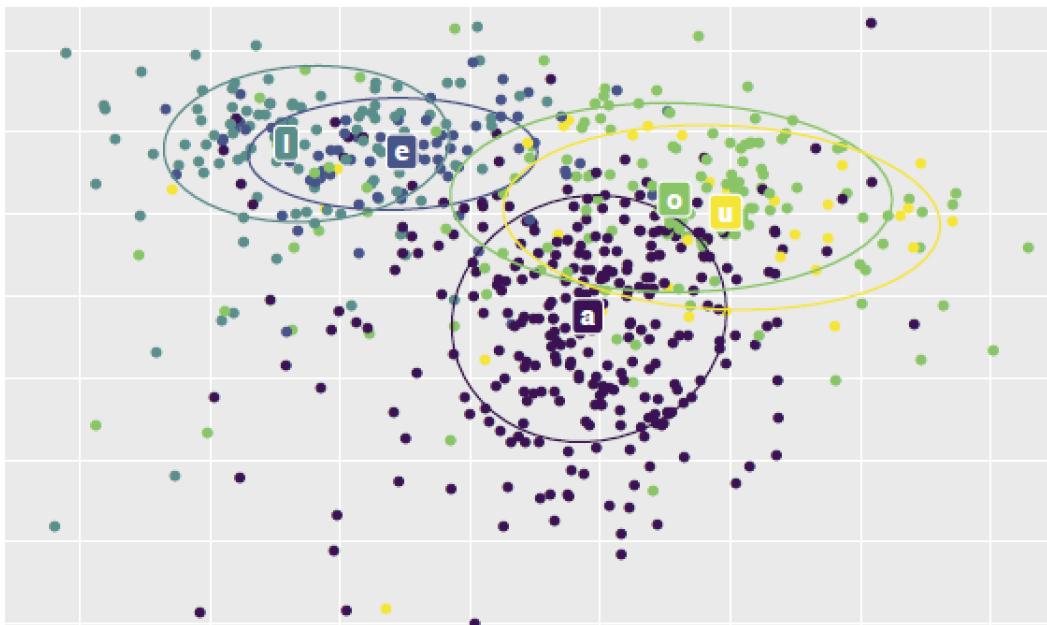
Diphthongs also appear to follow this tendency given that the formant trajectories in Media Lengua look strikingly similar to Quichua diphthongs (e.g., size, shape, variability). However, given that the mid- and high-vowels have ‘solidified’ into highly overlapping acoustic spaces, more reminiscent of the 3-vowel Quichua system, Spanish origin diphthongs were forced to accommodate to these regions while maintaining contrastive. This might suggest why Media Lengua diphthongs may act more like what would be expected from Quichua, if such sounds existed, rather than Spanish.



# Future research

## Functional load

| Vowel | e   | o   | i   | u   |
|-------|-----|-----|-----|-----|
| Count | 461 | 524 | 588 | 286 |
| %     | 33% | 37% | 42% | 20% |
| Count |     | 985 |     | 788 |
| %     |     | 70% |     | 62% |



## Cognitive load reaction time/ eye-tracking experiment

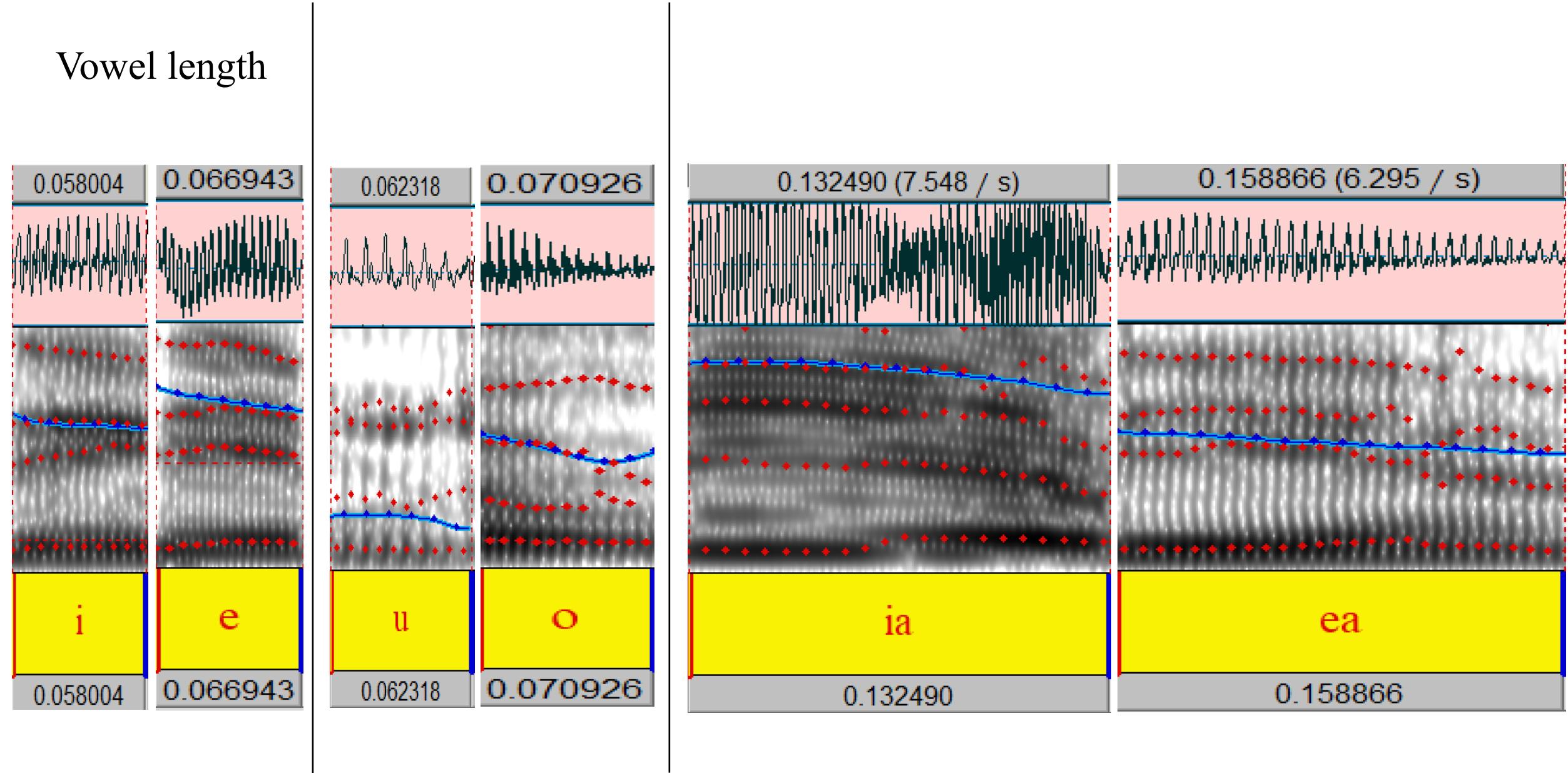


piscadu      pescado  
piscado      pescado



# Future research

Vowel length



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