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Longer vowel duration correlates with tongue root advancement in Italian and Polish: An ultrasound study

Stefano Coretta

The University of Manchester

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Background

The **voicing effect**

- shorter vowels before voiceless stops, longer vowels before voiced stops

Heffner (1937); House & Fairbanks (1953); Belasco (1953); Peterson & Lehiste (1960); Halle & Stevens (1967); Chen (1970); Klatt (1973); Lisker (1974); Raphael (1975); Javkin (1976); Maddieson & Gandour (1976); Farnetani & Kori (1986); Kluender et al. (1988); Laeufer (1992); Fowler (1992); Hussein (1994); Esposito (2002); Lampp & Reklis (2004); Warren & Jacks (2005); Durvasula & Luo (2012)

Still **no consensus** on source!

Background

Proposed accounts:

- **production**
  - constant articulatory force (Belasco, 1953; Delattre, 1962)
  - durational trade-off (Slis & Cohen, 1969; Lehiste, 1970)
  - laryngeal adjustment (Halle & Stevens, 1967)
  - closing gesture duration (Chen, 1970)
- **perception**
  - misperception (Javkin, 1976)
  - enhancement (Kluender et al., 1988)
- but **problems** (Maddieson & Gandour, 1976; Fowler, 1992)

Background

- Aereodynamic Voicing Constraint (Ohala, 2011)
  - $\Delta P < \theta$
- **Tongue root advancement** (Rothenberg, 1967; Westbury, 1983)
  - voiced stops are produced with advanced tongue root

Background

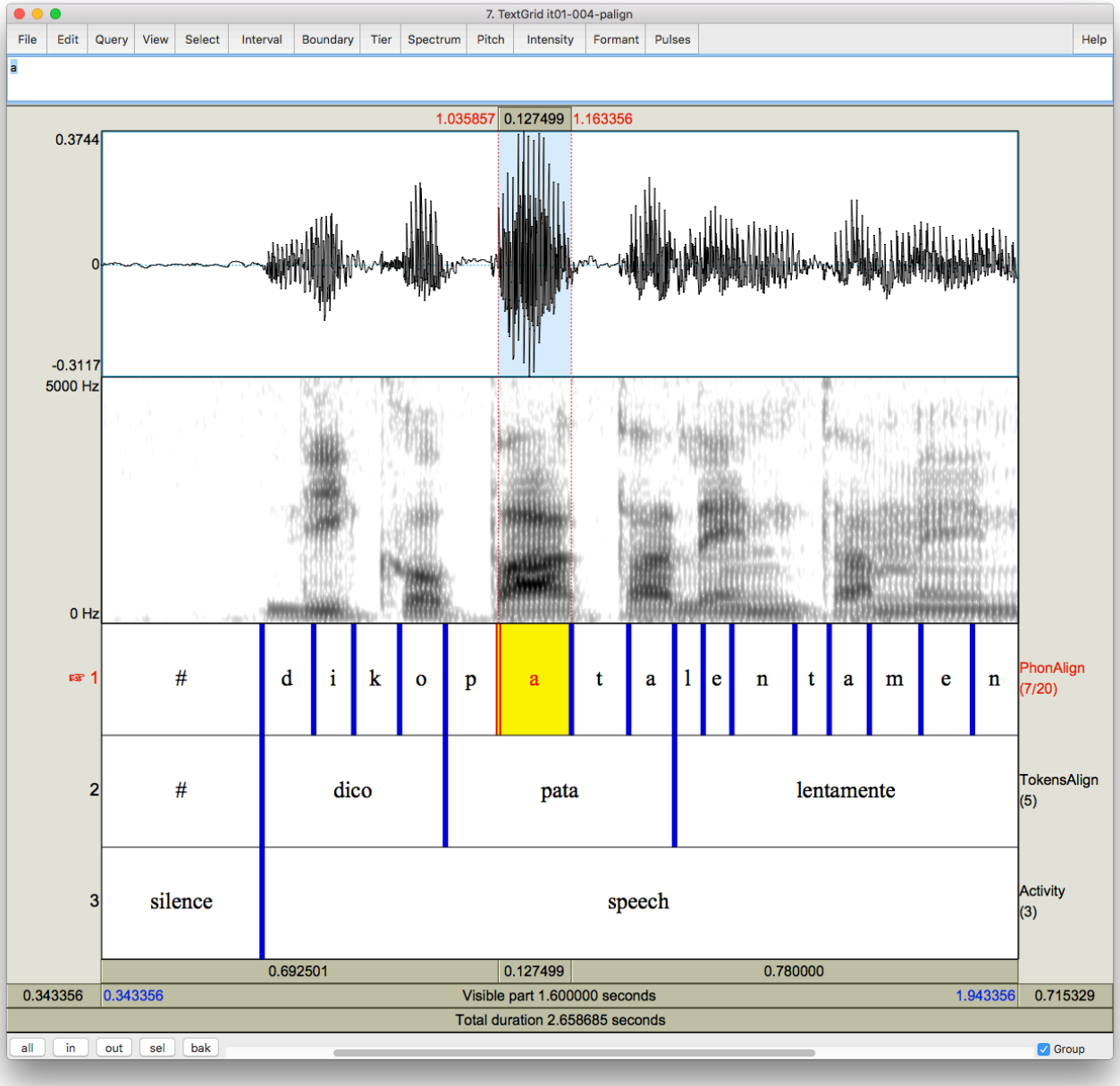
This talk:

- Support for **durational trade-off hypothesis** of the voicing effect
- Link between **vowel duration**, **closure duration**, and **tongue root position**

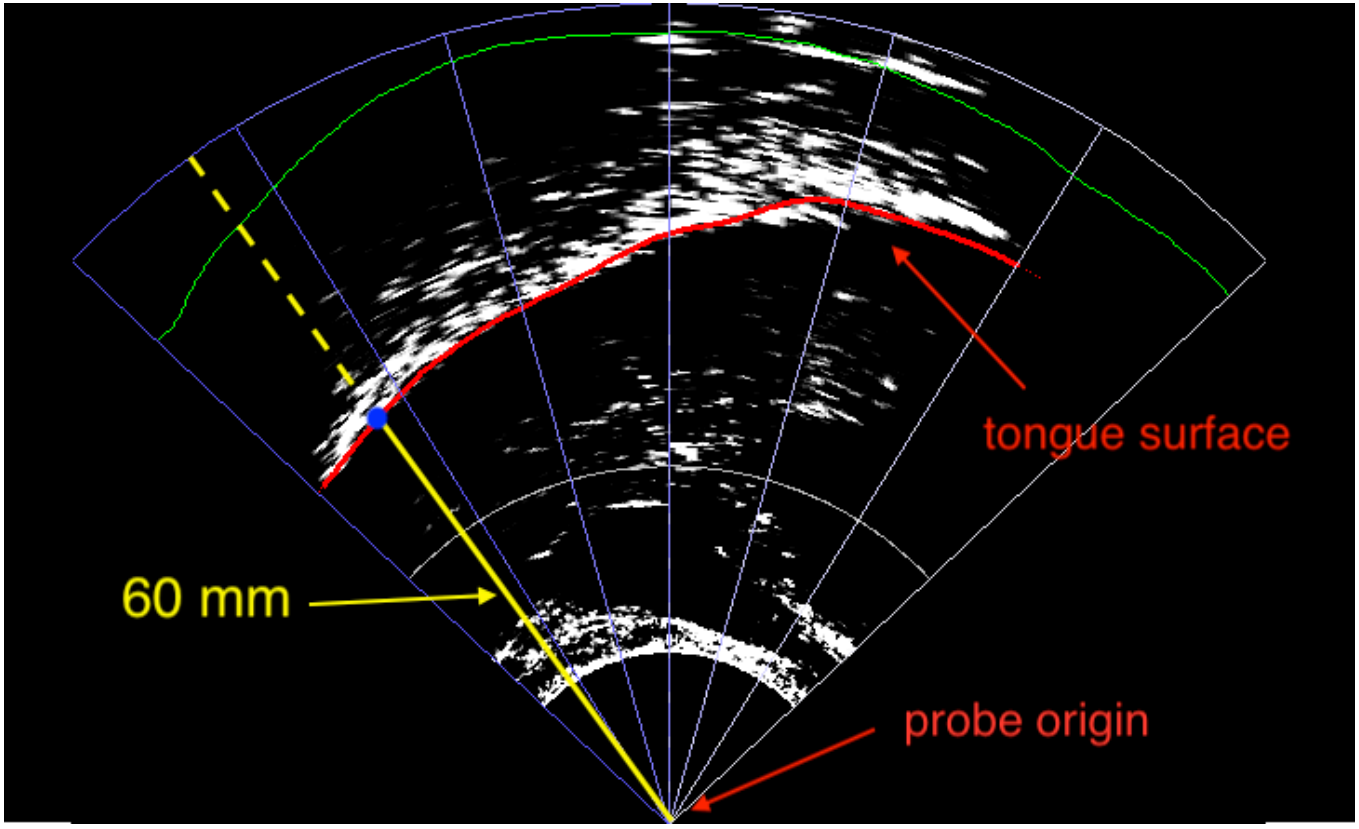
Methods

- **Participants**: 11 Italians (5 F, 6 M), 6 Polish (3 F, 3 M)
- Targets
  - $C_1V_1C_2V_1$ (C_1 = /p/, V_1 = /a, o, u/, C_2 = /t, d, k, g/)
  - *pata*, *pada*, *paka*, ..., *poto*, *podo*, ...
- Frame sentence
  - *Dico X lentamente*, 'I say X slowly'
  - *Mówię X teraz*, 'I say X now'
- Reproducibility
  - https://github.com/stefanocoretta/2018-labphon
- Measurements
  - Durational data from acoustics (Boersma & Weenink, 2016)
  - Tongue root position (advancement) from ultrasound tongue imaging (Articulate Instruments Ltd™, 2011, 2008)

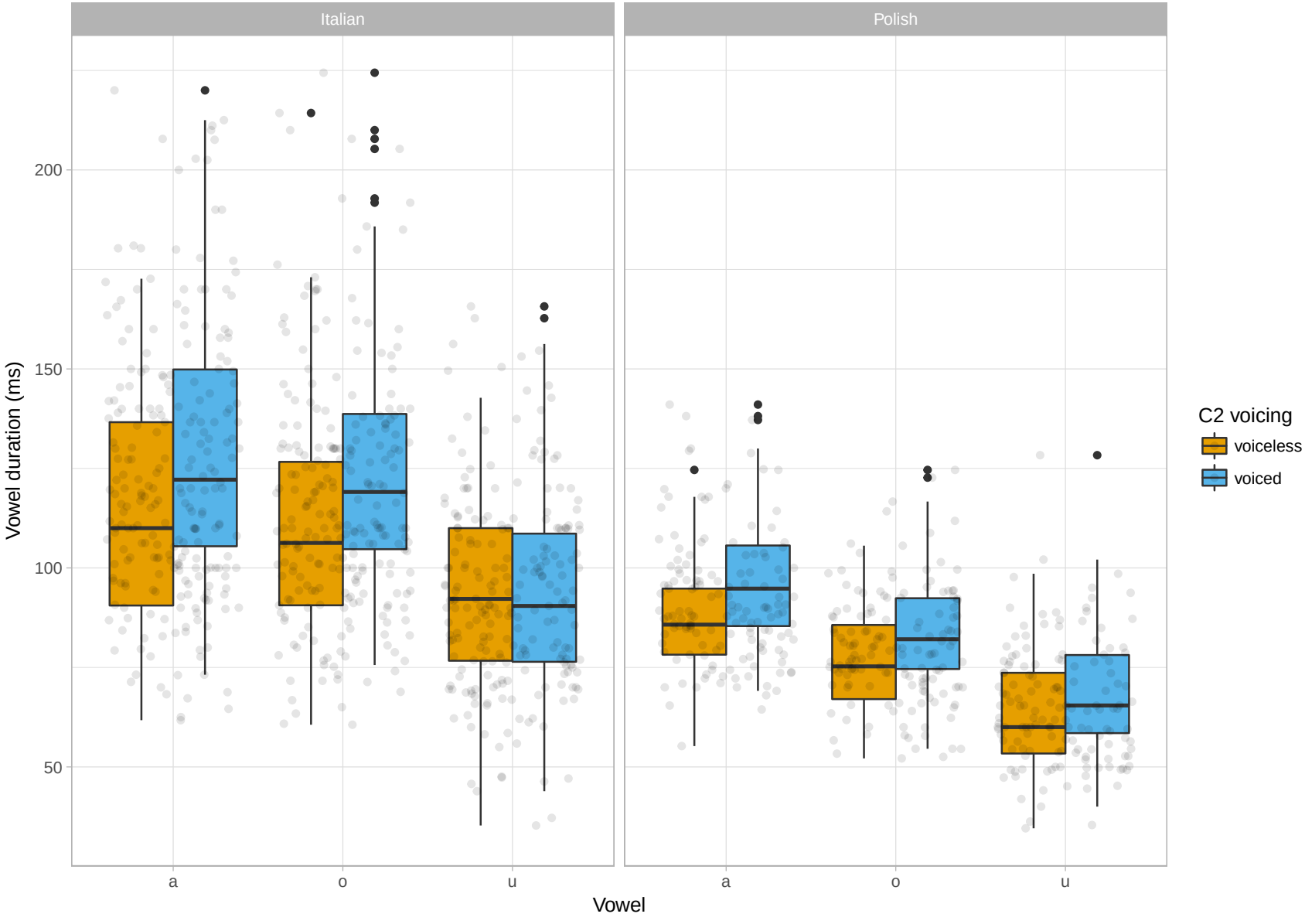
Methods: Acoustic landmarks



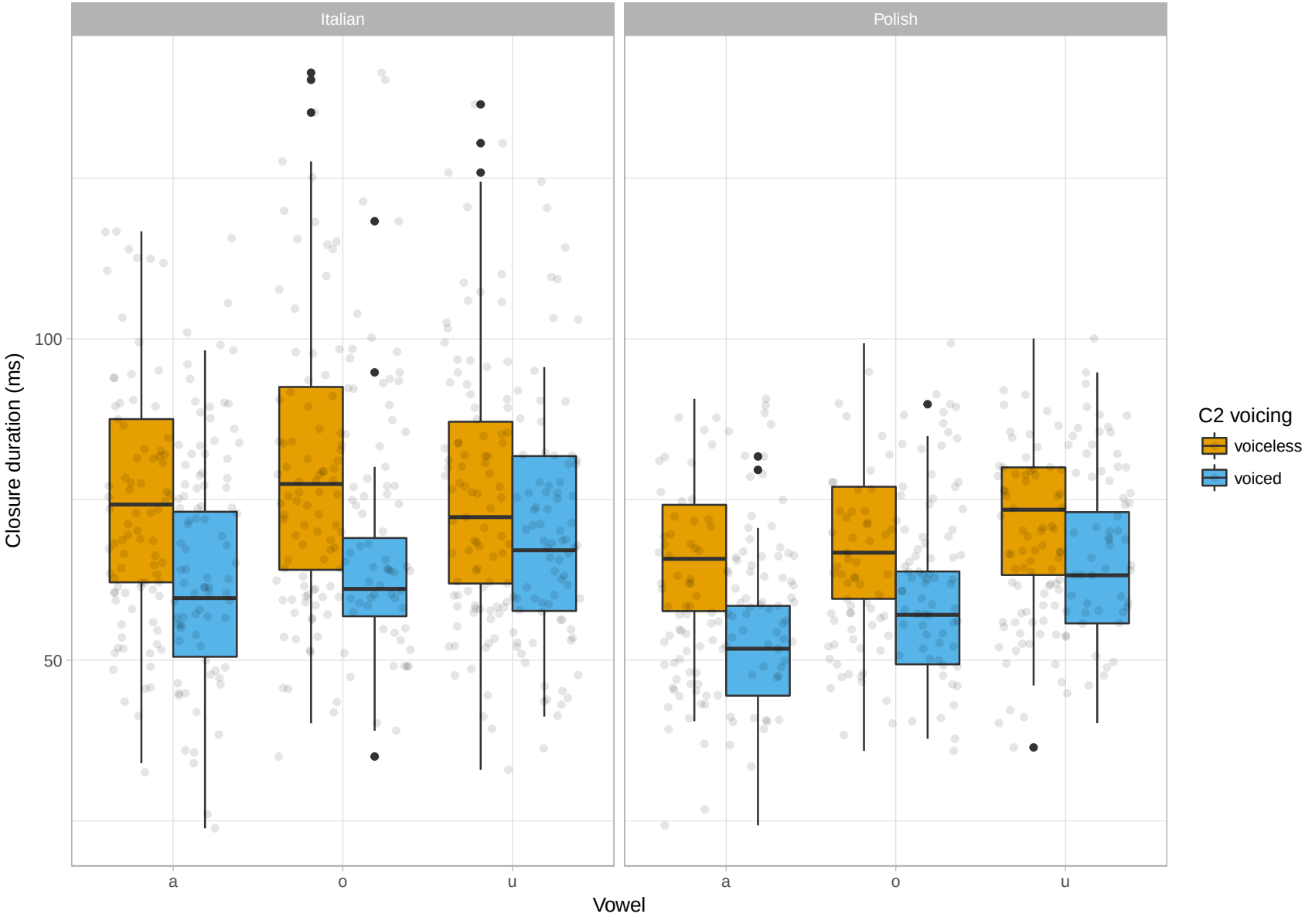
Methods: Tongue root position



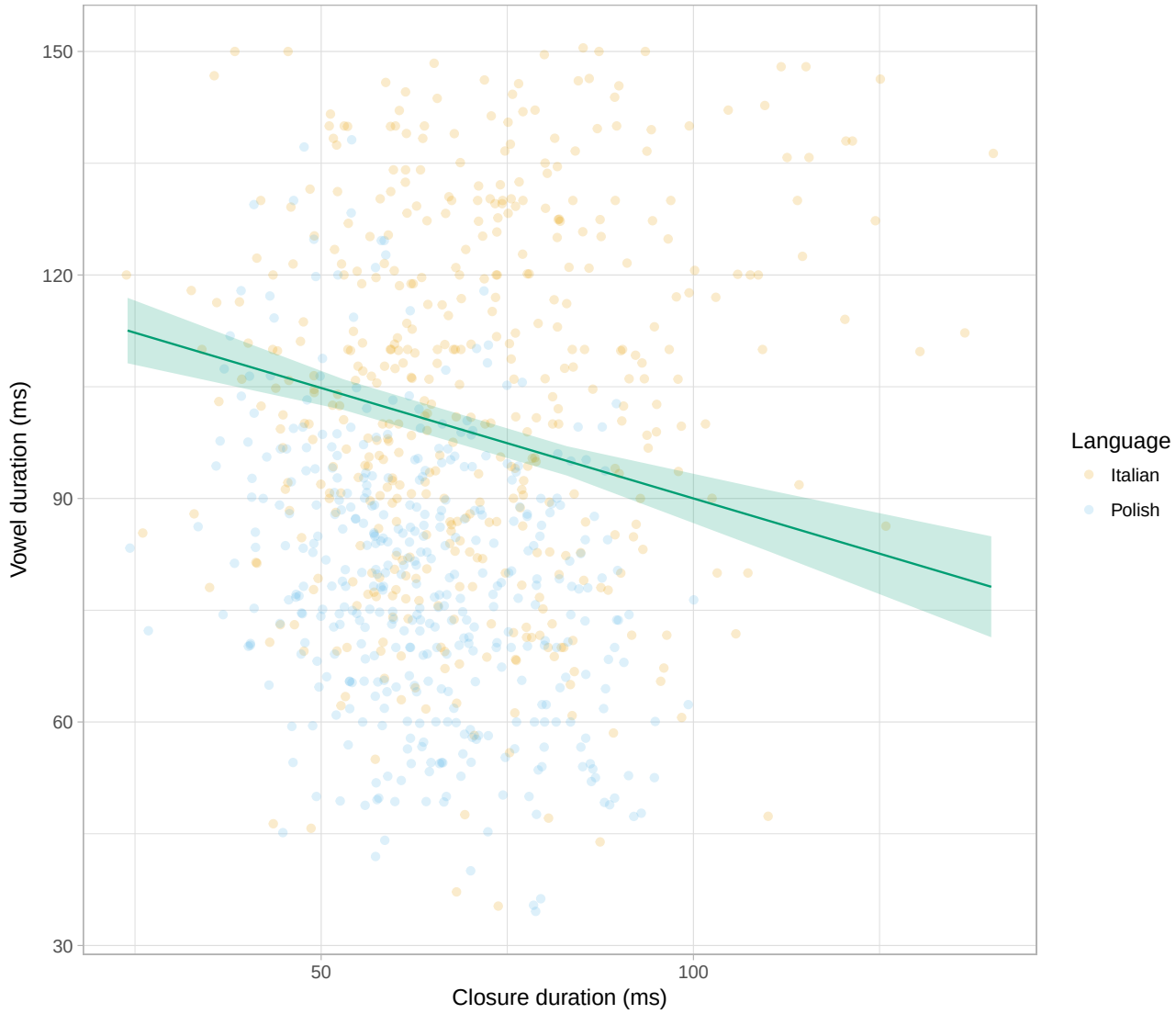
Results: Vowel duration



Results: Closure duration



Results: Vowel and closure duration



Results: Interim summary

According to LMERs, in Italian and Polish:

- Vowels are **15 ms longer** when followed by a voiced stop
- Consonant closure is **16 ms shorter** if it is a voiced stop
- Vowel duration is inversely correlated with closure duration

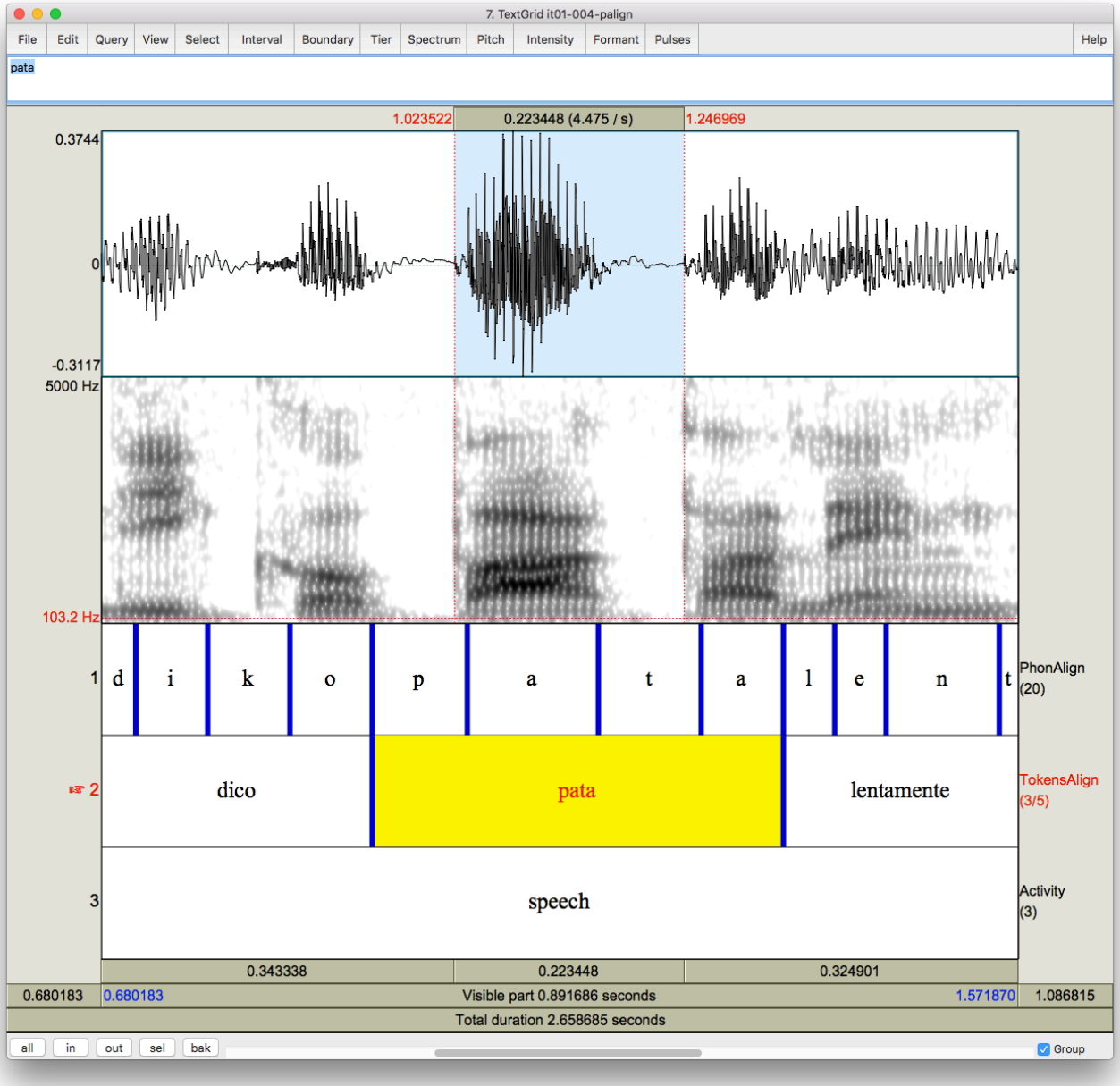
Durational trade-off?

Results: Interim summary

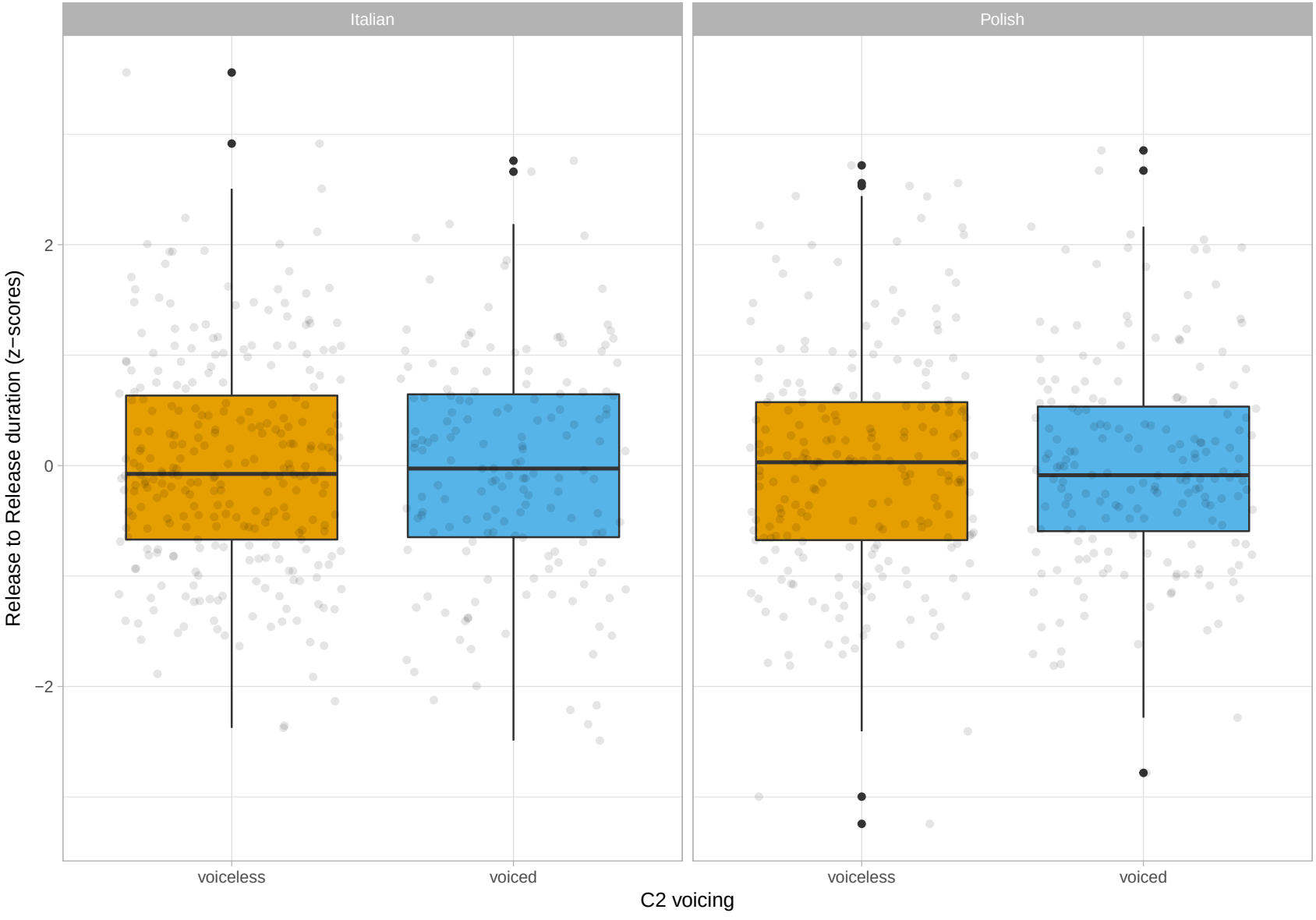
(a) voiceless

(b) voiced

Results: Release to Release duration

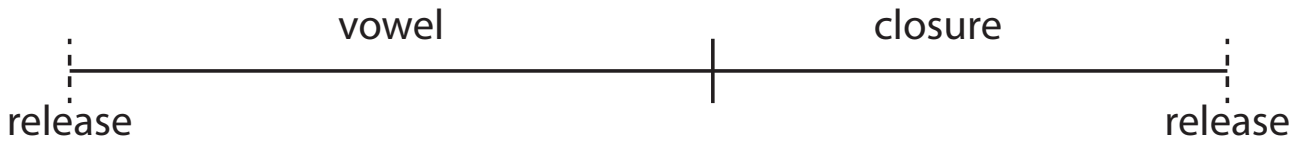


Results: Release to Release duration

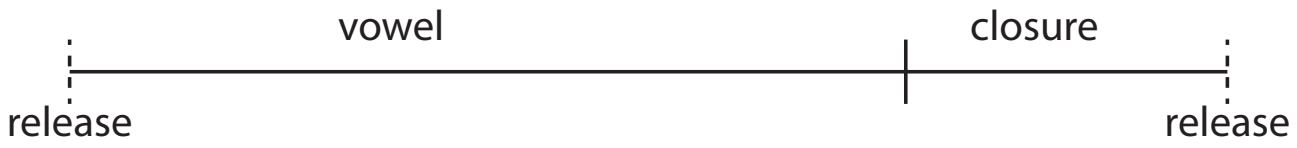


Discussion: Durational trade-off

(a) voiceless



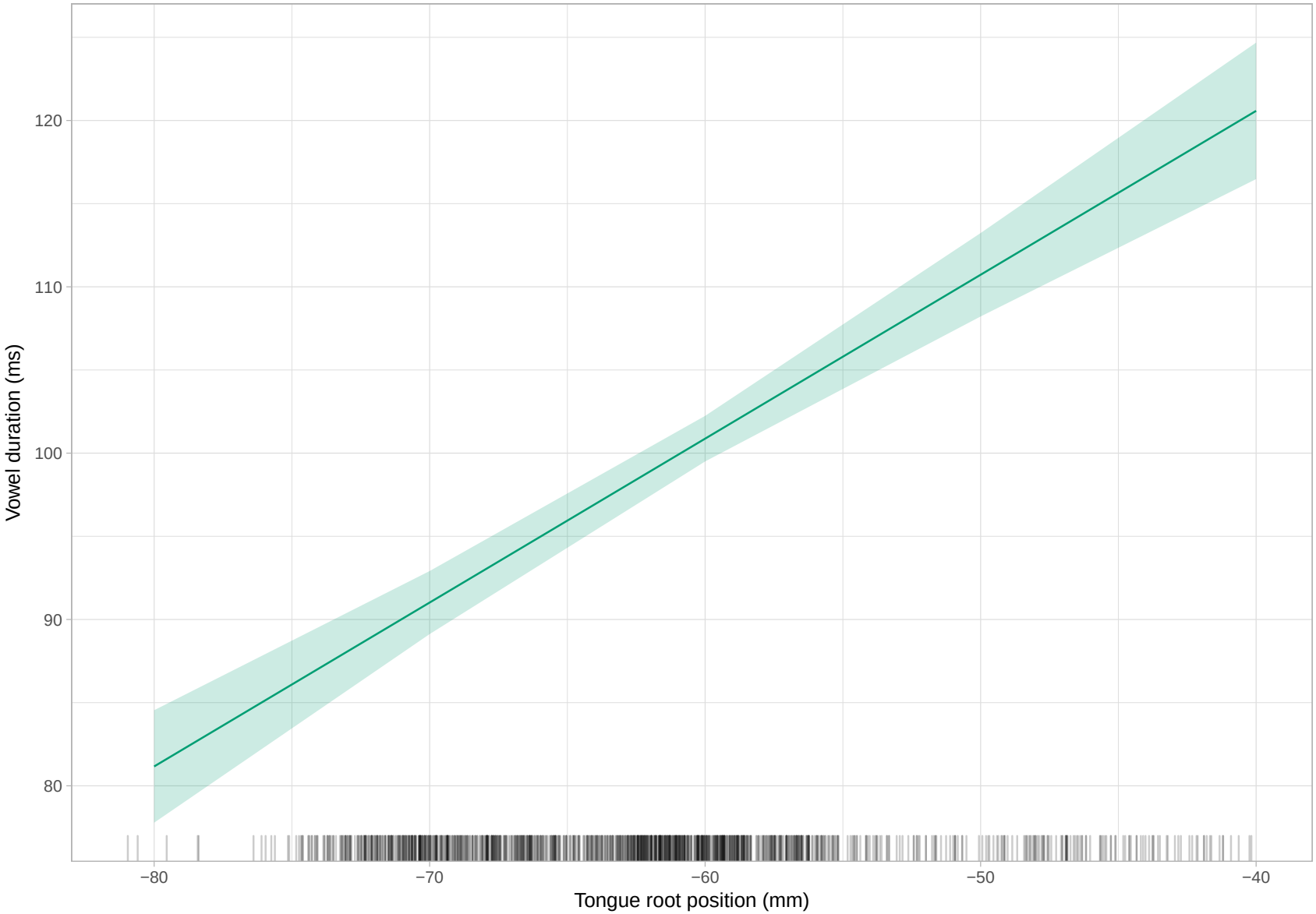
(b) voiced



Discussion: Vowel duration and tongue root position

- Advancing root during vowel **in voiced and voiceless stops**
  - voiced stops have greater advancement at closure onset
- Vowel duration correlates with tongue root position
  - But **no interaction** between C2 voicing and tongue root position on vowel duration

Discussion: Vowel duration and tongue root position



Discussion: Vowel duration and tongue root position

- **Hypothesis**: A later closure onset is (diachronically) selected in the context of voiced stops because it allows for more root advancement within closure (which facilitates voicing)
- Different possible scenarios regarding timing and velocity of advancement gesture
    - same/different timing
    - same/different velocity

Conclusions

- **Release to Release** invariance supports a durational trade-off account for the voicing effect
- Vowel duration and closure duration are **inversely correlated**
- Vowel duration and tongue root position are **directly correlated**

Thanks!

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