Phonologization, nasalization, and sound change: an MRI analysis of two varieties of English.

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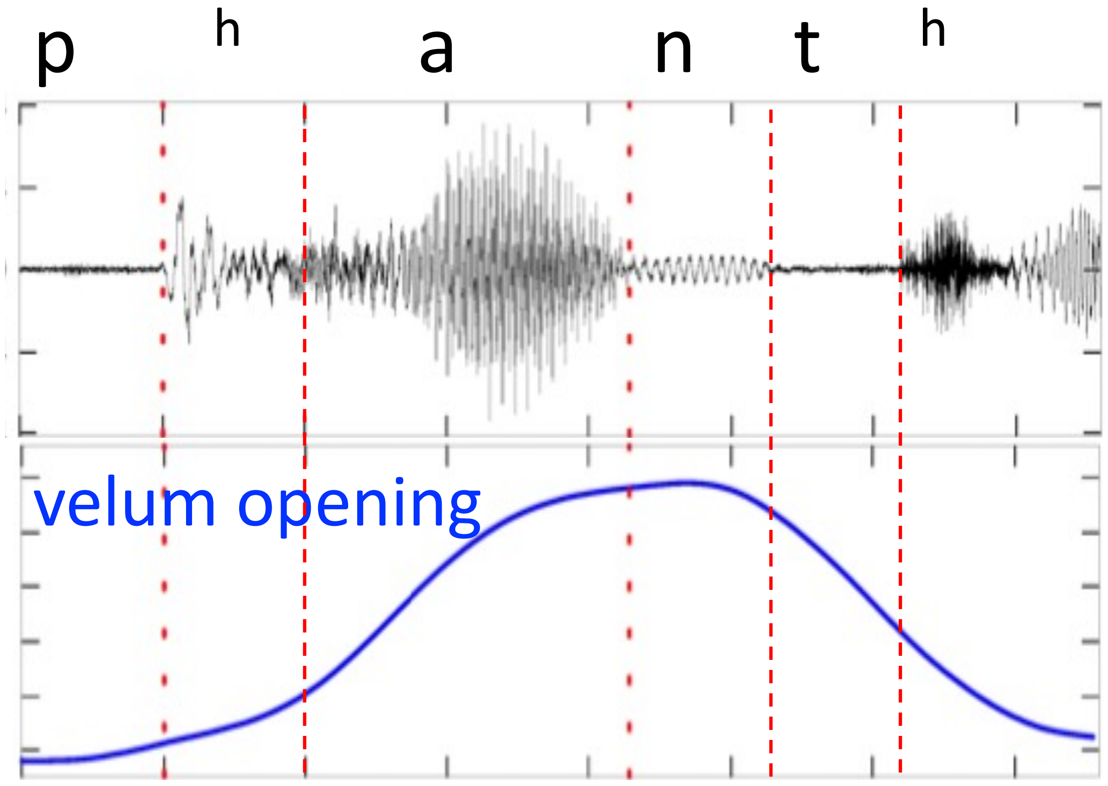
Coarticulatory vowel nasalization in VN

German: *Panther*



VN_t

(acoustic boundary between V and N)

Sound change in VN

Lt. *sonus*
Ital. *suono*

Vn > Ṽn > Ṽ^n > Ṽ

French, Portuguese: /sõ/

Bolognese Italian

VINU > vin > vĩn > vĩ > vẽ > vẽŋ > veŋ

Hajek, 1991[1]; Saunders, 1979[2]:

Chengdu Chinese

an > ãn > ɛ̃n > ɛ

Sishi Liao, IPS [3].

1. Hajek 1991. In Bertinetto, Kenstowicz, Loporcaro; eds. 2. Saunders, 1979. In Hollien & Hollien eds; 3. Liao et al (2022, *Interspeech*; Liao et al, 2023, *Int. Cong. Phon. Sci.*

Linking coarticulation and sound change

Work out the mapping between **two sets of synchronic data** positioned at different points **on the diachronic path of sound change**.

this study $Vn > \tilde{V}n > \tilde{V}^{n} > \tilde{V}$

1. Beddor (2009, *Language*). Beddor, McGowan, Boland, Coetzee, Brasher (2013, *J. Acoust. Soc.* Am). Beddor, Coetzee, Styler, McGowan, Boland (2018, *Language*)

Sound change less advanced in  ?

$Vn > \tilde{V}n > \tilde{V}^{n} > \tilde{V}$

/n/deletion in *sent*	Tongue raising in *pan* beyond [ɛ]
no	no
yes: e.g. Beddor et al (2013)	yes: e.g. Mielke et al (2017)

Model of Beddor and colleagues [1]

Findings

More vowel nasalization and shorter /n/ in *sent* vs. *send*

Sound change more likely in /$nC_{voiceless}$/ clusters (see also Carignan et al, IPS, 2021) [2]

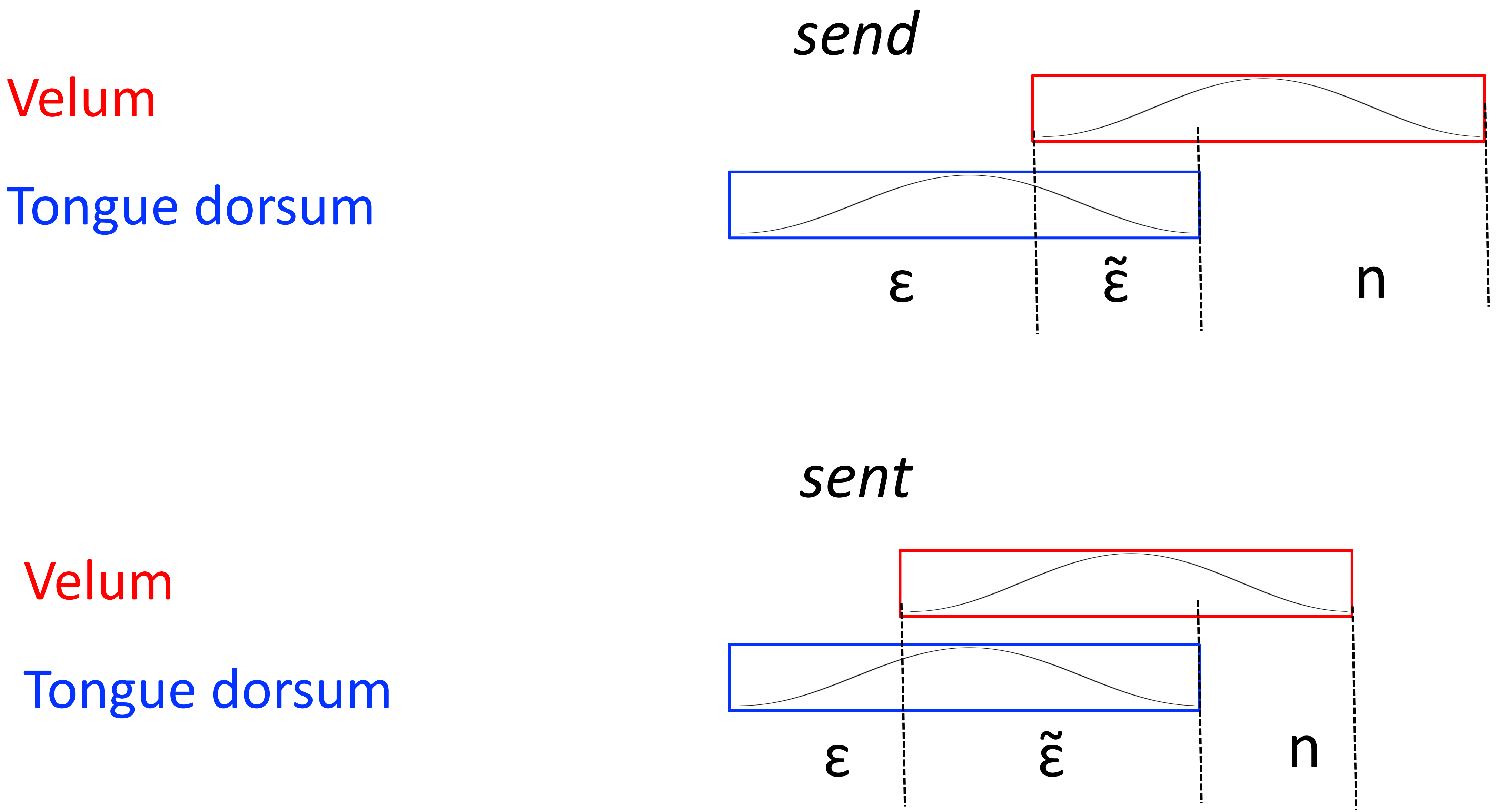
Model

An **earlier phasing** of a **stable** velum gesture

1. Beddor (2009, *Language*). Beddor, Beddor, McGowan, Boland, Coetzee, Brasher (2013, *J. Acoust. Soc. Am.*); Beddor, Coetzee, Styler, McGowan, Boland (2018, *Language*); Beddor (2023, *J. Phon*)

2. Carignan et al, (2021) *Language*

Model of Beddor and colleagues



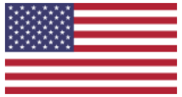
The present study

Does this model work for British (BRE) vs. American English (USE) in the same words (e.g. comparing BRE vs. USE *Ben*?)

What happens to the **oral** gesture of N e.g. tongue tip (TT) of /n/ in *Ben*?[1]

According to this:

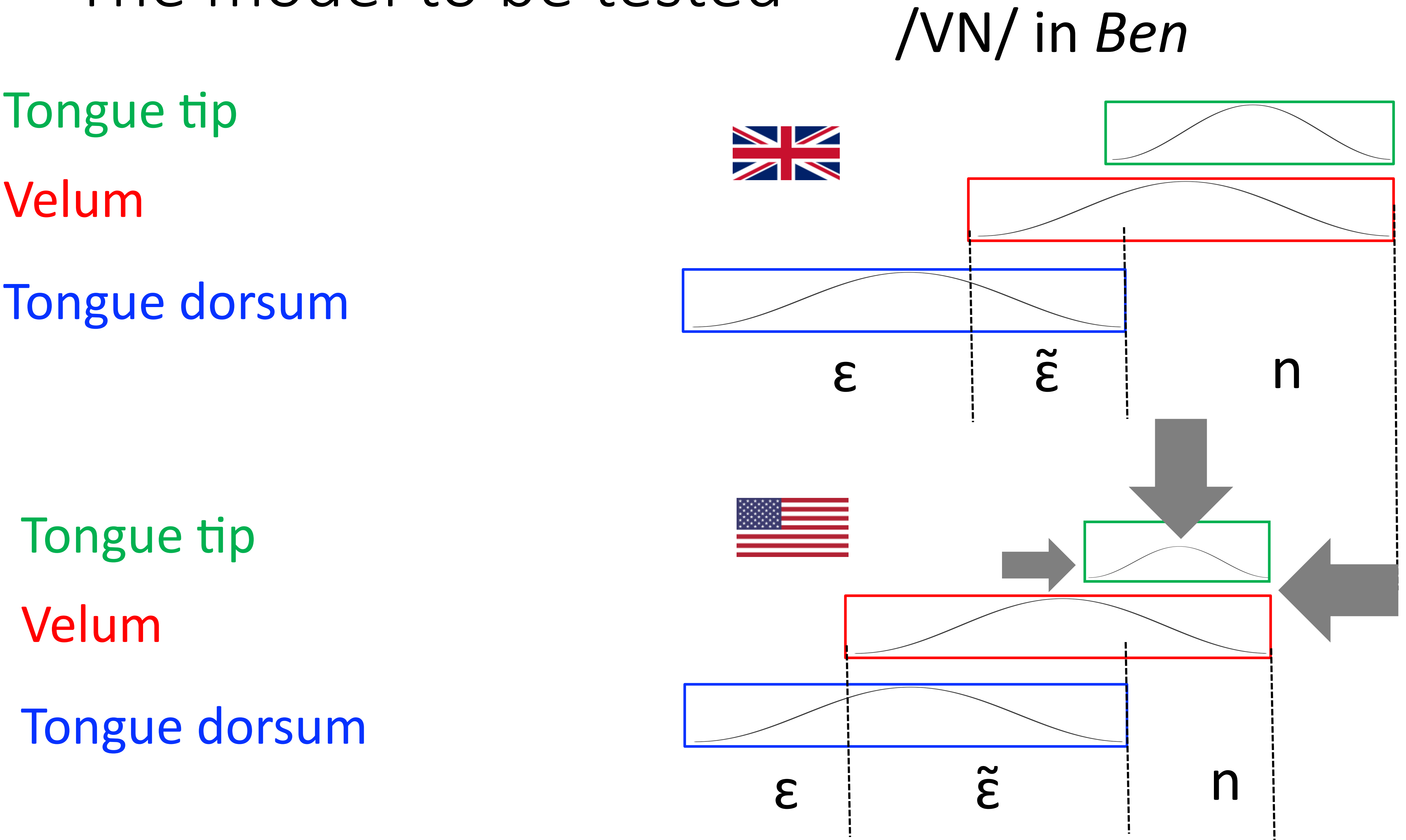
Vn > Ṽn > $\tilde{V}^n$ > Ṽ



the TT should **shorten and lenite as the velum gesture slides to the left** (earlier in time)

see also Bongiovanni (2021, *J. Labphon*; 2021, *Ling. Vanguard*)

The model to be tested



Speakers

BRE

27 speakers (13 F) of standard Southern British median age 20 years, age range 18-46 years.

USE

16 speakers (7 F) approximately equally distributed between Midland, Northeast, Southern, West, median age 26 years, age range 20-37 years.

Materials

saw <targetword> about two/four/five/six/ten"

47 real word monosyllables formed from CVN(d|z)

C = any of /b, p, f/ rarely /s/. E.g.:

	æ	eɪ	ʌ	ɛ	ɪ
n	ban	feign	bun	Ben	bin
nd	band	feigned	fund	bend	binned
nz	bans	feigns	buns	Ben's	bins

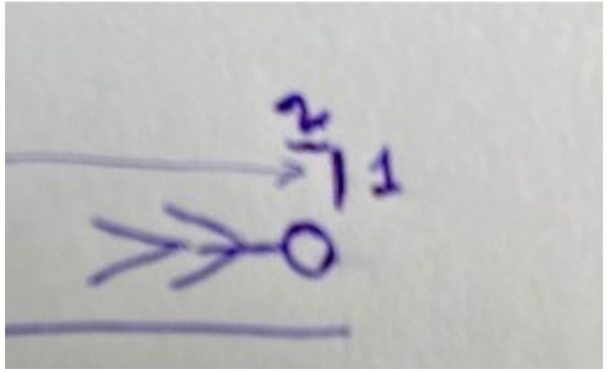
Each word typically repeated once per speaker

Around 2020 tokens from 47 words types × 43 speakers.

Subject recording

50.05 frames per second. 3T MRI system

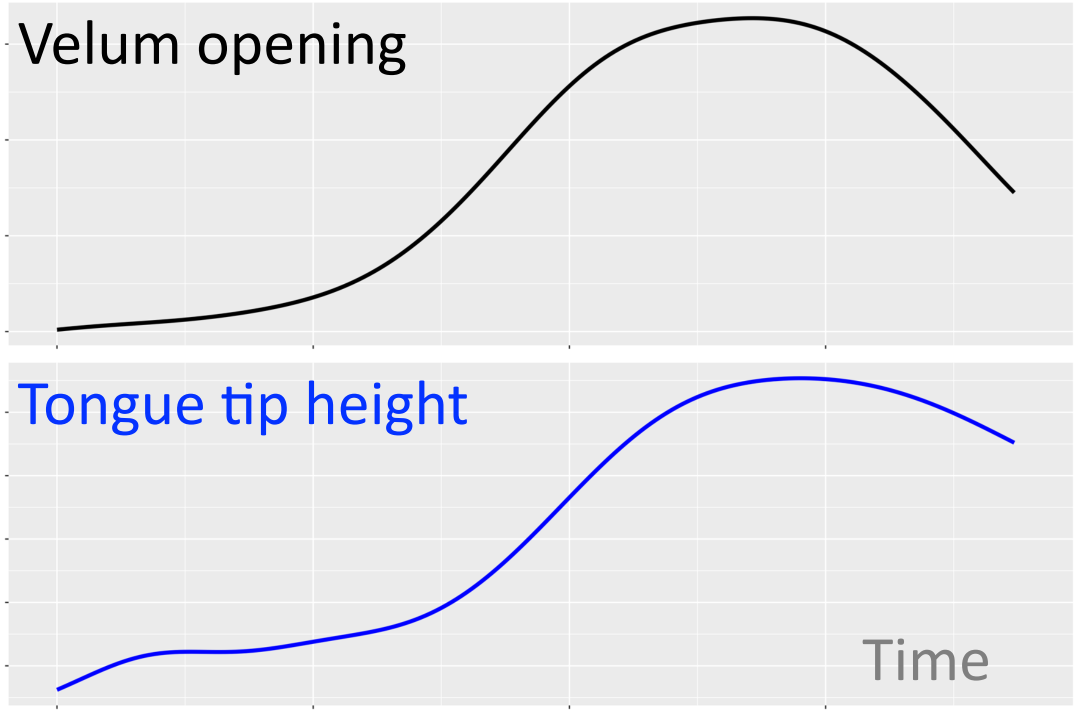
External monitor with word list

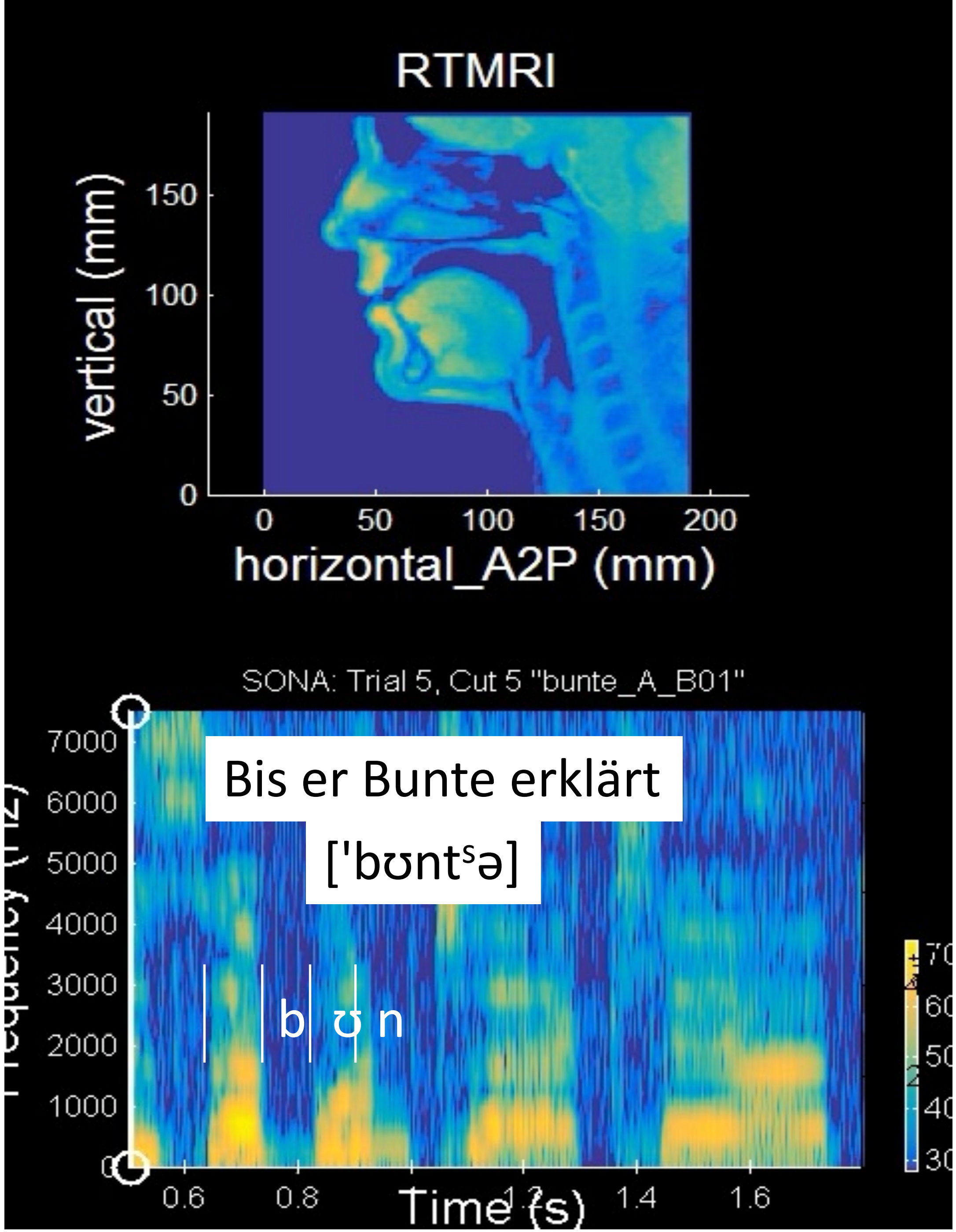


mirror 1 reflected onto mirror 2

Fiberoptic microphone

Real-time MRI

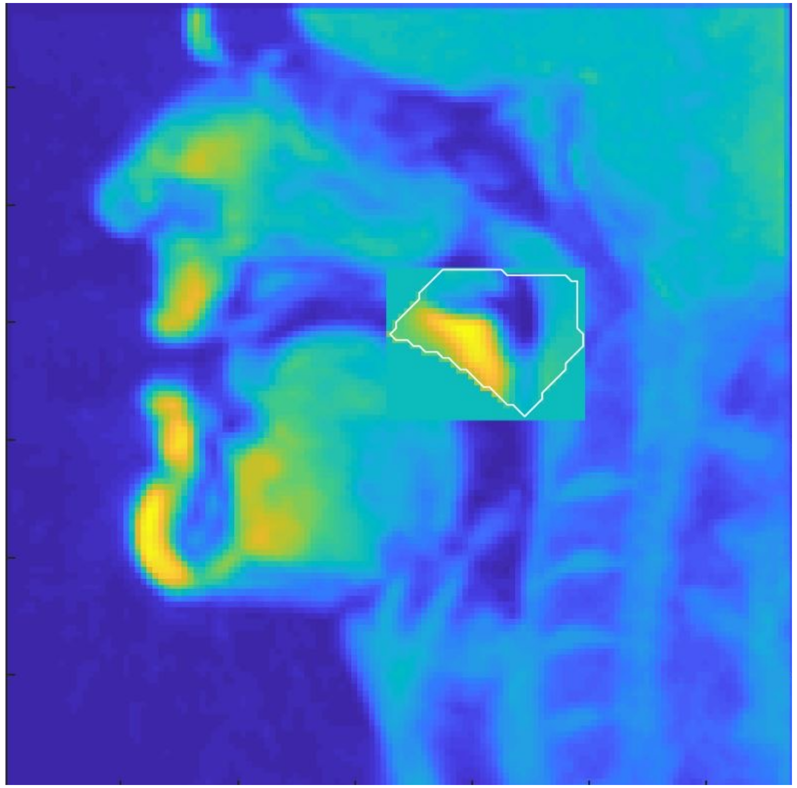




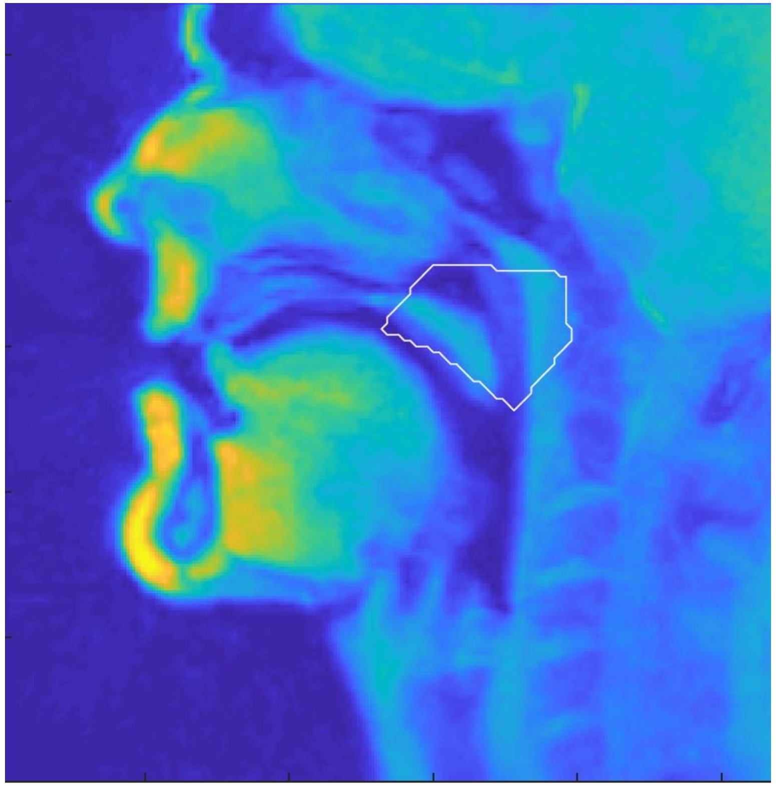
Processing velum opening

Application of Principal Components Analysis to a region of interest

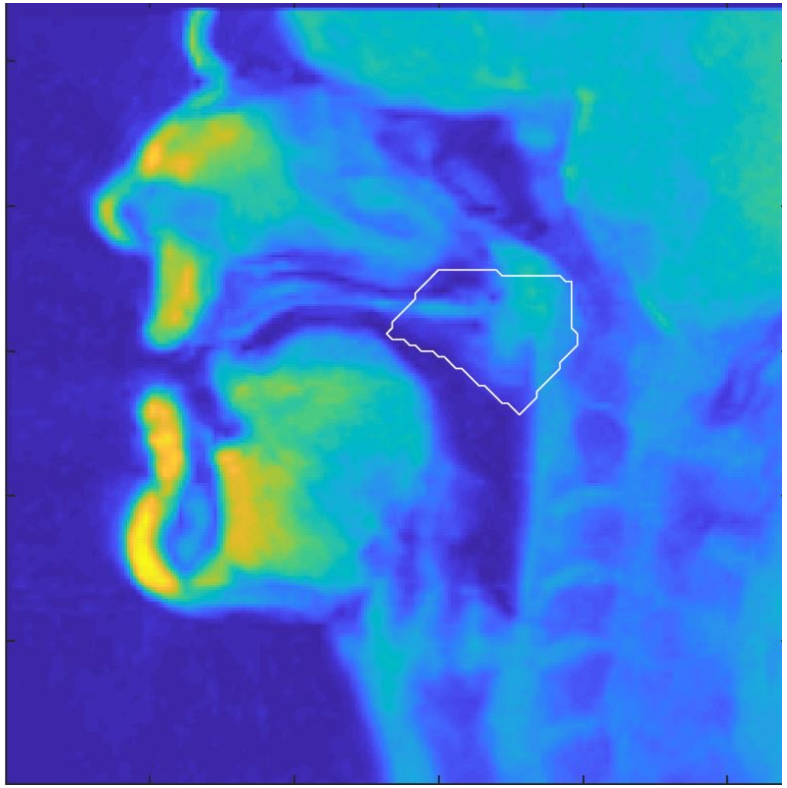
PC weights in region of interest



High PC score (lowered velum)

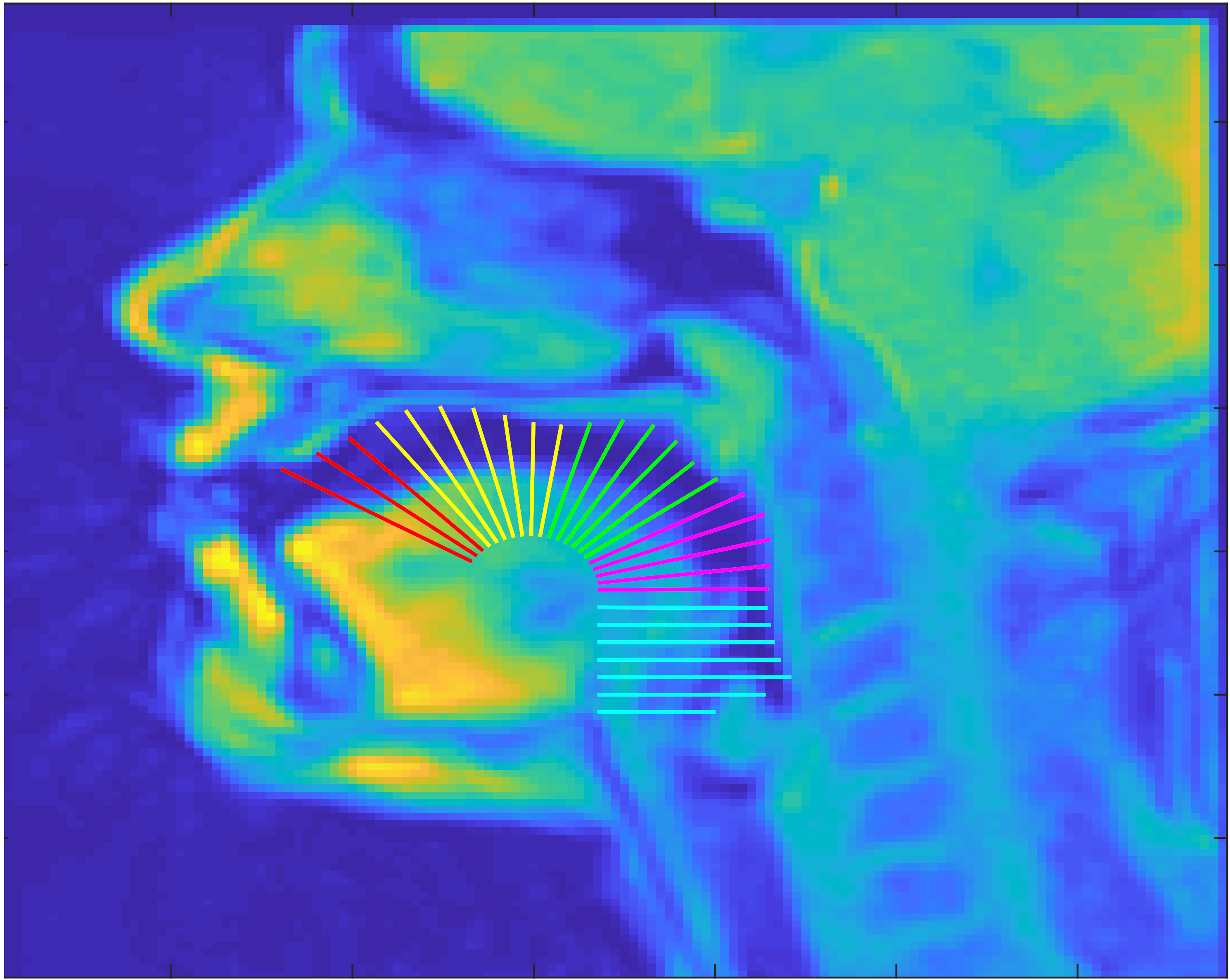


Low PC score (raised velum)

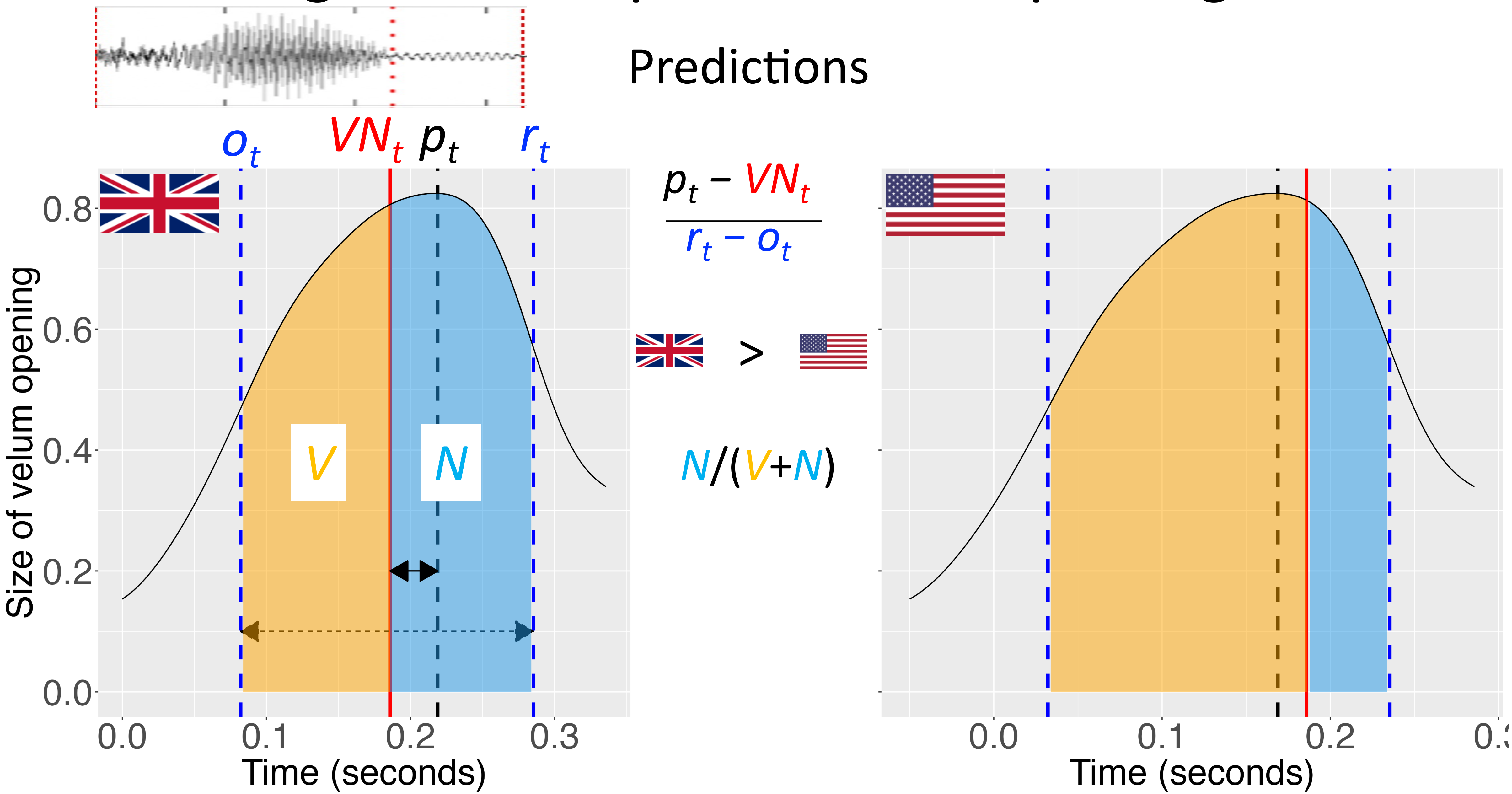


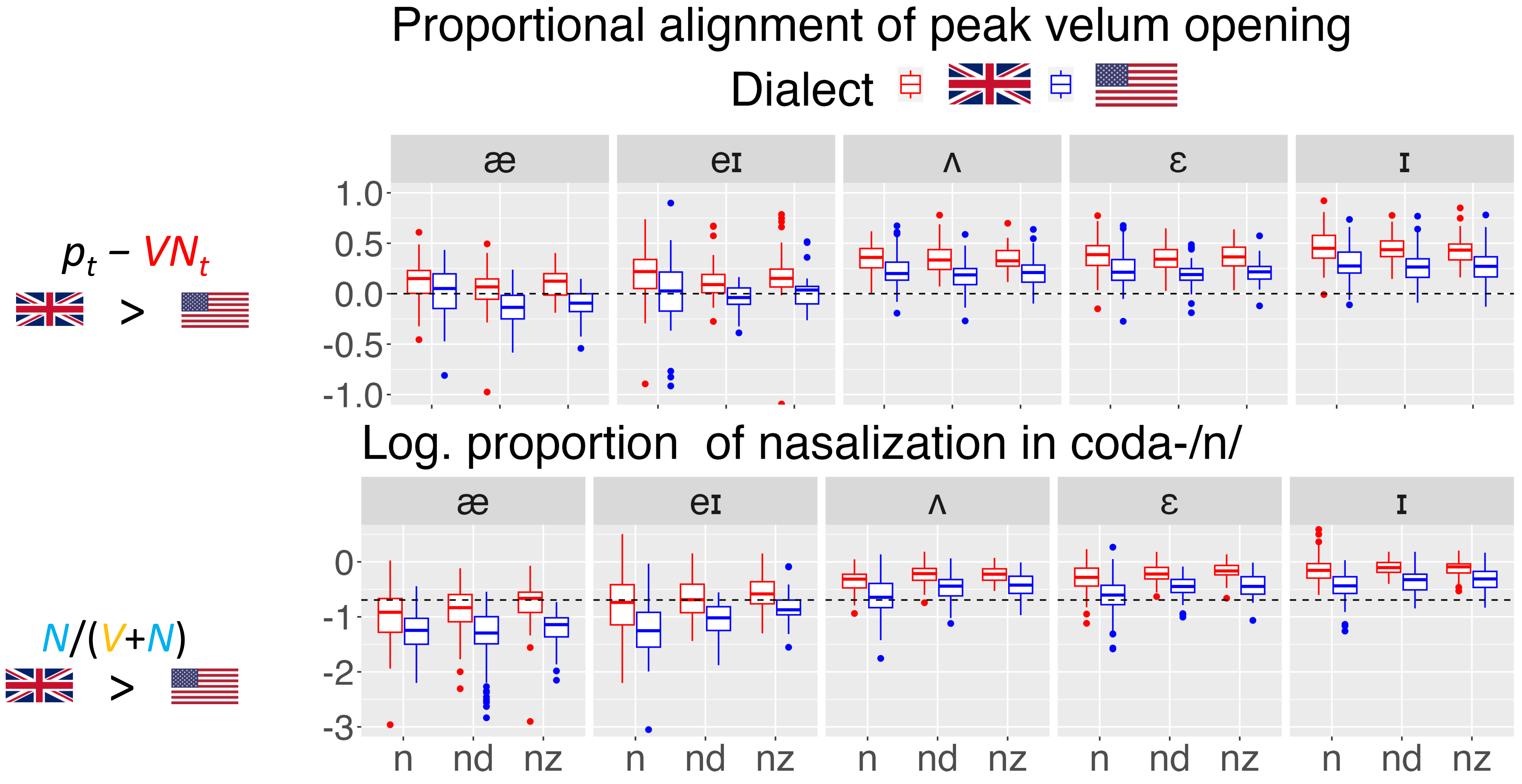
Processing tongue tip height

Tongue tip height:
mean pixel intensity calculated per grid line then averaged over the first three lines



1. Alignment of peak velum opening




Proportional alignment of peak velum opening
Dialect
$p_t - VN_t$
>
1.0
0.5
0.0
-0.5
-1.0
æ
eɪ
ʌ
ɛ
ɪ
Log. proportion of nasalization in coda-/n/
$N/(V+N)$
>
0
-1
-2
-3
n
nd
nz

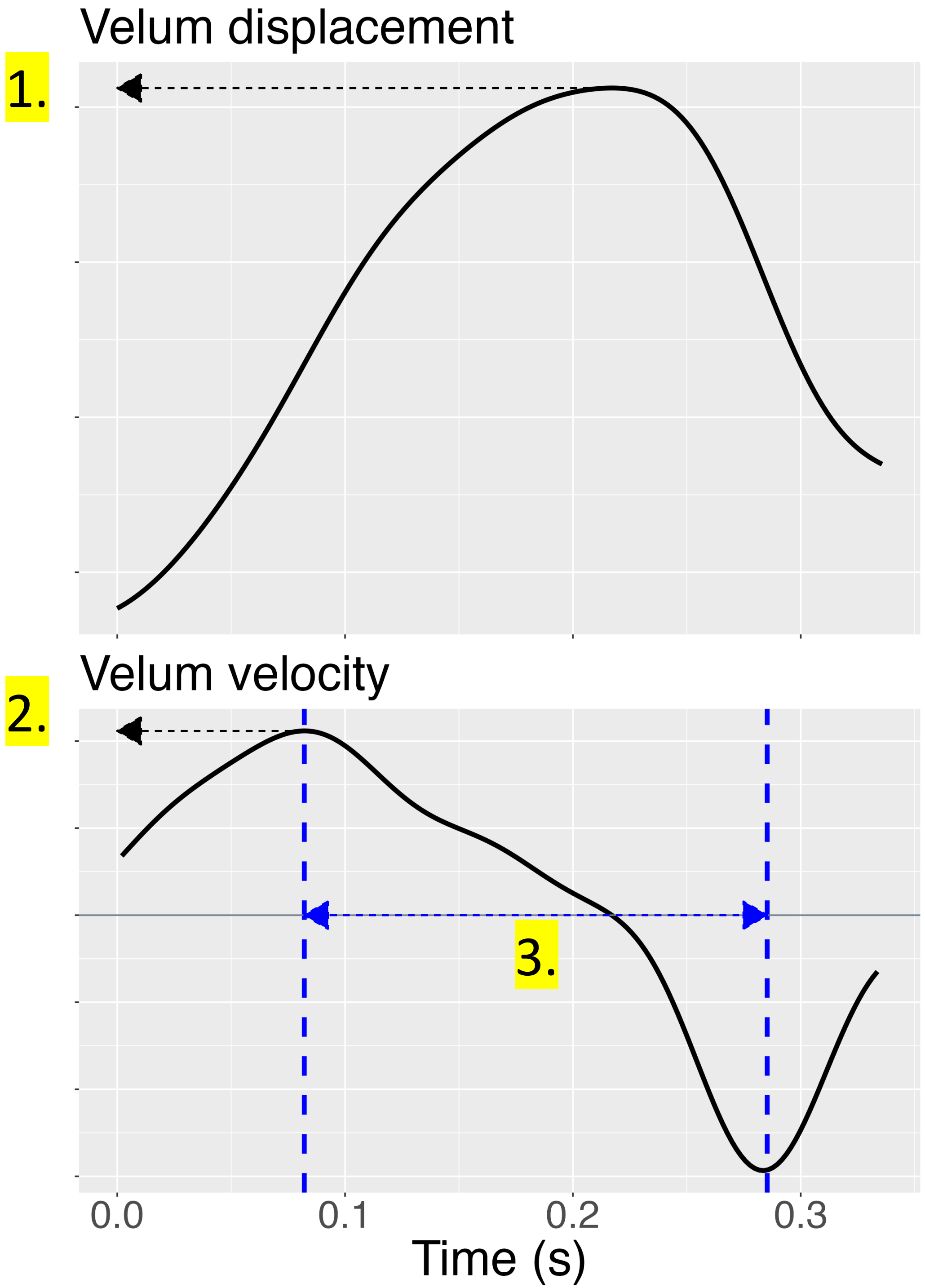
2. Stability of velum gesture

1. Peak velum displacement.
2. Peak velum opening velocity.
3. Velum articulatory duration.

Prediction

≈

if the velum gesture is stable



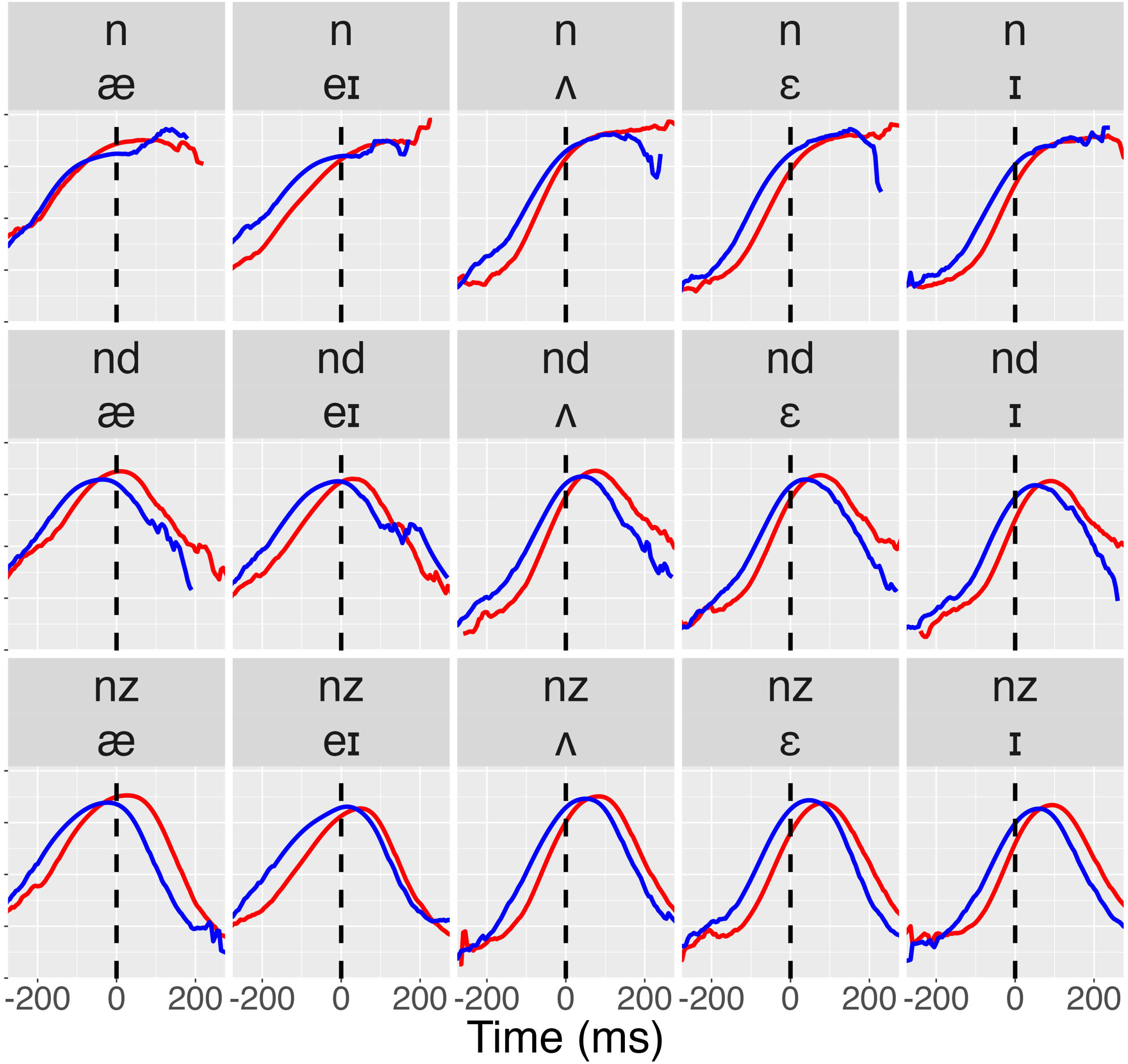
Stability of velum gesture

1. Peak velum displacement.
2. Peak velum opening velocity.
3. Velum articulatory duration.

For 1-3:

 ≈ 

Velum displacement
Aligned at acoustic onset of nasal consonant



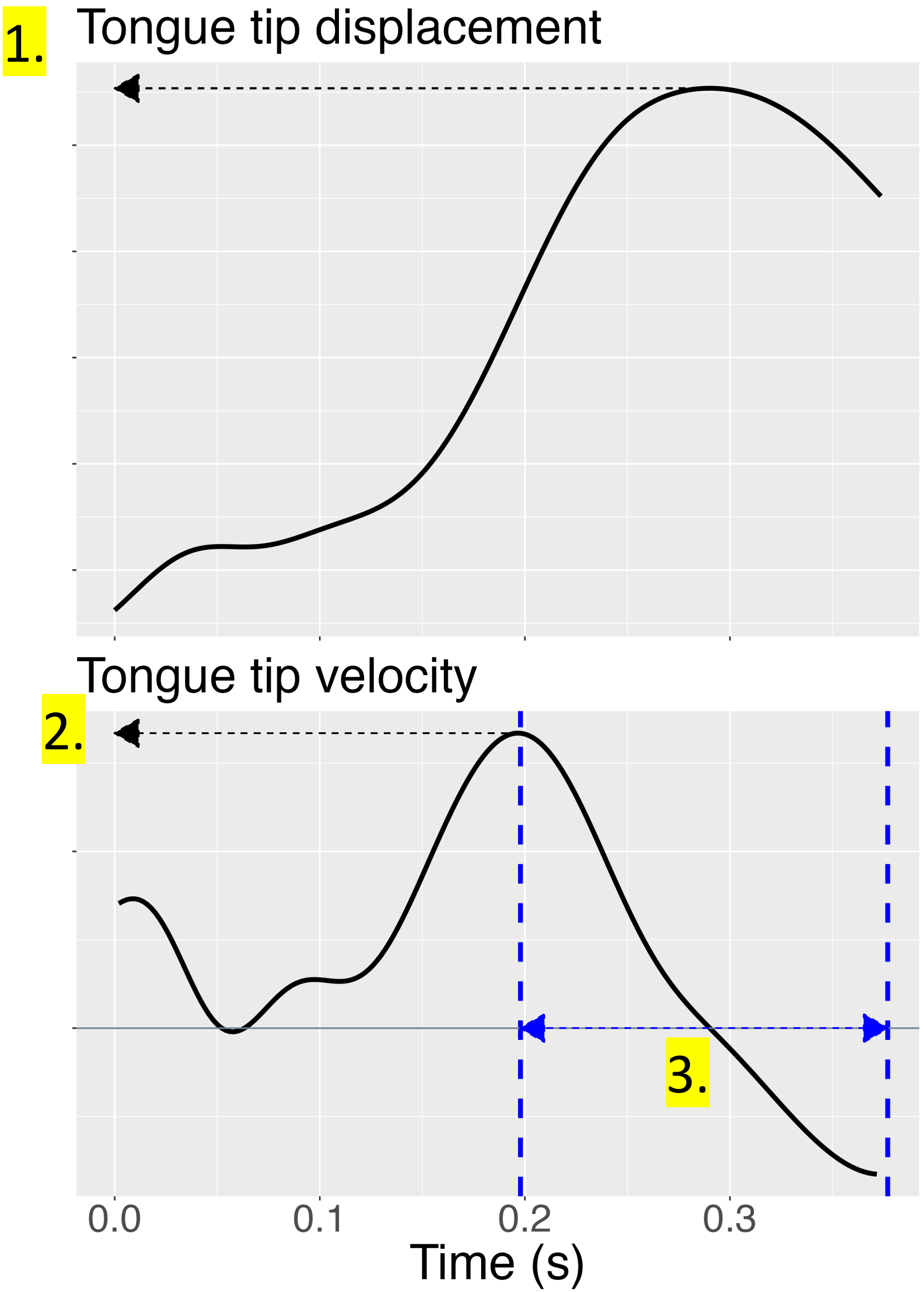
3. Reduction of tongue tip gesture

1. Peak TT displacement.
2. Peak TT velocity.
3. TT articulatory duration.

Prediction for 1-3:

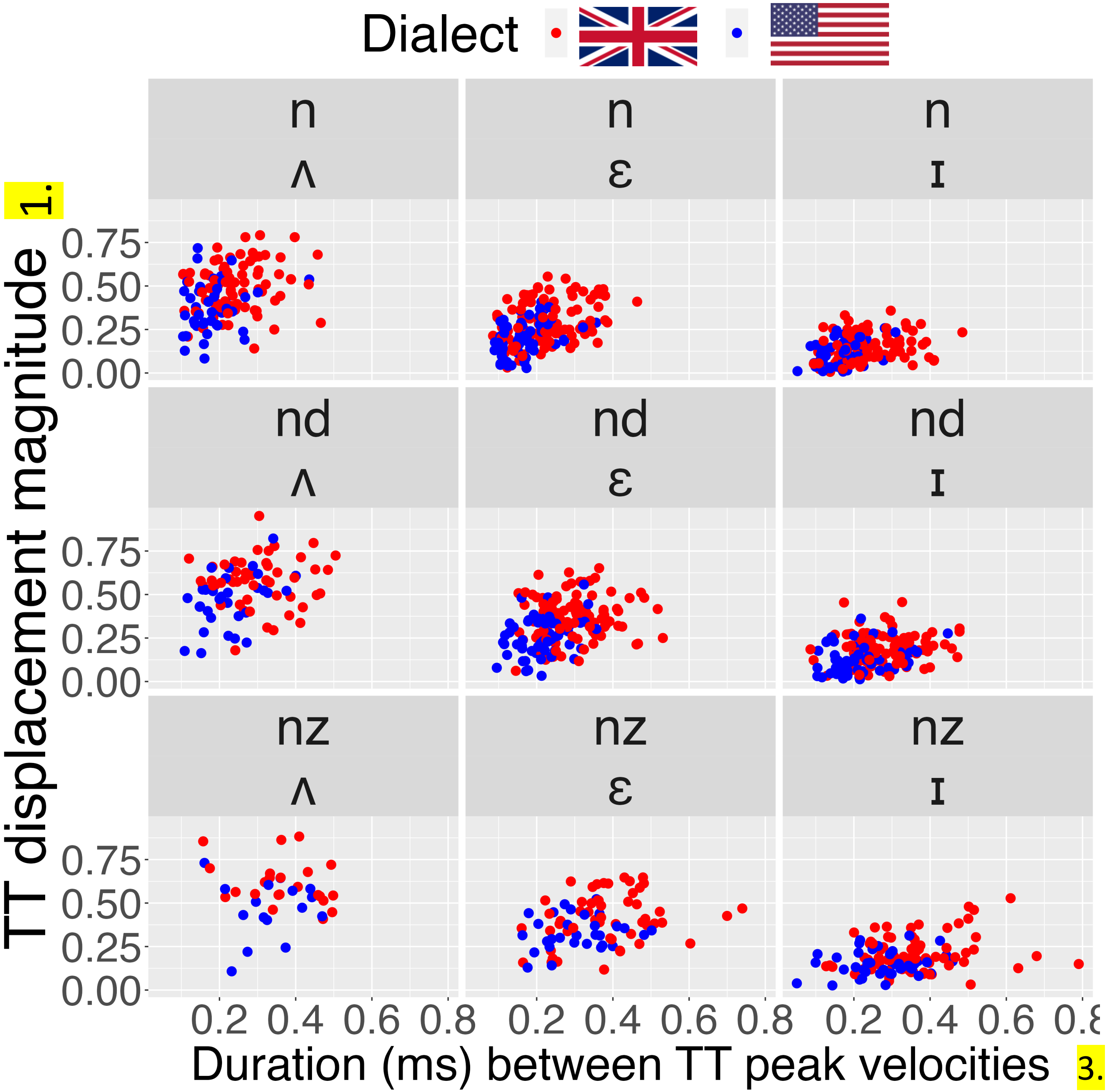
 > 

(TT data not analysed for /æ, eɪ/)



Size/length TT gesture in coda-/n/

1. Peak TT displacement.
2. Peak TT velocity.
3. TT articulatory duration.

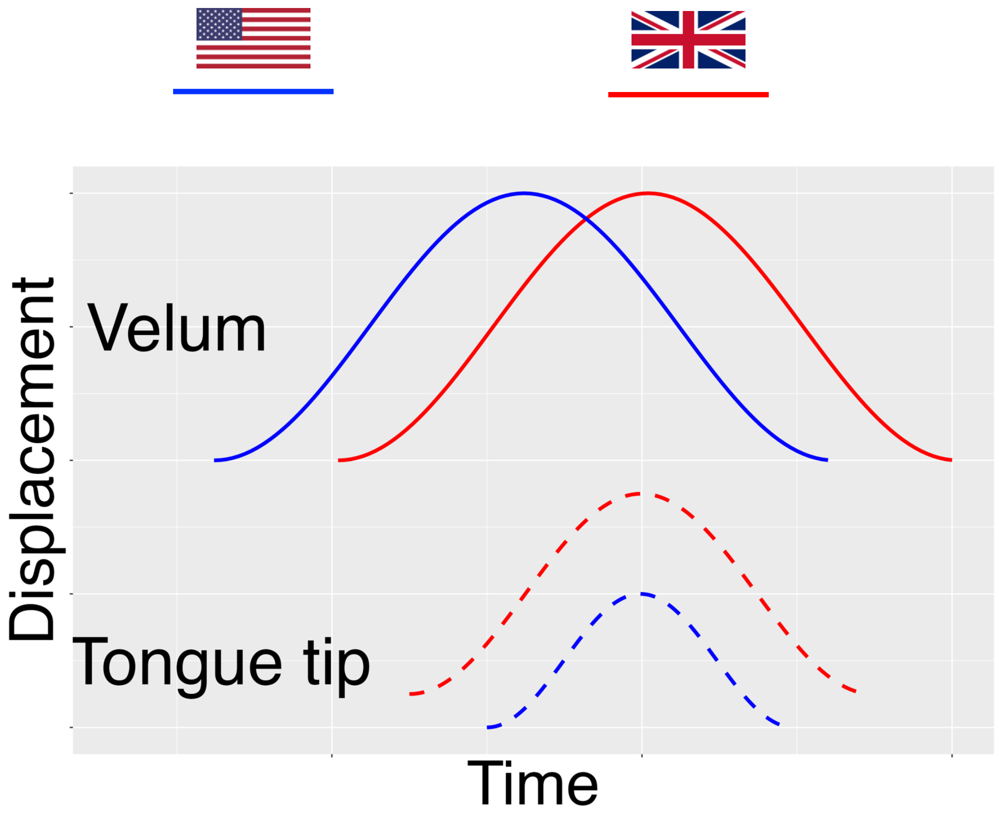


Results.

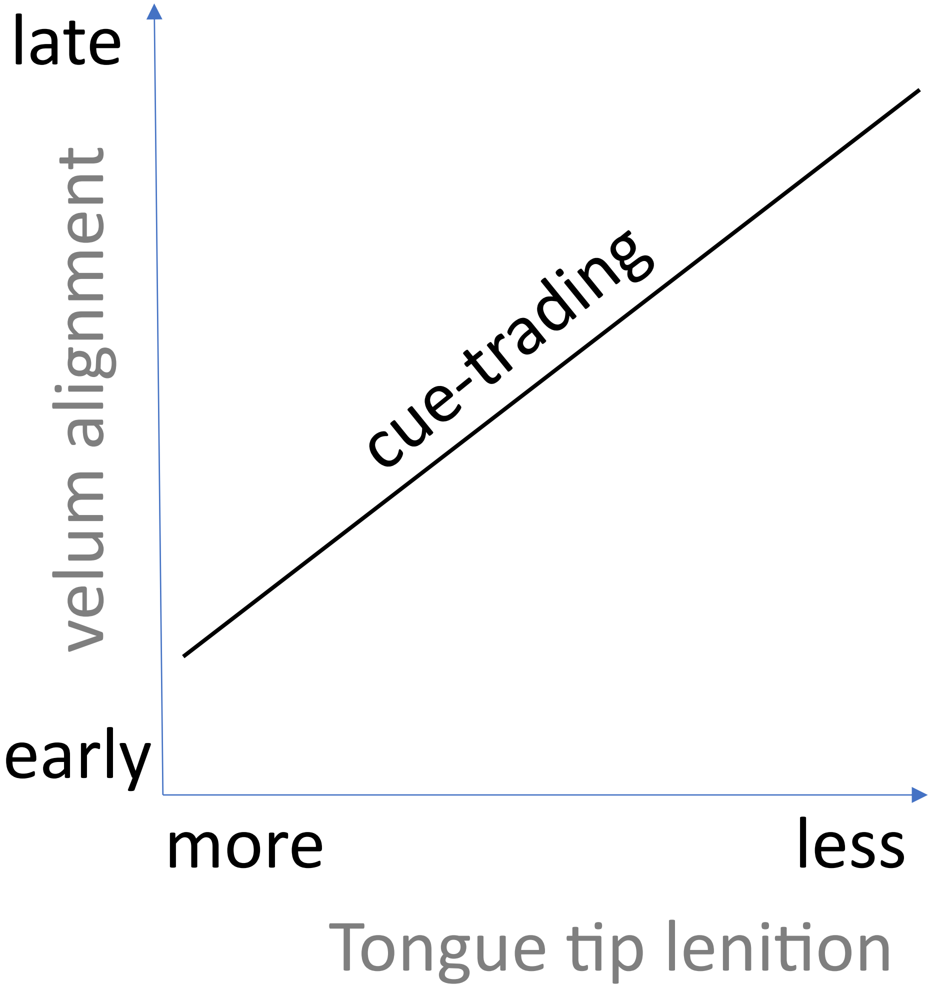
1, 3:  > 

2:  ≈ 

Summary so far

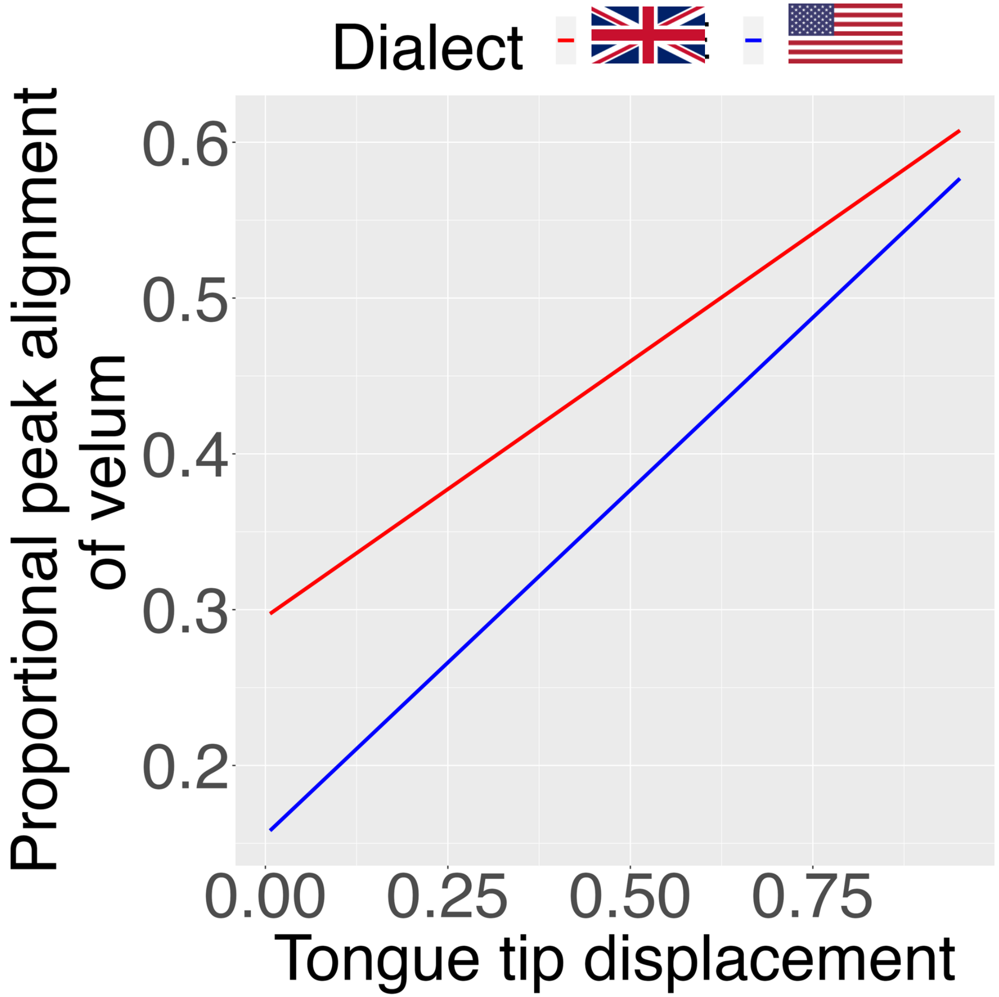


Test of cue-trading

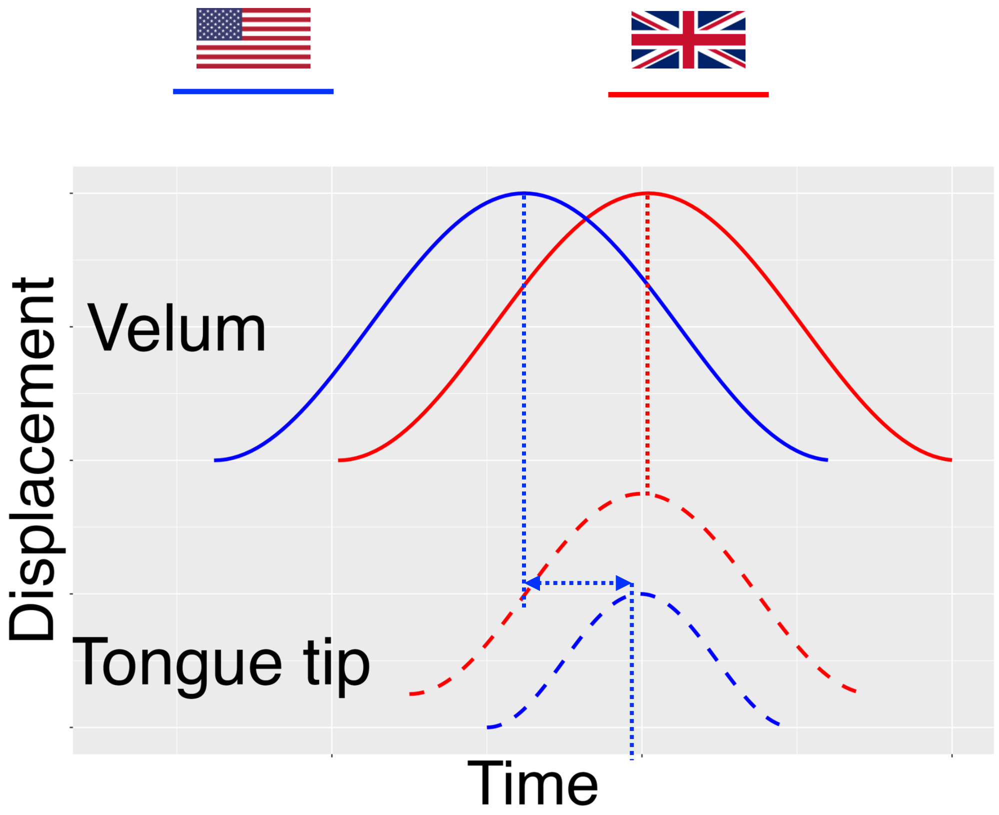


There is cue-trading

Within each dialect, an early alignment of the velum (= greater vowel nasalization) predicts tongue tip lenition.



Summary so far



\+ cue-trading

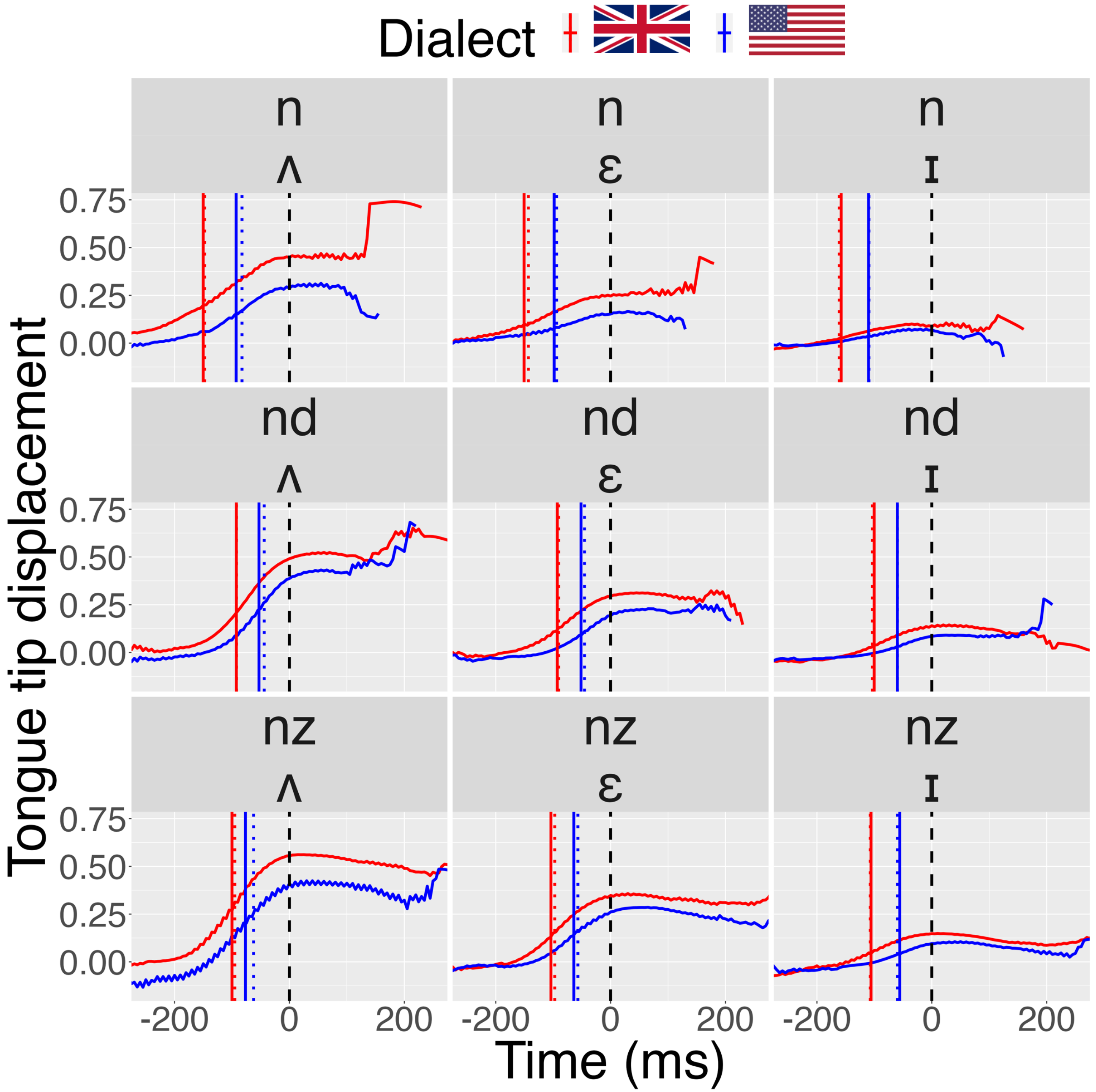
But...

the model predicts **an increasing asynchrony between the velum and tongue tip** as the velum slides to the left, earlier in time (leaving the tongue tip 'stranded').

Is this asynchrony greater in  than in  ?

No.

Tongue tip aligned at peak velum lowering ($t = 0$)



time of tongue tip peak velocity

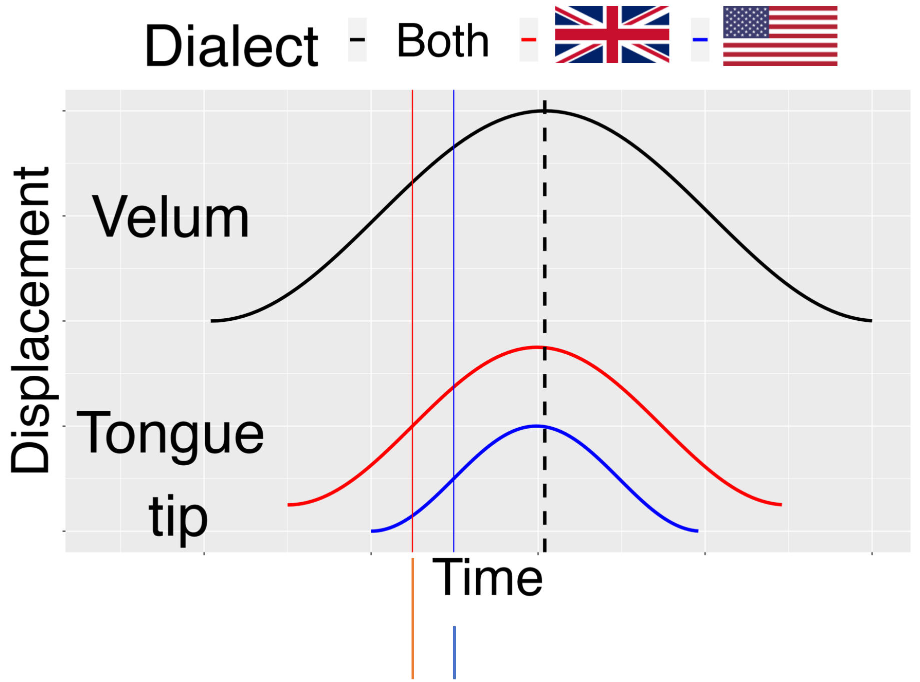
≈

time of acoustic boundary between V and N

Schematic summary

In USE vs. BRE

The velum gesture doesn't move to the left: instead, the VN boundary moves to the right (as a consequence of tongue tip lenition).



Times of tongue tip peak velocity

≈

Acoustic boundary times between V and N

Conclusion

What drives Vn > $\tilde{V}n$ > $\tilde{V}^{n}$ > $\tilde{V}$?

1. Lenition of the oral gesture in N both 'vertically' (TT lenition) and 'horizontally' (encroachment of V on N)

2. Because of 1., **the integrity (segmenthood) of N as [+coronal, +nasal] is dismantled** (reduction/lenition targets [+coronal] *but not* [+nasal]).

3. Cue-reweighting is a gradual and **inevitable** consequence of TT reduction (the more TT reduces, the more the VN boundary shifts later in time).

4. In this proposed lenition model, the tongue-tip gesture in N is not stranded by a moving velum gesture (the velum gesture doesn't move).