Speech errors in vowels: trace effects.

LSA Organized Session 2025 -
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Overview

- **Speech error literature.**
  - Trace effects in speech errors.
  - An example for consonants.
- **DFT model of trace effects in consonants.**
- **Vowel errors**: what do trace effects in vowel errors look like?
- **Extending the consonant model to vowels.**
  - Model parameter choices.
  - Simulation.
- **Discussion/Future work.**

Trace effects in consonant errors

- Speech errors are not phonetically equivalent to their canonical counterparts.

Error		Non-Error	
Intended	Produced	Intended	Produced
b	p	p	p

≠

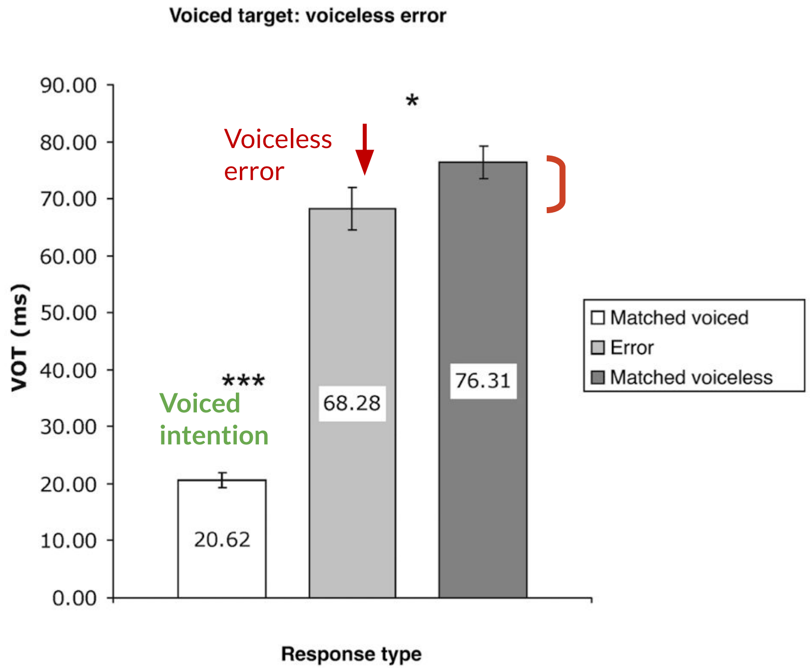
- Instead, we see **trace effects:** an influence of the intention on the production.

- These effects have been found in acoustic (voice onset time; VOT) and articulatory measures (tongue height) for consonants (Goldrick & Blumstein 2006; Pouplier 2007).

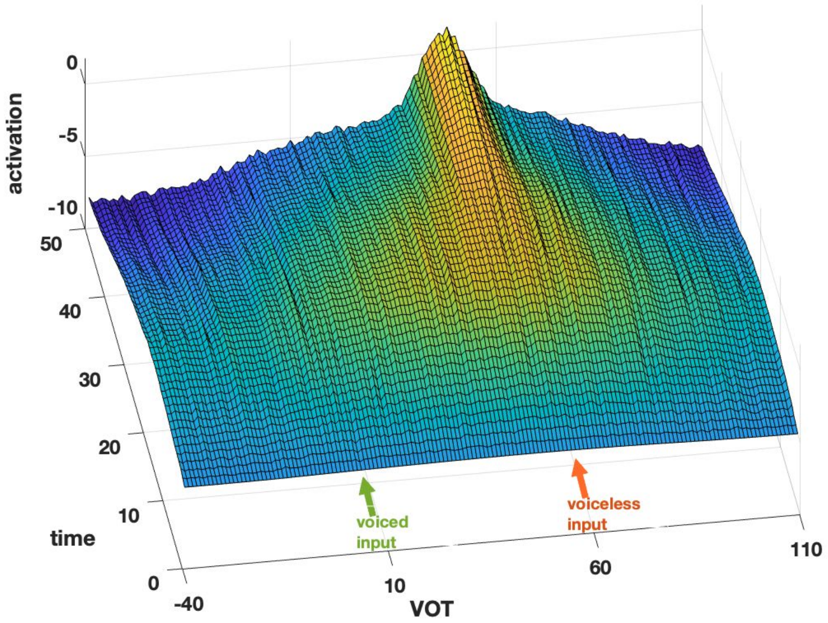
Consonant trace effects: VOT example.

- Tongue twisters of the form *keff geff geff keff.*
- Measure of interest: VOT.

Takeaway: In speech errors, the intended sound influences the final production!



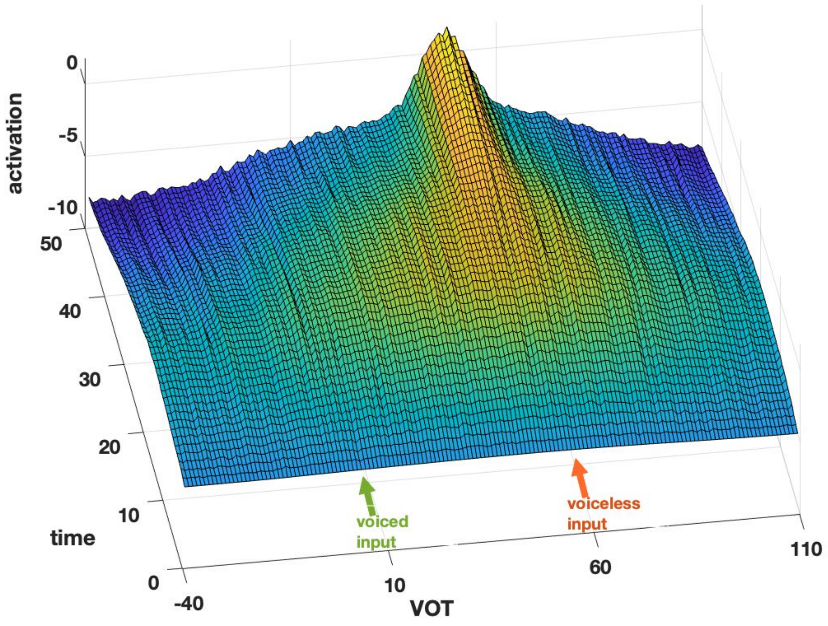
DNF model of consonant trace effects (Stern et al. 2022).

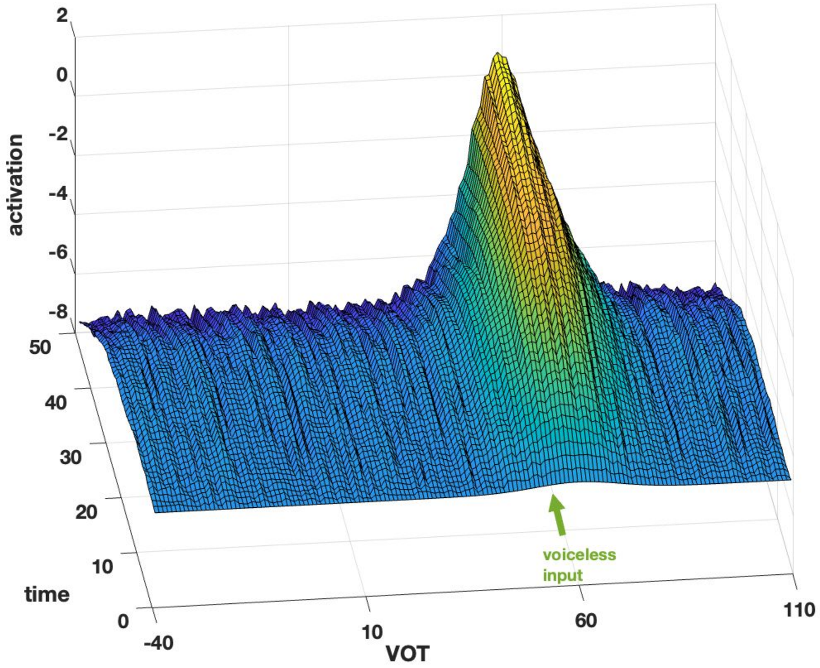


1. **Two inputs** into a VOT planning neural field (error: high activation, intention: low activation)
2. Trace effect derived from **overlapping inputs** → dynamics of model stabilize these into **one intermediate peak**
3. Voiced to voiceless error: Presence of voiced input (the *intention*) results in stabilized peak at a **lower VOT** location than if there had been no voiced input at all.

DNF model of consonant trace effects (Stern et al. 2022).

1 Two inputs into a VOT





Will vowel errors show trace effects as well?
Given a field sensitive to some dimension of articulation, the DNF model of consonant traces predicts: yes.

However, this is not a given: consonants and vowels show various processing differences like brain region and mutability. (e.g., Caramazza et al. 2000, Van Ooijen 1996).

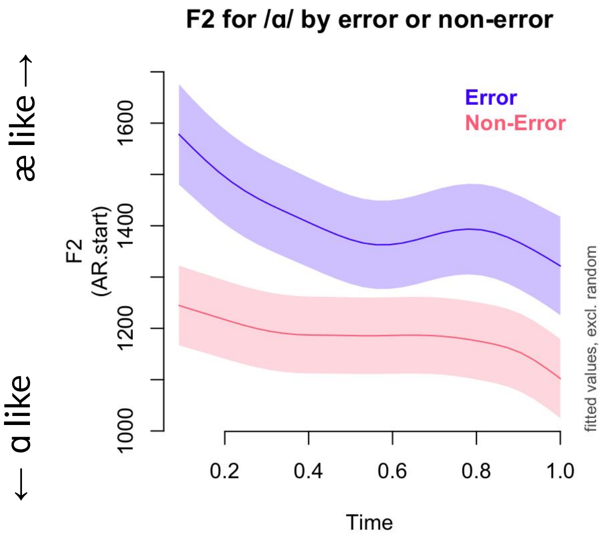
Vowel errors experiment (Chaturvedi & Shaw, submitted)

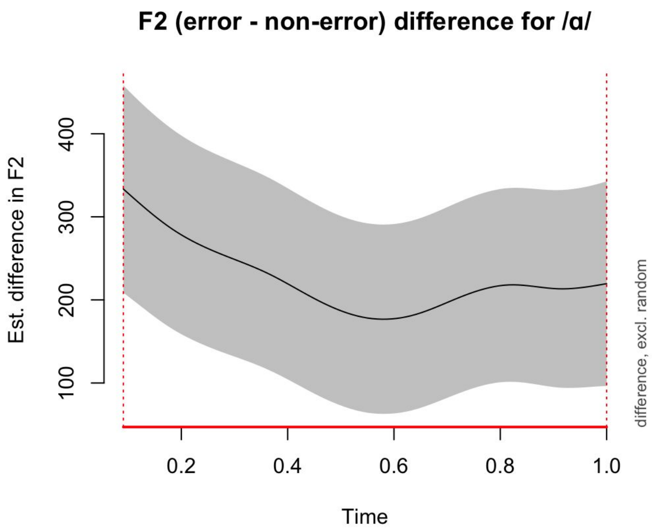
- Design based on Goldrick & Blumstein (2006) consonant error study.
- Tongue twister experiment, 155 bpm metronome.
- Stimuli example:
  ab ahb ahb ab & ahb ab ab ahb [For the pair æ - ɑ]
  Controls: ab ab ab ab, ahb ahb ahb ahb
- Measure of interest: formant measurements, like F2.
- Error classification done using a support vector machine trained on control tokens.

Question: Are tokens classified as errors equivalent to their canonical counterparts, or do they show a trace of the intention?

Results.

- We do see trace effects, in vowel formants (F1/F2).
- We will zoom in on /æ/ → [ɑ] errors.





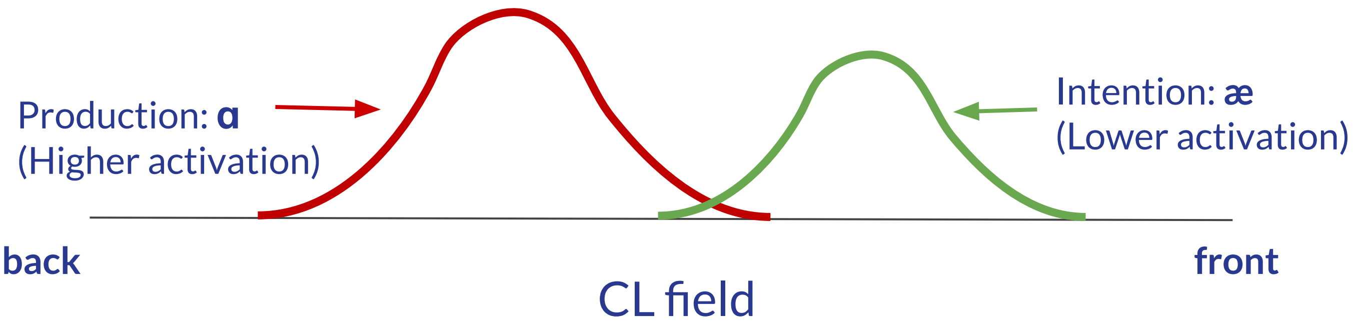
What do the results indicate?

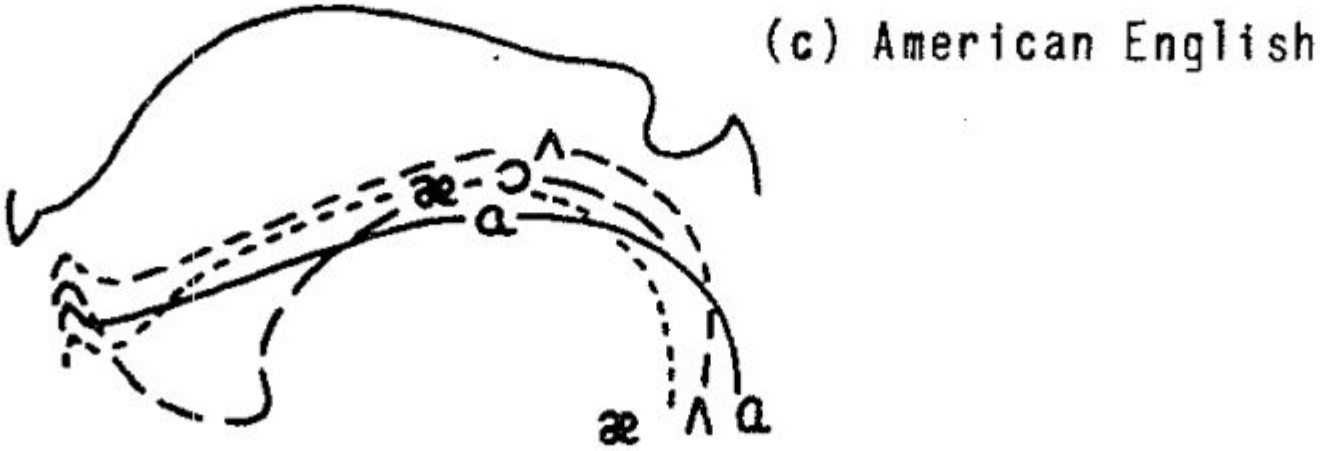
- Similar mechanisms may underlie the production of vowels and consonants.

This means that trace effects in both could be captured by the interaction of two inputs into a planning field.

DNF model of trace effects in vowel errors

- Overlapping inputs into a planning field.
- Articulation-based field.
  - Constriction location (defined as highest point of the tongue) for backness dimension: related to F2.
  - Lower CL: more back (as measured from pharynx).

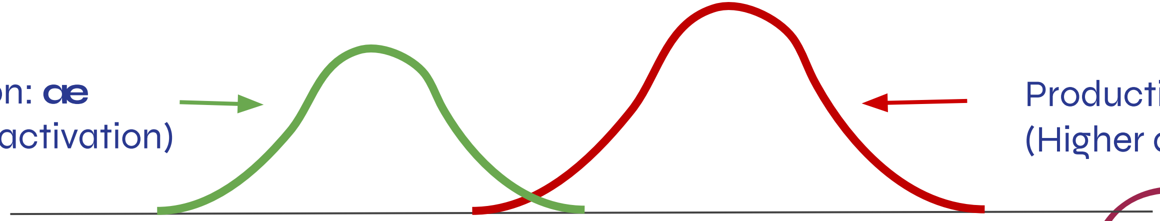




Wood (1975)

Intention: æ
(Lower activation)

Production: ɑ
(Higher activation)



front

High
value

CL field

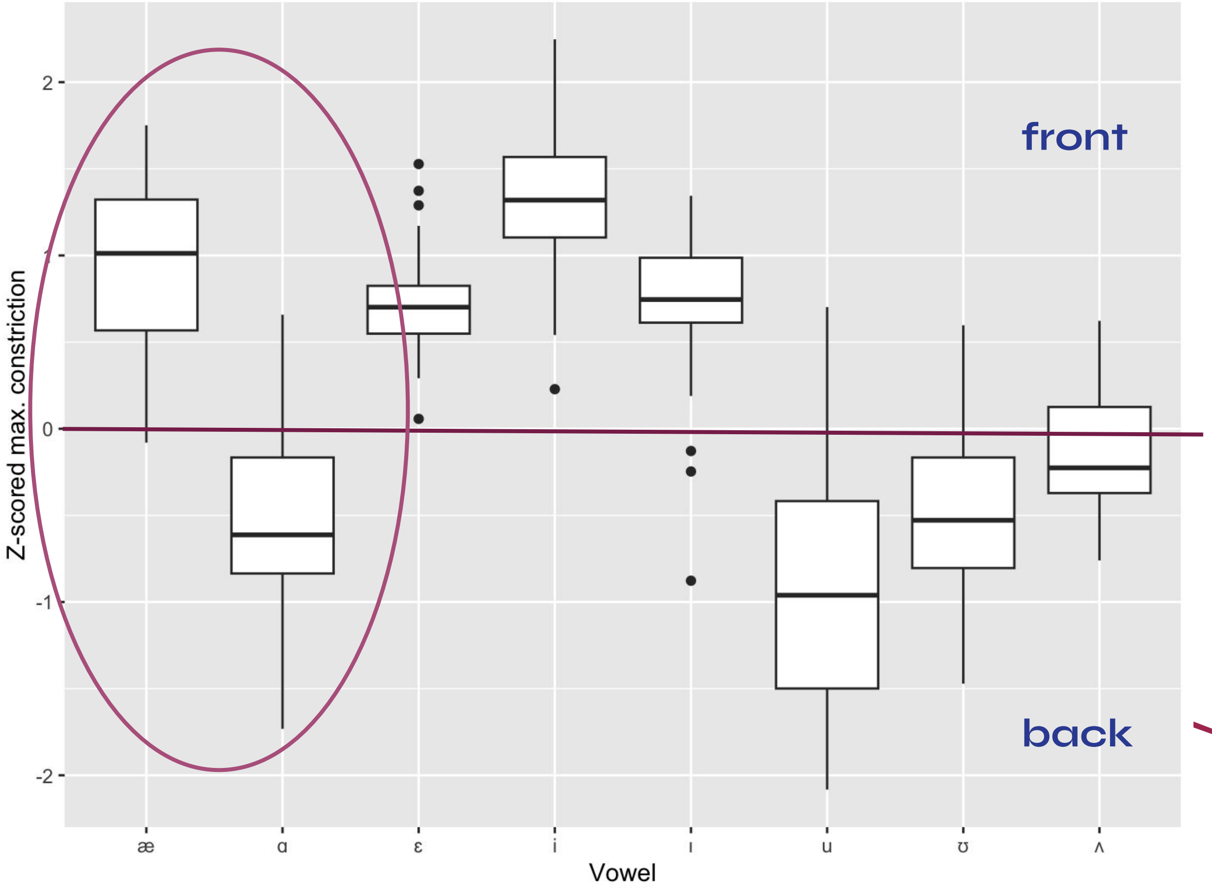
back

Low
value

Choice of parameters

- We can look at articulatory data of American English vowels to get an idea.
  - EMA data

- 2 initial questions:
  - What is the target of the tongue for each vowel (center of input; p)?
  - What is the variability of articulation within a speaker (width of input; w)?

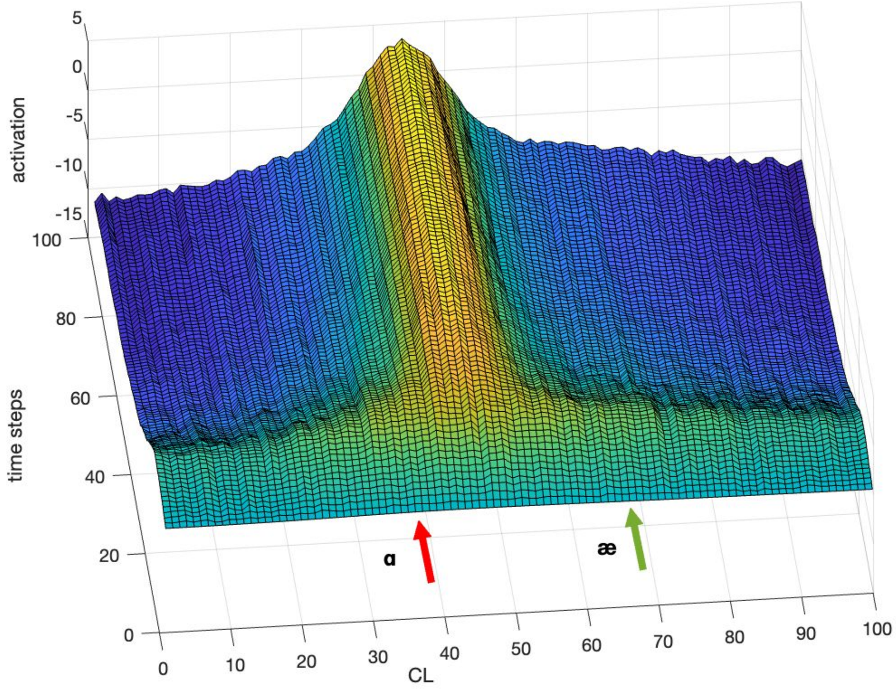


front
back
2
1
0
-1
-2
Z-scored max. constriction
æ
ɑ
ɛ
i
ɪ
u
ʊ
ʌ
Vowel

Model simulations

- p: 68 (æ), 39 (ɑ)
- w: 28 (æ) , 18 (ɑ)

w (æ) > w (ɑ).



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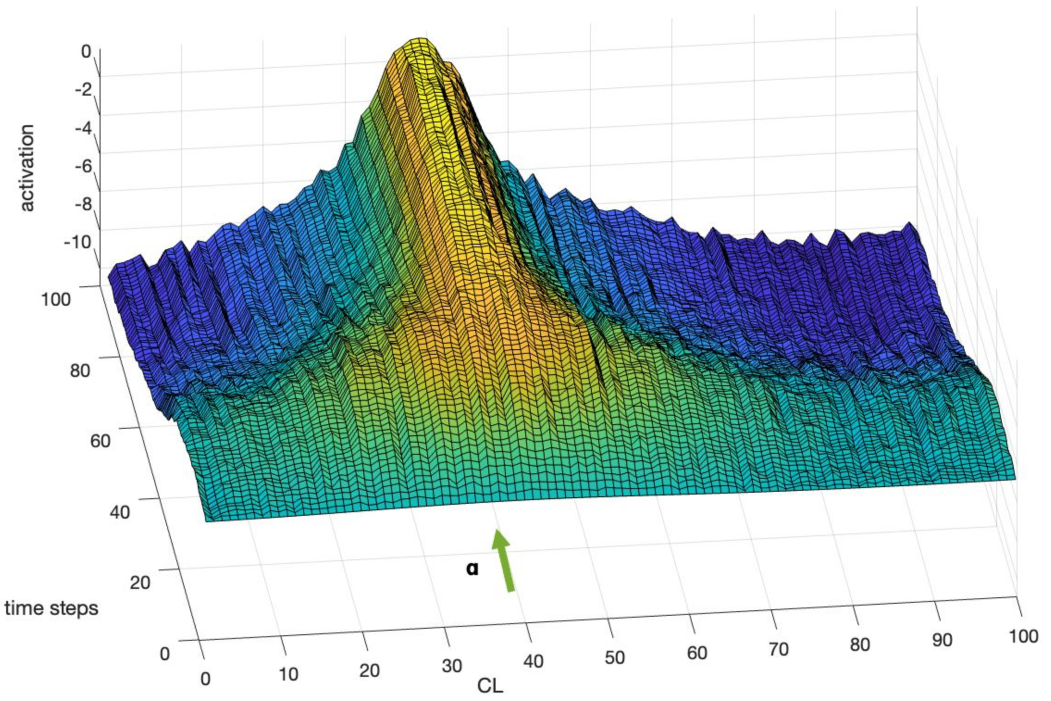
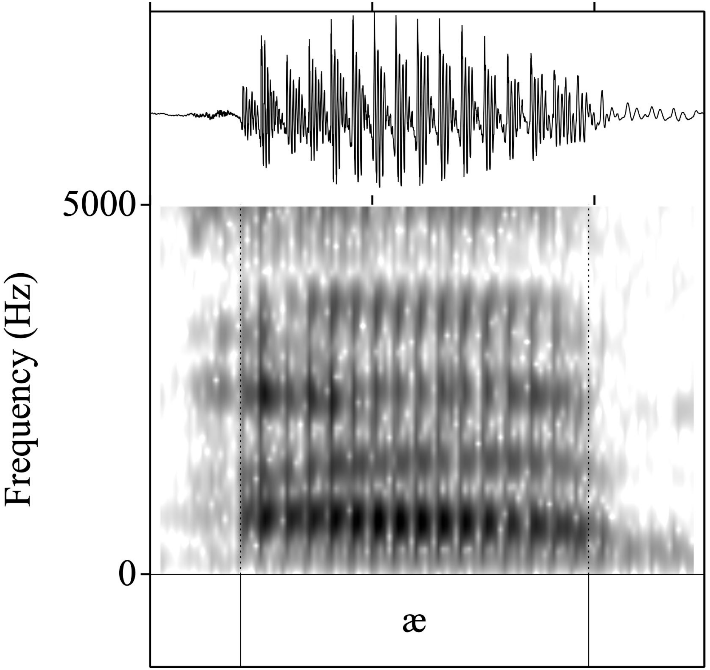


Discussion

- We can derive phonetic effects of intention/error coactivation in the same way for both vowels and consonants.

- Not all vowel pairs showed significant trace effects (/i/ → [u] errors): could be related to the fields related to different articulatory dimensions and how they interact.
Errorful [u]s saved from trace because rounding saves them from the influence of /i/!

- Experiment showed **blends**: increasing influence of intention over time: could be modelled by increasing activation of intention in field.



References

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