LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Compensation for coarticulation in prosodically weak words contexts

Jessica Siddins, Felicitas Kleber, Jonathan Harrington

IPS LMU

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Motivation & Background

Research question

Is the mismatch between perception and production of coarticulation in CVC sequences magnified in prosodically weak positions?

***Harrington, J., Kleber, F., and Reubold, U. (2008)**. Compensation for coarticulation, /u/-fronting, and sound change in Standard Southern British: an acoustic and perceptual study. Journal of the Acoustical Society of America, 123, 2825-2835.*

- /u/-fronting in production and perception in young, but **not** in old speakers, of standard British English
- Differences in the degree of compensation for coarticulation between the age groups

Two main theories of sound change:

Ohala, J. (1993). *The phonetics of sound change. In Charles Jones (Ed.), Historical Linguistics: Problems and Perspectives. London: Longman. pp. 237–278.*

- Listener fails to parse coarticulation as intended by the speaker
- Listener then produces the misperceived coarticulatory patterns

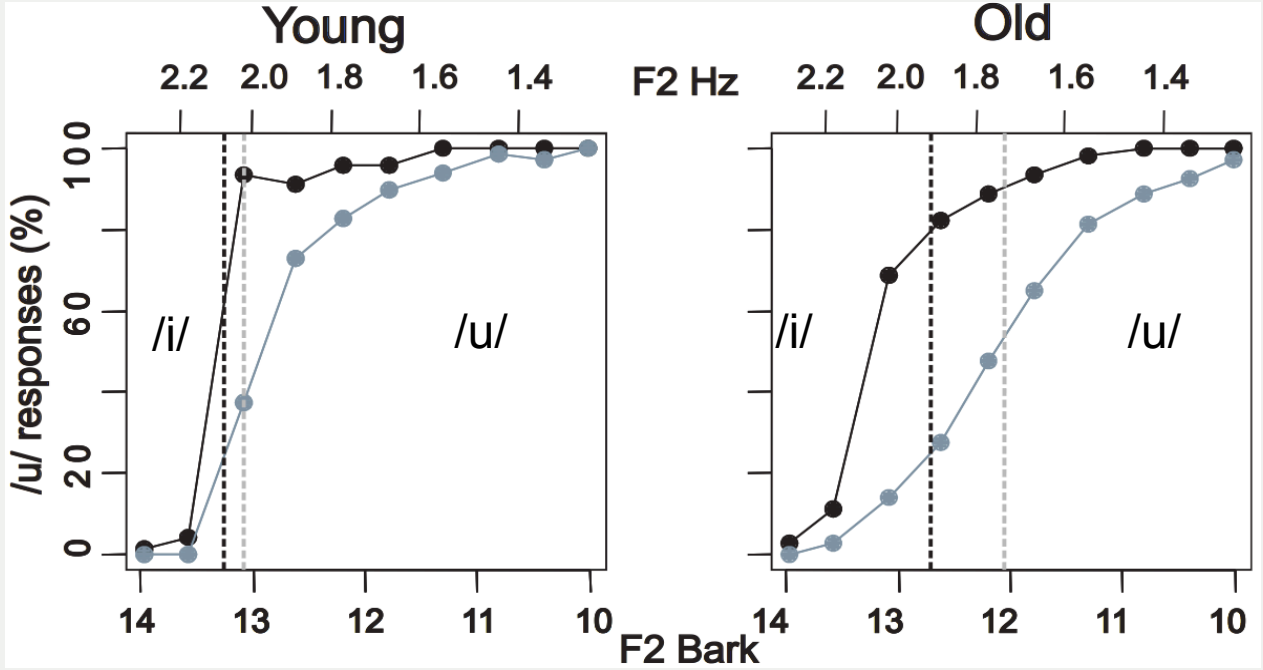
➔ Misperception of coarticulation is a factor in sound change

Two main theories of sound change

Lindblom, B., Guion, S., Hura, S., Moon, S-J., and Willerman, R. (1995). *Is sound change adaptive? Rivista di Linguistica, 7, 5–36.*

- Sound change often occurs in prosodically weak contexts
  - Hypoarticulation in weak contexts causes more coarticulatory overlap
  - Listener overwhelmed by ambiguous information → perceptual undercompensation for coarticulatory effects
  - Lindblom et al. (1995): in prosodically weak contexts the listener concentrates less on “what” is being said and more on “how”, and is therefore more likely to pick up pronunciation variants suggested in these contexts
- Inability to correctly perceive/compensate for coarticulation a precursor to sound change

Compensation for coarticulation



Harrington et al. (2008):

- /u/ fronting in production of younger speakers
- Two continua: **yeast-used** (fronting effect, expected increase in F2) vs. **sweep-swoop** (backing effect).
- More /u/ responses by both listener groups in yeast-used because a higher F2 is attributed to the consonantal context.
- Younger speakers fail to attribute higher F2 in palatal context to the consonant (i.e. compensate far less for these coarticulatory effects than older speakers) and instead interpret it as phonologically intended.

Current study

Relationship between production and perception of coarticulation in prosodically weak words contexts and the role it plays in sound change

- Exact same /U/ - /Y/ continuum embedded in CVC sequences (pVp, tVt)
- Normally, these contexts would have opposing effects on F2:
  - Labial context: coarticulatory effect of lowering F2
  - Alveolar context: coarticulatory effect of raising F2
- However, because the vowel continuum was created independent of context, it was not influenced by these coarticulatory effects

Expectations

Therefore, if listeners are sensitive to coarticulatory effects of the labial and alveolar contexts, we would expect the following patterns in compensation for coarticulation:

- **/U/ bias in alveolar context** (overcompensation: listener would accept a higher F2 and attribute it to the context rather than /Y/)
- **/Y/ bias in labial context** (overcompensation: listener would accept a lower F2 and attribute it to context rather than /U/)

Objectives

Hypothesis 1: Listeners compensate perceptually for coarticulation

Hypothesis 2: Listeners compensate **less** for the coarticulatory effects of context in unaccented words

That is, in our CVC sequence we expect to see **less** of a /U/ bias toward alveolar contexts or a /Y/ bias toward labial contexts in prosodically weak words

Hypothesis 3: There is more coarticulation (hypoarticulation) in prosodically weak words

The combination of hypotheses 2 and 3 enables us to answer our research question:

Is the mismatch between perception and production of coarticulation in CVC sequences magnified in prosodically weak positions?

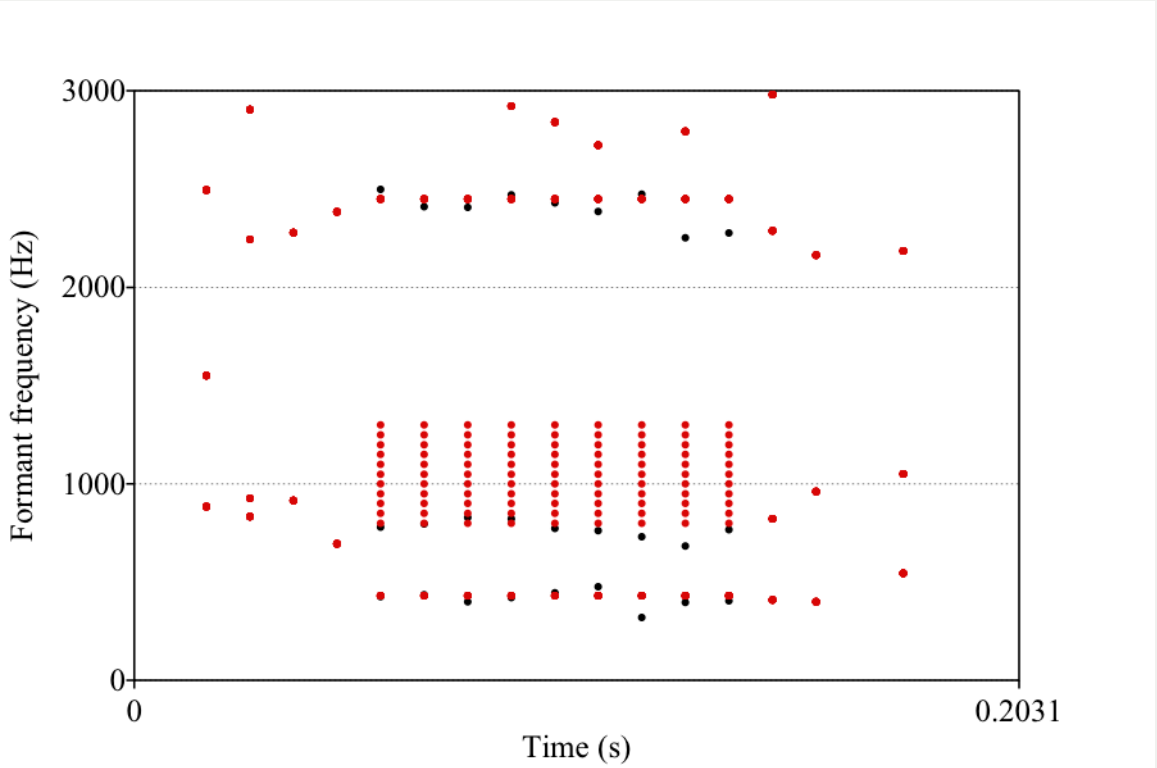
Method - Perception

Carrier sentence and stimuli (Maria hat CVC gesagt) recorded by a phonetically trained male speaker with stress on the target word

a) Preparation of target words:

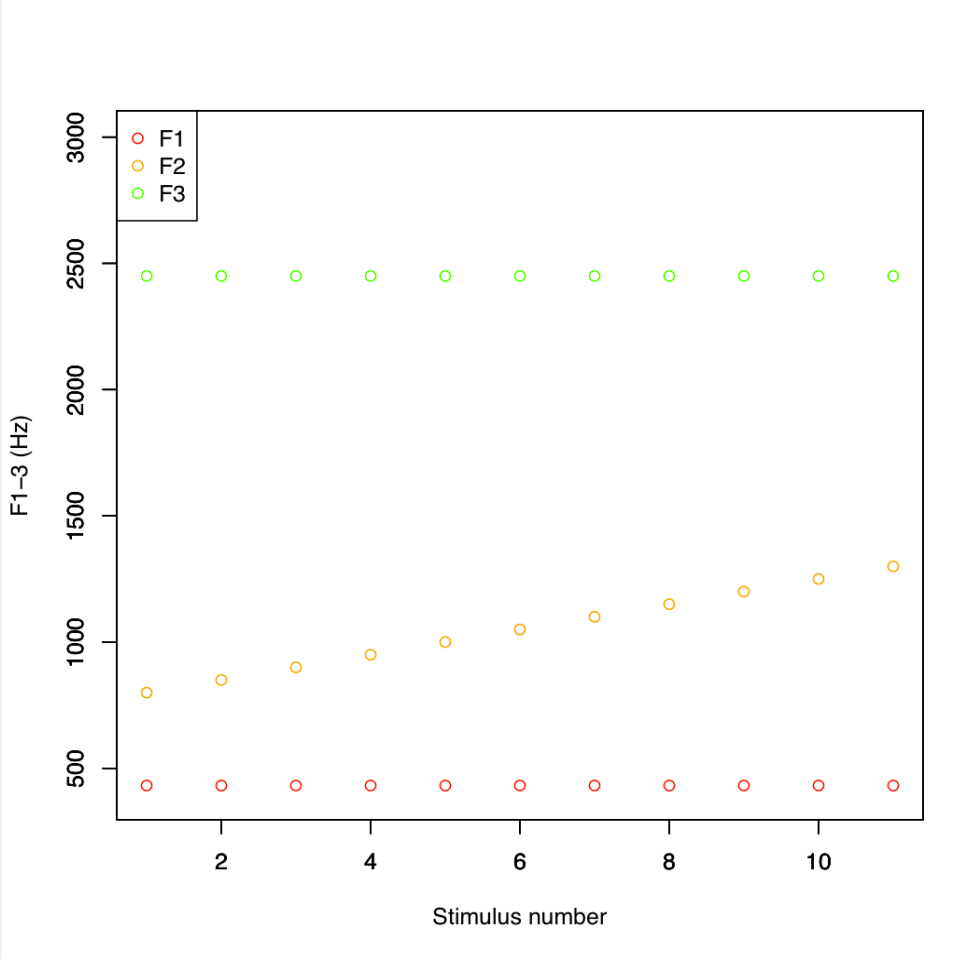
- 11-step continuum morphed (statically) in Praat/Akustyk
- Vowel context: a /pUp/ (most backed /U/)→ /tYt/ (most fronted /Y/) continuum was morphed and the consonantal context removed
- Consonantal context: /p/ from /pUp/ (most backed /p/) and /t/ from /tYt/ (most fronted /t/)
  - Natural vowels deleted and synthetic continuum inserted in these two contexts in order to strengthen the effects of coarticulation and keep them constant throughout the continuum

Method - Perception



The synthesised vowel continuum, each of the 11 red dots in F2 (y-axis) representing the 11 different steps in the continuum.

Method - Perception



Each of the synthesised steps on the vowel continuum (/pUp/ → /tYt/). F1 and F3 remained unaltered throughout the 11 steps of the continuum.

Method - Perception

b) Insertion of target words into carrier sentence:

- Synthesised stimuli inserted into carrier sentence at 1.007354s
- /t/ aspiration in <hat> deleted, closure phase of /g/ in <gesagt> lengthened
- Prosody manipulated for unaccented contexts
  - f0: peak on Maria
  - Duration: /a/s in <Maria> lengthened
  - Intensity: <Maria> raised by 5dB, target word lowered by 5dB

/pUp/ - /pYp/ (acc)
/pUp/ (Stim 1, unacc.)
/tUt/ - /tYt/ (acc)

Method - Perception

c) The perception experiment:

- 2 alternative forced-choice labelling experiment created in Praat (each stimulus played once only, i.e. no opportunity to hear stimulus again)
- “Please click on the word you heard:”

- Each stimulus repeated 10 times over the course of the experiment
- Button order randomised (pupp|püpp and püpp|pupp)
- Reaction times recorded
- Opportunity for a break every 44 stimuli to avoid fatigue

Results - Perception

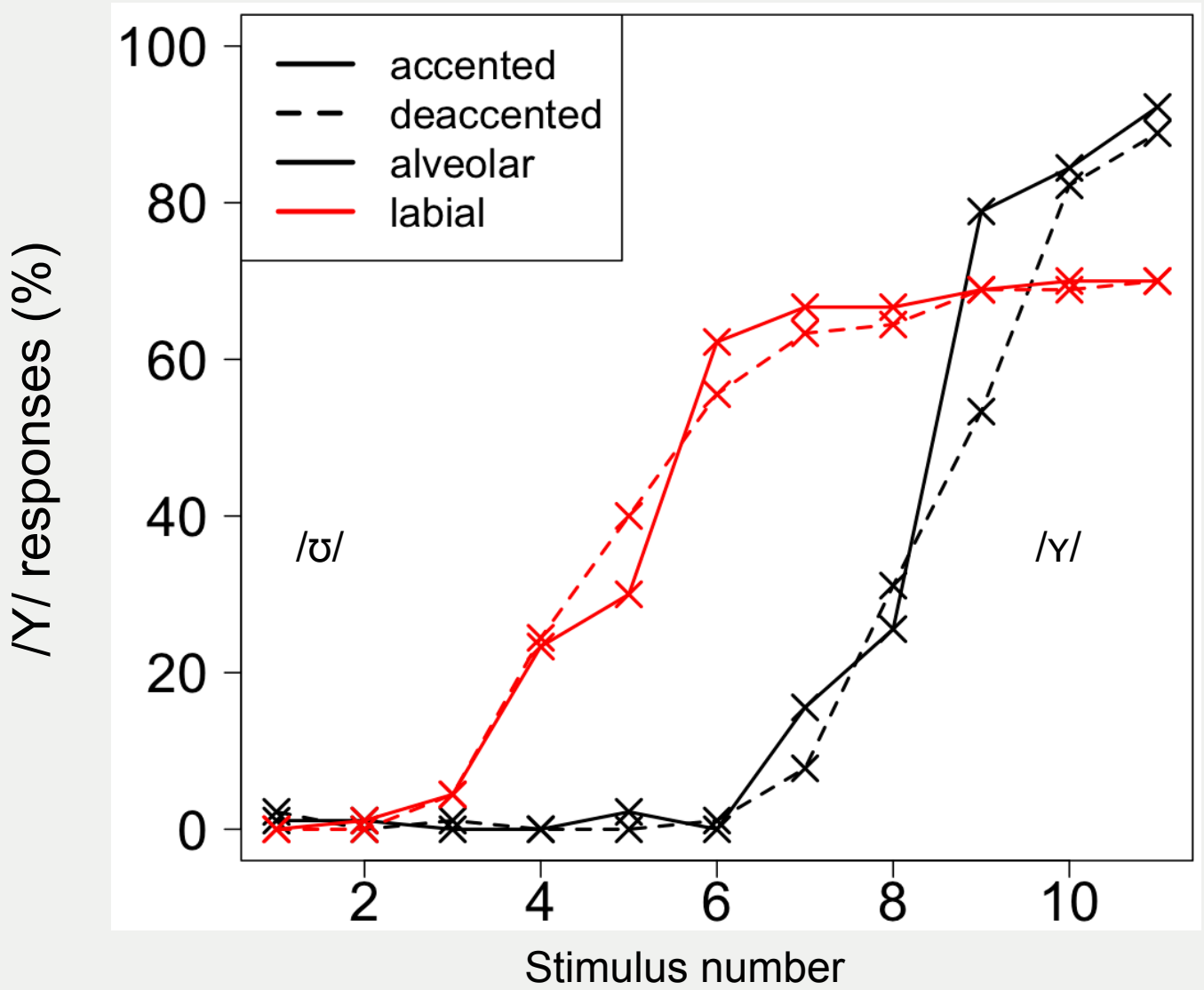
H1: Is there perceptual compensation for coarticulation?

- Yes - /U/ bias in favour of the alveolar context

H2: Is there less perceptual compensation for coarticulation in prosodically weak words?

- No – virtually the amount of compensation as in accented words

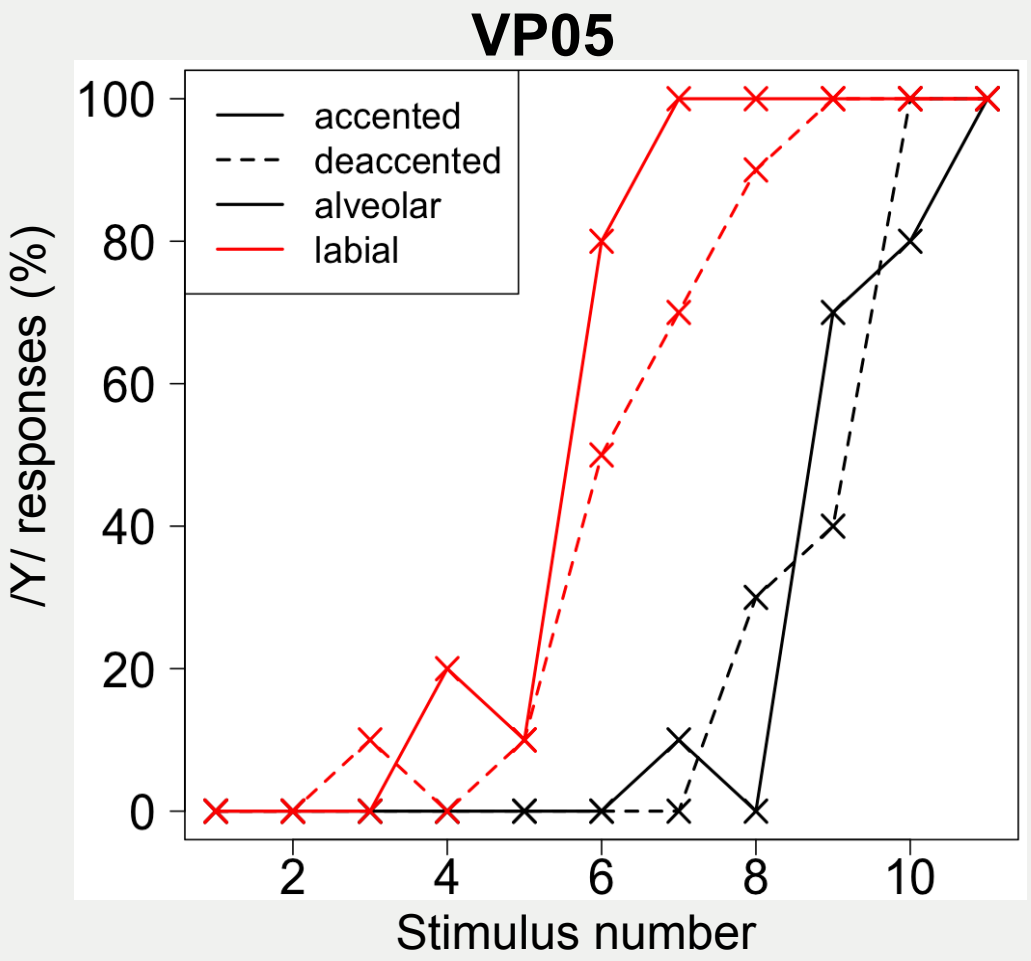
Results - Perception

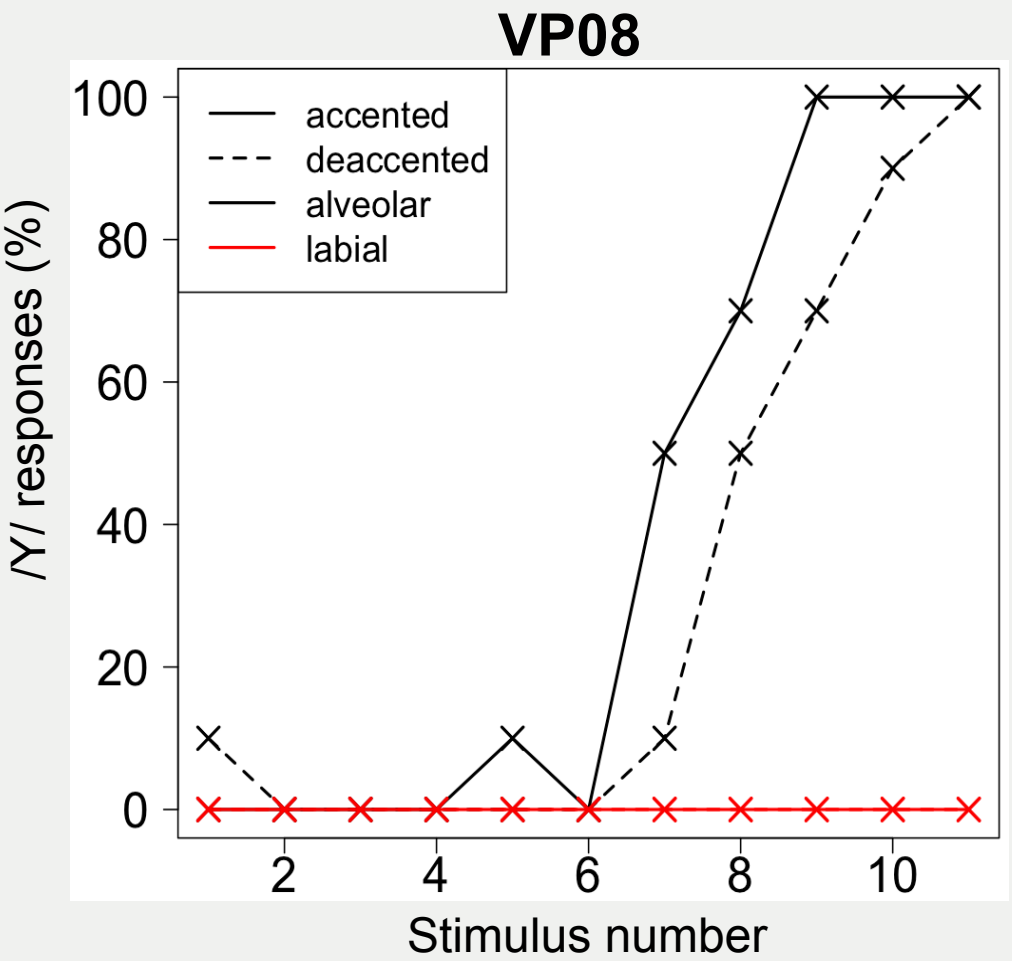


Clear /U/ bias in the alveolar context

- At best, only c. 70% of labial stimuli were recognised as /Y/ when a clear /Y/ was presented
- Might be attributed to consonantal context in /pVp/ (i.e. transitions & loci for most backed /U/, which participants VP07, VP08 and VP09 might have relied on for vowel perception and therefore could not perceive /pYp/)

Results - Perception





Summary - Perception

- **H1**: There is perceptual compensation for coarticulation (/U/ bias in favour of the alveolar context)
- **H2**: Listeners do **not** compensate less for coarticulation (perceptually) in prosodically weak words
  - But this is not necessarily a bad result!
  - If our production data shows evidence of more coarticulation in unaccented words, then we can still answer our research question*

* namely, whether the mismatch between perception and production of coarticulation in CVC sequences is magnified in prosodically weak positions

Method - Production

- 10 test subjects (German native speakers)
- Recorded in the sound studio at IPS Munich using SpeechRecorder software
- **Unaccented target word:**
  Q: Wer hat CVC gesagt? (Who said CVC?)
  A: *Maria* hat CVC gesagt. (*Maria* said CVC).
  /tUt/ (unacc.)
- **Accented target word:**
  Q: Was hat Maria gesagt? (What did Maria say?)
  A: Maria hat *CVC* gesagt. (Maria said *CVC*).
  /tUt/ (acc.)
- One speaker excluded from further analysis as she was unable to produce the lax /U/ and /Y/ vowels, instead pronouncing the tense versions (and therefore also excluded from the perception results)

More coarticulation in prosodically weak words?

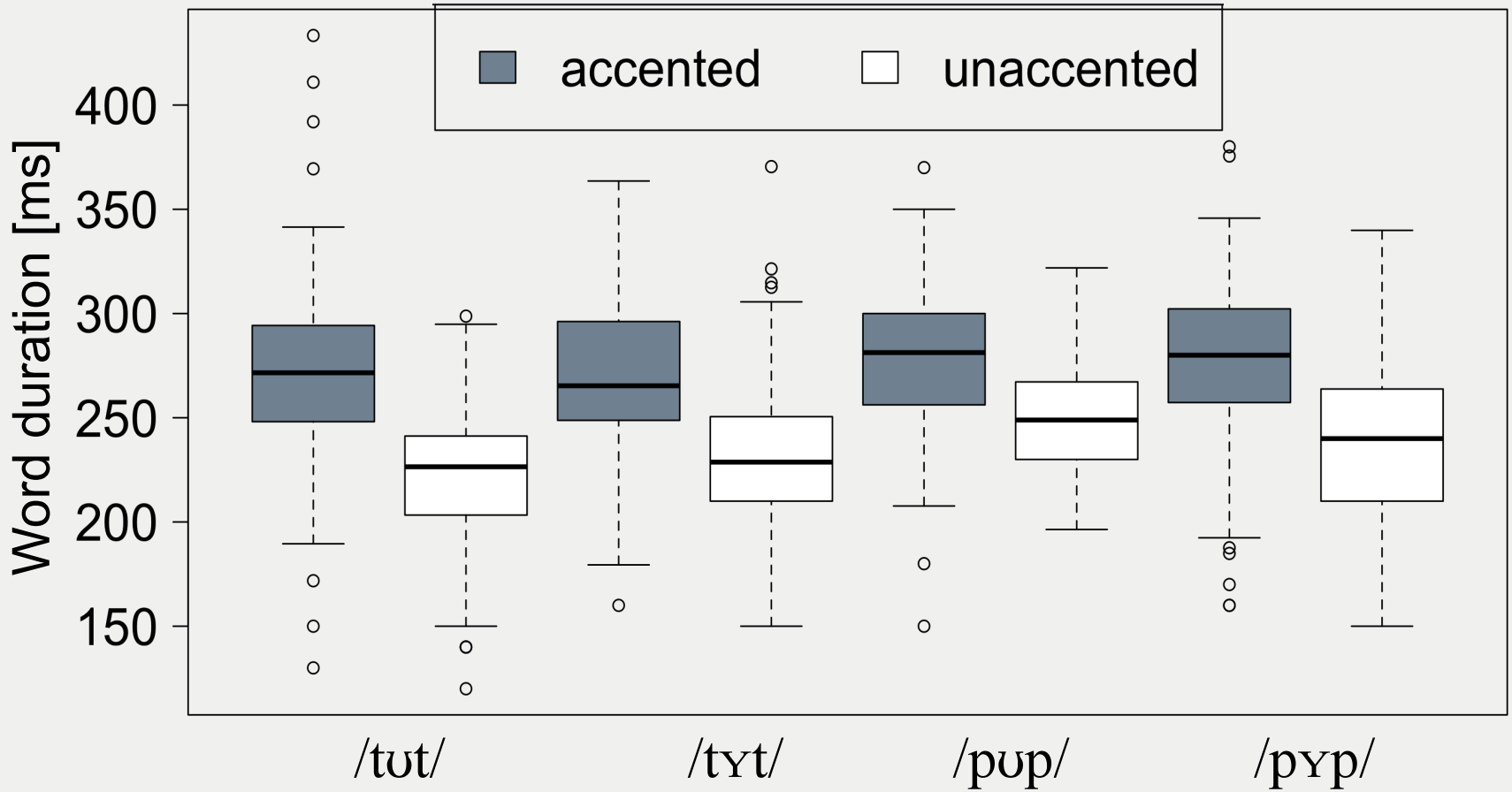
Expectations for accented vs. unaccented words

- shorter durations (vowels, words, stops) in unaccented words than in accented words
- more centralized vowel quality in unaccented words
- target undershoot in unaccented words

Expectations for consonant-on-vowel coarticulation

- **Are the coarticulatory effects that the consonants exert on the vowel (backing/fronting) greater in unaccented than in accented words?**

Results - Production

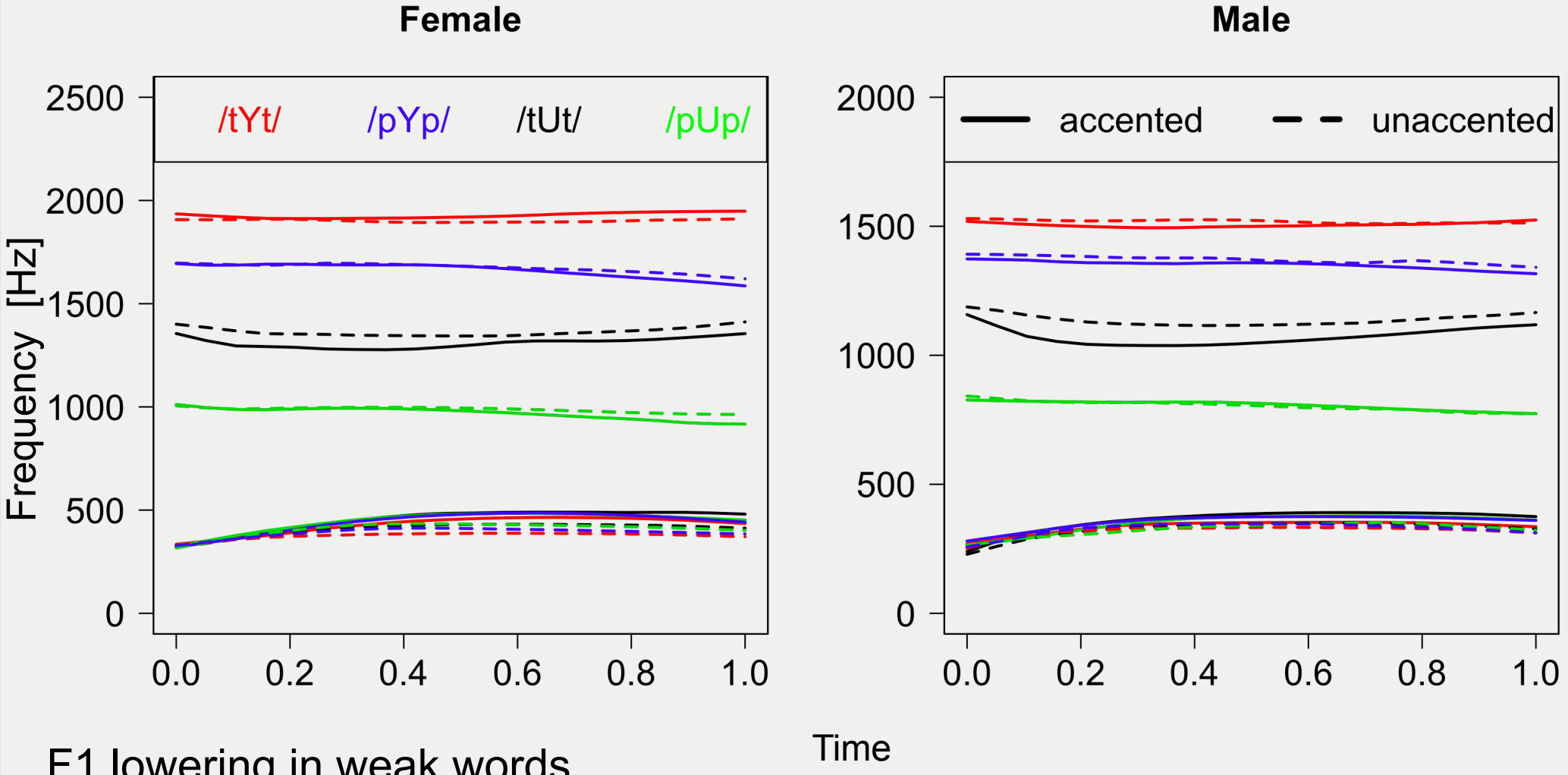


Mixed Model with **word duration** as the dependent variable (n=720)

Vowel: F[1,60] = 0.3, n.s.; **Stress**: F[1,60]=184.1 ***; **POA**: F[1,60] = 25.1 ***

no significant interaction effects

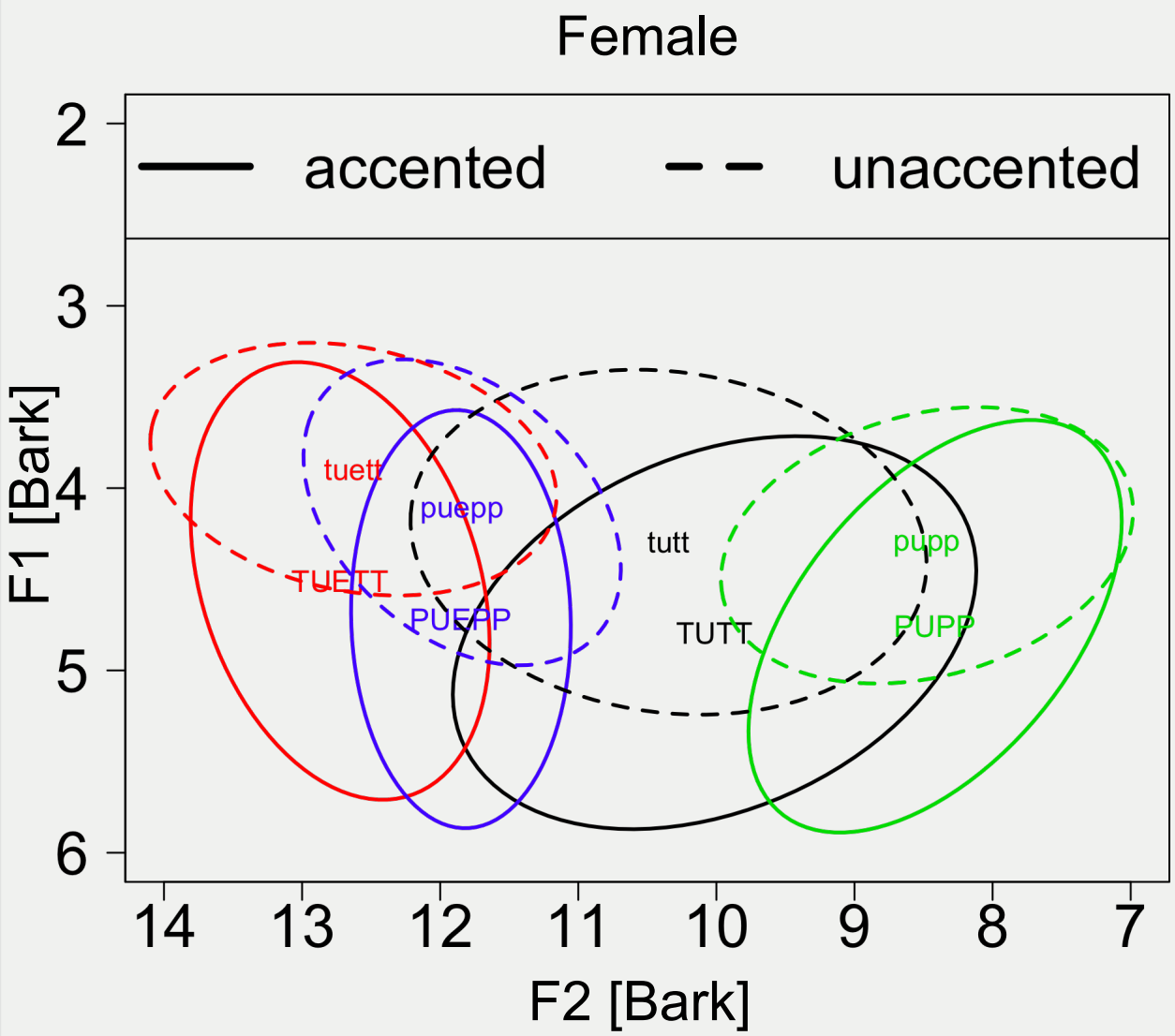
Results - Production



F1 lowering in weak words

not much target undershoot in unaccented words, except for /tʊt/

Results - Production



/tYt/
/pYp/
/tUt/
/pUp/

Mixed Model with **F1** as the dependent variable (random factors: Subject, Gender)

Vowel F[1,60] = 35.5 ***

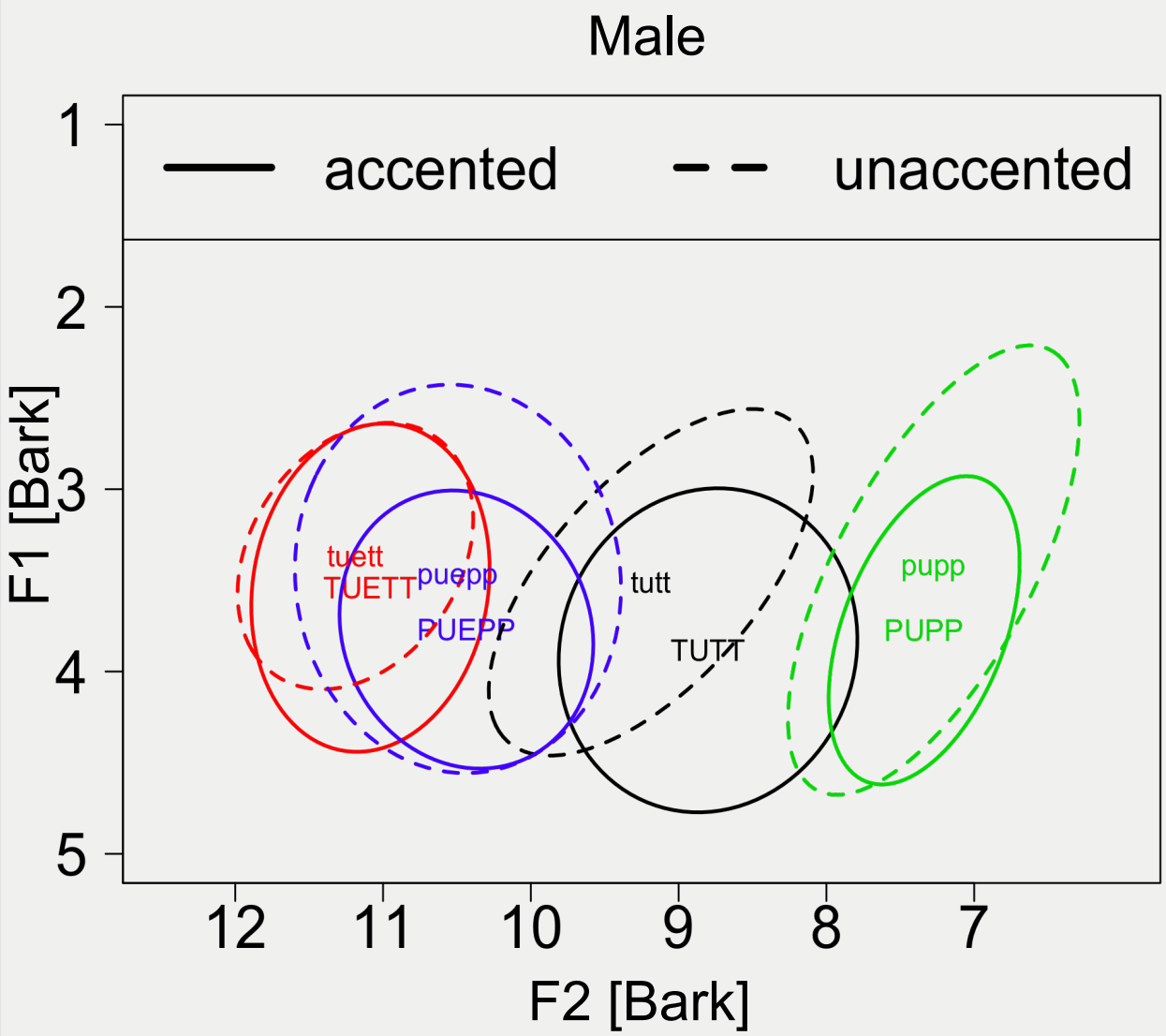
Stress F[1,60] = 213.7 ***

POA F[1,60] = 7.1 **

Vowel*POA F[1,60] = 21.2 ***

no other significant interactions

Results - Production



/tYt/
/pYp/
/tUt/
/pUp/

Mixed Model with **F2** as the dependent variable (random factors: Subject, Gender)

Vowel F[1,60] = 9139.6 ***

Stress F[1,60] = 11.5 **

POA F[1,60] = 1773 **

and each interaction was significant, including

Stress*POA F[1,60] = 9.5 **

Summary - Production

Differences between accented and unaccented words

- significant longer word duration (probably due to longer stop duration)
- F1 lowering in weak words

Consonant-on-vowel coarticulation

Are the coarticulatory effects that the consonants exert on the vowel (backing/fronting) greater in unaccented than in accented words?

- Yes, in particular with respect to the fronting effect on /ʊ/

Production – Perception relationship

Is the mismatch between perception and production of coarticulation in CVC sequences magnified in prosodically weak positions?

H2: Is there less perceptual compensation for coarticulation in prosodically weak words?

→ **No**

H3: Is there more coarticulation in prosodically weak words?

→ **Yes**, in particular with respect to the fronting effect on /ʊ/

Conclusion

Production – Perception relationship

Is the mismatch between perception and production of coarticulation in CVC sequences magnified in prosodically weak positions?

Yes, although there is more coarticulation in prosodically weak words, listeners do not compensate more for (this additional amount of) coarticulation in unaccented words

therefore prosodically weak words are not only a very likely environment for sound changes to occur / spread, but also for an increased perception/production mismatch of coarticulation which may be the source of sound change

Outlook

To do

Experiment (production and perception) with **word stress** in VCV stimuli

/ˈpʏpeːl/, /ˈpʊpeːl/, /ˈpʏpoːl/, /ˈpʊpoːl/ vs. /pʏˈpeːl/, /pʊˈpeːl/, /pʏˈpoːl/, /pʊˈpoːl/

1. more /ʊ/-responses to stimuli from the /ˈpʏpeːl - ˈpʊpeːl/ continuum than to stimuli from the /ˈpʏpoːl - ˈpʊpoːl/ continuum, because listeners should expect V_2 to exert a coarticulatory fronting effect on V_1
2. The extent of perceptual compensation for coarticulatory influences of V_2 on V_1 is less when the initial syllable has secondary stress

➔ Is the mismatch between perception and production of coarticulation in CVC sequences magnified in prosodically weak positions?

Thank you!