Predictability and phonological context interact in conditioning the acoustic reduction of Seoul Korean lenis obstruents

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CorpusPhon

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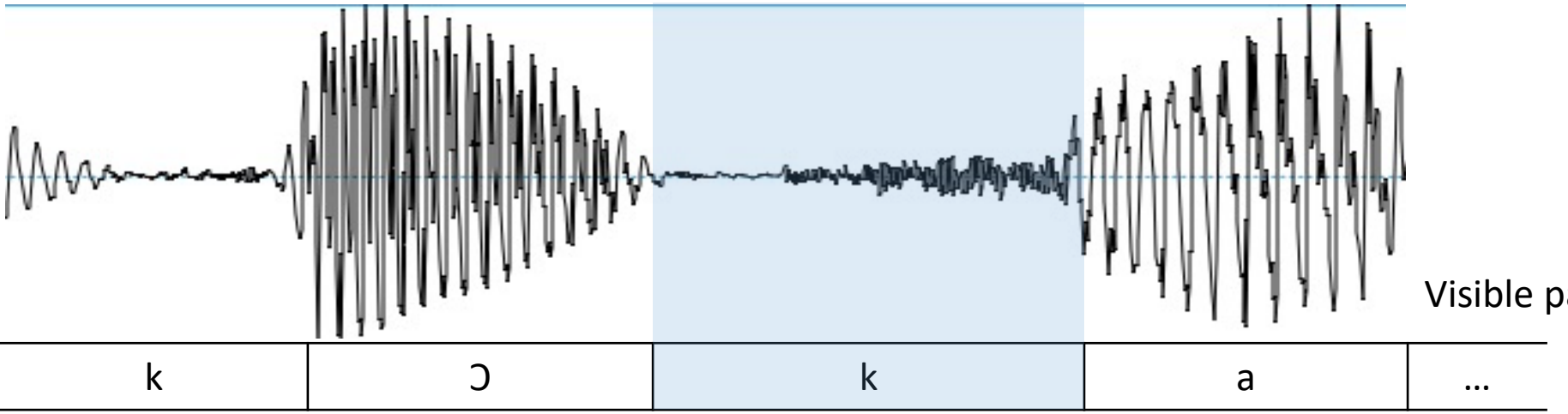
UMassAmherst

/i.kɔ/ /ka.ri.kʰjɔ.tʃwɔ/

this teach-IMP ‘Teach (me) this’

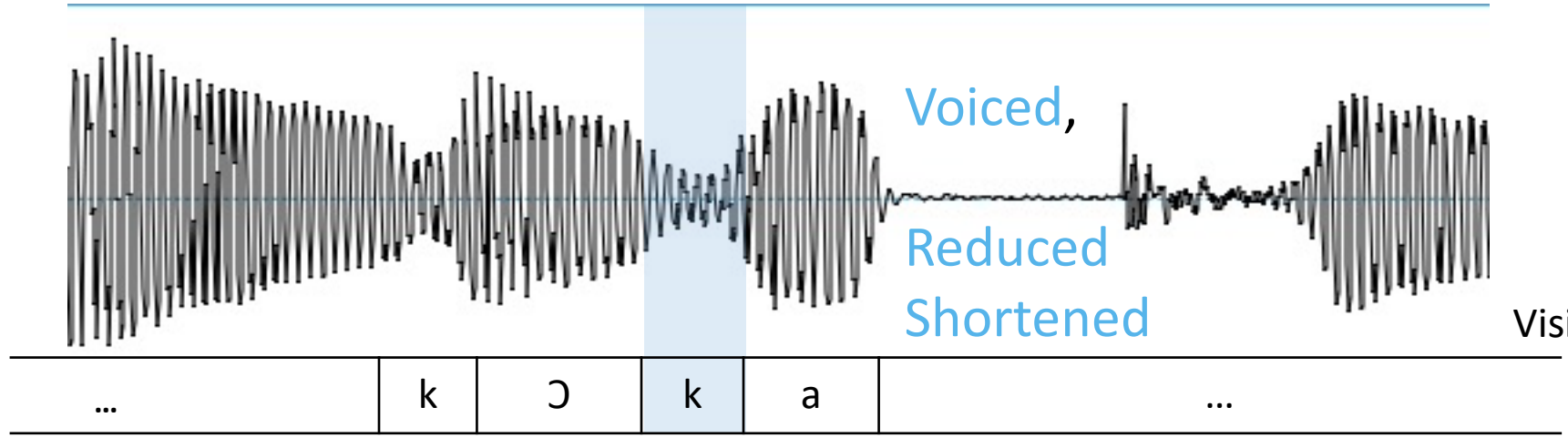


Visible part: ~586 ms

/k/
in prosodic word-initial
phrase-initial position

/ma.mu.ri.han / /kɔ/ /ka.tʰe.jɔ/

finialize-PERF COMP be.like (it seems…) ‘It seems that (I) finalized (it)’



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/k/
in prosodic word-initial
phrase-medial position

Prosodic constituents in Seoul Korean

- K-ToBI model of Seoul Korean intonational phonology
  - (Utterance, pause delimited speech interval)
  - Intonational Phrase (IP)
  - (intermediate phrase (ip))
  - Accentual Phrase (AP)
  - PWd
  - Syllable

Require prosodic transcription!

a.o., Jun 1998, Jun 2000

Previous work on the phonetic realization of Seoul Korean lenis obstruents

- Lenis obstruents are voiced in the AP medial position
- They are voiceless in the AP initial position
- Optional and gradient
- Speech rate
  - Faster speech → more likely to be fully voiced

Jun 1994, Jun 1998, Han 2000

Related poster on Day 2
D2:37(R2)

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Lenis obstruent realization other than voicing

- Lenis obstruents are not just voiced but they are shortened and reduced in intensity (Silva 1992, Cho and Keating 2001, SH Lee 1995, Yoo 2020)
- Few studies on the reduction of lenis obstruents (c.f. SH Lee 1995, Yoo 2020)
- No studies looked at the reduction of lenis obstruents in a spontaneous speech corpus
- Methodological challenges:
  - Most spontaneous speech corpora are not prosodically transcribed
  - Hard to quantify the degree of reduction

Related poster on Day 2
D2:37(R2)

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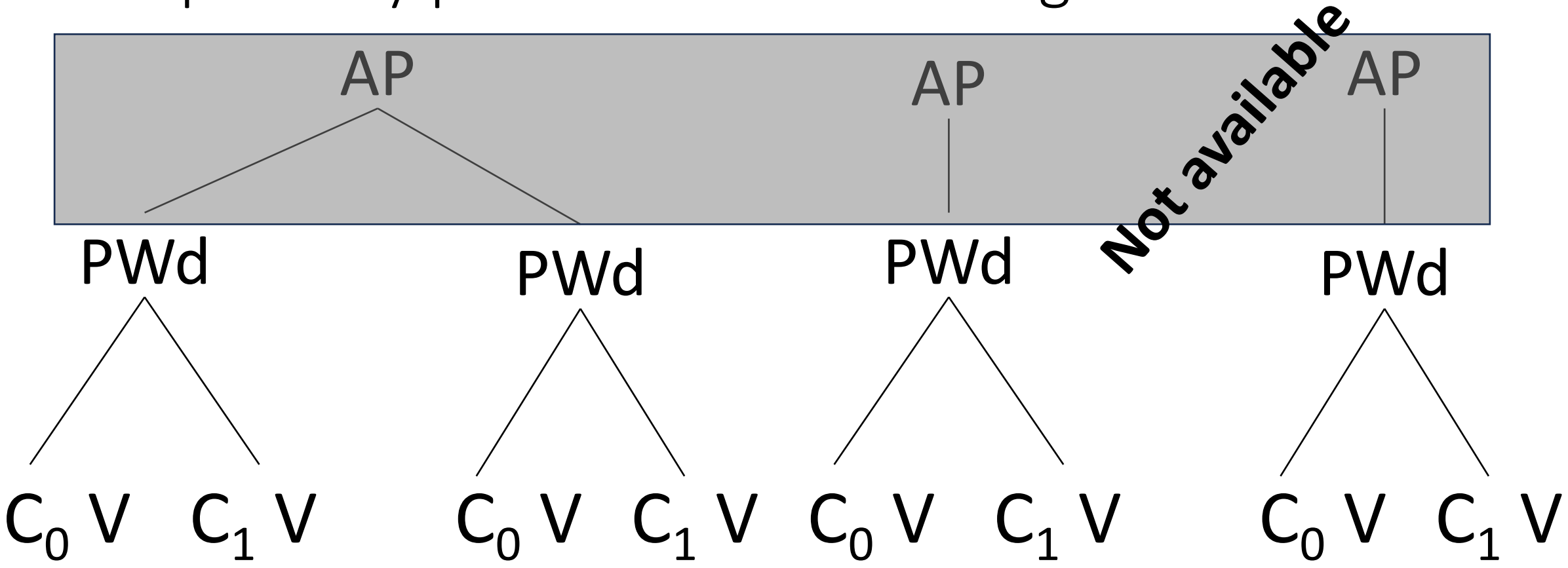
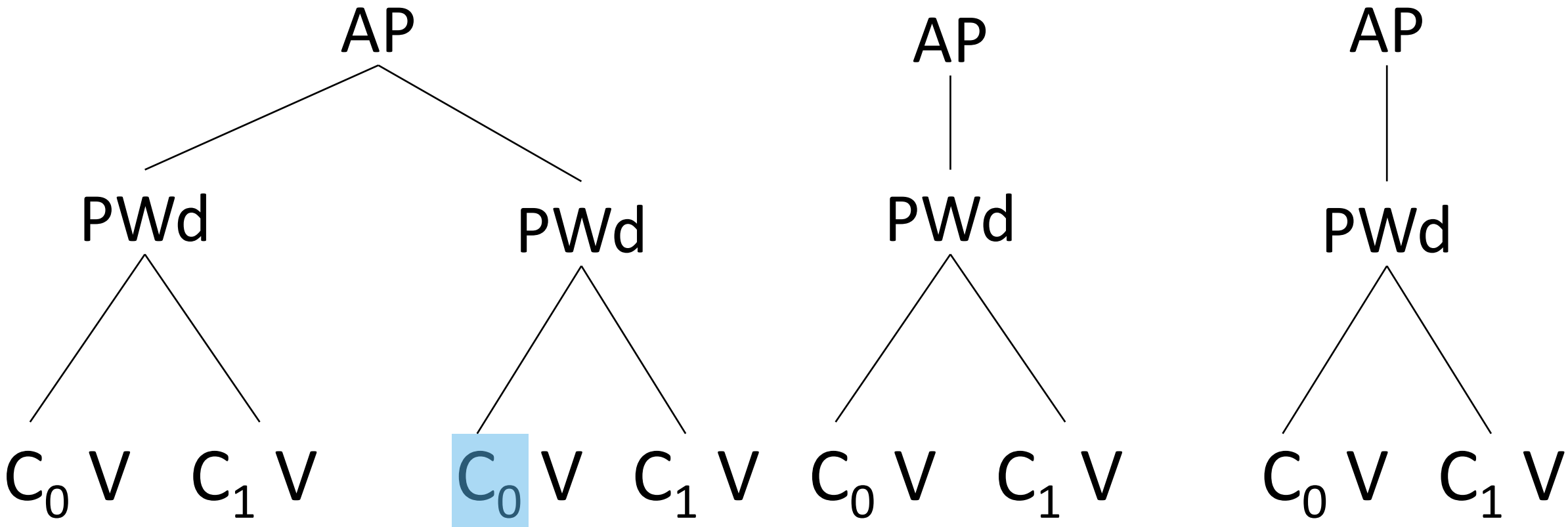
Corpus only provides PWd level segmentation…



Spontaneous speech corpus only provides word-level segmentation

PWd-initial C_0 can either be AP-initial or AP-medial



Reduced realization

How do we predict which lenis obstruent is reduced, without the prosodic transcription?

Prosodic transcription is Expensive

- Prosodic transcription training (e.g., ToBI)
- Multiple transcribers required (inter-labeler agreement)
- Spontaneous speech corpus not controlled for the syntactic structures
- Prosodically transcribed spontaneous speech corpus is very rare

Other factors that condition obstruent reduction

- Transitional probability (a.o. Jurafsky et al. 2001, Kilbourn-Ceron et al. 2018)
- Neighboring vowel height (Kirchner 1998, SH Lee 1995, Kim et al. 2016)

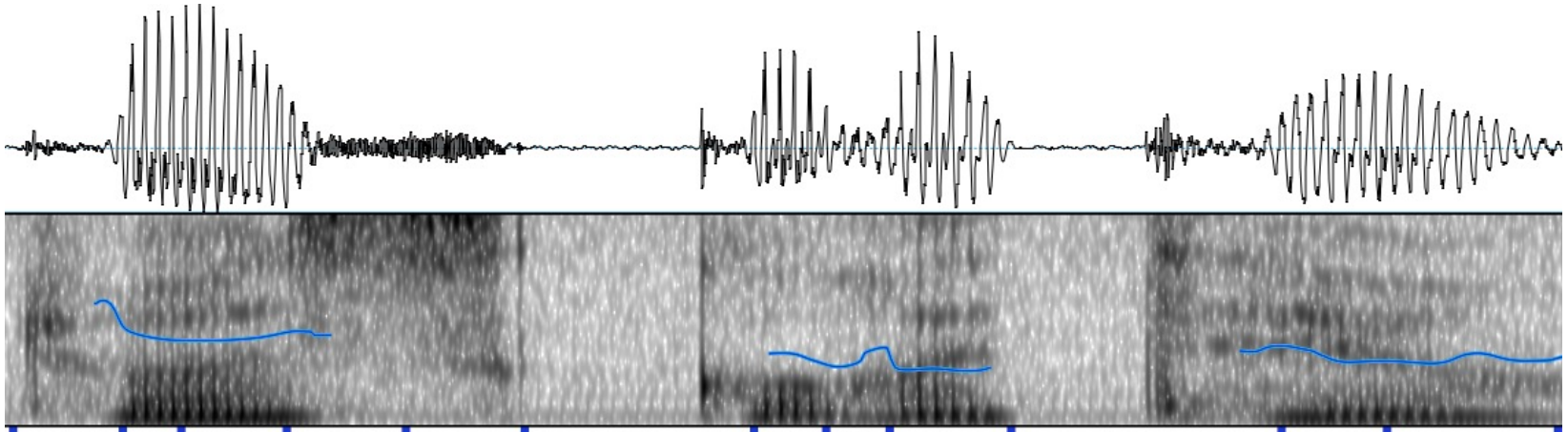
Research questions

- How do we study a prosodically conditioned segmental process, lenis obstruent reduction, in a corpus without the prosodic transcription?
  - Can we use ‘transitional probability’ to predict the degree of reduction?
  - How might transitional probability be related to the prosodic structure?
- Does preceding/following vowel height condition lenis obstruent reduction in Seoul Korean?
  - How does the transitional probability interact with the vowel height?

Present study: the Seoul Corpus (Yun et al 2015)

- 40 speakers: 2 gender X 4 age groups
- 42.8 hrs of interview (1 hr per speaker, both speakers & the interviewer)
- 24.2 hrs of speech from speakers, excluding nonspeech like laughter
- 91,112 intervocalic (PWd-initial and medial) lenis obstruent tokens
- **Current presentation: 36,795 PWd-initial tokens**

Corpus segmentations



c0	oo	aa	ss	xx	kk	vv	k0	aa	th		ee	yv
조아쓰					꺼		가태여					
c0oo-aa-ssxx					kkvv		k0aa-thEE-yv					
조아쓰 꺼 가태여												
좋았을					거		같아요					
c0oohh-aass-xxll					k0vv		k0aath-aa-yo					
좋았을 거 같아요												

Phone tier – Pronunciation (SR)

PWd tier – Pronunciation (SR)

Utterance tier – Pronunciation (SR)

PWd tier – Orthography (UR)

Utterance tier – Orthography (UR)

No AP or IP level segmentation

Transitional probability

- Obstruents tend to be lenited in a frequent word or in a predictable context (high transitional probability)
- Claim: Speakers lenite obstruents when they are predictable given the preceding word (‘transitional probability’)
- e.g., Transitional probability predicts the likelihood of English Flapping in the word final position
  - /d/ in ‘instead of’ is very likely to be flapped due to a high probability of ‘of’ being after ‘instead’ (Kilbourn-Ceron et al. 2020)

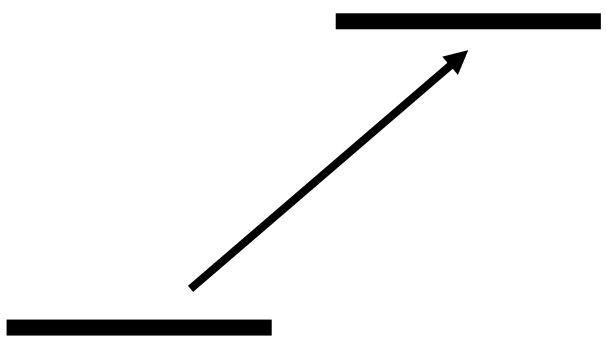
Phonological context (vowel height) effect

- Kirchner (1998) conducted a cross-linguistic survey of lenition patterns and claimed that obstruent lenition is affected by the openness of the neighboring vowel
- Claim: Speakers lenite obstruents to minimize the articulatory effort.

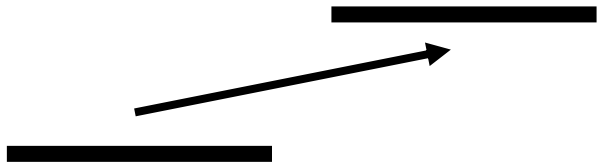
Articulatory effort perspective: Vowel height

- Articulatory effort is assumed to be greater for /ab/ than /ib/
  - e.g., Lower vowel → more open jaw → more effort to fully close the lips

(Kirchner 1998)



a b



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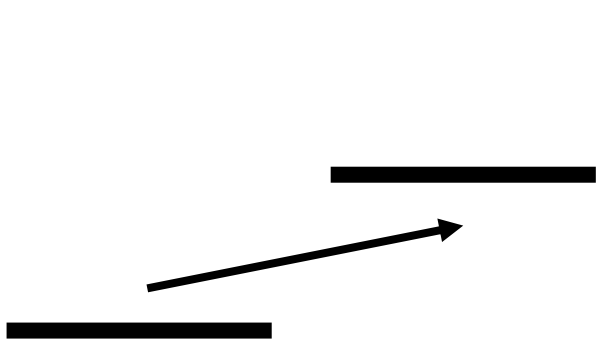
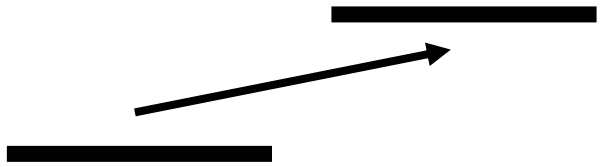
Articulatory effort perspective: Vowel height

- To reduce the effort, speakers might not achieve a full closure to produce the stop ***after*** or before a low vowel



a β



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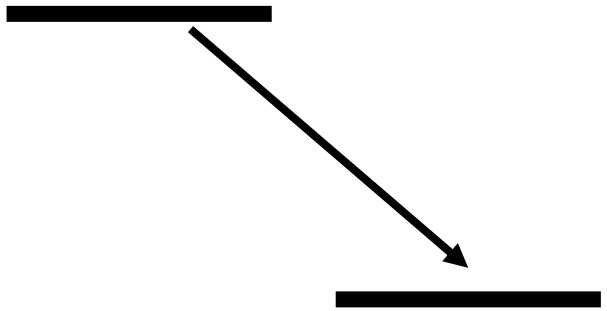
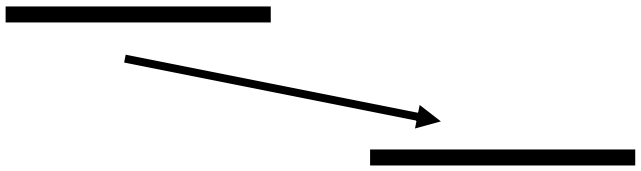
Articulatory effort perspective: Vowel height

- To reduce the effort, speakers might not achieve a full closure to produce the stop after or ***before*** a low vowel



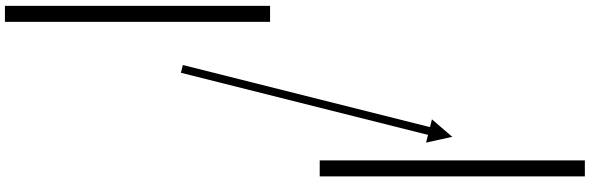
b a



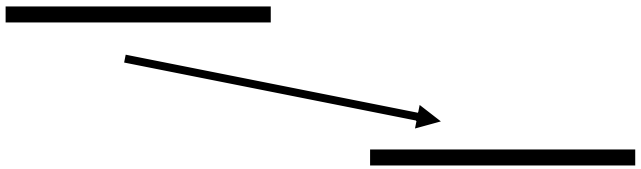
b i

Articulatory effort perspective: Vowel height

- To reduce the effort, speakers might not achieve a full closure to produce the stop after or ***before*** a low vowel
- Preceding/Following Lower vowel leads to more reduction



β a



b i

Previous work: vowel height / predictability and Seoul Korean lenis obstruent

- Low vowel effects lead to more deletion (Kim et al 2016)
- No lexical frequency effect on voicing (Choi et al 2006)
- However, these studies have not controlled for other factors affecting the realization of lenis obstruent, e.g., speech rate
- And they did not investigate the vowel height factor and the usage-based factor together in one data set

Methods

- Morphological analysis of the corpus using a Morpheme analyzer and compute transitional probabilities between morphemes

  (‘Khaiii’, Kakao Corp 2018 https://github.com/kakao/khaiii)

- Automatic acoustic quantification of the degree of lenition

  (Kingston 2008, Ennever et al 2017, Katz and Pitzanti 2019)

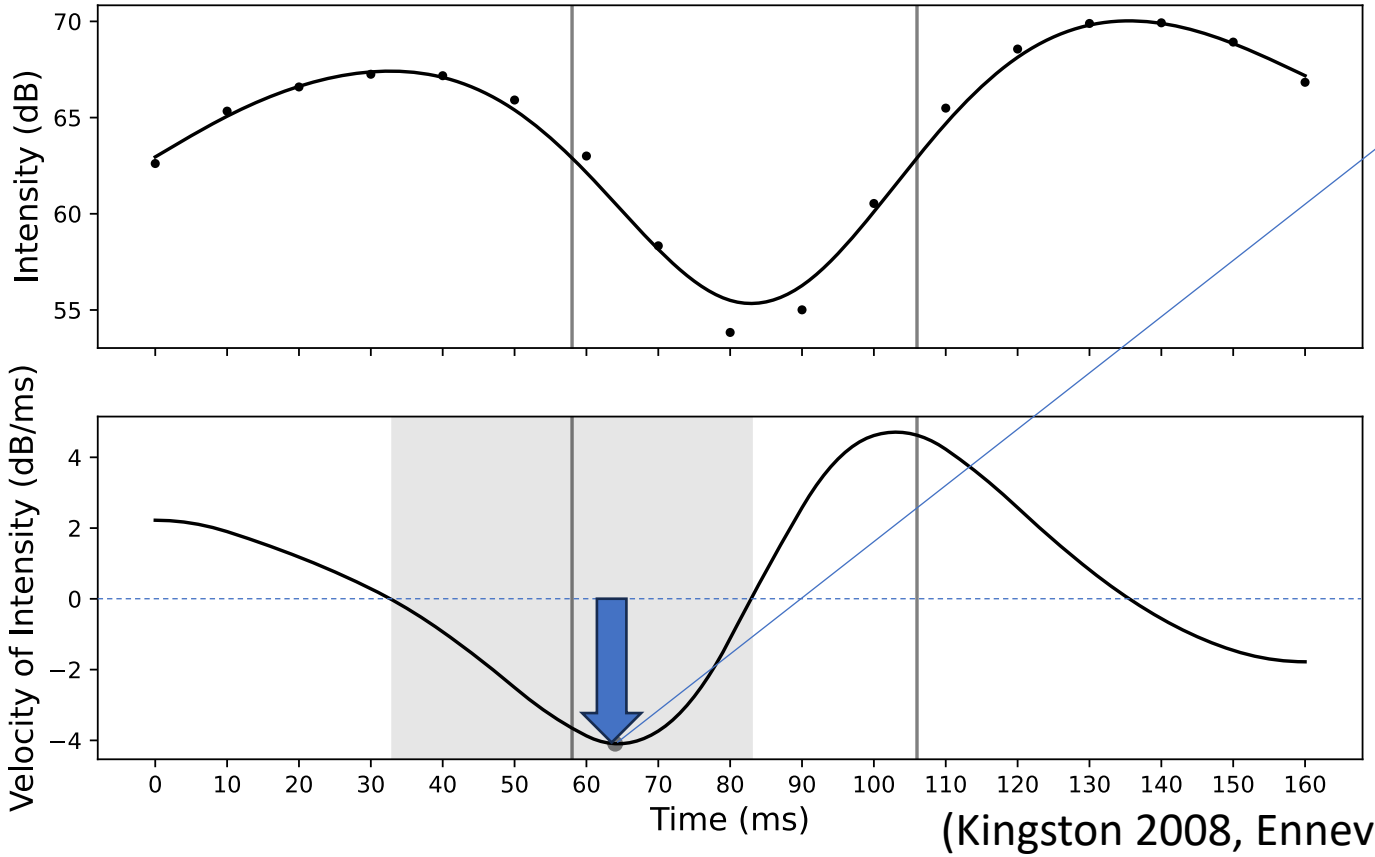
Computing transitional probability

- PWd includes inflectional and derivational suffixes
- and Korean is rich in suffixes and sentence-final particles
- e.g., PWd-initial /k/ in the same morpheme (/kat^{h}-/ ‘to be like’) was realized in 58 different ‘PWds’
  - /kat^{h}.a.jo/ ‘(it) is like…’ Declarative + honorific
  - /kat^{h}.ɨn.te/ ‘(it) is like …, but’
  - /kat^{h}.ɨ.mjɔn/ ‘if (it) is like …’
  - /kat^{h}.a.sɔ/ ‘(it) is like …, therefore’

  …
- Morpheme analyzer (Kakao Corp 2018)
  - All of these PWds can be grouped as one morpheme

Automatic quantification of the degree of lenition

Preceding Vowel (high intensity) /ɔ | **Lenis Obs.** **k** | Following Vowel (high intensity) i/



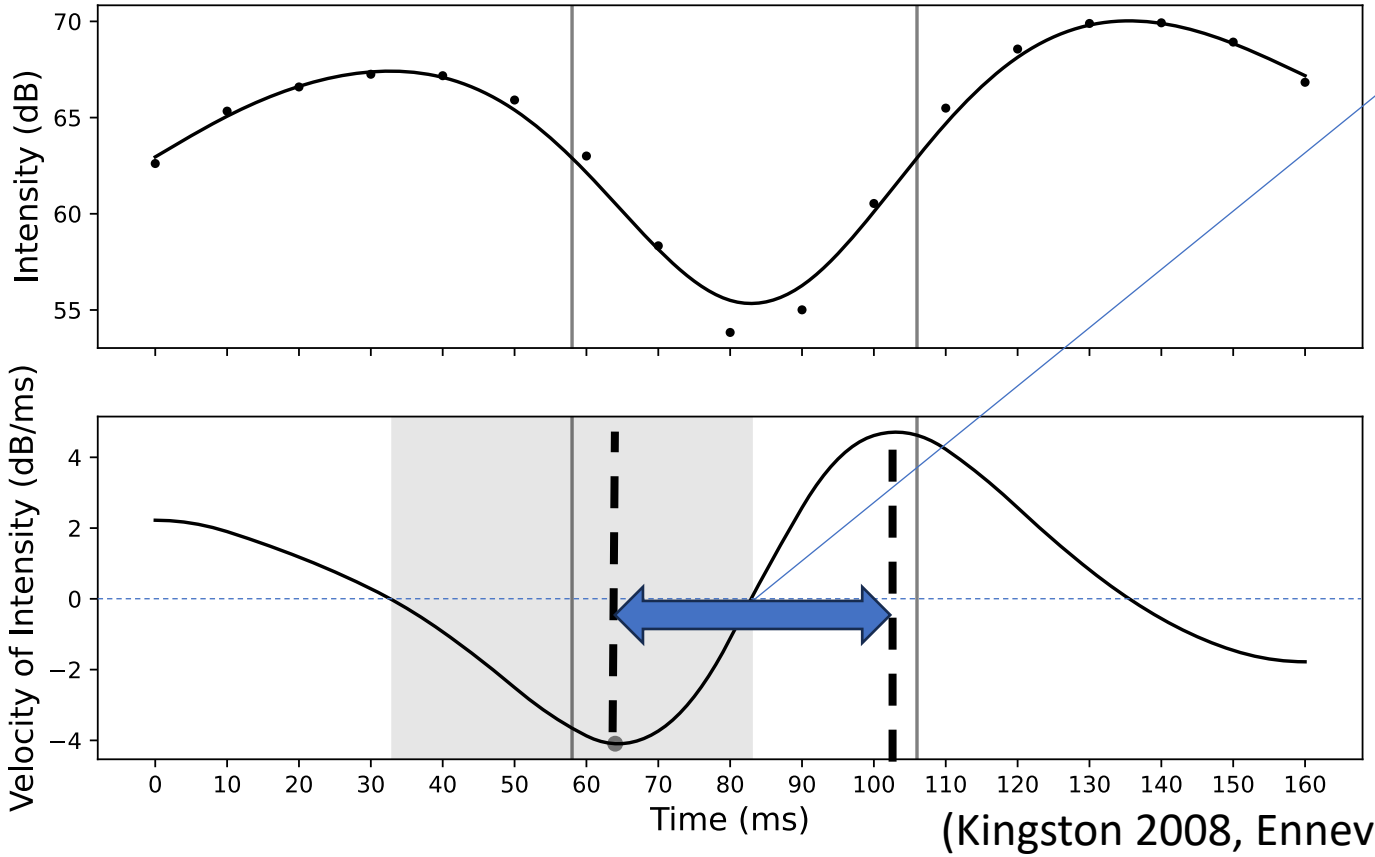
Closure Velocity Extremum (CVE)

= the velocity of the intensity fall is the fastest

Less extreme (and closer to 0) if the obstruent is more lenited (= has a similar intensity as the preceding vowel)

(Kingston 2008, Ennever et al 2017, Katz and Pitzanti 2019)

Preceding Vowel (high intensity)	**Lenis Obs.**	Following Vowel (high intensity)
/ɔ	**k**	i/



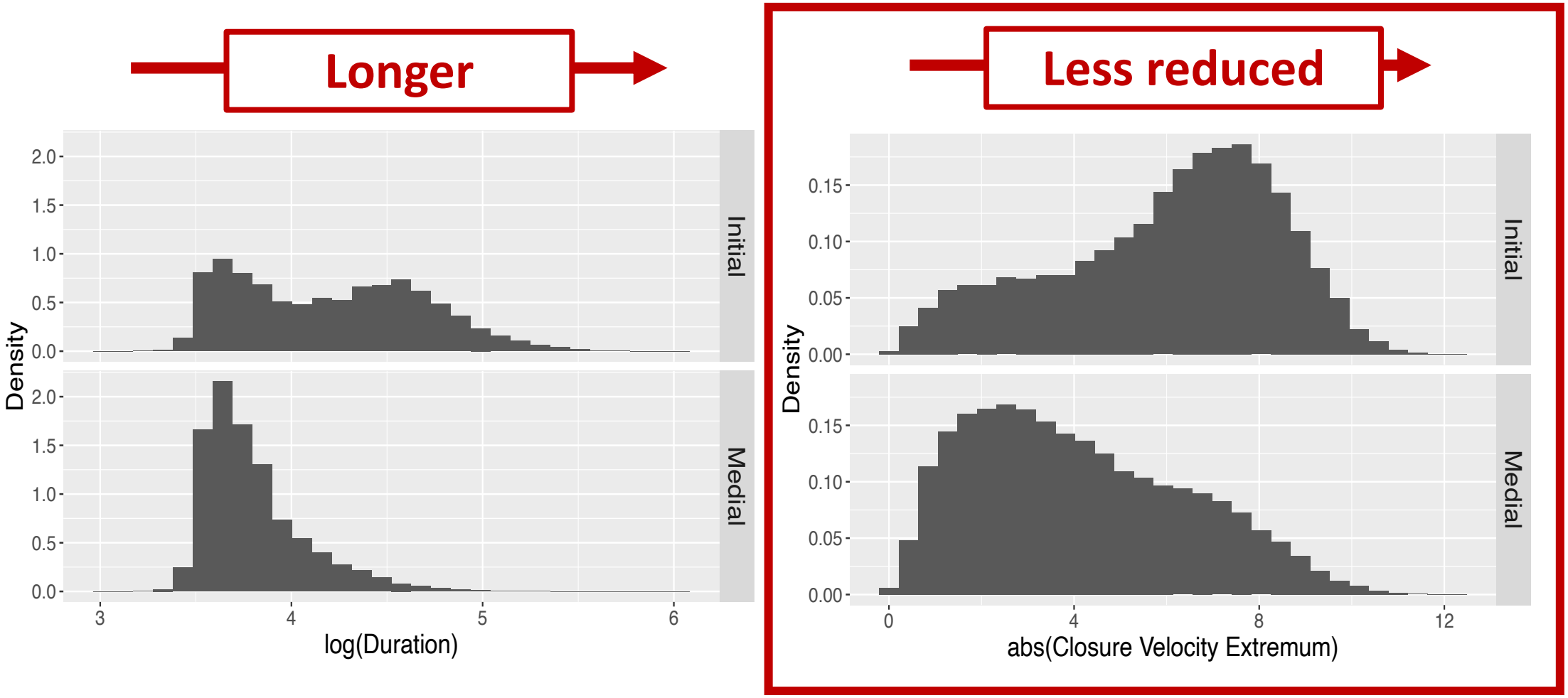
Duration

= Interval between the two inflection points in the velocity of intensity contour

Shorter if the obstruent is more lenited

(Kingston 2008, Ennever et al 2017, Katz and Pitzanti 2019)

Duration and CVE by PWd position

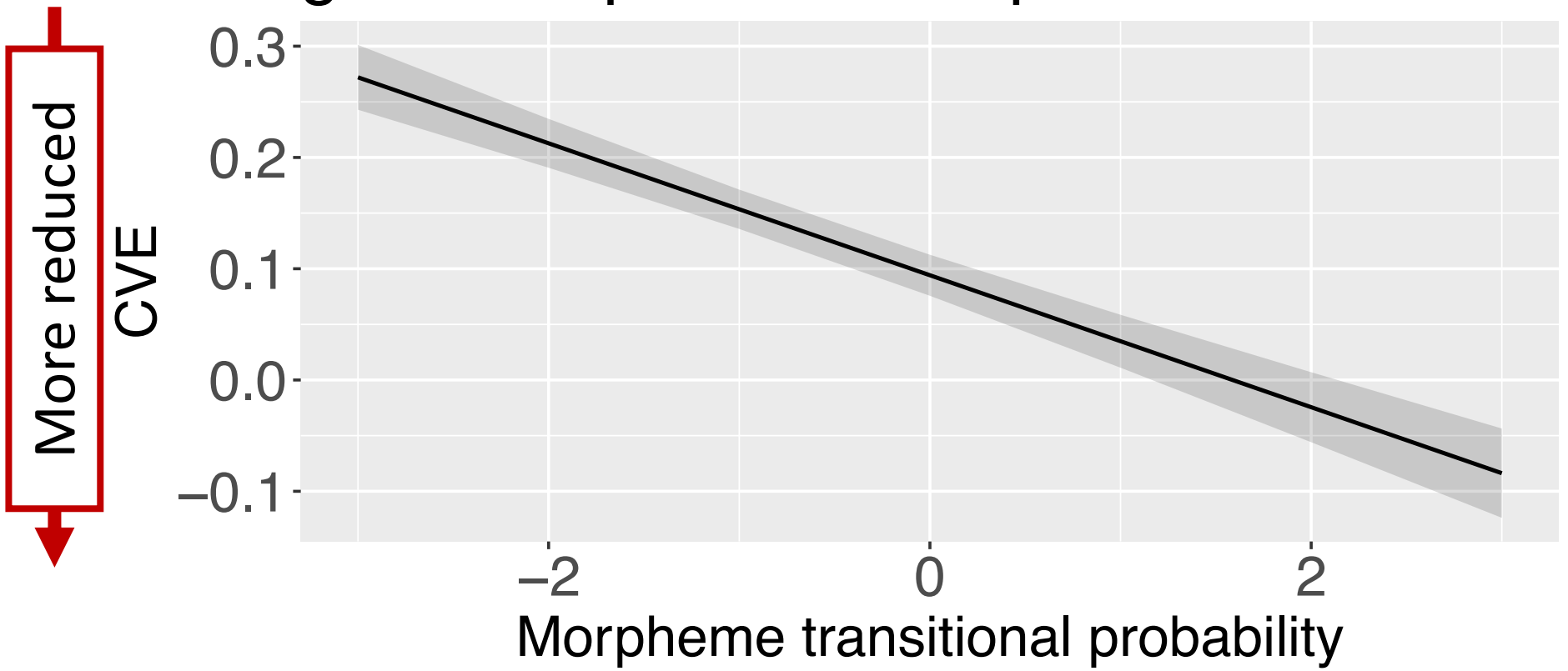


Analysis: Linear mixed effects regression

- The degree of reduction (CVE) ~
  - Bi-morphemic transitional probability ($p(\mu_{current}|\mu_{previous})$) (Predictability) +
  - Preceding/Following Vowel Height (-low and +low) +
  - Vowel Height X Predictability +
  - control predictors (speech rate/speaker age/speaker gender/proportion of voiceless interval/duration) +
  - (1|morpheme)
- Predictability, Speech rate, and duration are log-transformed
- and continuous variables (CVE, log(Predictability), log(Speech rate), voicing, and log(duration)) are by-speaker z-scored

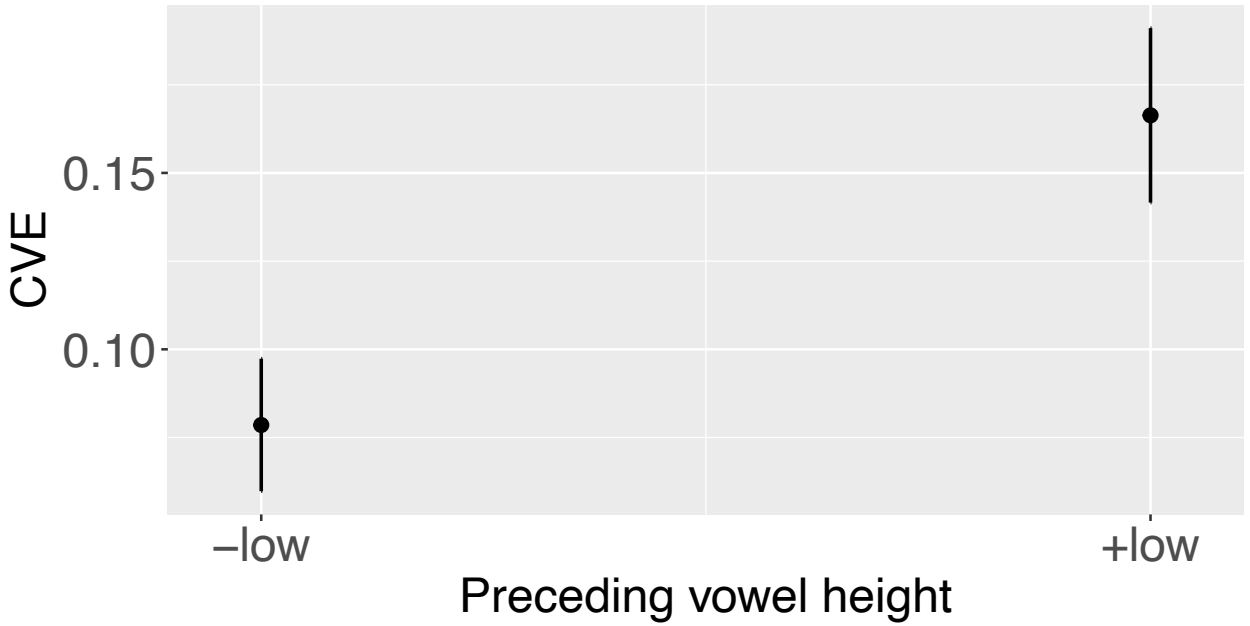
Predictability effect ✓

More reduced
if the morpheme is more predictable
given the previous morpheme



Asymmetrical vowel height effects

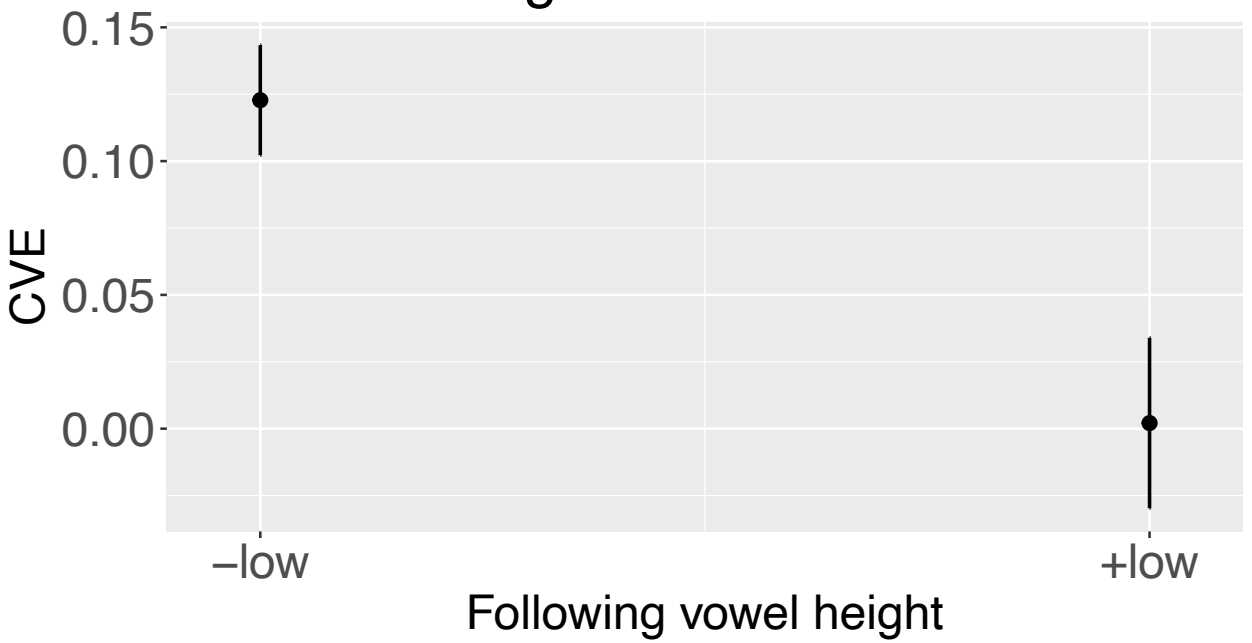
More reduced
when preceding vowel was not low



Articulatory effort perspective

✗

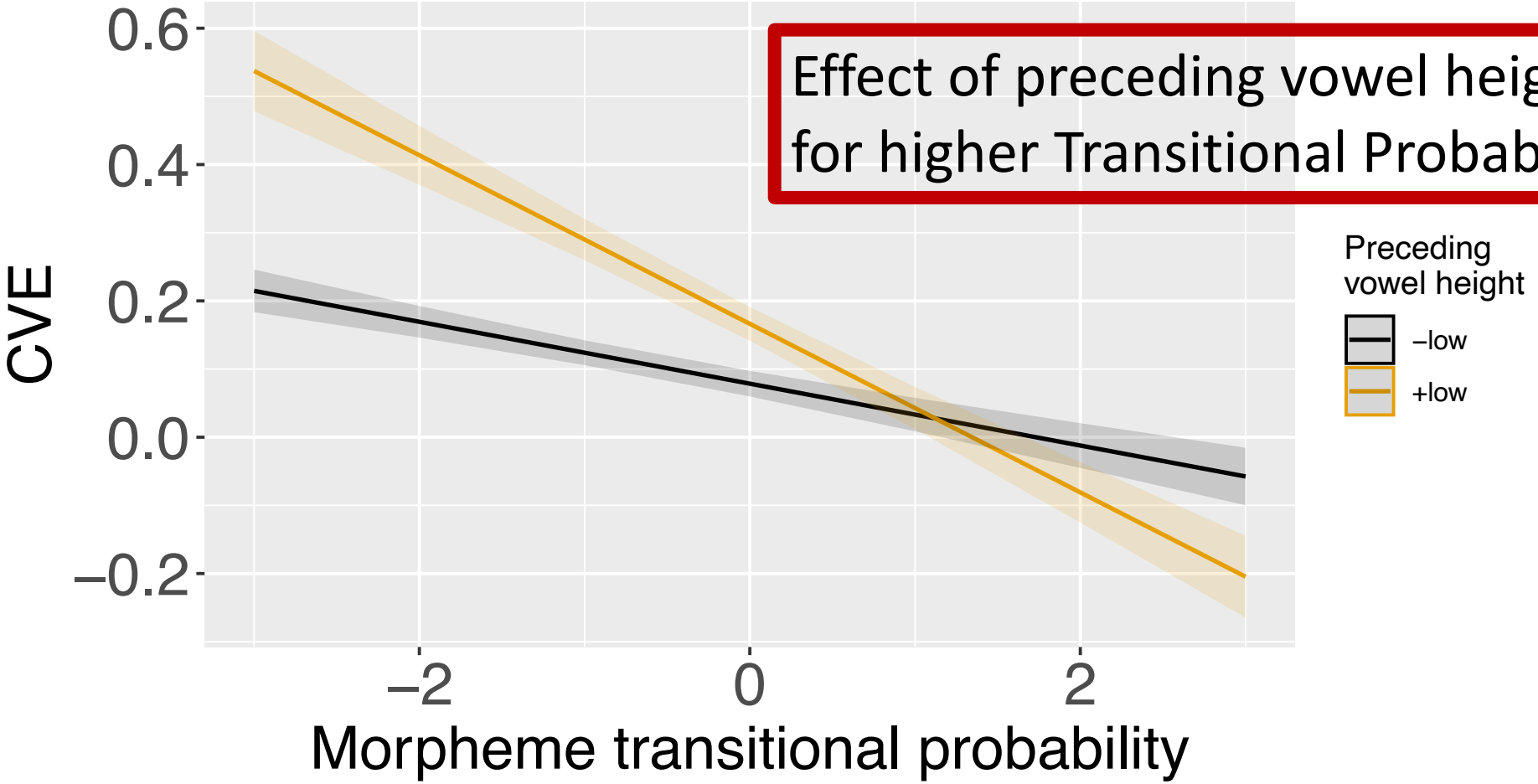
More reduced
when following vowel was low



Articulatory effort perspective

✓

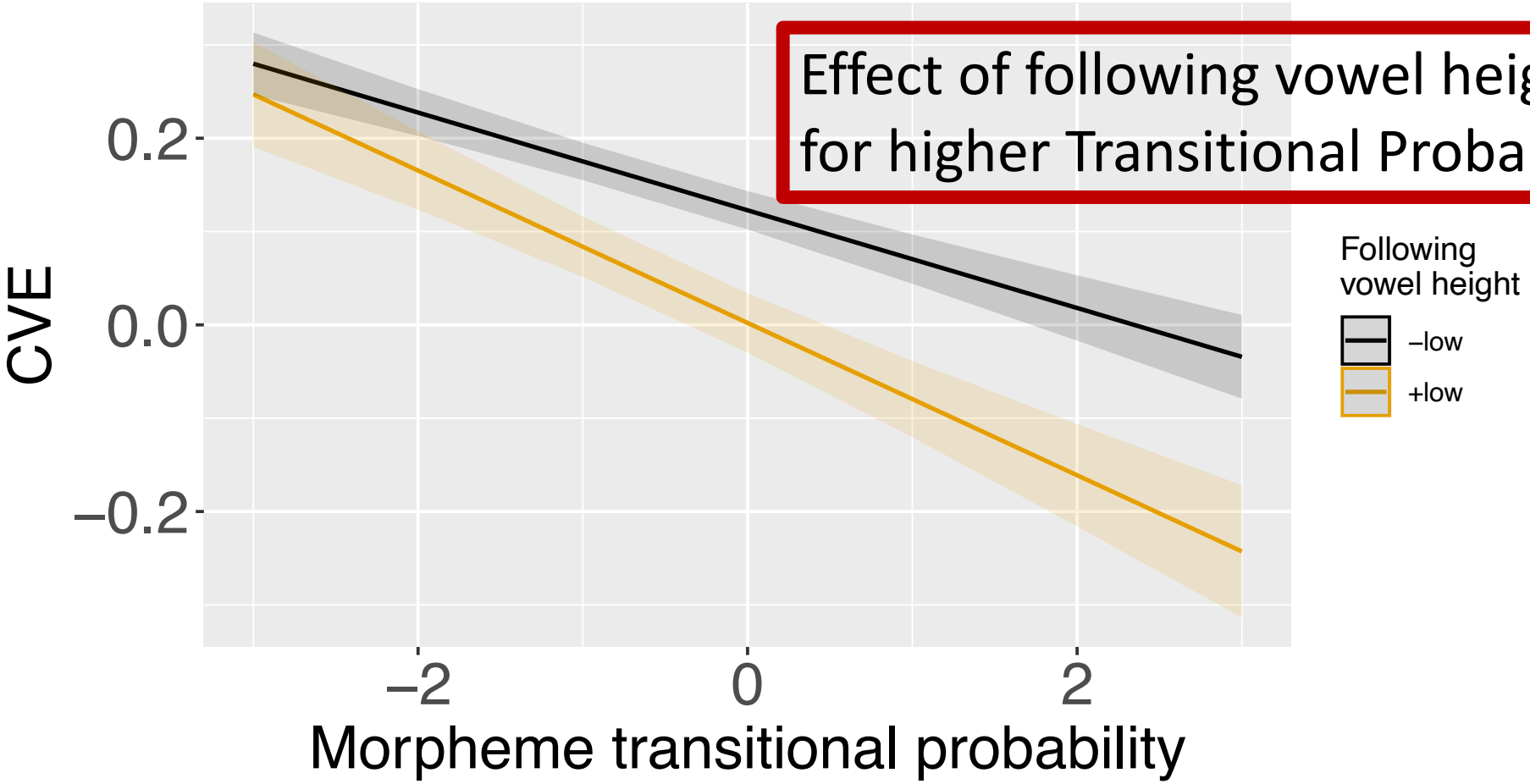
Morpheme transitional probability interacts with Preceding vowel height



Effect of preceding vowel height is **reversed** for higher Transitional Probability

Significant transitional probability effect for both vowel heights

Morpheme transitional probability interacts with Following vowel height



Significant transitional probability effect for both vowel heights

Key results

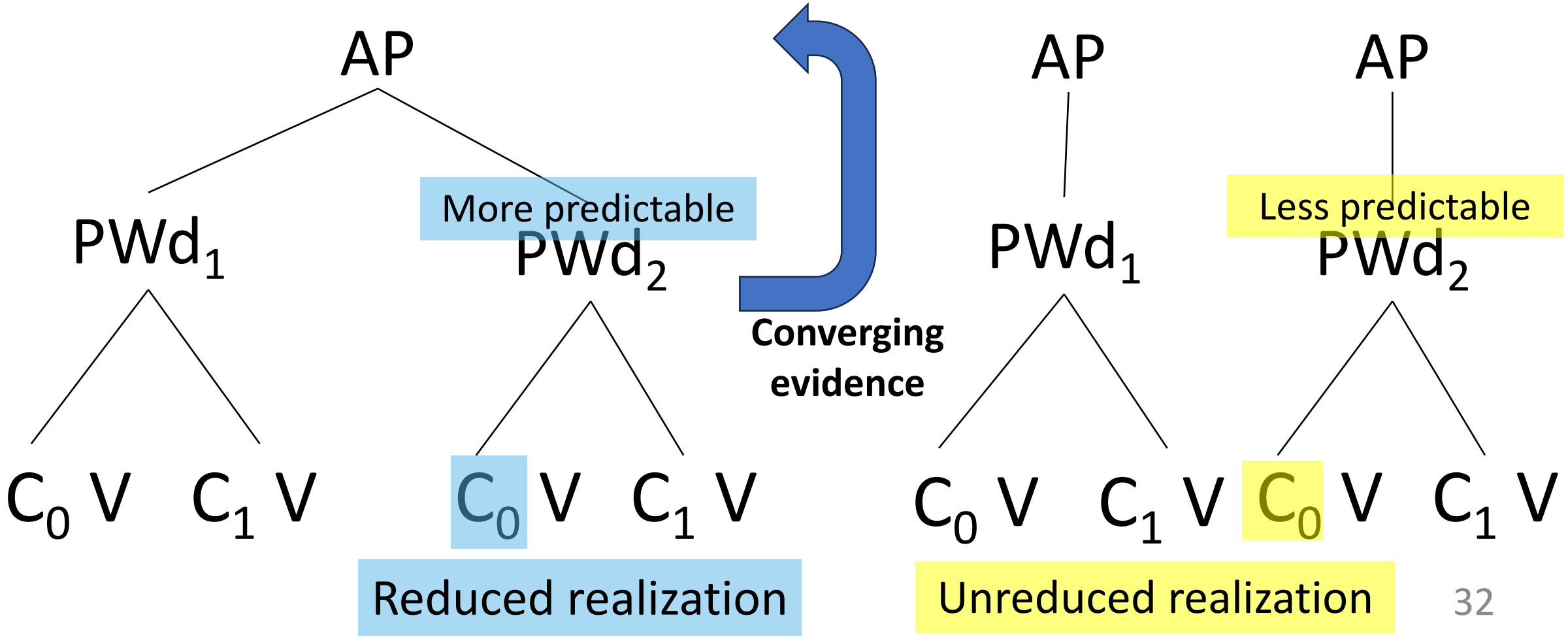
- Vowel height effect wasn’t consistent across transitional probabilities
- Transitional probability effect was consistent across vowel heights

Transitional probability and prosodic position

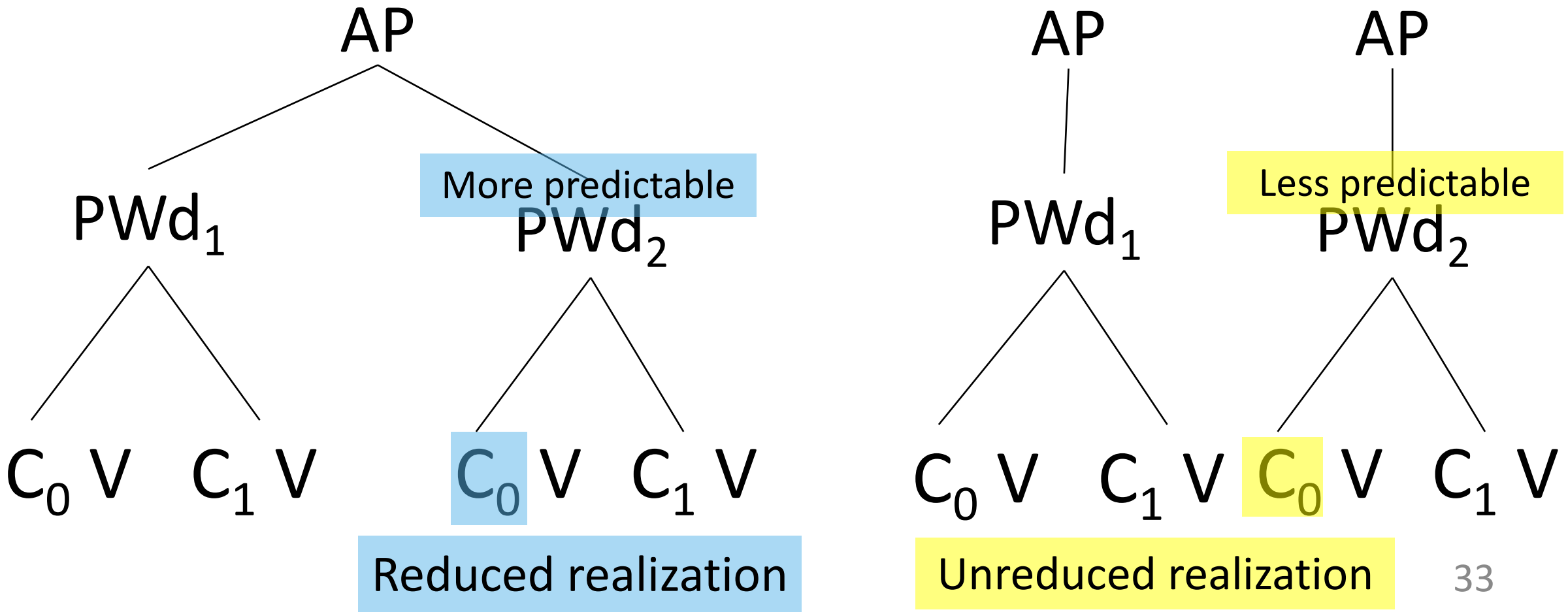
- If a word is highly predictable given the preceding word (high transitional probability), it means that they were frequently produced together.
- When two words are frequently produced together, they are also likely to (though they don't always have to) be produced in one prosodic constituent.
  - e.g., 'instead of' is very likely to be produced without a prosodic break

How is Transitional probability effect related to prosodic structure?

When PWd_2 is more predictable given the preceding PWd_1,
and when the PWd_2 initial segment is reduced,
it is more likely that the initial segment of PWd_2 is AP-medial



There is evidence that the reduced realization reliably mark the prosodic position (my poster on Day 2)



When does predictability fail to predict prosodic position?

- Some of the PWd-initial tokens were IP-initial in the corpus
- e.g., there were many sequences of sentence-final particle (honorific marker) followed by a filler word /kɨ/
- Though the PWd /kɨ/ would have a high transitional probability, tokens of /k/ in these sequences were not reduced, since it is followed by a sentence final particle, which probably meant they were beginning a new IP.
- Therefore, transitional probability cannot completely replace a prosodic transcription

RQ1: How do we study a prosodically conditioned segmental process, lenis obstruent reduction, in a corpus without the prosodic transcription?

- We can use ‘transitional probability’ to predict the degree of reduction.
- Transitional probability seems to be correlated with the presence/absence of prosodic boundary, though it is not always a good indicator of the prosodic structure
- Nonetheless, it is easier to compute the transitional probability than to get prosodic transcription of a large corpus
- Studying the effect of transitional probability can be a first step towards investigating prosodically conditioned segmental process

RQ2: Do preceding/following vowel heights condition lenis obstruent reduction in Seoul Korean? How do the vowel heights interact with transitional probability?

- Yes, but the preceding vowel height effect is not predicted from the articulatory effort perspective, and the vowel height effects change depending on the transitional probability
- On the contrary, transitional probability is consistent across different vowel heights
- If one only includes the vowel height effect, but not an interaction between vowel height and the Transitional probability, the results could be misleading.

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Poster related to this presentation on Day 2

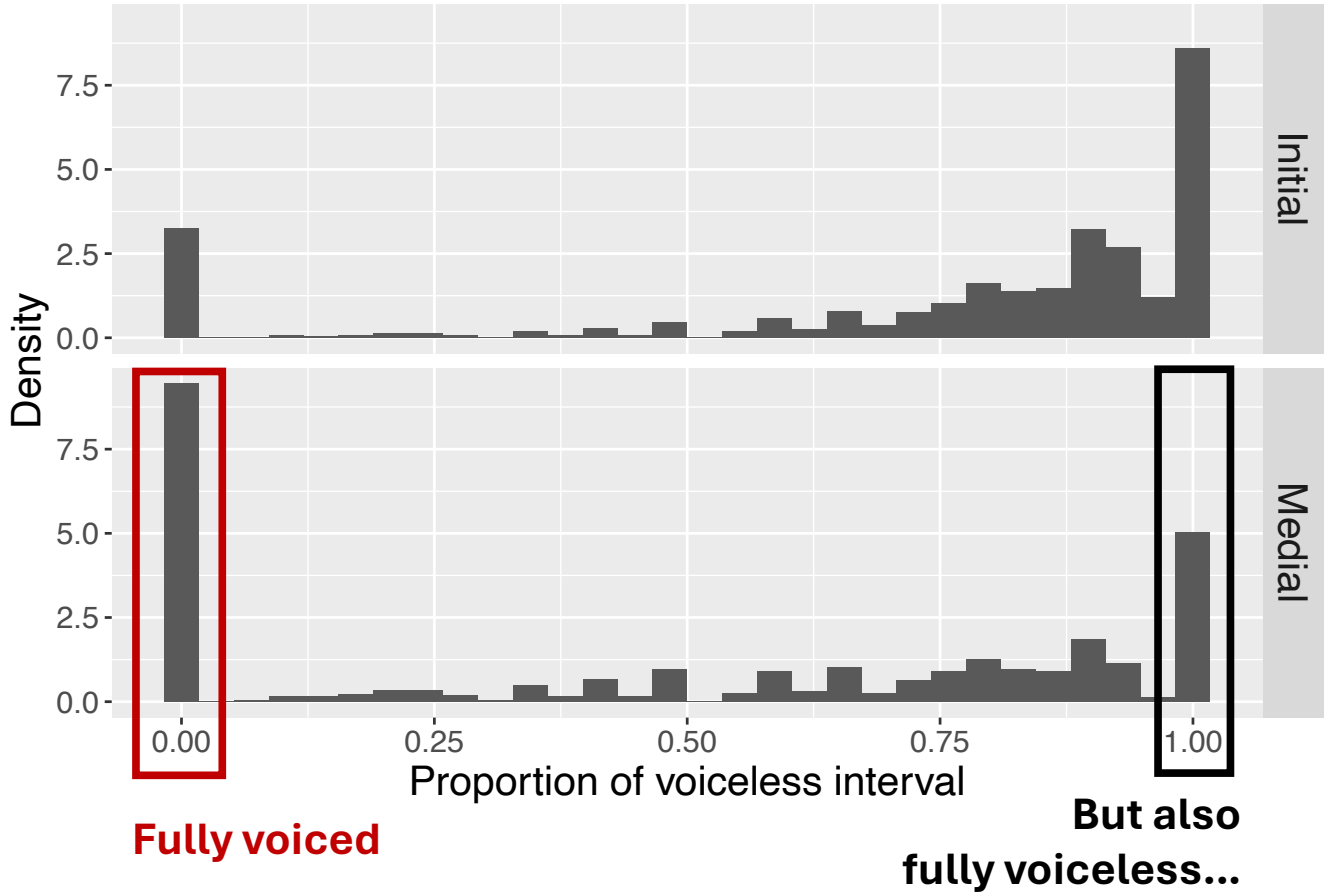
What does it mean that the vowel height effect interact with the transitional probability?

- If there is a real phonological effect of vowel height, then the effect would be consistent across different transitional probabilities.
- In particular, the preceding vowel height effect was reversed, and it cannot be predicted by a simplistic Articulatory effort perspective

Have you tried to include other random effects/random slopes?

- (1+TP|morpheme) – nothing much changes, near 0 variance on the random slope
- (1|speaker) – Near 0 variance
- Other random intercepts/slopes: near 0 variance, partially because the continuous variables have been by-speaker z-scored

Why not voicing? Why reduction?



Poster on Day 2 D2:37(R2)
‘Prosodically conditioned lenition, not voicing, of lenis obstruents in Seoul Korean spontaneous speech’

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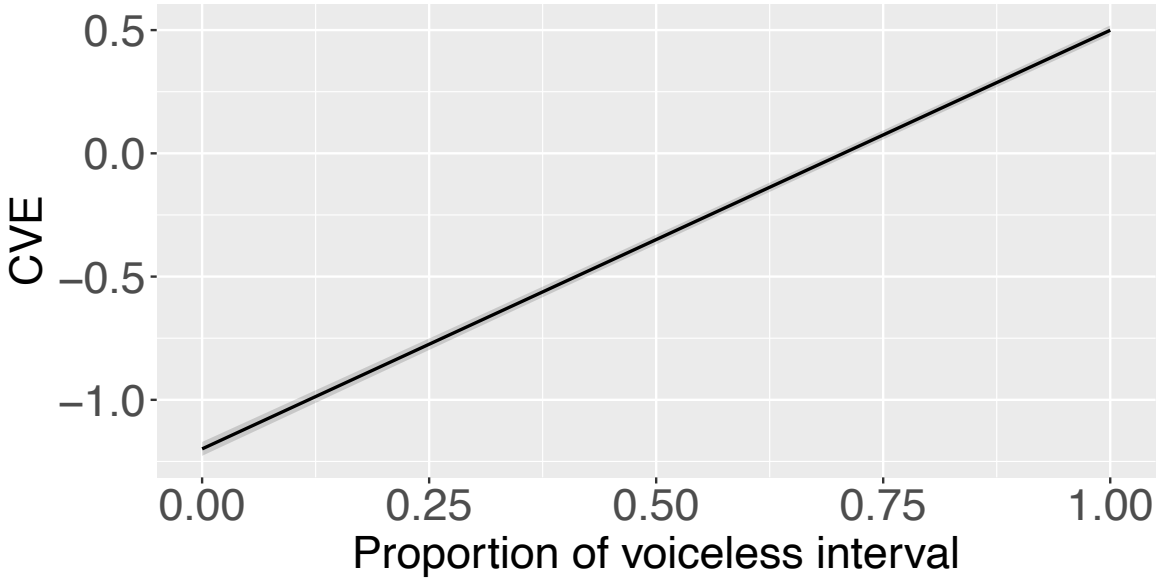
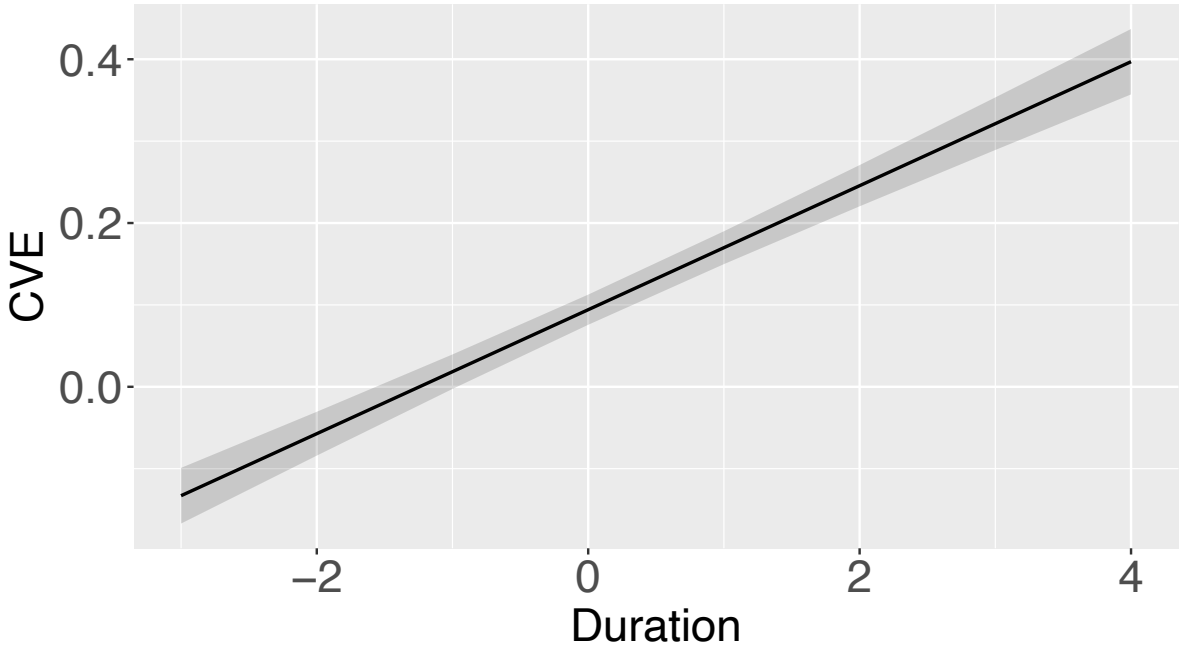
Results: phonetic variables

More reduced

Less reduced,
if lenis obs. is more voiceless

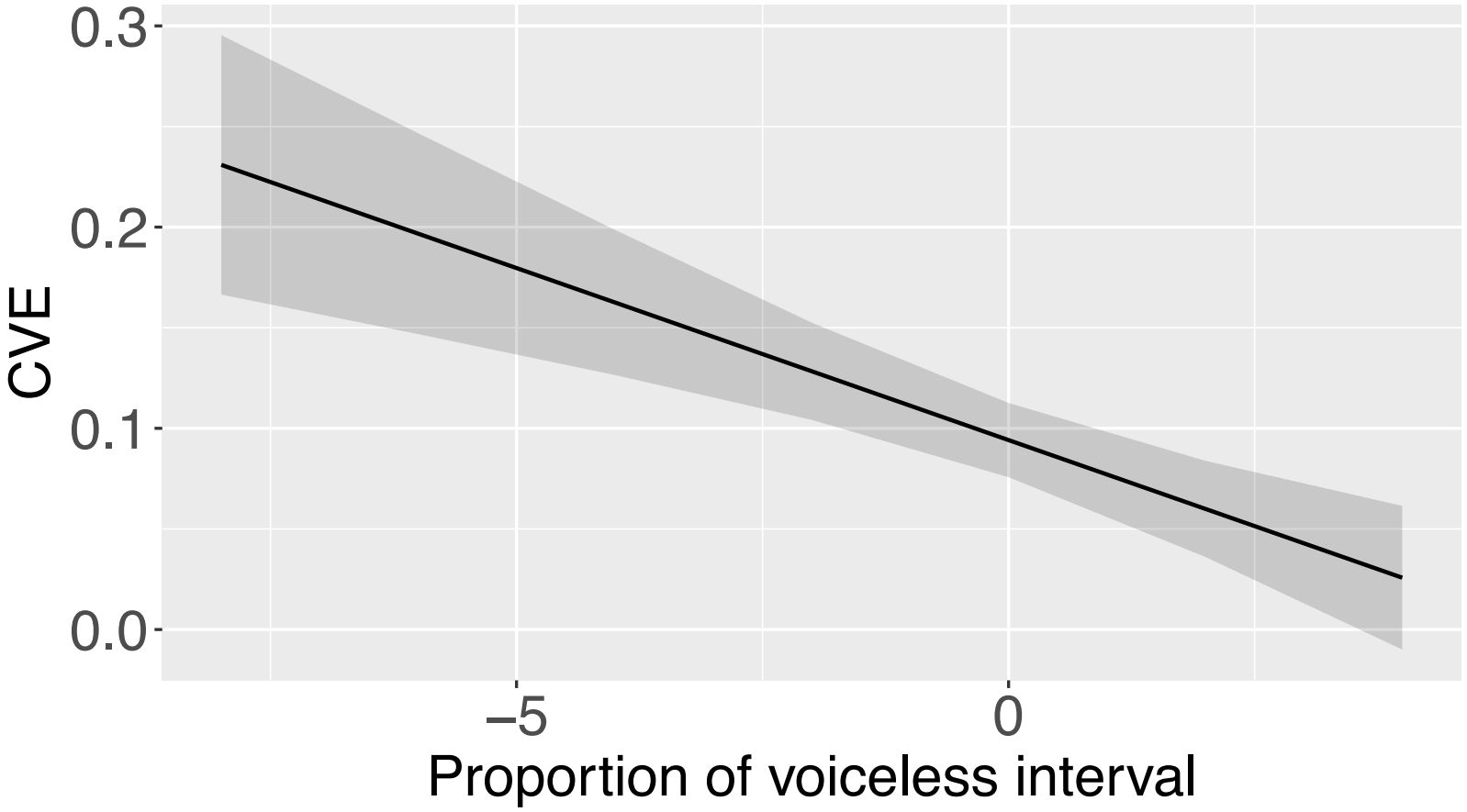


Less reduced, if lenis obs. is longer

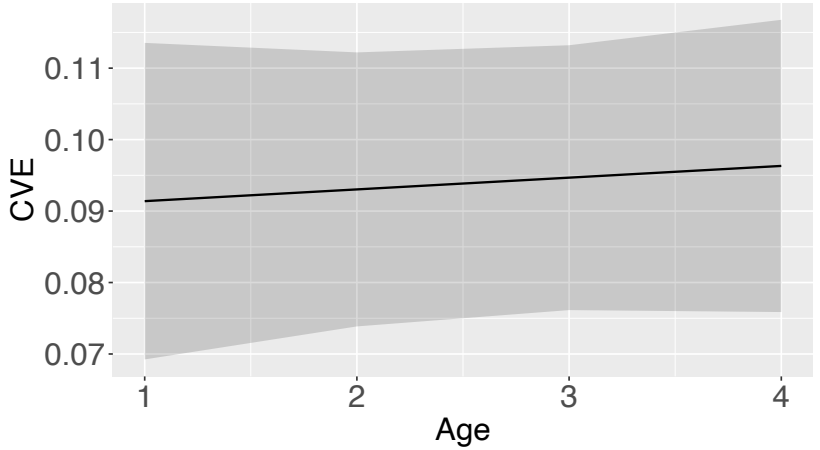


Results: other control factors

More reduced in faster speech

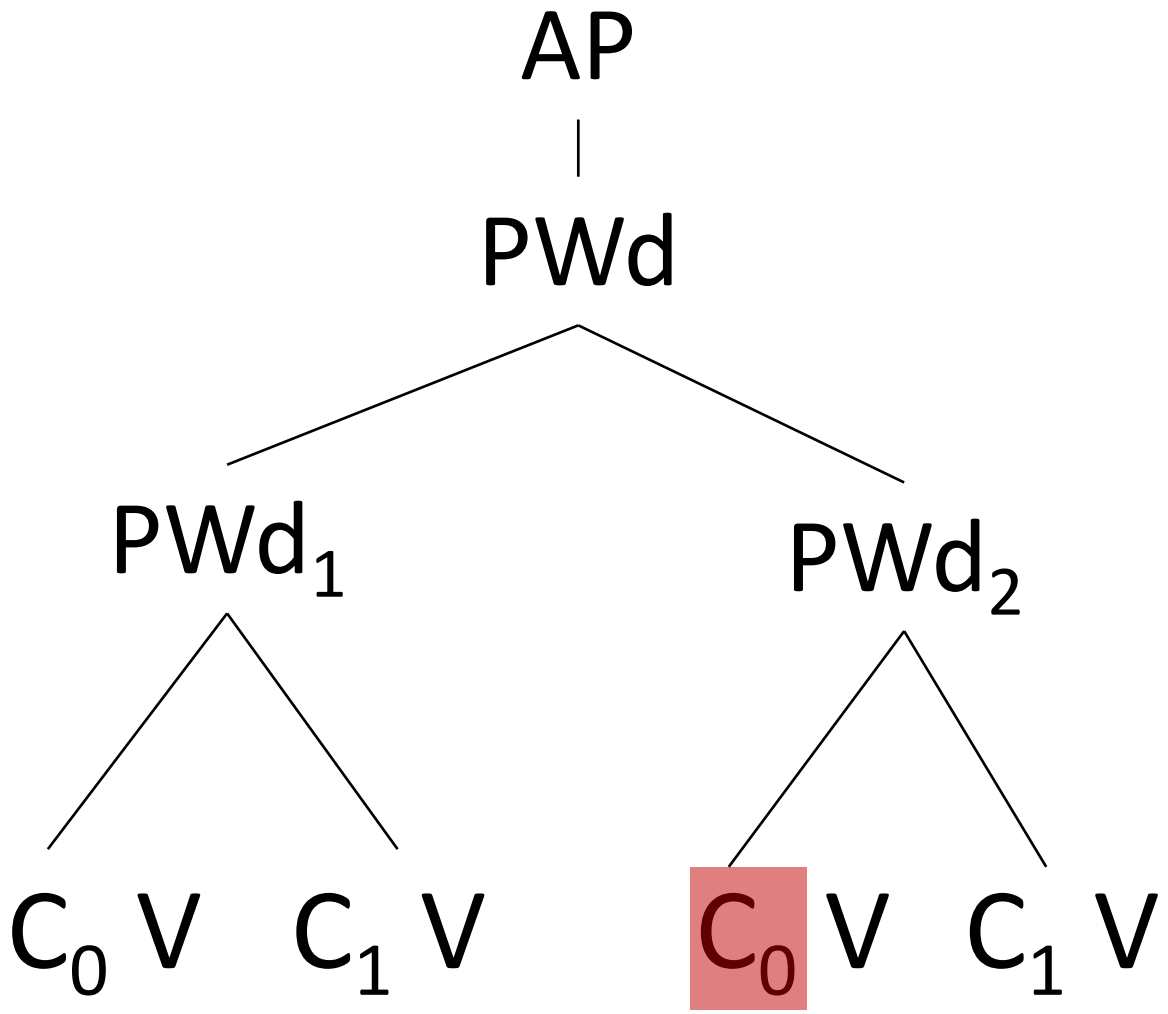


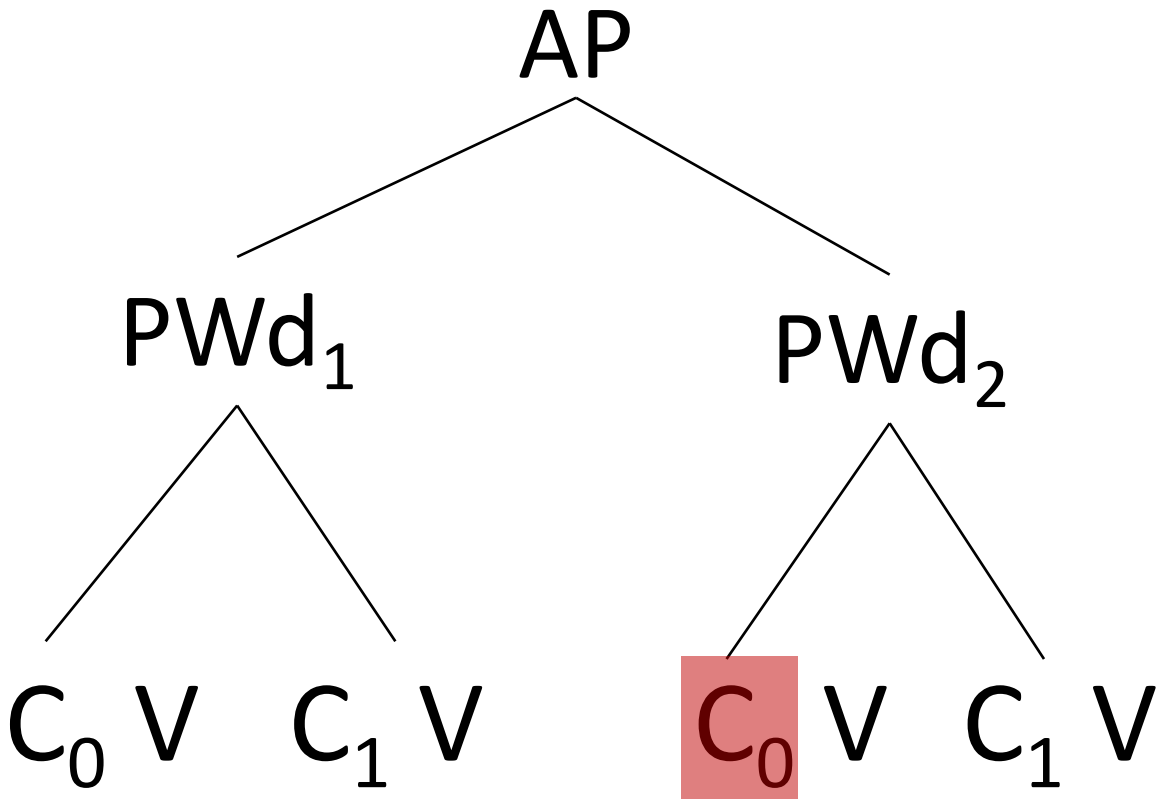
No significant effect of speaker age



More reduced in female speech

Alternative prosodic structure: PWd recursion?





What about PWd medial lenis obstruents?

- Predictability effect is still significant (bisyllabic transitional probability)
  - PWd-medial tokens all are in the same prosodic position
  - Predictability still affects the degree of lenition

What about PWd medial lenis obstruents?

- Similar asymmetry of vowel height effect:
  - More reduced when Preceding vowel height is -low
  - More reduced when Following vowel height is +low
- When preceding vowel height is -low, then the vowel is more likely to be devoiced, and lenis obstruent is more reduced after a devoiced vowel
  - Because a devoiced vowel is already small in intensity,
  - And a lenis obstruent can’t be dramatically smaller in intensity after a devoiced vowel, hence more reduced

Have you done mediation analysis for the relationship between duration and CVE?

- Yes
- However, unlike previous studies that investigated the relationship between duration and intensity (Cohen Priva and Gleason 2020, Katz and Pitzanti 2019), duration did not fully mediate intensity, and intensity did not fully mediate duration either.
- There were partial mediation in both directions, and duration was still a better mediator for intensity than vice versa.

F0 and predictability

- If lower predictability reflects a greater likelihood of prosodic boundary, then we might expect to find greater pitch movement indicating a prosodic break
- Something to investigate in future studies