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Contrasting phonetic effects of morphological boundaries for vowel and consonant suffixes

Motoki Saito

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Phonetic reduction and enhancement

Phonetic reduction and enhancement

- Phonetic reduction:
  - Unclearer speech
  - Shorter duration
  - More centralized formant/tongue positions

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  - Unclearer speech
  - Shorter duration
  - More centralized formant/tongue positions
- Phonetic enhancement:
  - Clearer speech
  - Longer duration
  - More peripheral formant/tongue positions

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- Phonetic **enhancement** effects of morphological boundaries on affixes.

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- Shorter affix duration (vs. pseudo-affix) [9, 10, 13, 19].

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- Phonetic **reduction** effects of morphological boundaries on affixes

Research question

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Why are the opposite effects observed?

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⇒ **Enhancement effects of a morphological boundary are limited to vowels?**

Morphological effects on affixes

- Enhancement effects
  - *un-* [7, 8].
  - *dis-* [8].
  - /n/ of *un-/in-* [3].
  - /s/ of *-s* [11, 17].
  - /ɪ/ of *mis-/dis-* [12].

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  - /s/ of *-s* [13] (for 2-year-old children).
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- Reduction effects
  - /s/ of *-s* [9, 19].
  - /s/ of *-s* [13] (for 2-year-old children).
  - /s/ of *mis-/dis-* [12].
- Null effects
  - /z/ of *-s* [9].
  - /s/ of *-s* [13] (for adults).
  - *in-* [8].
  - *-ly* [8].
  - /t/ of *-ed* [11].
  - /m/ of *mis-* [12].
  - /d/ of *mis-* [12].

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  - None

Hypothesis

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Vowels are subject to enhancement, while consonants are not.

$\Rightarrow$ Segments with higher sonority are enhanced, while those with lower sonority are not.

Target suffixes of interest

- German affixes *-er* [ɐ] and *-t* [t].

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Target suffixes of interest

- German affixes *-er* [ɐ] and *-t* [t].
  - Both are affixes made of a single segment.
  - [ɐ] (a low open vowel) is at the highest end of the sonority hierarchy.
  - [t] (a voiceless plosive) is at the lowest end of the sonority hierarchy.

The suffix *-er*

- *-er* [ɐ]

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    e.g., *schön+er* [ʃøn+ɐ] “nicer/more beautiful”.
  - A derivational suffix for the agent.
    e.g., *Arbeit+er* [aʁbaɪt+ɐ] “worker”.

The suffix *-t*

- *-t* [t]

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  - An inflectional suffix for the present 3rd-person singular.

    e.g., *sie spiel+t* [ziː ʃpiːl+t] “she plays”.

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    e.g., *ihr spiel+t* [ɪɐ ʃpiːl+t] “you (pl.) play”.
  - An inflectional suffix for the past-participle.
    e.g., *ge+spiel+t* [gə+ʃpiːl+t] “played”.

Karl Eberhards Corpus (KEC)

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- All the words that contain word-final [ɐ] or [t] from the Karl Eberhards Corpus of spontaneously spoken southern German (KEC) [1].

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- KEC (Audio)
  - 39 speakers
  - Dialogues between two speakers.
  - About 35 hours of audio recordings.
- KEC (Articulography)
  - 13 speakers
  - Dialogues between two speakers.
  - About 2 hours of articulography (EMA) data.

Variables of interest

- Segment/affix duration
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  - Collected from the Articulography section of KEC.

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- Segment/affix duration
  - Calculated from time stamps available in KEC.
- Tongue tip position
  - Collected from the Articulography section of KEC.
- Morphological status of the target affixes was determined with the CELEX database [2].

  e.g., *Arbeiter*: `((arbeit)[V],(er)[N|V.])[N]`

  e.g., *Kinder*: No entry in the lemma section + `(Kind)[N]` + `S1/P4`

  e.g., *macht*: No entry in the lemma section + `3SIE,2PIE,rP`

Analyses

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- **Acoustic analysis**
- Articulatory analysis

Acoustic analysis: Dependent variable

- Suffix duration (`SuffixDur`).
  - Log-transformed.

Acoustic analysis: Predictors of the main interest

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  - An utterance was defined as a stretch of an utterance bound by pauses.

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  - An utterance was defined as a stretch of an utterance bound by pauses.
- Word duration (`WordDur`).
- Utterance duration (`UttDur`).
- PC1
  - About 99% of the variance by `NumSylWord`, `NumSylUtt`, `WordDur`, and `UttDur` was explained.

Acoustic analysis: Other predictors

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- Speaker identity (`Speaker`).
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  `+ UttInitial + UttFinal + s(PC1, k=3)`
  `+ s(WordFreq, k=3) + s(Speaker, bs='re')`

Acoustic analysis: Results

(A. Parametric)	β	SE	t	p
Intercept	-2.32	0.01	-295.12	$<$0.01
Suffix=*-t*	-0.45	0.00	-126.09	$<$0.01
Morph=TRUE	0.06	0.01	7.74	$<$0.01
UttInitial=TRUE	0.02	0.00	4.26	$<$0.01
UttFinal=TRUE	0.39	0.00	107.32	$<$0.01
Suffix=*-t*:Morph=TRUE	-0.06	0.01	-7.36	$<$0.01
(B. Smooth)	edf	Ref.df	F	p
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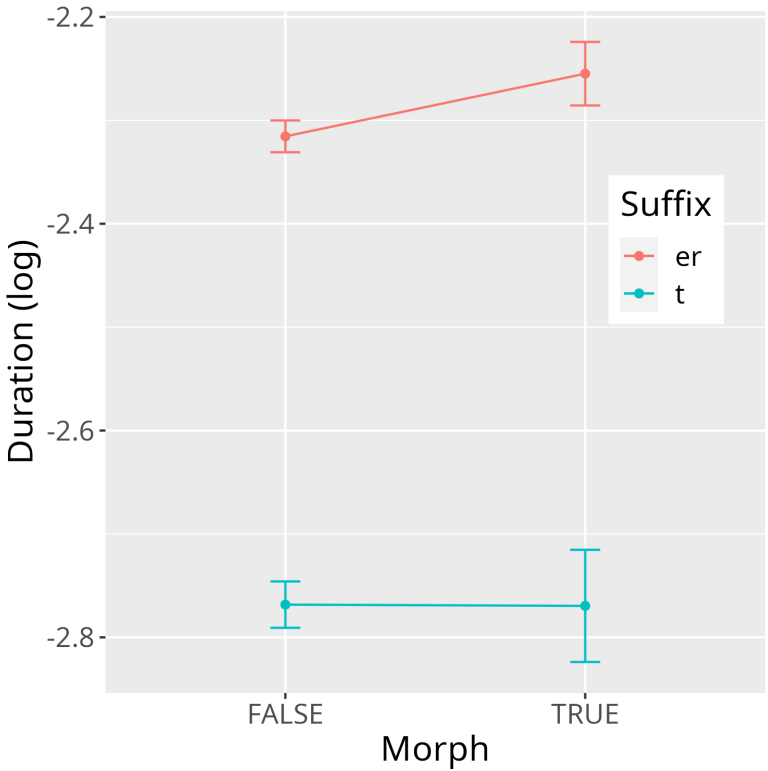
- Suffixal *-er* is longer than non-suffixal *-er*.
  - $\beta = 0.06, p < 0.01$.
- Effects of `Morph` are significantly smaller for *-t*.
  - $\beta = -0.06, p < 0.01$.

Acoustic analysis: Estimated effects of Morph and Suffix



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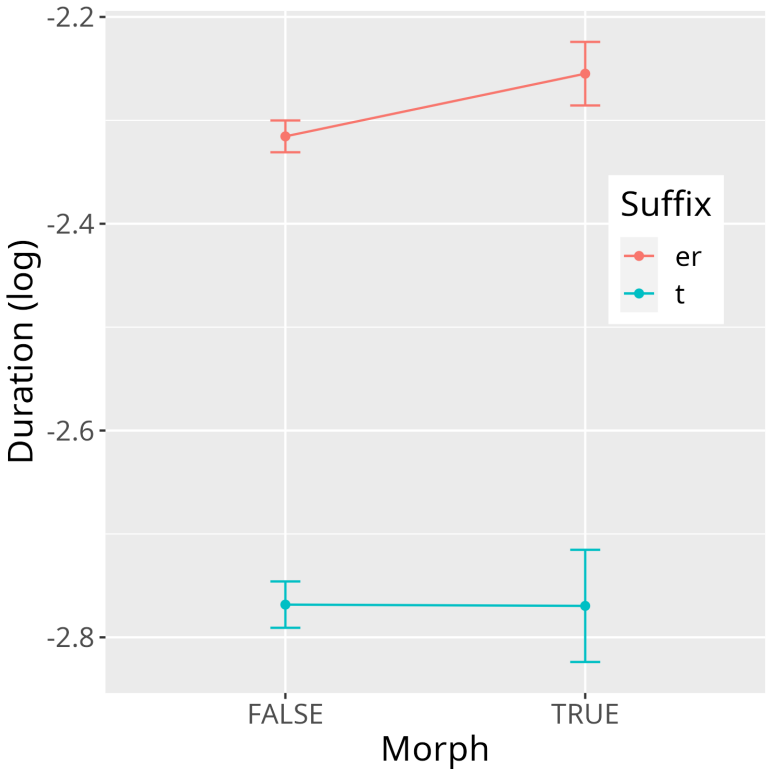

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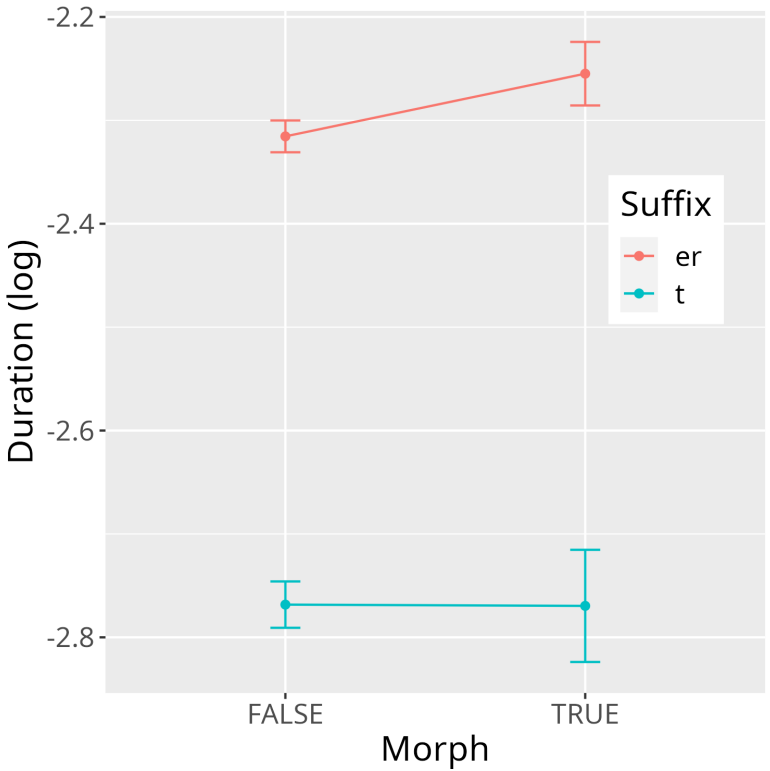

- Enhancement for *-er*.
- No effect for *-t*.

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- Articulatory analysis

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  - *-er*
  - *-t*

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  - ***-er***
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Articulatory analysis (*-er*): Dependent variable

- Vertical tongue tip positions (`TTpos`).

Articulatory analysis (*-er*): Predictors of the main interest

- ~~Suffix identity (`Suffix`).~~
  - ~~*-er* vs. *-t*.~~
- Morphological status (`Morph`).
  - Pseudo-suffix vs. Suffix

  e.g., *Vater* vs. *Kind+er*.

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  e.g., *Vater* vs. *Kind+er*.
- **Time** (`Time`)
  - Normalized between 0 and 1.
  - 0 $\rightarrow$ Onset of the target segment/suffix.
  - 1 $\rightarrow$ Offset of the target segment/suffix.

Articulatory analysis (*-er*): Phonological predictors

- Utterance-initial (`UttInitial`).
- Utterance-final (`UttFinal`).
- PC1
  - A combined measure for `NumSylWord`, `NumSylUtt`, `WordDur`, and `UttDur`.

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Articulatory analysis (*-er*): Other predictors

- Word frequency (`WordFreq`).
  - Collected from the SdeWaC corpus [5].
  - Log-transformed.
- Speaker identity (`Speaker`).
  - As an random effect.

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- Word frequency (`WordFreq`).
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  - Log-transformed.
- Speaker identity (`Speaker`).
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- **Duration of the target segment/suffix** (`SuffixDur`)
  - Log-transformed.

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- `s(Time, by=Morph, k=3)`
  → Difference between tongue contours between non-morphemic and morphemic *-er*.
- `Morph`
  → Overall (average) differences in tongue height between non-morphemic and morphemic *-er*, irrespective of time.

Articulatory analysis (*-er*): Results (Parametric terms)

(A. Parametric)	β	SE	t	p
Intercept	4.19	0.929	4.507	$<$0.01
Morph=TRUE	-0.59	0.160	-3.702	$<$0.01
UttInitial=TRUE	-0.02	0.115	-0.213	0.83
UttFinal=TRUE	-0.89	0.957	-0.928	0.35

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* *-er* [ɐ] is a low vowel.

i.e., Lower positions $\approx$ clearer [ɐ].

Articulatory analysis (*-er*): Results (Smooth terms)

(B. Smooth)	edf	Ref.df	*F*	*p*
s(Time)	2.00	2.00	150.07	$<$0.01
s(Time):Morph=TRUE	1.99	2.00	37.99	$<$0.01
s(WordFreq)	1.00	1.00	2.55	0.11
s(PC1)	1.68	1.90	1.03	0.36
s(PrevSeg)	20.14	23.00	714.94	0.57
s(NextSeg)	49.76	58.00	520.66	0.18
s(Speaker)	31.91	33.00	1620.28	0.04

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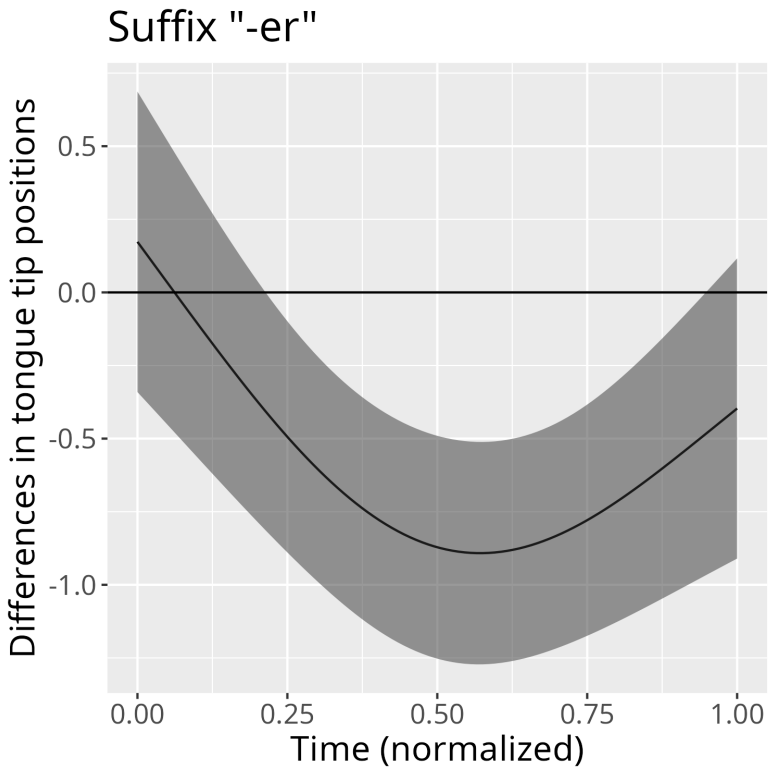
- Tongue trajectories of Non-suffixal *-er* are significantly different than a flat straight line.
- Shape of tongue trajectories are significantly different between suffixal *-er* and non-suffixal *-er*.

Articulatory analysis (*-er*): Estimated effects of Morph



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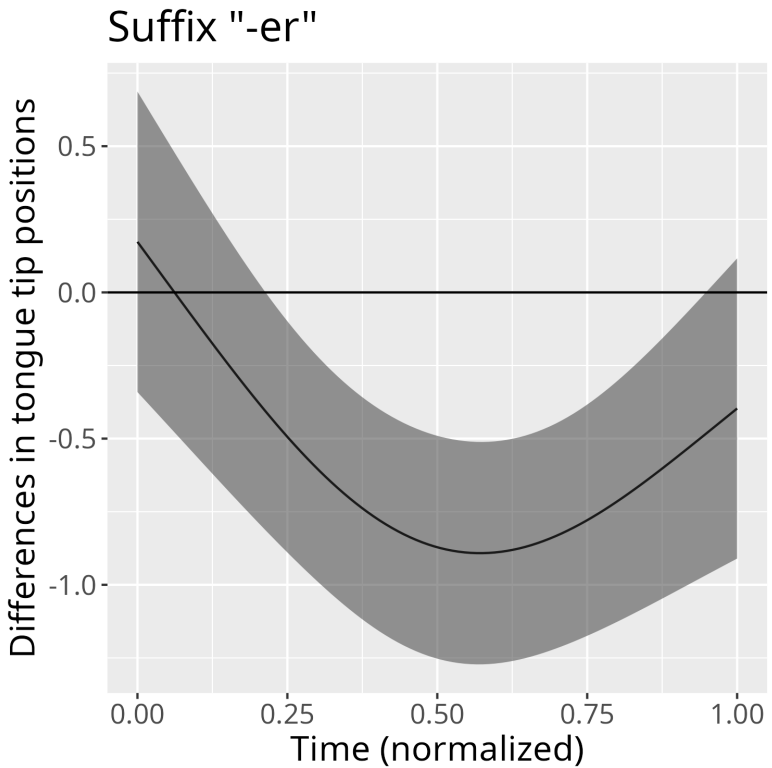

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  - → No difference in tongue positions between suffixal and non-suffixal *-er* at the point in time.

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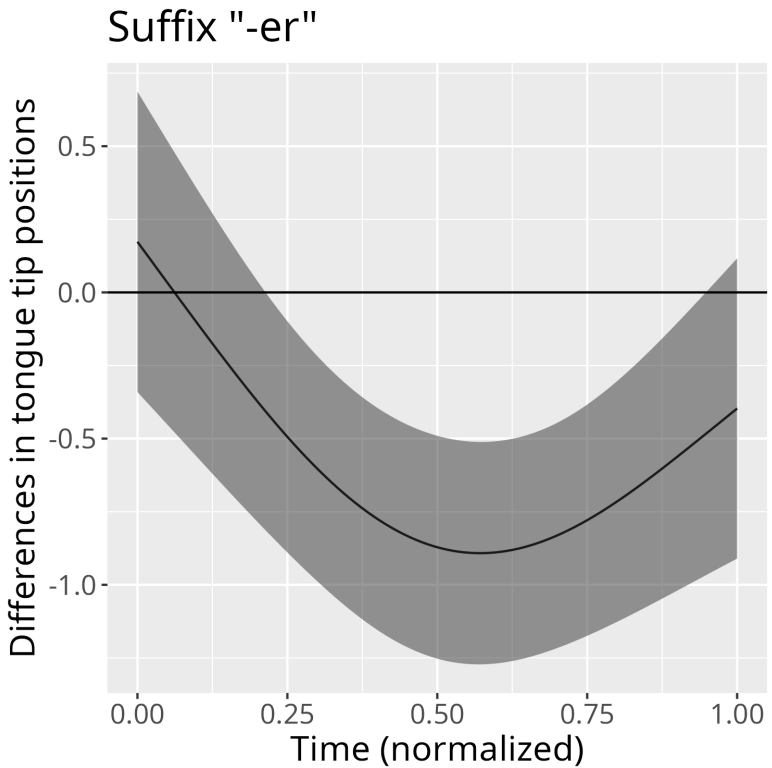

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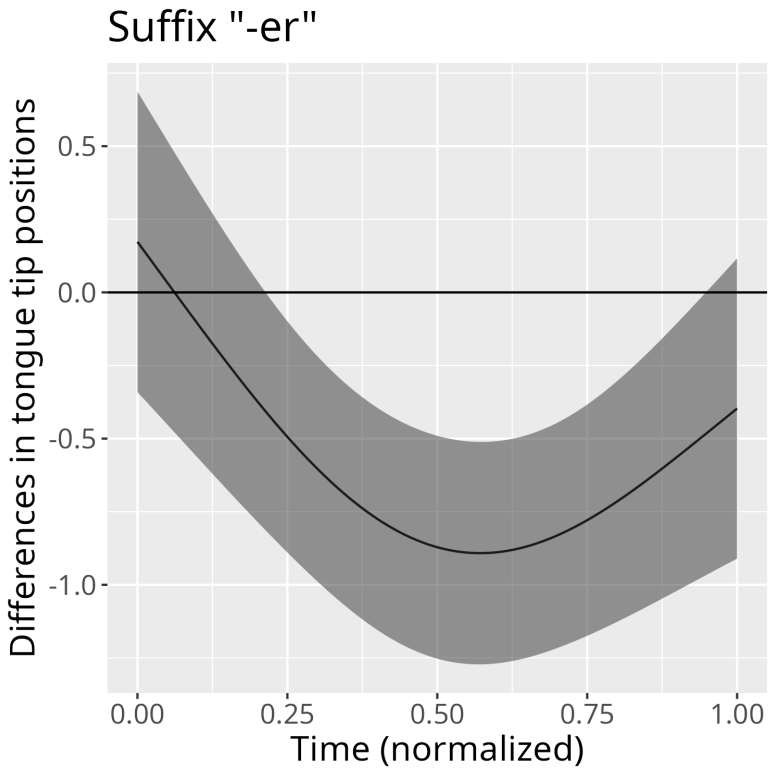

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- Suffixal *-er* has lower tongue positions at the middle of *-er*.

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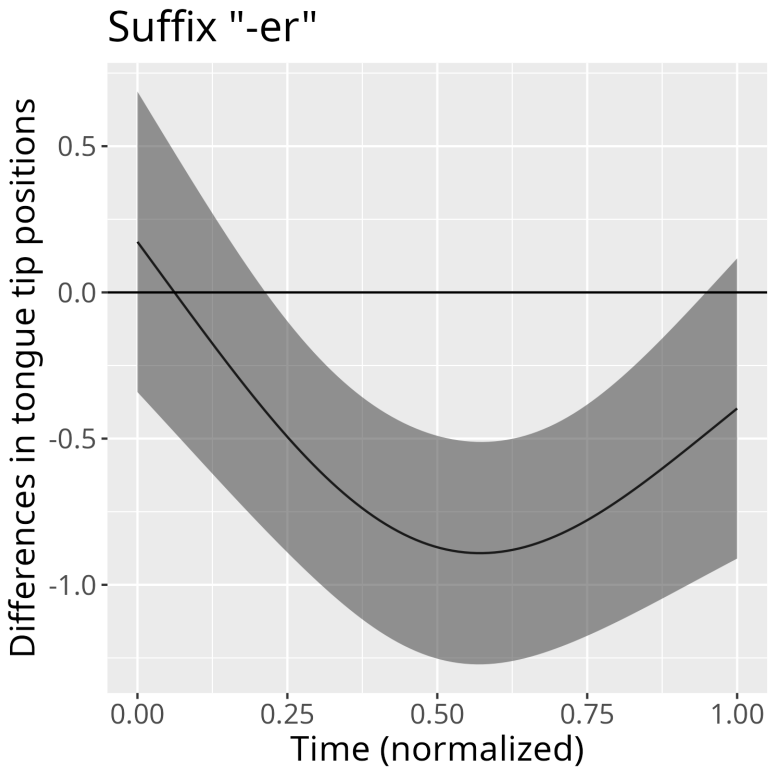

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- Suffixal *-er* has lower tongue positions at the middle of *-er*.
- Clearer realization / Enhancement for suffixal *-er*.

Analyses

- Acoustic analysis
- **Articulatory analysis**
  - *-er*
  - *-t*

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Articulatory analysis (*-t*): Results (Parametric)

(A. Parametric)	β	SE	t	p
Intercept	8.27	0.89	9.29	$<$0.01
Morph=TRUE	0.01	0.05	0.11	0.91
UttInitial=TRUE	0.09	0.06	1.50	0.13
UttFinal=TRUE	-0.12	0.67	-0.19	0.85

Articulatory analysis (*-t*): Results (Parametric)

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Intercept	8.27	0.89	9.29	$<$0.01
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- No mean differences in tongue positions between suffixal and non-suffixal *-t*.

Articulatory analysis (*-t*): Results (Smooth)

(B. Smooth)	edf	Ref.df	*F*	*p*
s(Time)	2.00	2.00	354.71	$<$0.01
s(Time):Morph=TRUE	1.35	1.58	0.48	0.45
s(WordFreq)	1.99	2.00	35.91	$<$0.01
s(PC1)	1.98	2.00	21.89	$<$0.01
s(PrevSeg)	21.32	27.00	1197.37	$<$0.01
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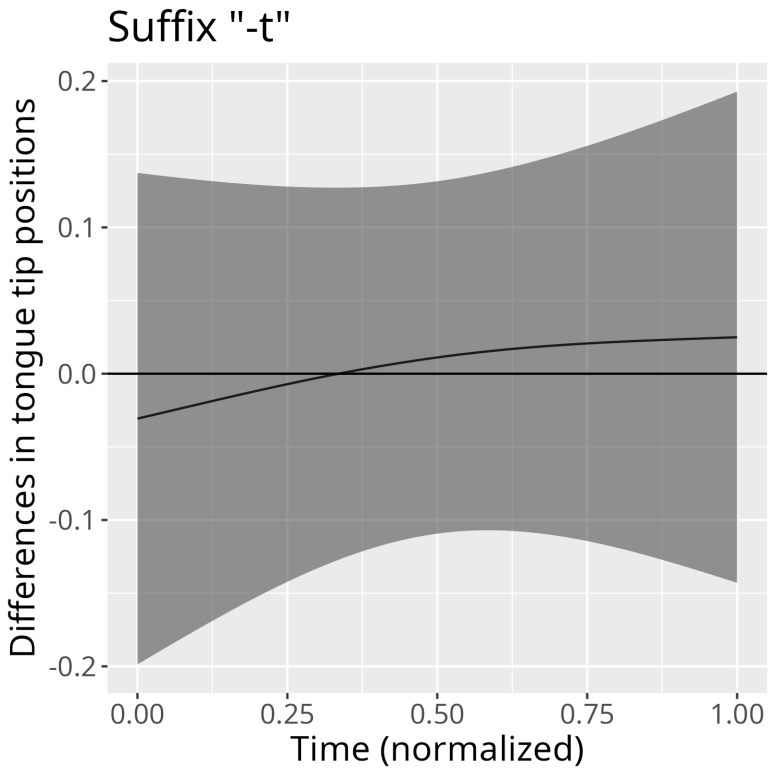
- There is no difference in tongue trajectories between suffixal and non-suffixal *-t*.

Articulatory analysis (*-t*): Estimated effects of Morph



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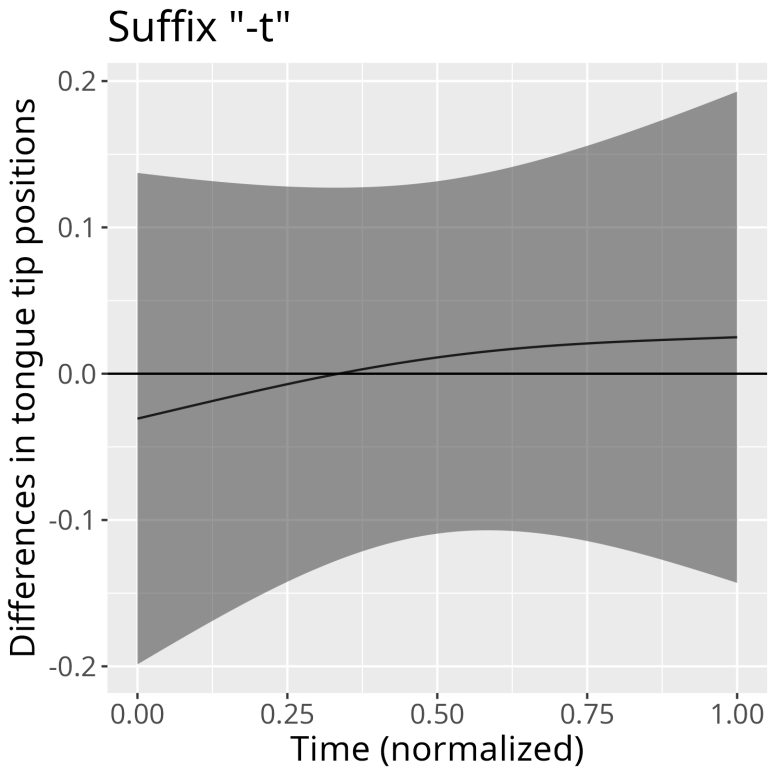

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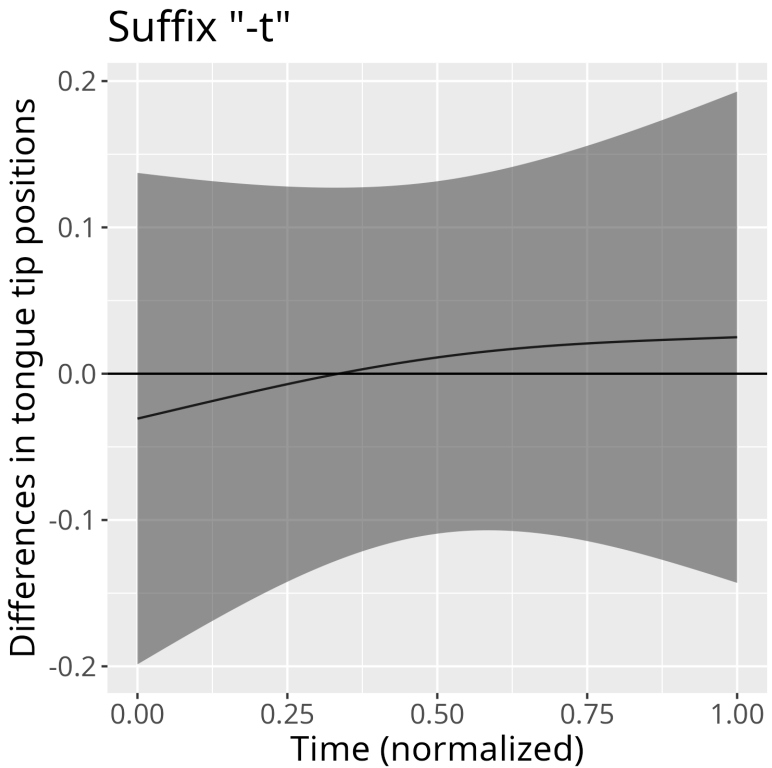

- Confidence intervals containing $y = 0$ $\rightarrow$ No difference between suffixal and non-suffixal *-t*.
- No morphological effects for *-t*.

Summary of the current observations

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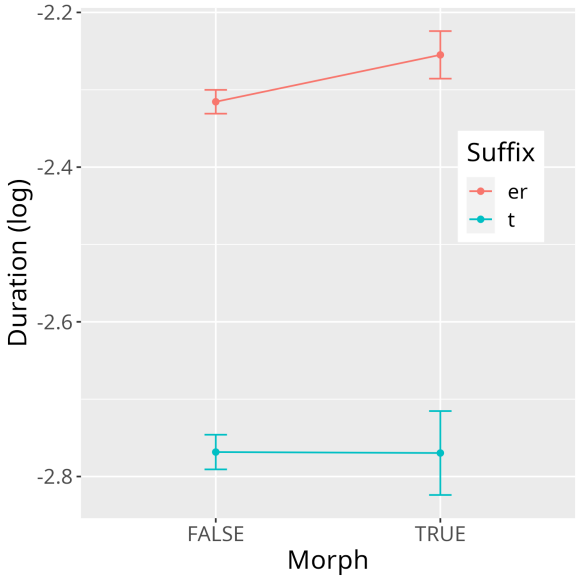
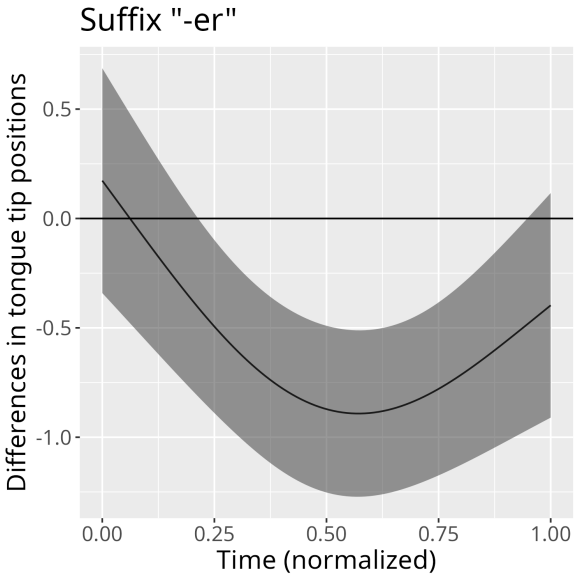
  - → Lower perceptibility [4]
  - → Enhancing *-t* does not contribute to “clearer speech” so much as *-er*.

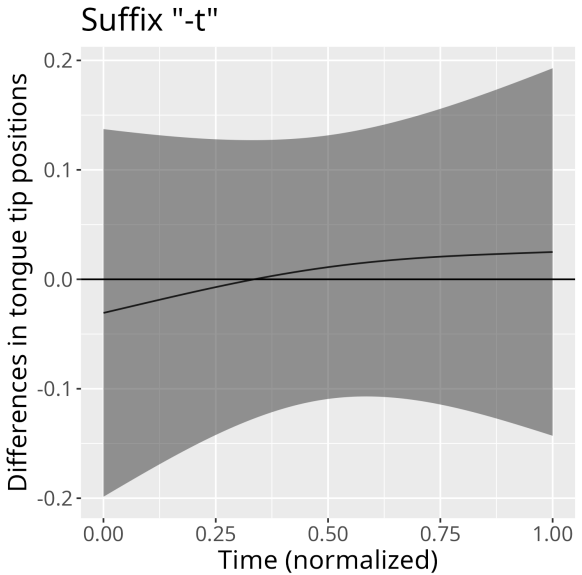
Limitations of the current study

- Only *-t* and *-er* were investigated.
  - In order to generalize the current findings to sonority, more different segments/affixes should be included.

Thanks for listening!







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