

Structure-Dependent Tone Sandhi in Real and Nonce Words in Shanghai Wu

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Why is tone sandhi interesting?



Many Chinese dialects have tone sandhi patterns that pose serious analytical challenges to theoretical phonology.

- Sheer complexity.
- Phonetic arbitrariness.
- Phonological opacity.
- Structure dependency.

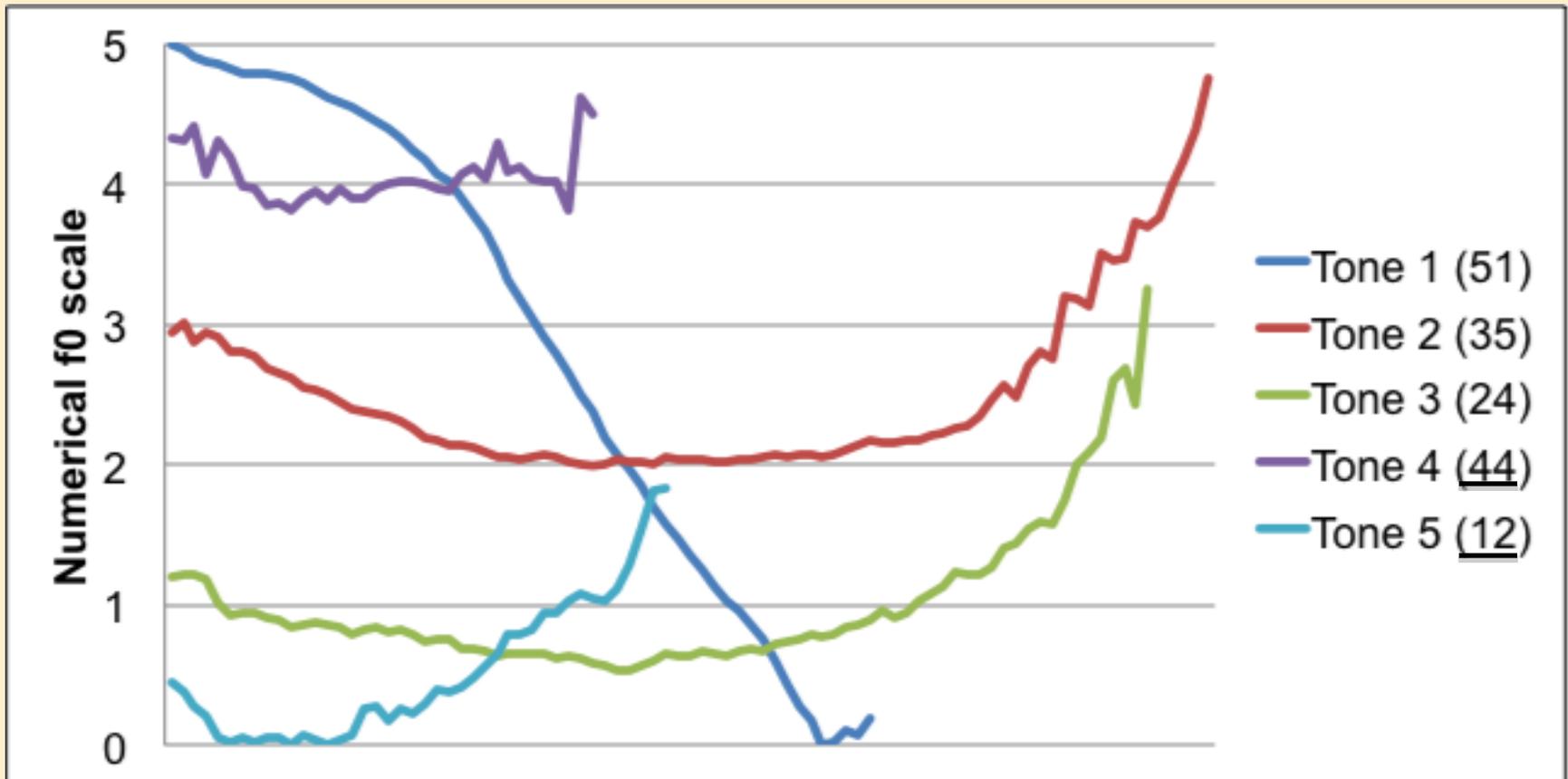
Why is tone sandhi interesting?



Contra traditional descriptions:

- Incomplete neutralization (e.g., Peng 2000).
- Free and lexical variations (e.g., Zhang and Liu 2011a).
- Unproductivity (e.g., Zhang et al. 2011).

Shanghai Wu tones



Shanghai Wu tone sandhi

- **Modifier-Noun:** left-dominant, spreading.

51-X → 55-31

35-X → 33-44

24-X → 22-44

44-X → 33-44

12-X → 11-13

Contour extension

Contour displacement

Shanghai Wu tone sandhi

- **Verb-Noun:** right-dominant, contour leveling, especially if low frequency.

| | | |
|--------------|---|--------------|
| 51-X | → | 44-X |
| 35-X | → | 44-X |
| 24-X | → | 33-X |
| <u>44</u> -X | → | <u>44</u> -X |
| <u>12</u> -X | → | <u>22</u> -X |

(Zee and Maddieson 1980, Xu and Tang 1997, Zhu 1999, 2006, etc.)

Research questions



- Are the sandhis truly neutralizing?
- Are Shanghai speakers sensitive to structure-dependency of tone sandhi when “wug”-tested?
- Are the sandhis productive in nonce words?
- Are there productivity differences among different tonal combinations?

Experiment 1: Real words



- Structures:
Modifier-Noun (M-N)
Verb-Noun (V-N)
- Speakers hear two syllables in base tones separated by 800ms and see Chinese characters on computer screen as the syllables play, then pronounce disyllabic word.

Experiment 2: Nonce words

- σ_1 = accidental gap syllable
 σ_2 = real noun
- Structures: M-N, V-N
- Same σ_1 cues either a modifier or verb definition, given both aurally and in written form.
- E.g., *mang*, M-N structure:
“If there is a color called *mang*, and there is a flower with this color *mang*, then we can call this flower a ___.”

Experiment 2: Nonce words

- E.g., *mang*, V-N structure:

“If to buy merchandize on line is called *mang*; if flowers have not been *manged*, then we can also say that we have not ____.”

- Nonce syllable provided in base tone twice.
- Each speaker sees only one version.

Results — overview



From 48 speakers:

- Neutralization
- Structure sensitivity
- Productivity

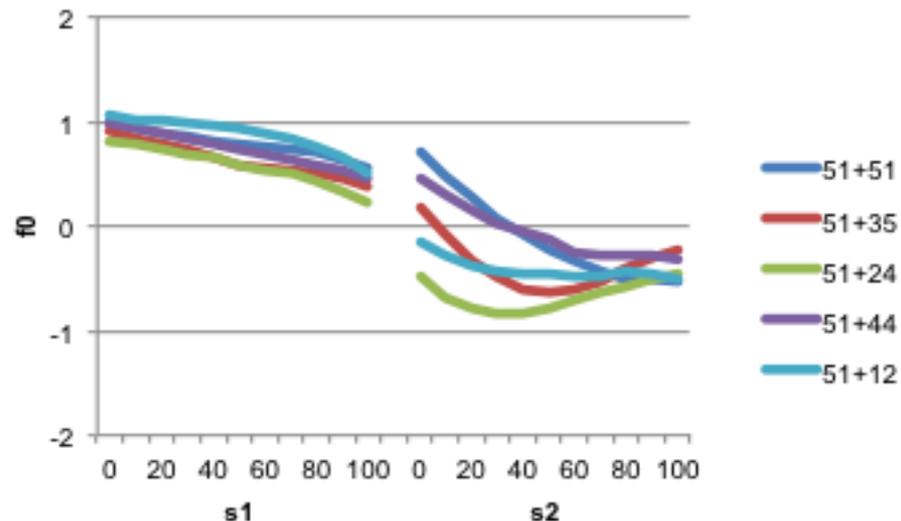
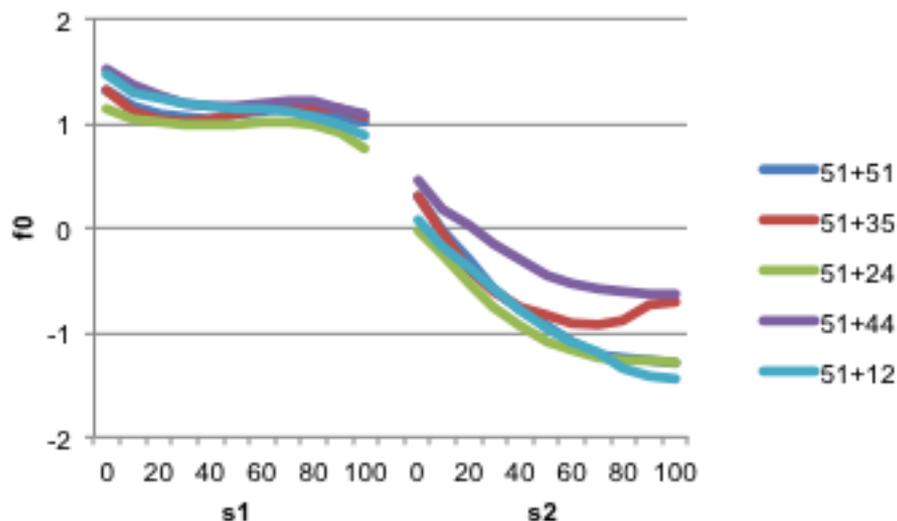
Results — neutralization

Modifier-Noun (**left-dominant**) sandhi:

Real words

Nonce words

- **51-X** → **55-31**:



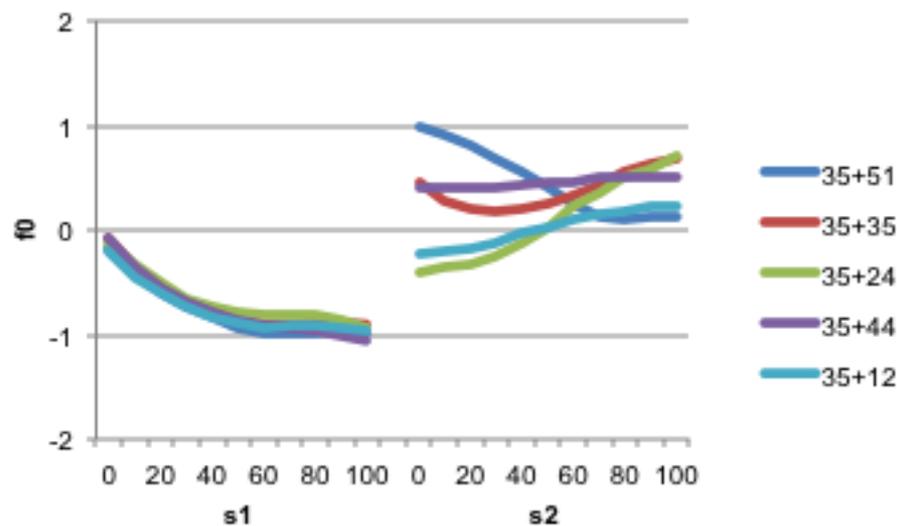
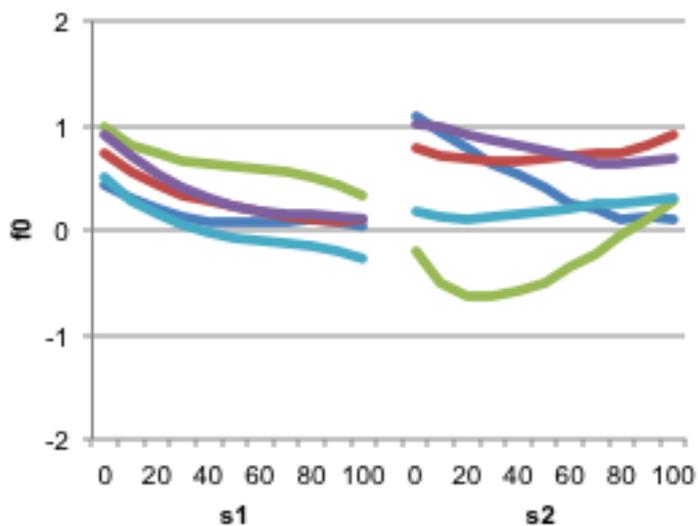
Results — neutralization

Modifier-Noun (**left-dominant**) sandhi:

Real words

Nonce words

- **35-X** → **33-44**:



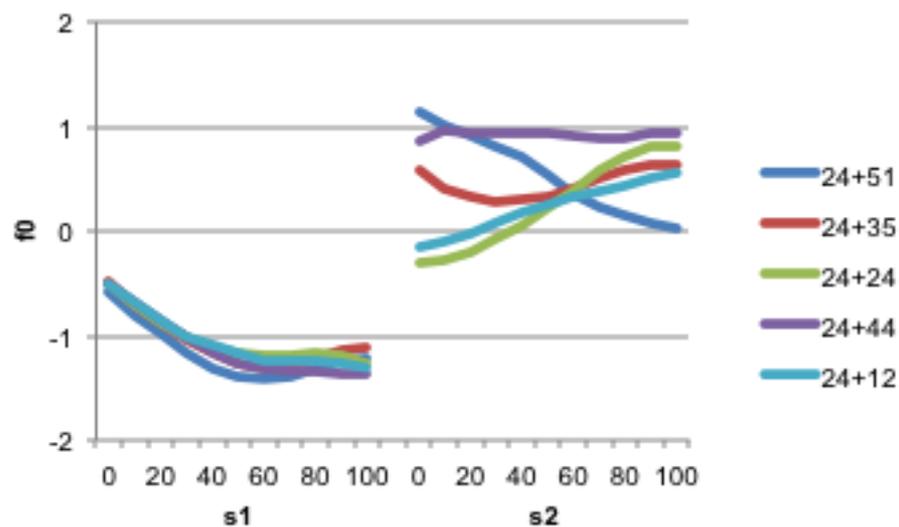
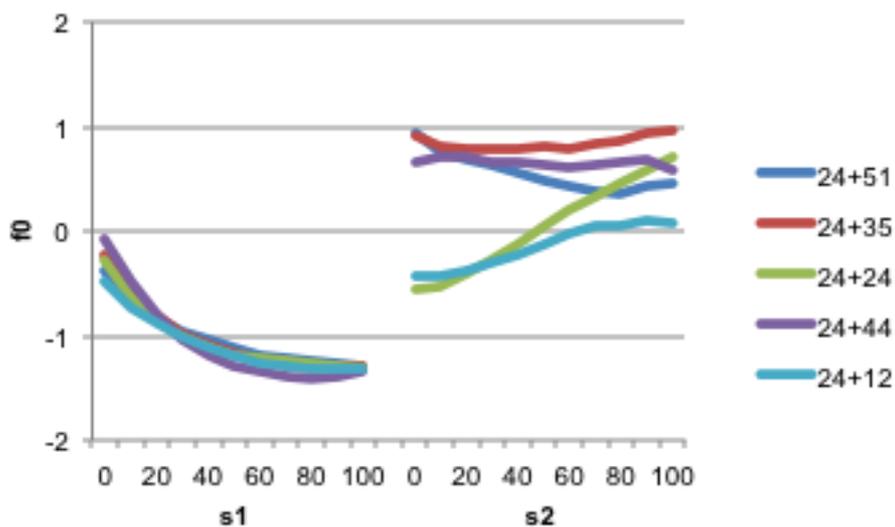
Results — neutralization

Modifier-Noun (**left-dominant**) sandhi:

Real words

Nonce words

- **24-X** → **22-44**:



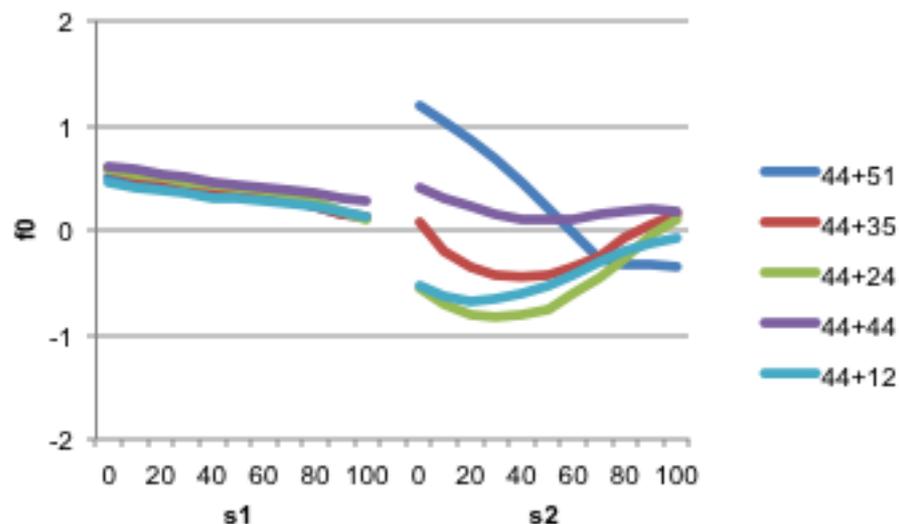
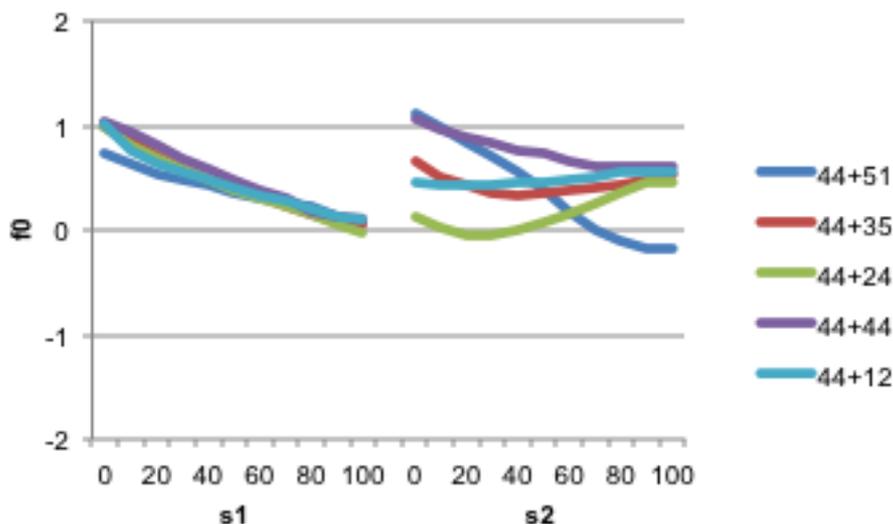
Results — neutralization

Modifier-Noun (**left-dominant**) sandhi:

Real words

Nonce words

- 44-X → 33-44:



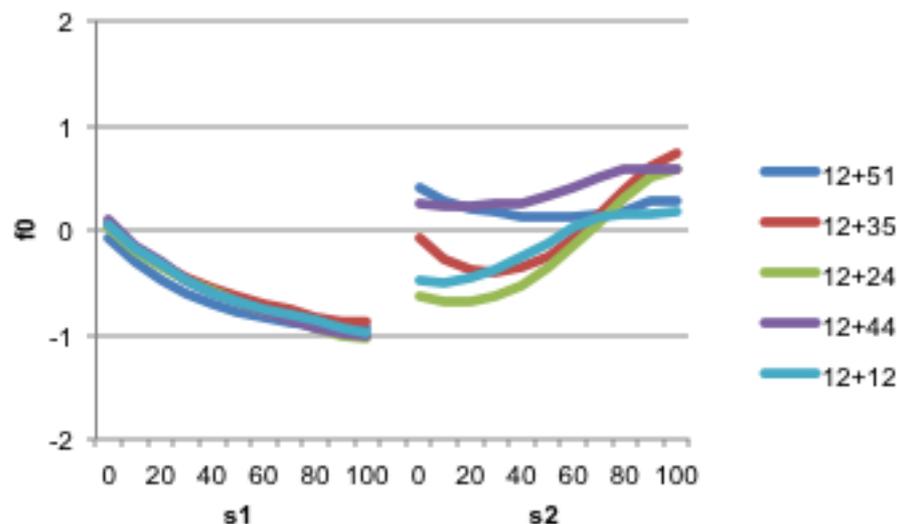
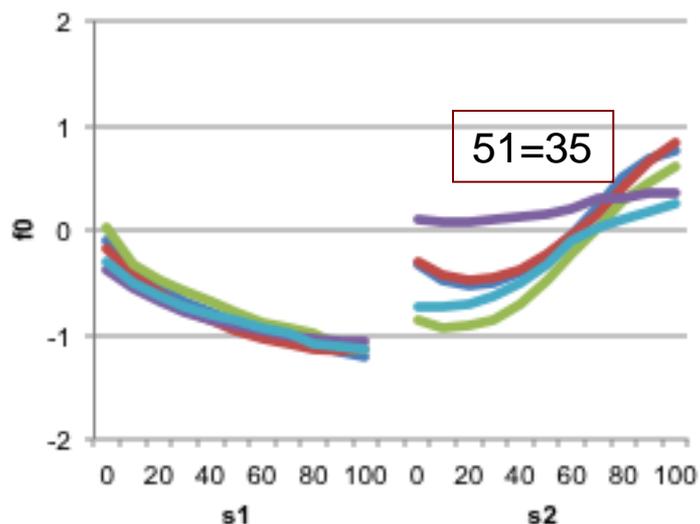
Results — neutralization

Modifier-Noun (**left-dominant**) sandhi:

Real words

Nonce words

- 12-X → 11-13:



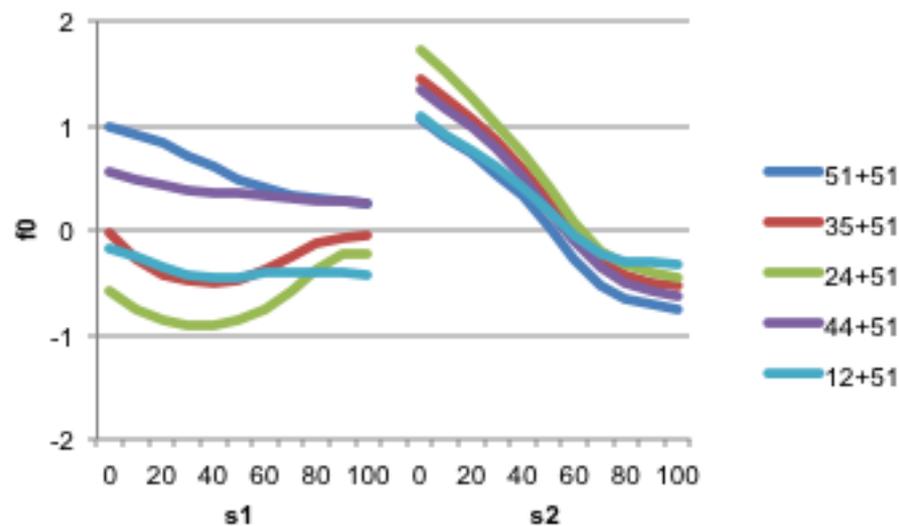
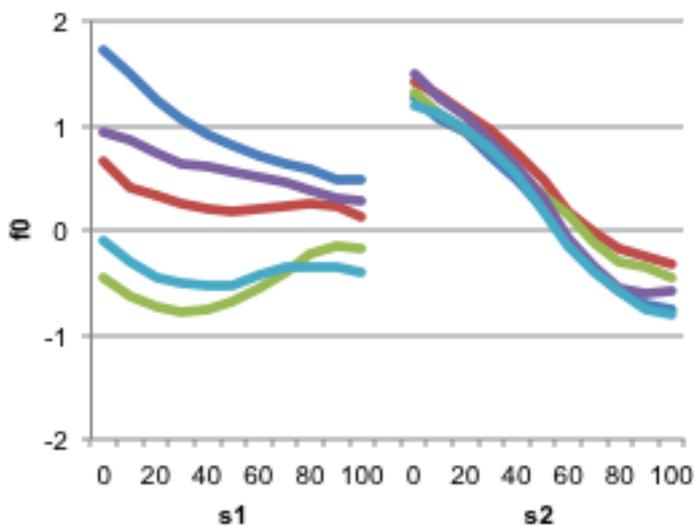
Results — neutralization

Verb-Noun (**right-dominant**) sandhi:

Real words

Nonce words

- **X-51** → **Y-51**:



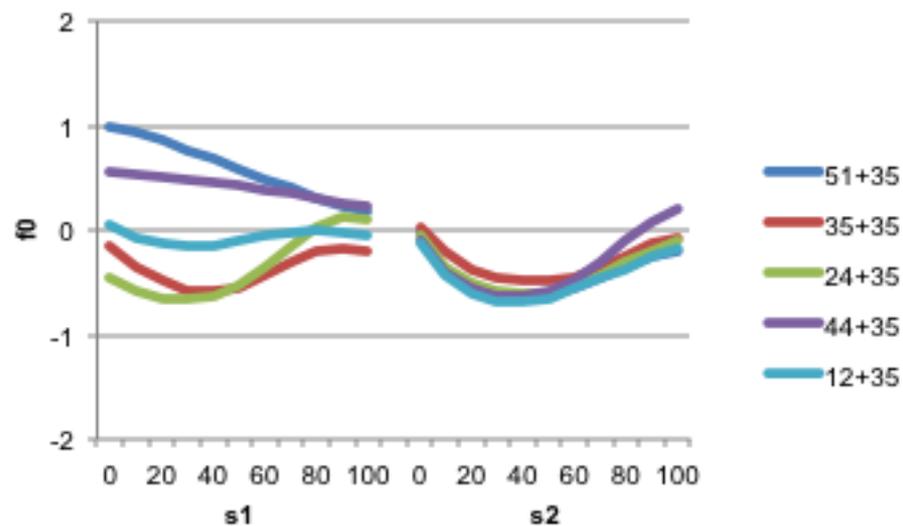
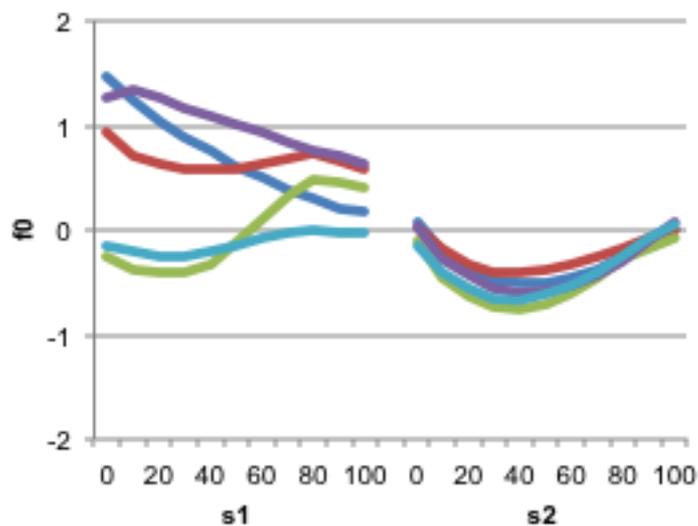
Results — neutralization

Verb-Noun (**right-dominant**) sandhi:

Real words

Nonce words

- **X-35** → **Y-35**:



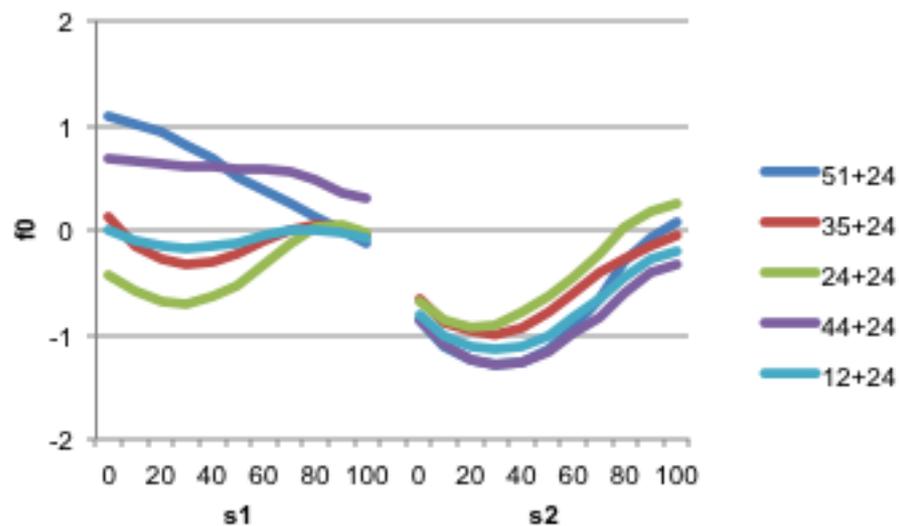
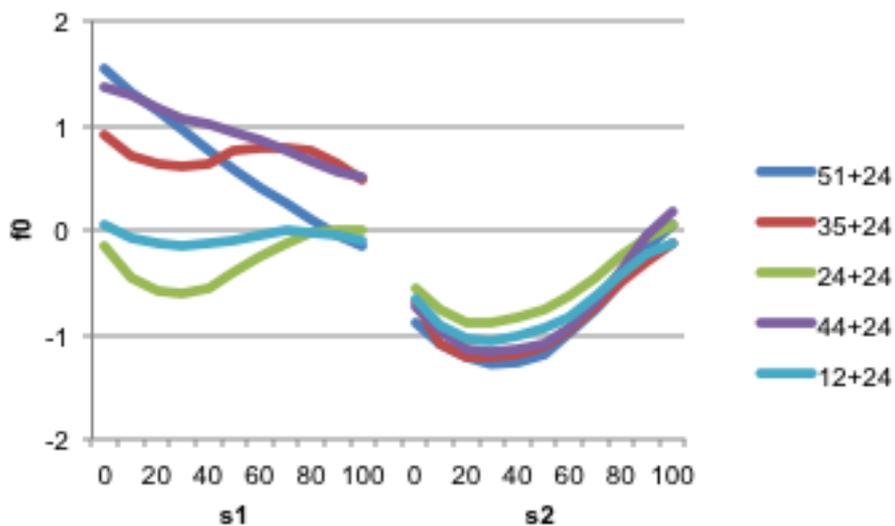
Results — neutralization

Verb-Noun (**right-dominant**) sandhi:

Real words

Nonce words

- **X-24** → **Y-24**:



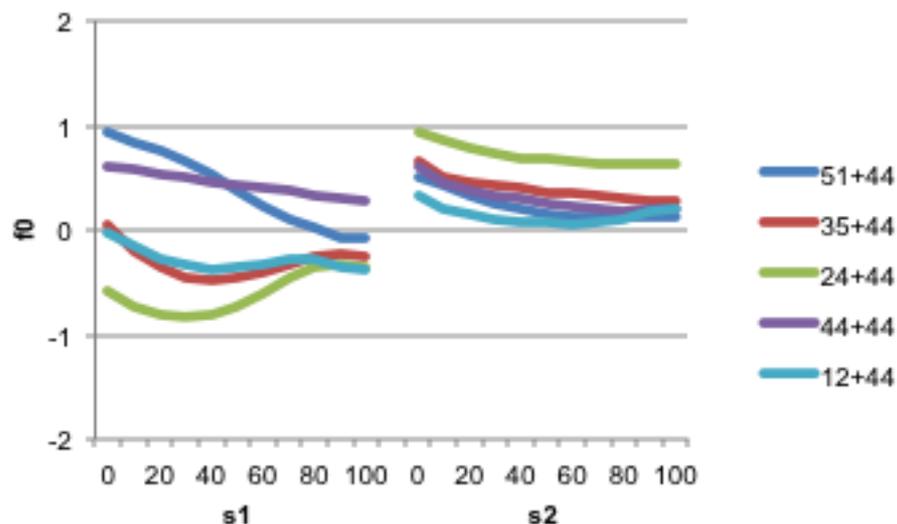
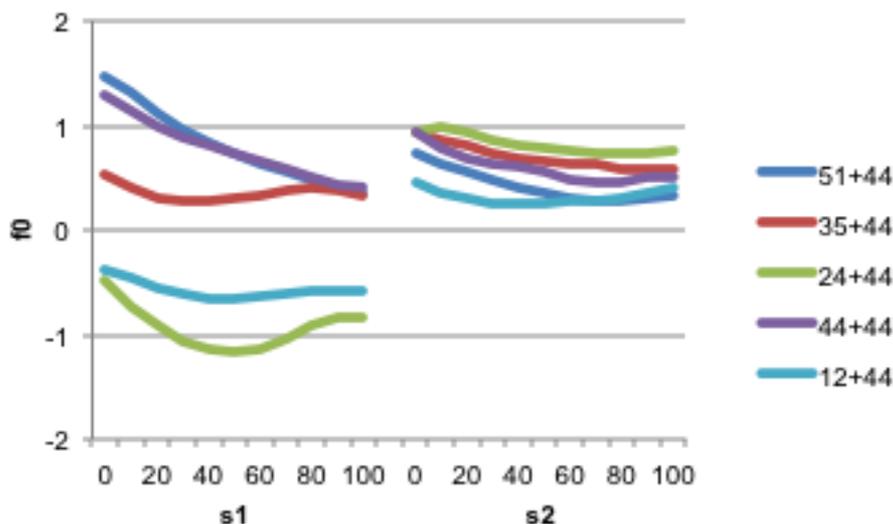
Results — neutralization

Verb-Noun (**right-dominant**) sandhi:

Real words

Nonce words

- **X-44** → **Y-44**:



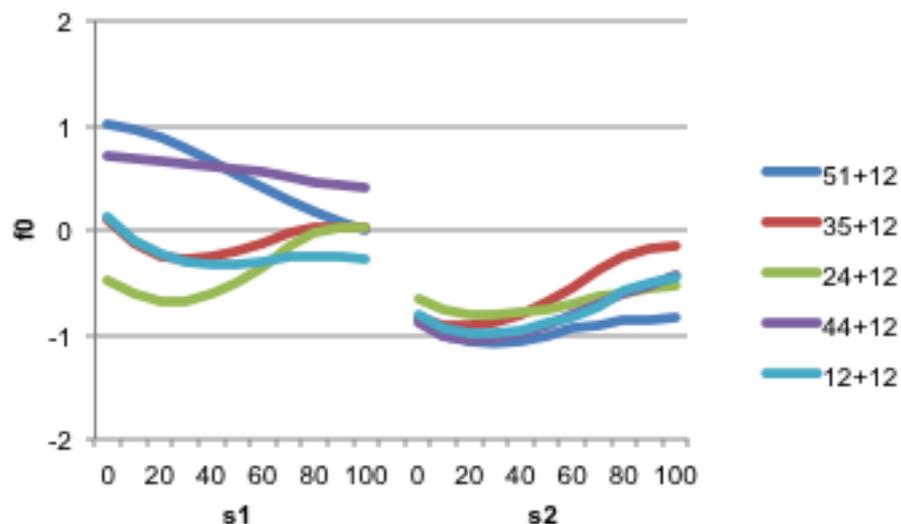
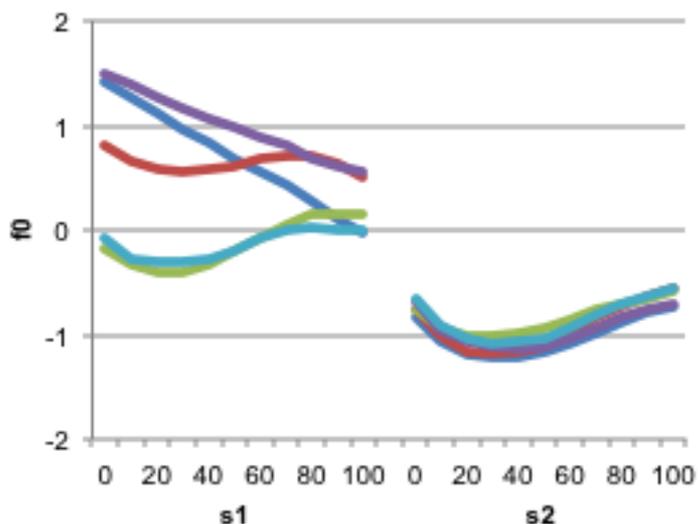
Results — neutralization

Verb-Noun (**right-dominant**) sandhi:

Real words

Nonce words

- **X-12** → **Y-12**:



Interim summary I



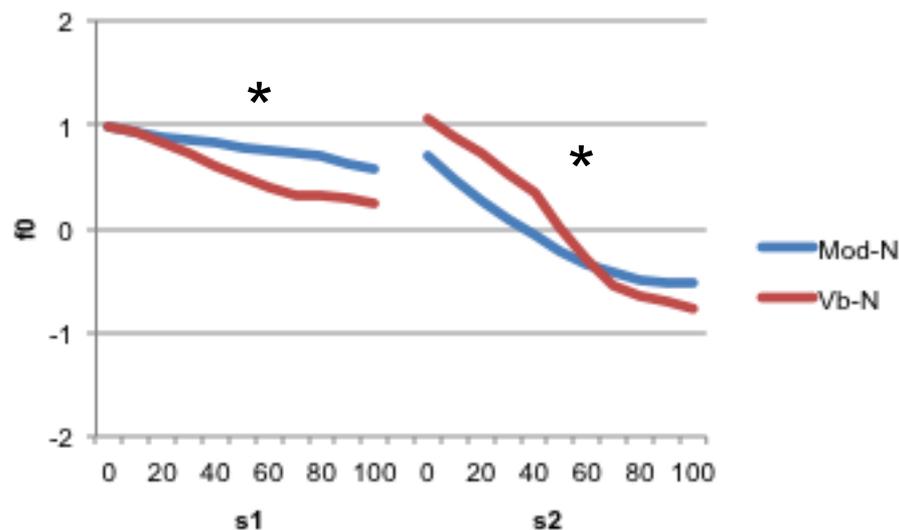
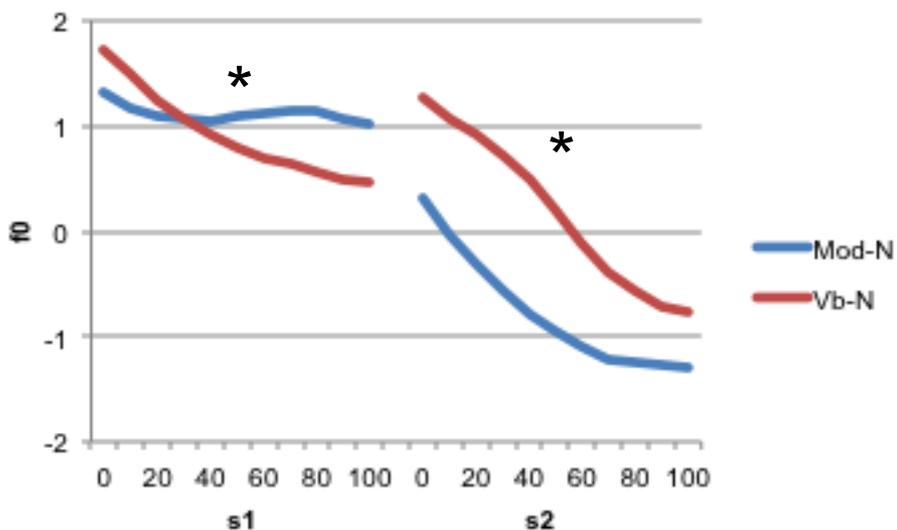
- Left-dominant sandhi is not truly neutralizing in either real or nonce words.
- Right-dominant sandhi shows less pronounced contours on σ_1 , but height and direction of contours are largely maintained, indicating that the sandhi likely results from phonetic contour reduction.

Results — structure sensitivity

Real words

Nonce words

- 51-51 → **55-31** (Mod-N); 44-**51** (Vb-N):

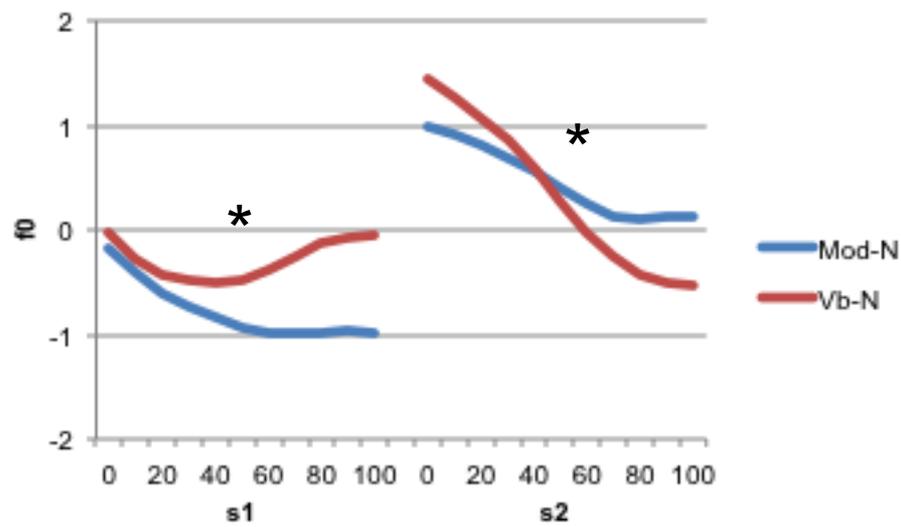
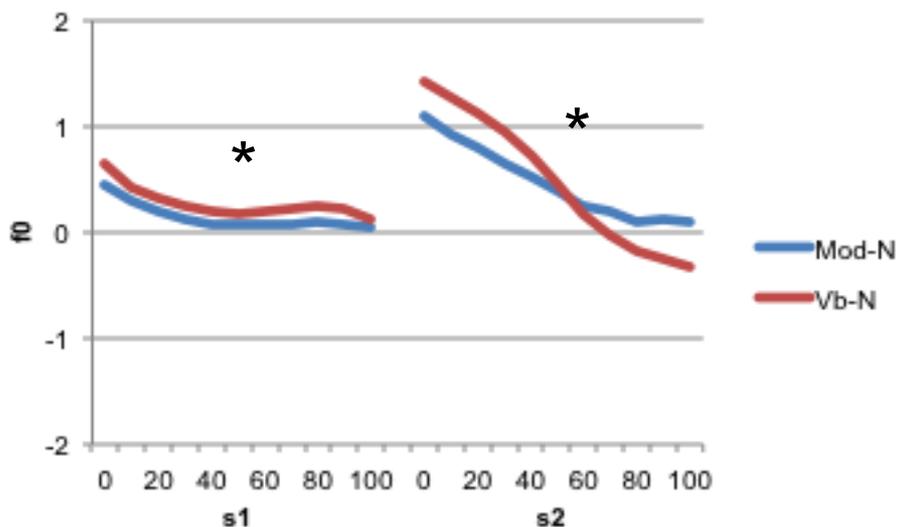


Results — structure sensitivity

Real words

Nonce words

- 35-51 → 33-44 (Mod-N); 44-51 (Vb-N):

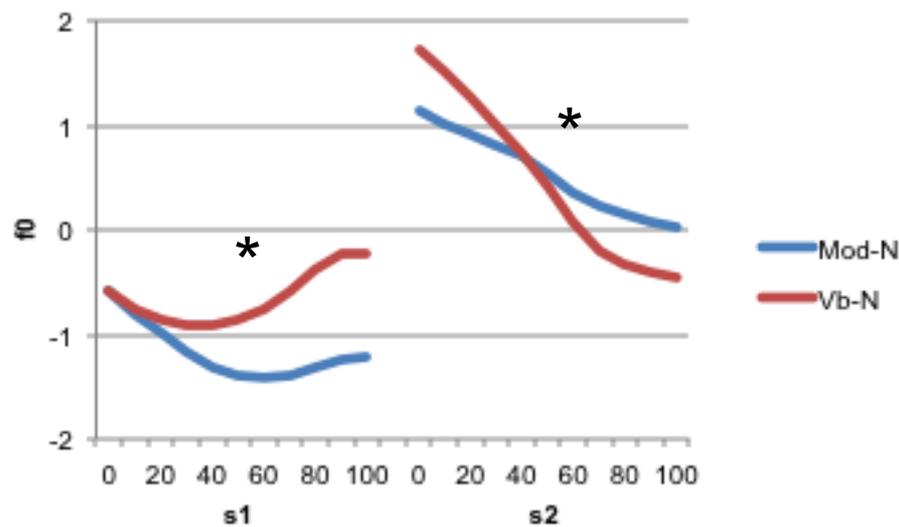
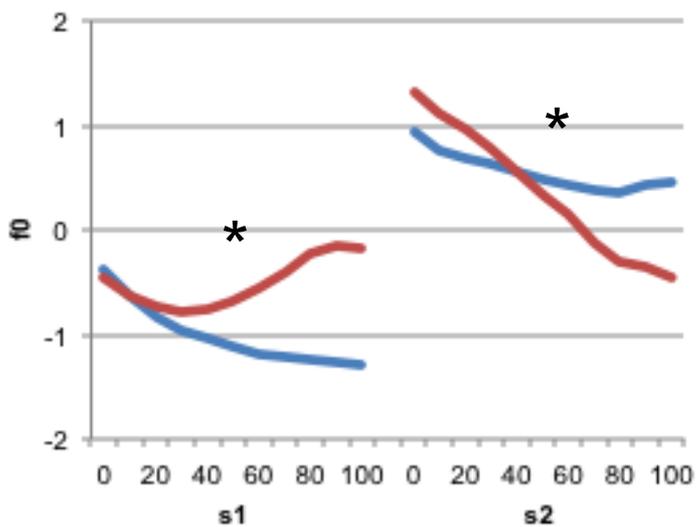


Results — structure sensitivity

Real words

Nonce words

- 24-51 → **22-44** (Mod-N); **33-51** (Vb-N):

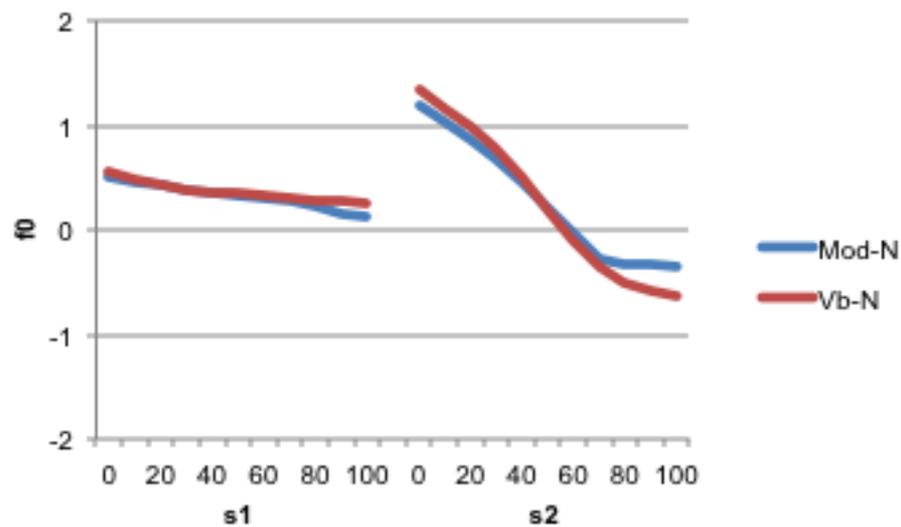
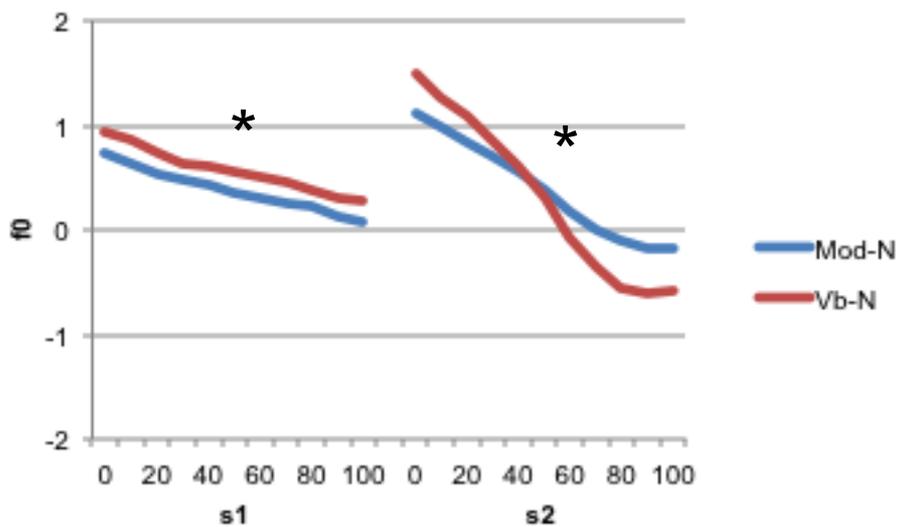


Results — structure sensitivity

Real words

Nonce words

- 44-51 → 33-44 (Mod-N); 44-51 (Vb-N):

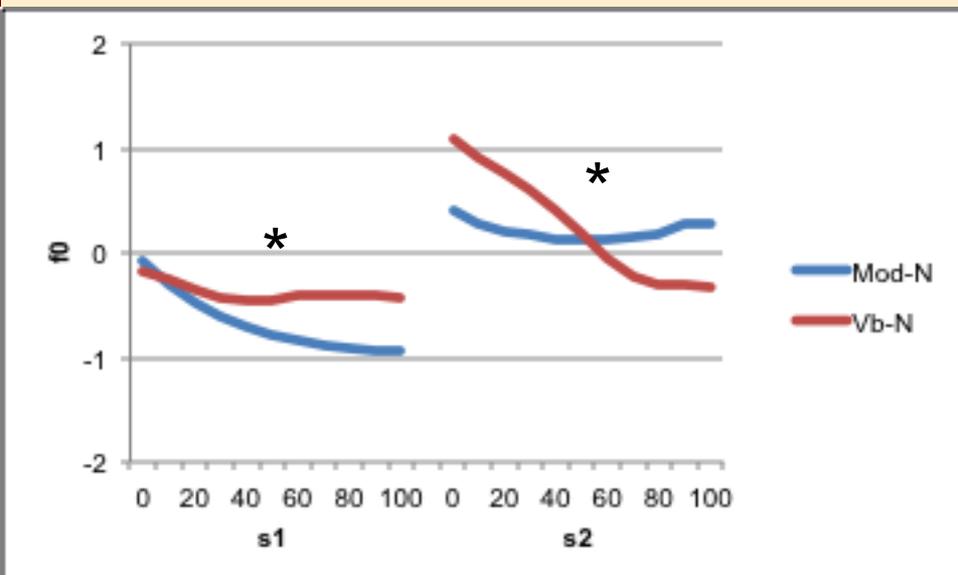
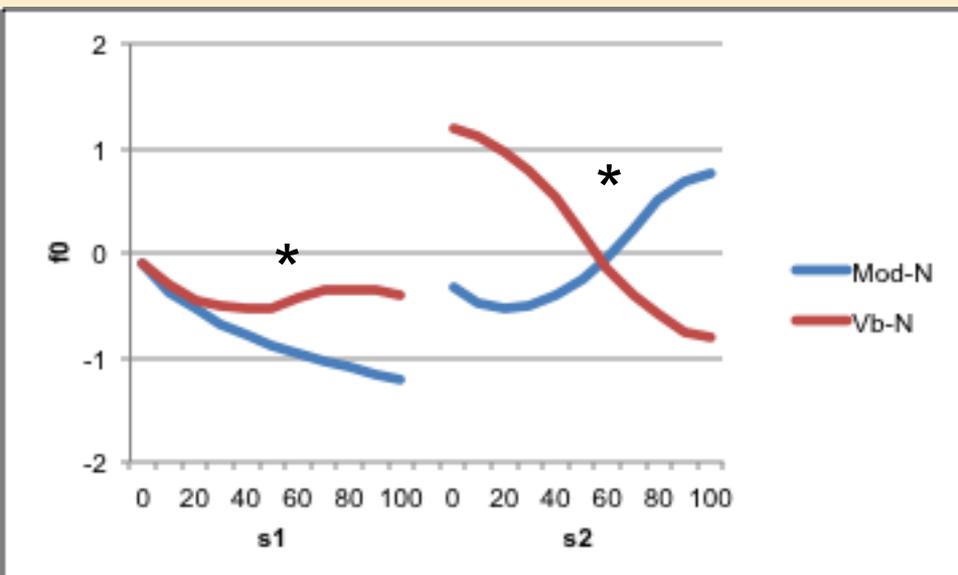


Results — structure sensitivity

Real words

Nonce words

- 12-51 → 11-13 (Mod-N); 22-51 (Vb-N):

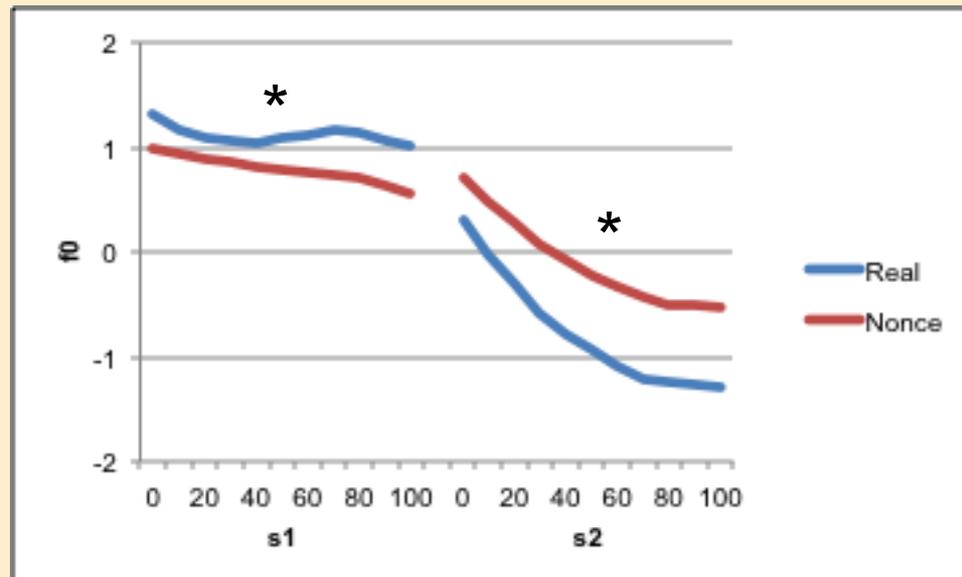


Interim summary II

- Speakers are sensitive to structure-dependency of tone sandhi.
- But structure-induced differences are attenuated in nonce words for some of the tonal combinations (51-51, 44-51, 12-51).
- Due to lack of complete productivity for left-dominant sandhi in nonce words?

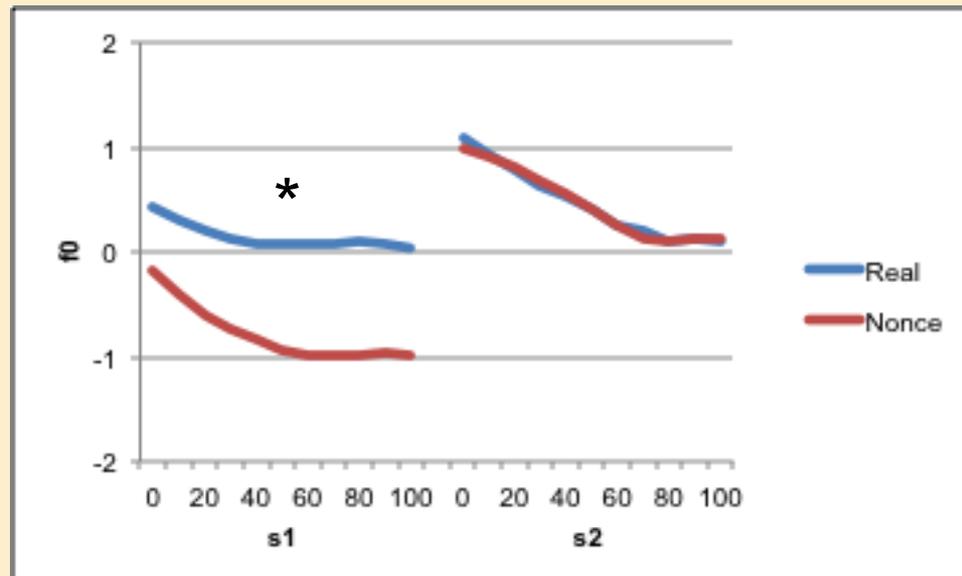
Results — Productivity of left-dominant sandhi

- **51-51 → 55-31:**



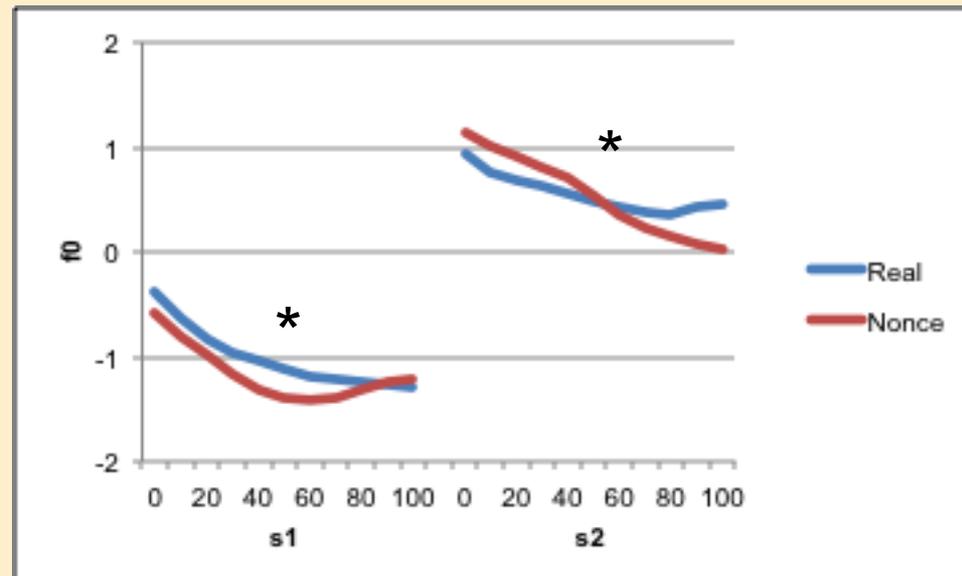
Results — Productivity of left-dominant sandhi

- **35-51 → 33-44:**



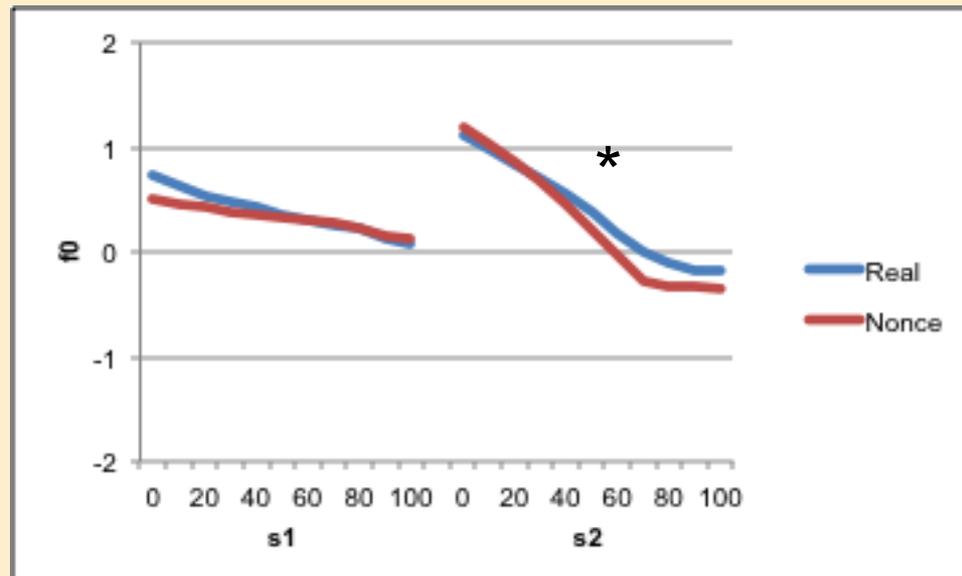
Results — Productivity of left-dominant sandhi

- **24-51 → 22-44:**



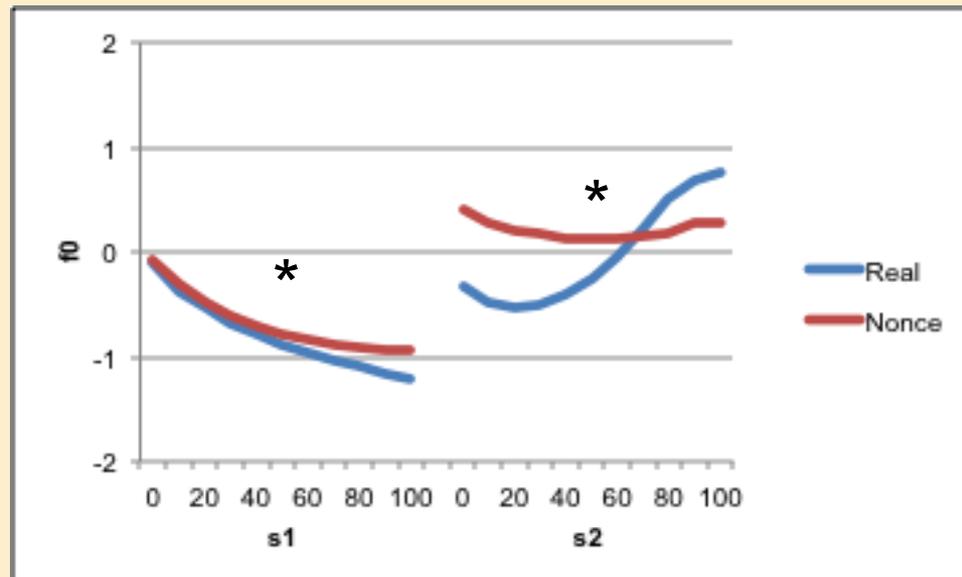
Results — Productivity of left-dominant sandhi

- 44-51 → 33-44:



Results — Productivity of left-dominant sandhi

- 12-51 → 11-13:



Interim summary III



- Left-dominant contour displacement is unproductive and likely mislearned as contour extension.
- Other left-dominant sandhis also not fully productive.

Conclusion



- Neither left-dominant nor right-dominant sandhi in Shanghai causes complete neutralization of disyllabic combinations.
- Shanghai speakers are sensitive to structure-dependency of tone sandhi in nonce words, but only gradiently so.
- Some left-dominant patterns are not fully productive, especially contour displacement.

Conclusion



- Tone sandhi grammar of Shanghai needs to be quantitative and flexible enough to capture the structure dependency, incomplete neutralization, and selective underlearning in the patterns.
- Discovery of tonal grammars is still difficult, but difficult in a different way from what we originally thought!

Acknowledgments



- Thanks to Department of Chinese Language and Literature at Fudan University for hosting us during data collection, especially Qi Haifeng, You Rujie, and Yuan Dan.
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Methodology



- Both experiments preceded by introduction in Shanghai and practice.
- Implemented in Paradigm[®]. (www.paradigmexperiments.com/)
- 48 speakers (20 M, 28 F) from urban areas of Shanghai; mean age 24.6. Tested in Shanghai.

Methodology

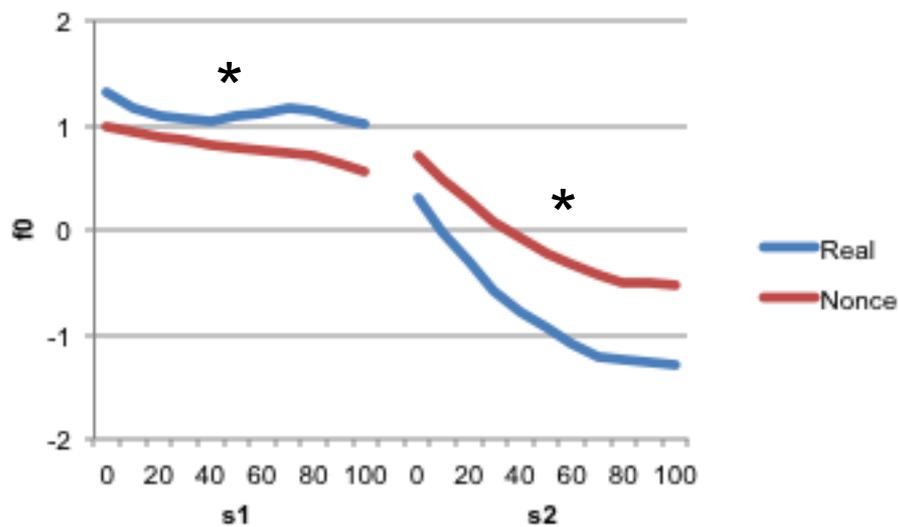


- f_0 of every 10% of target syllables measured using *ProsodyPro* (Xu 2005-2011) in Praat; results hand checked for each speaker.
- Statistical results obtained using Linear Mixed-Effects models with Speaker as random effect and Word-Type, Structure, Data-Point-in-Syllable as fixed effects.

Results — Productivity

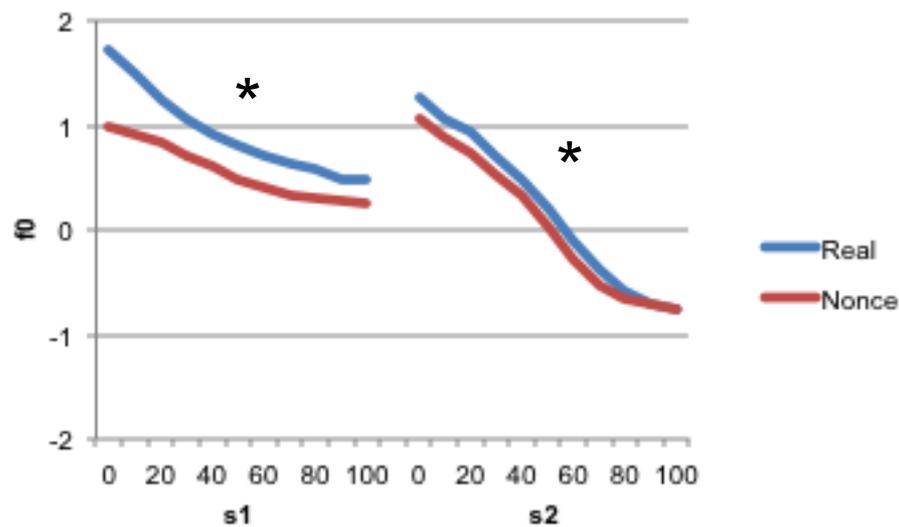
M-N structure

- **51-51** → **55-31**:



V-N structure

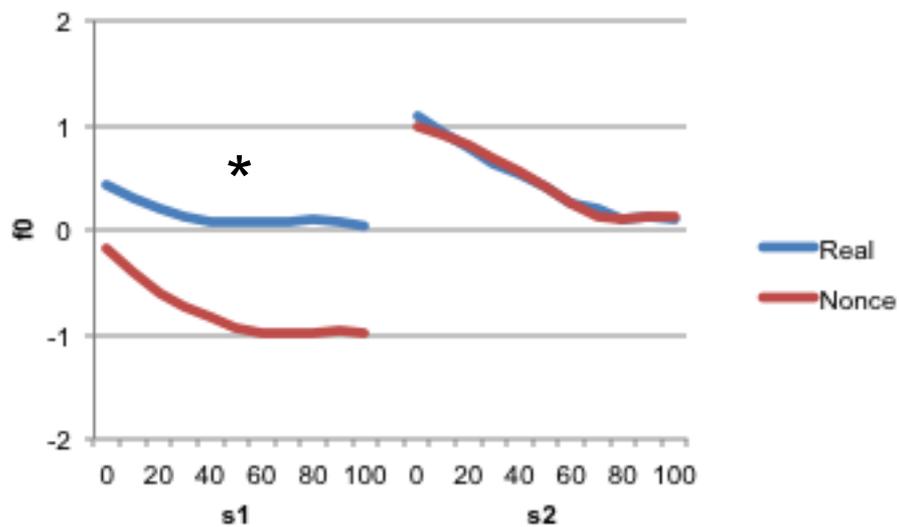
- **51-51** → **44-51**:



Results — Productivity

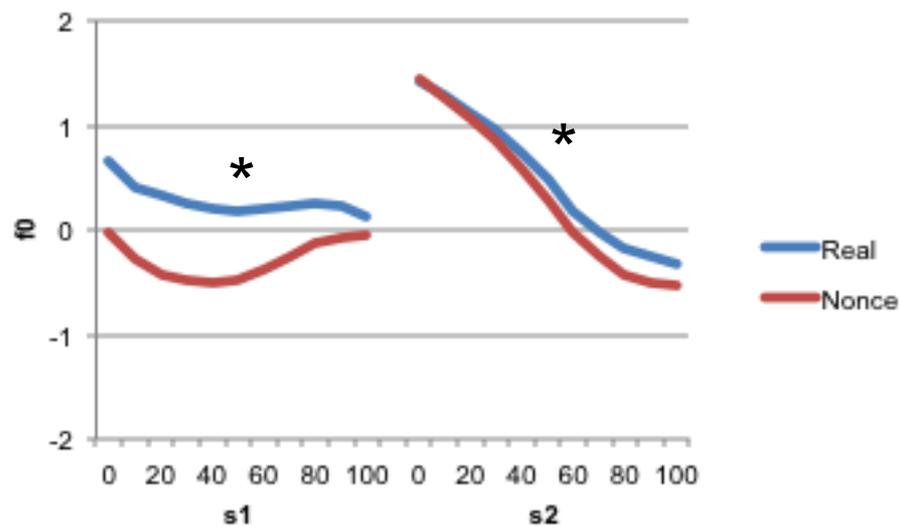
M-N structure

- **35-51** → **33-44**:



V-N structure

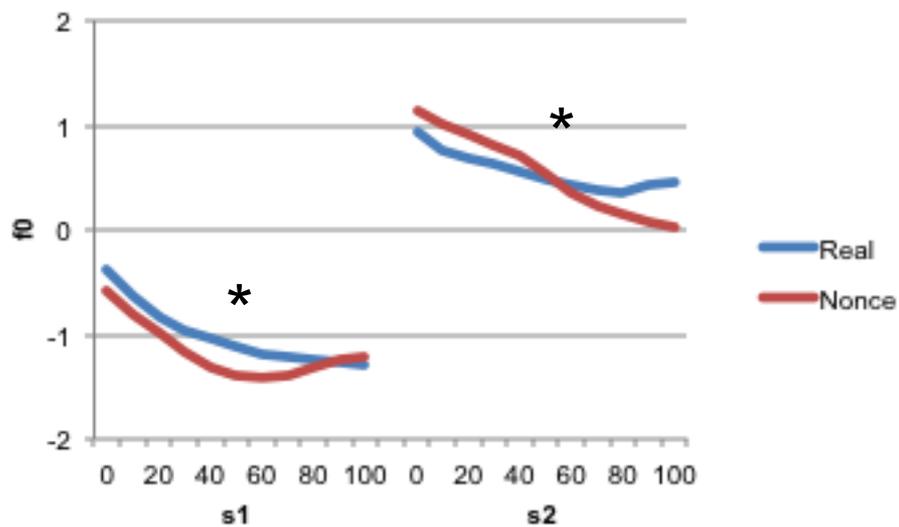
- **35-51** → **44-51**:



Results — Productivity

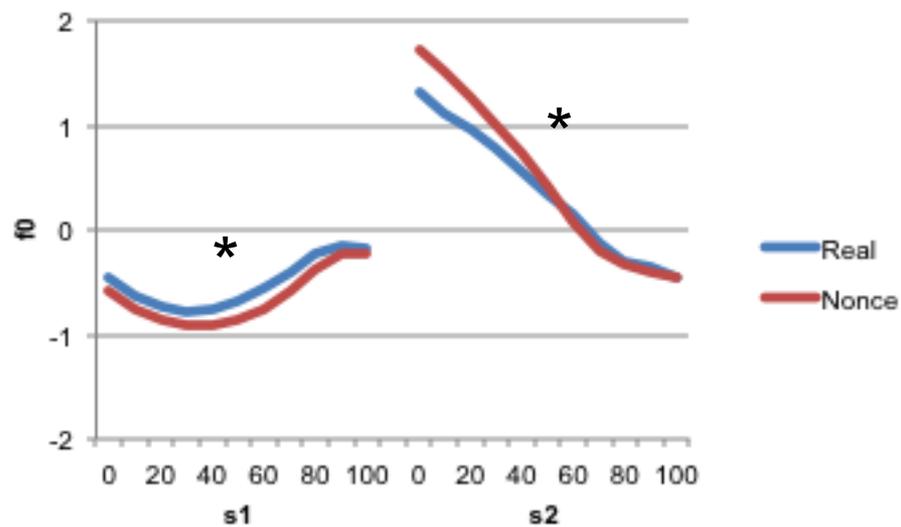
M-N structure

- 24-51 → 22-44:



V-N structure

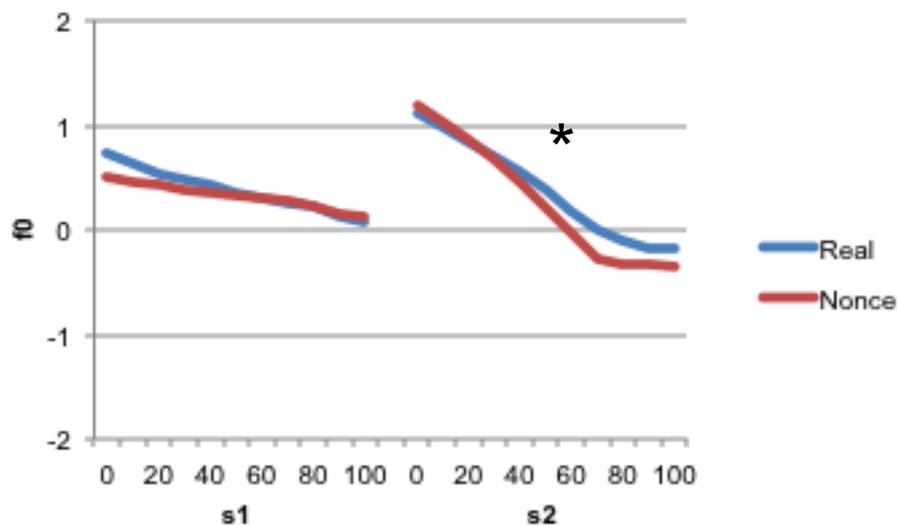
- 24-51 → 33-51:



Results — Productivity

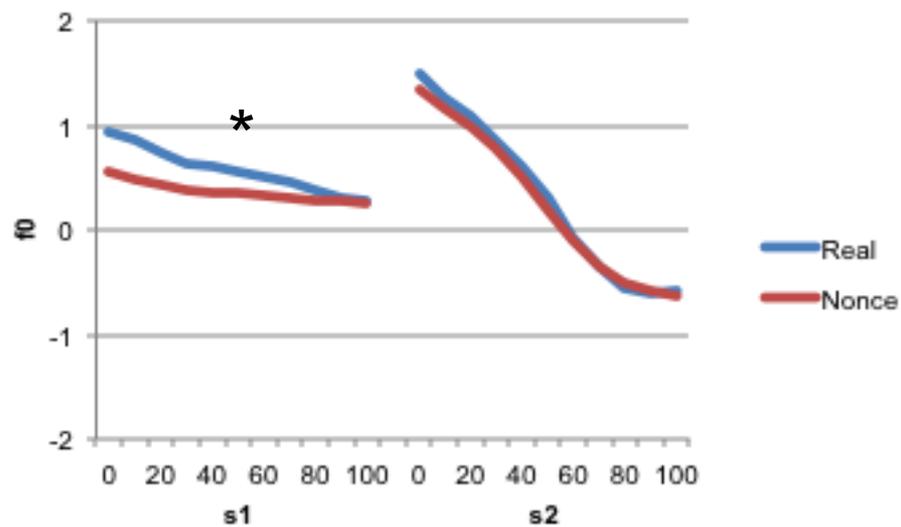
M-N structure

- 44-51 → 33-44:



V-N structure

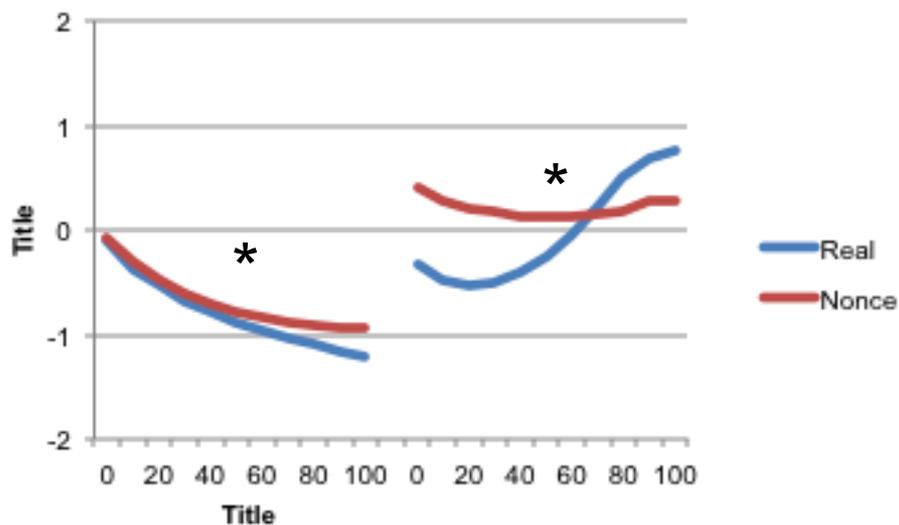
- 44-51 → 44-51:



Results — Productivity

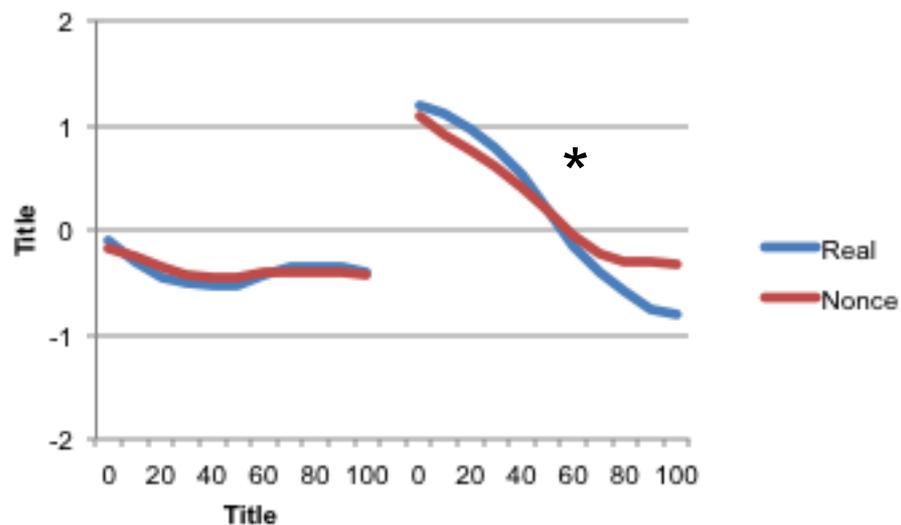
M-N structure

- 12-51 → 11-13:



V-N structure

- 12-51 → 22-51:



Discussion



Gradience in the data:

- Non-neutralizing tone sandhi in real words.
- Gradient productivity of structure-dependency of tone sandhi: structure-induced differences attenuated in nonce words.
- Attenuation caused by lack of full productivity of left-dominant sandhi (gradient underlearning) and possibly application of left-dominant sandhi to real V-N words.

Discussion



Nature of the gradient:

- Are the gradient differences result of phonetically gradient application of sandhi or lexical variation?
- Incomplete neutralization: most likely gradient production (Peng 2000, Xu 2003, etc.).
- Underlearning:
 - (a) Gradient production: Mandarin Chinese (Zhang and Lai 2010).
 - (b) Lexical variation: Taiwanese (Zhang et al. 2011).
 - (c) Combination of (a) and (b): Tianjin Chinese (Zhang and Liu 2011b).

Discussion



Nature of the gradience:

- Indications that gradient productivity is a combination of gradient production and lexical variation: classifying whether the left-dominant sandhi, right-dominant sandhi, or no sandhi has applied is a difficult task; some cases are clear, some blurry.

Discussion

Why are some sandhis more productive than others?

- Contour displacement (12-X → 11-13) is quite unproductive and speakers applied contour extension in nonce words.
- Not due to greater sandhi variability in the lexicon for 12-X combinations: 11-13 is consistently the sandhi form, while all contour extension cases have considerably more variations.
- Phonetic nature of the sandhi — mismatch between phonological stress and phonetic prominence, dissimilarity of base and sandhi contours, dispreference for pronounced rise?

Discussion



What does this all mean to the theoretical analysis of tone sandhi?

- Rushing into an analysis before testing the pattern experimentally is not a good idea: impressionistic descriptions have limitations, and speakers' knowledge may differ from lexical patterns.
- Differences in speakers' knowledge and lexical patterns are informative of the nature of phonological grammar (e.g., Hayes et al. 2009, Becker et al. 2011, Zhang et al. 2011).

Discussion



What does this all mean to the theoretical analysis of tone sandhi?

- Gradience and variation abound in tone sandhi patterns. A tonal grammar needs to be sufficiently quantitative and flexible to accurately reflect the patterns of gradience and variation.
- Discovery of tonal grammars is still difficult, but difficult in a different way from what we originally thought.