Relations between speech rhythm and segmental deletion

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Questions

- ***Does the rhythm (periodicity) of speech influence the likelihood of segmental deletion?***

- **Rhythm is not speech rate—*how do we measure it?***

Background

- **Cross-linguistic approaches to speech rhythm:**
  - **syllable vs. stress-timing: relative isochrony of interval durations (Pike 1945; Abercrombie 1965)**
  - **failure to find evidence for syllable or stress-timing, as well as cross-linguistic differences in syllable/foot isochrony (Bolinger 1965; Lehiste 1977; Dauer 1983)**
  - **Ramus et. al. (1999): ratios and variabilities of consonantal and vocalic interval durations; capture the distinction between syllable-timed and stress-timed languages**
  - **in syllable-timed languages, less deletion, less vowel-reduction, and simpler syllable structure, than in stress-timed languages (cf. Dauer 1983).**

- **Commonalities of interval-based approaches**
  - **measure rhythmic properties with durations of intervals (between syllables, stressed syllables, moras, sequences of C and V, etc.)**
  - **interval endpoints are defined by pre-conceived units: C, V, μ, σ, Ft**
  - **units are conceptualized as "containers"—size (duration) of container represents the container and the contents are either ignored or highly abstracted.**
  - **in the speech signal, intervals not so well-defined**

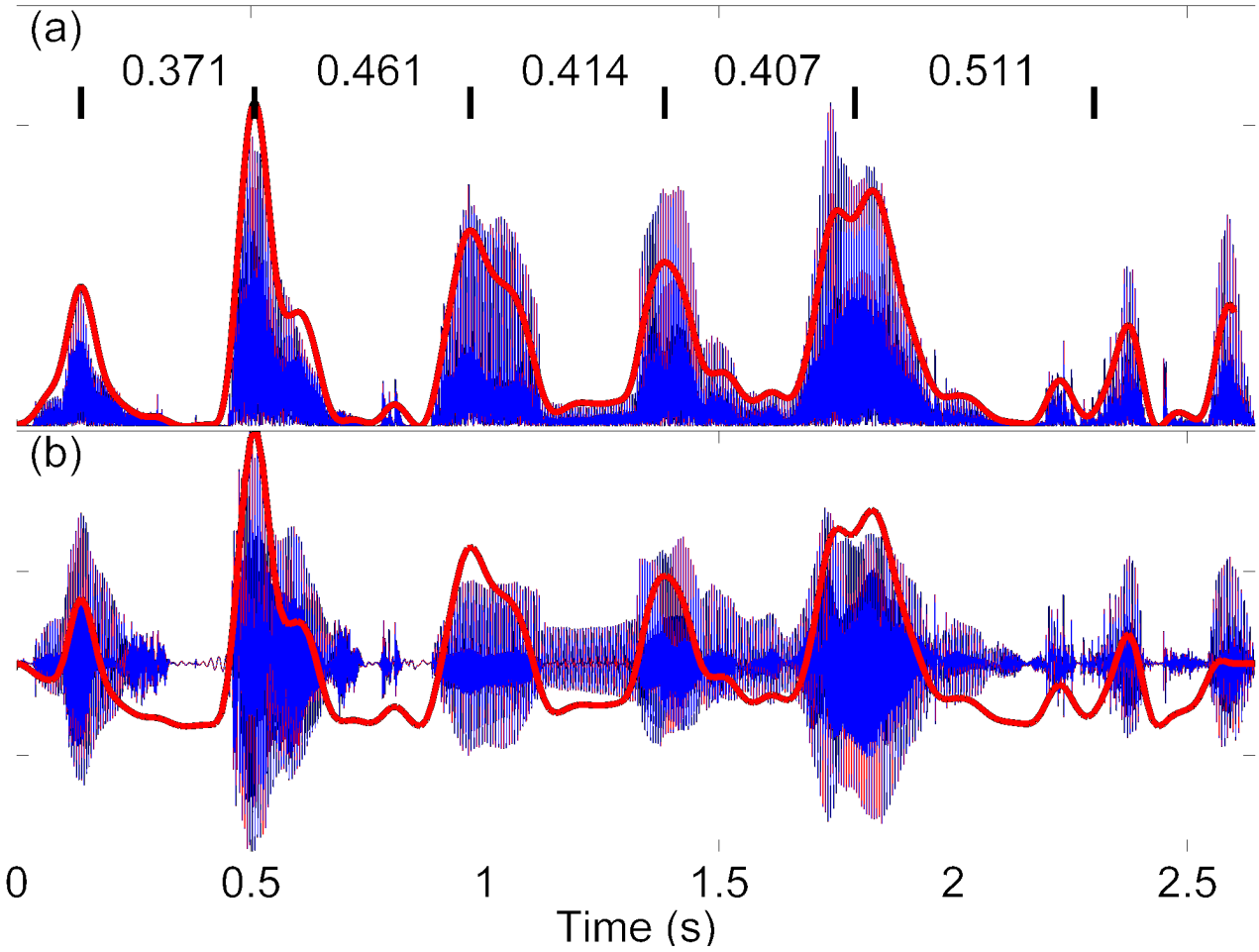
Method

- **Low-frequency Fourier Analysis of Speech Amplitude Envelope**
  ***developed in collaboration with* Keith Johnson**

  Tilsen, S. & Johnson, K. (to appear). Low-frequency Fourier analysis of speech rhythm. *Journal of the Acoustical Society of America.*

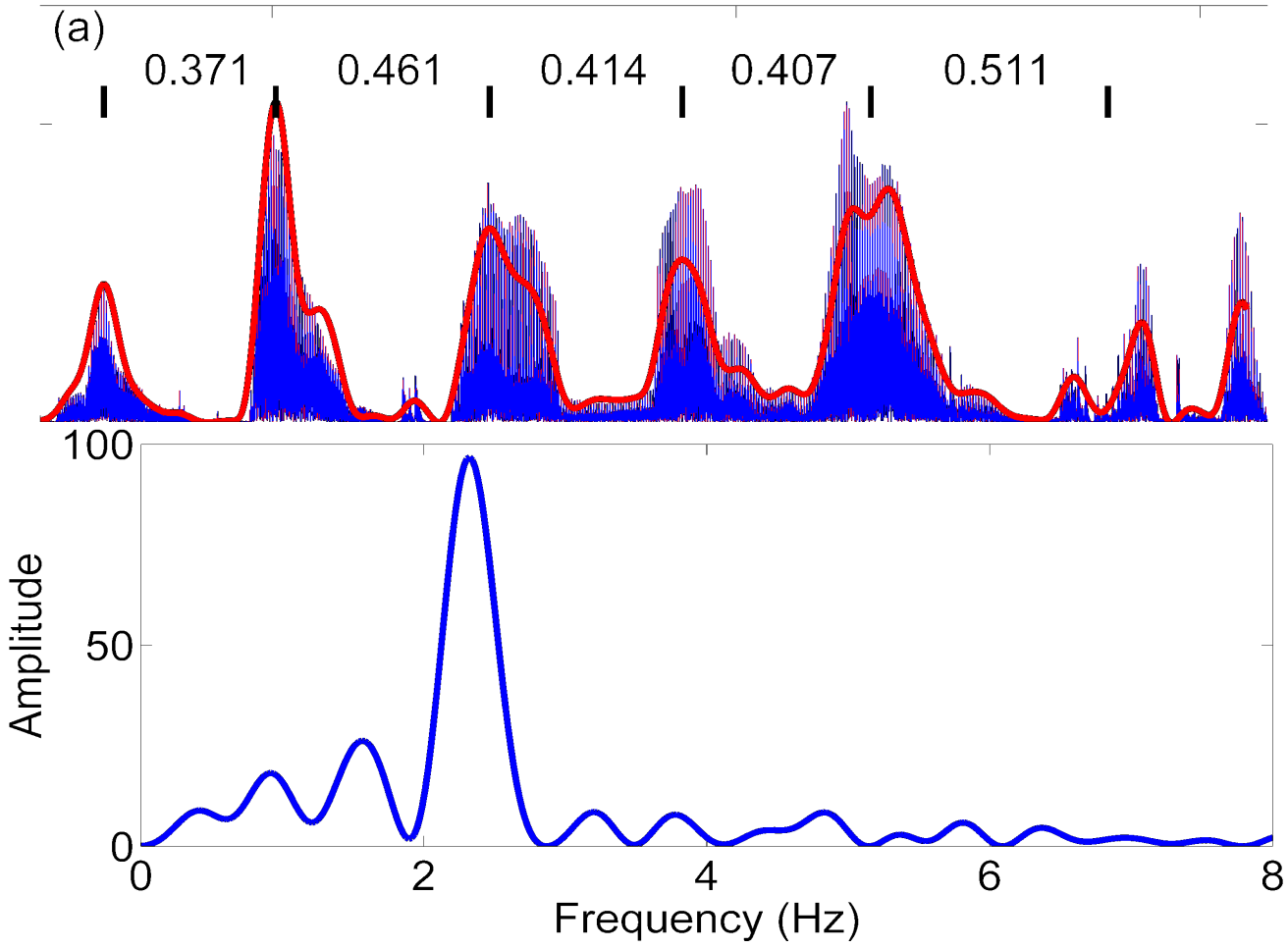
- **Use a representation of speech that does not rely upon intervals**

- **Vocalic energy amplitude envelope:**
  - **vocalic energy louder and more perceptually salient**
  - **children pay more attention to vocalic cues (Mehler et. al. 1996)**
  - **locations of syllable beats (p-centers) near onset of vowel (Allen 1972, 1975; Morton, Marcus, & Frankish 1976)**
  - **p-centers approximated by acoustic energy associated with vowel formants (Scott 1993; Pompino-Marschall 1989)**
  - **use Butterworth filter (gradual roll-offs in frequency domain) with 700-1300 Hz passband (Cummins & Port 1998)**
  - **amplitude envelope: lowpass filter the magnitude (absolute value) of the bandpass-filtered signal**



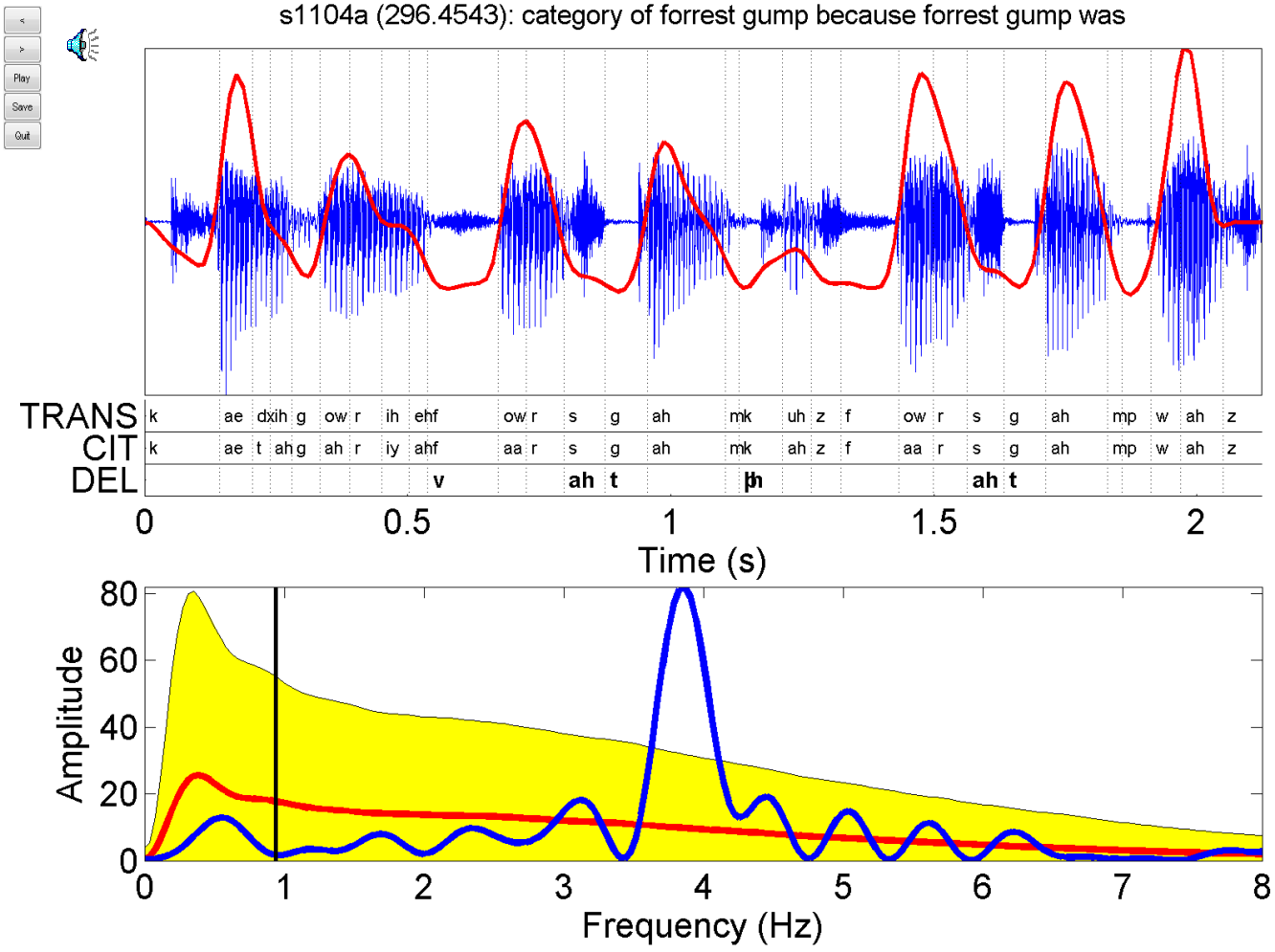
Method

- **Low-frequency Fourier analysis of amplitude envelope:**
  - **normalize, window (Tukey r=0.1), and zero-pad amplitude envelope**
  - **take squared magnitude of the FFT to obtain the power spectrum**
  - **analyze significant peaks (amplitude & frequency) in spectrum**



Method

- **Buckeye Corpus:**
  - **hand-labeled phonetic transcription, 40 native central Ohio English speakers from balanced set of ages and genders. Pitt, Johnson, Hume, Kiesling, Raymond (2005).**
  - **approx. 300,000 words**
  - **deletions are determined by comparison citation form to phonetic transcription**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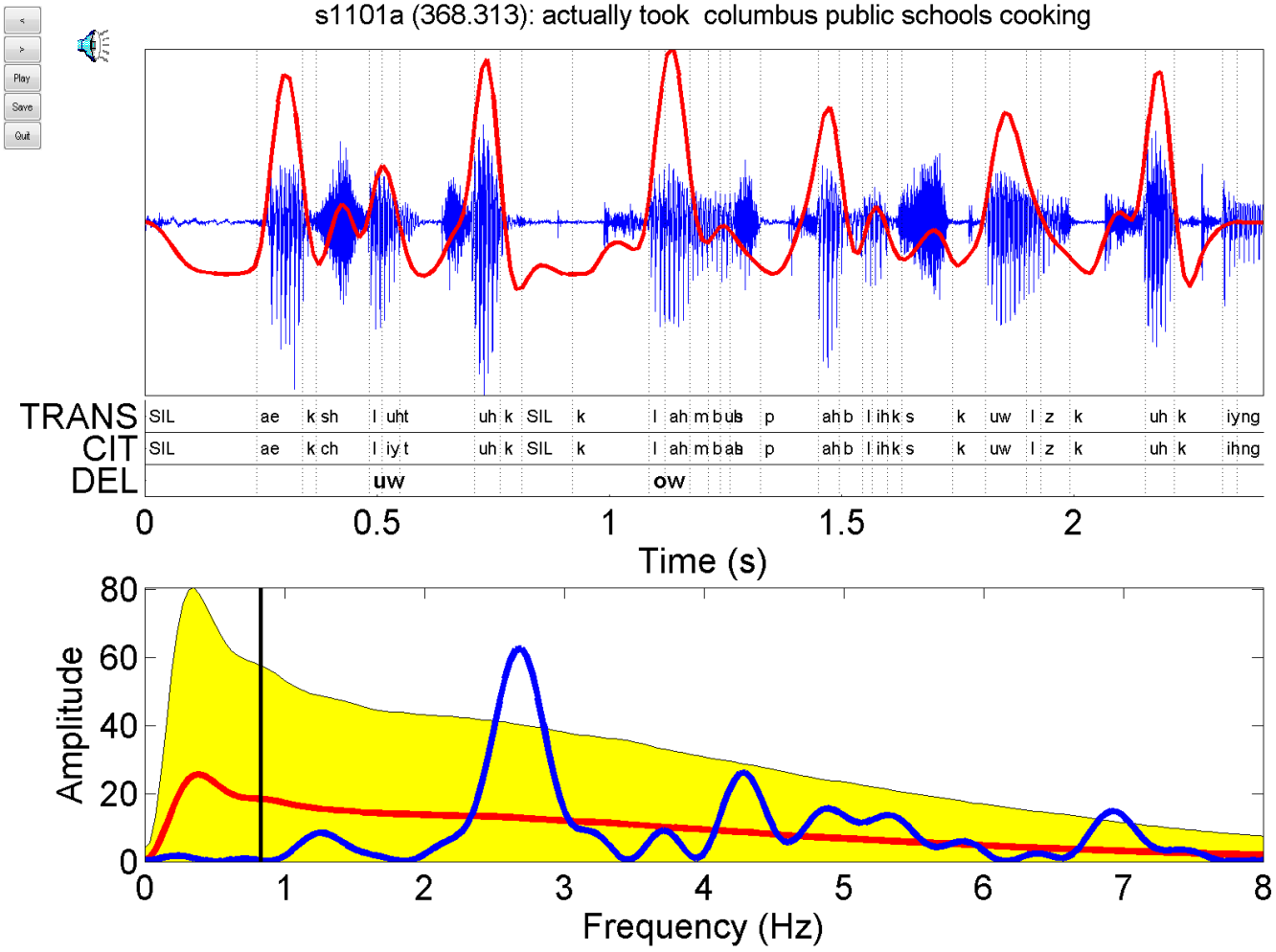
Time (s)
Amplitude
0 20 40 60 80
0 1 2 3 4 5 6 7 8
Frequency (Hz)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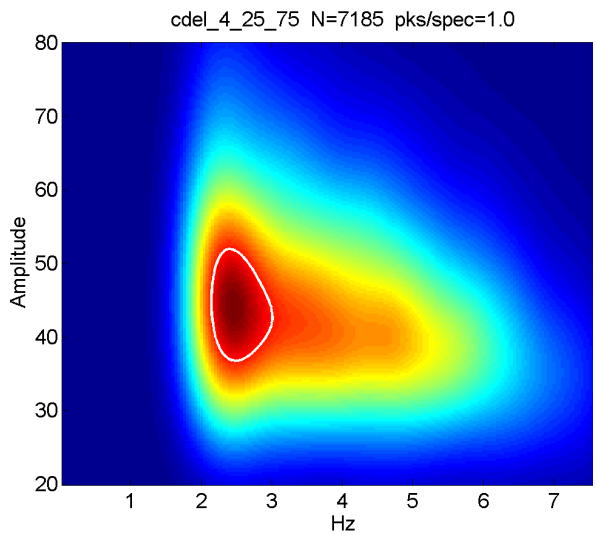
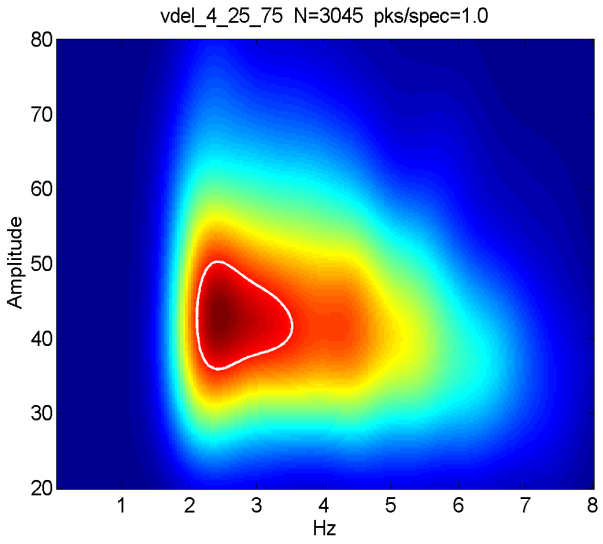
DEL uw ow
0 0.5 1 1.5 2
Time (s)
Amplitude
0 20 40 60 80
0 1 2 3 4 5 6 7 8
Frequency (Hz)

Analysis

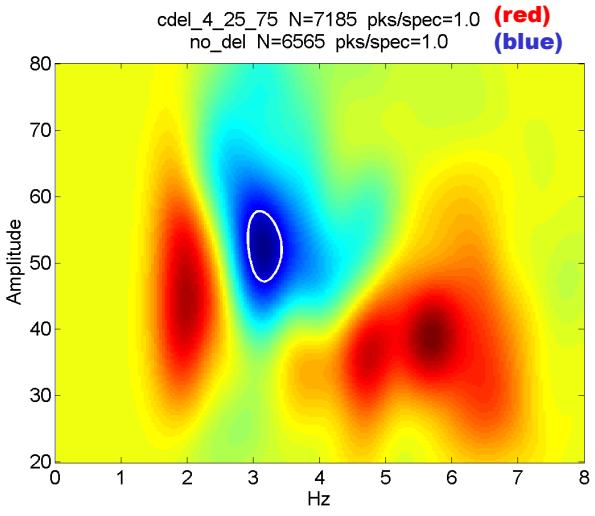
- **Take 2-3 s stretches (“chunks”) of speech centered upon a deletion**
- **Take the highest peak from each spectrum**
- **2-dimensional distribution of frequency-amplitude values**
- **consider “active” deletions (occur 25% - 75% of the time)**

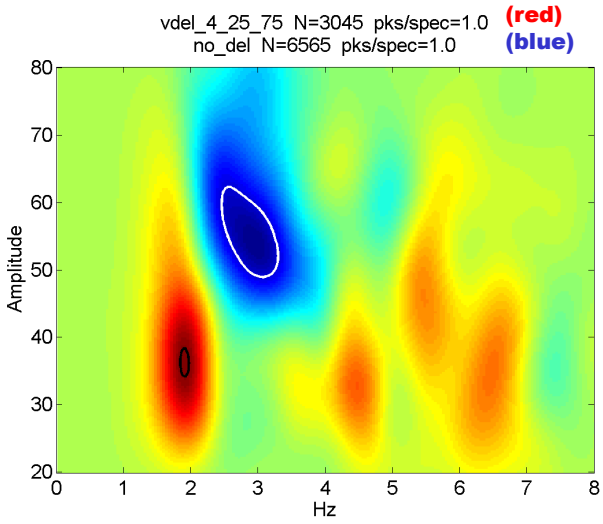




Analysis

- **comparison of chunks with and without deletions**

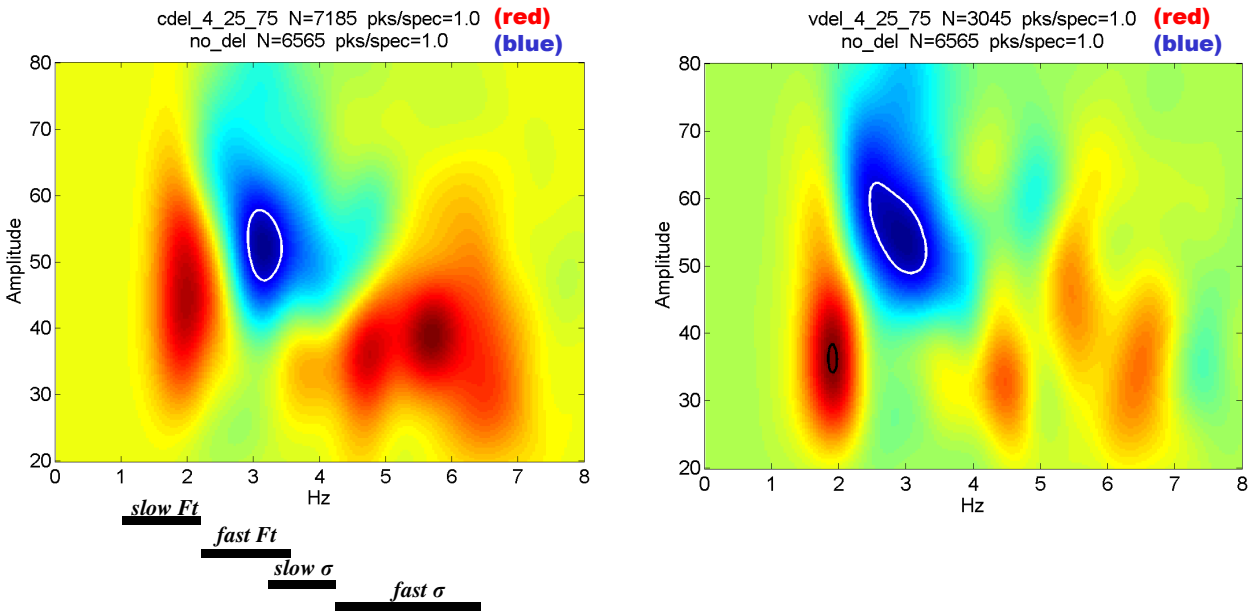




- **both C- and V-deletion are associated with rhythms in the 1.5-2.5 Hz range**
- **C-deletion is more strongly associated with rhythms in the 4.5-6 Hz range**
- **segmental preservation (absence of deletion) is associated with high-amplitude rhythms in the 2.5-3.5 Hz range**

Analysis

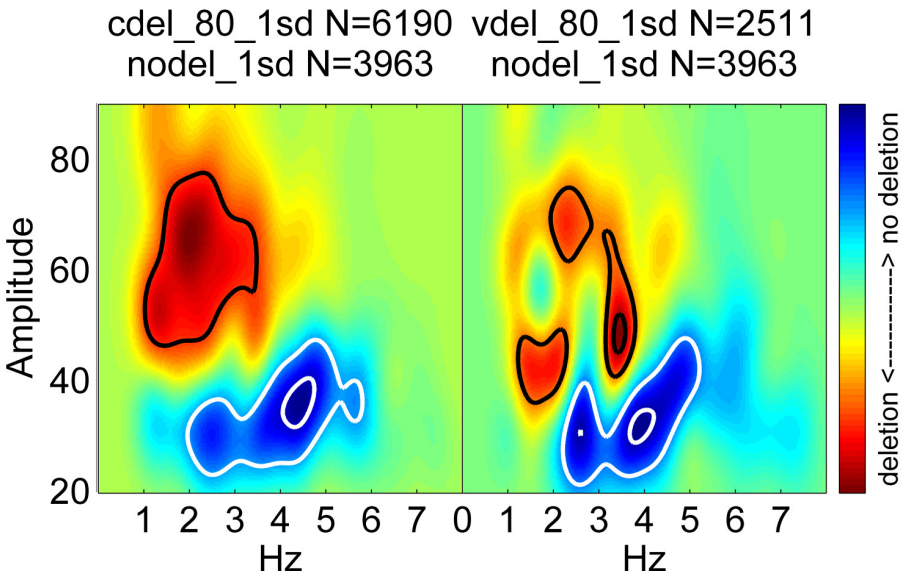
- **comparison of chunks with and without deletions**



- **deletion: slow-foot (C,V) and fast-syllable (C) timescales**
- **preservation: fast-foot timescale**
- **preservation may suggest a "rhythmic sweet-spot" for stability in gestural phasing (with certain assumptions)**

Analysis

- **comparison of chunks with and without deletions, controlled for speech-rate**



- **weak tendency for C-deletion to occur with rhythms in slow and fast-Ft range**
- **V-deletion associated with fast-Ft and slow-σ periodicity.**
- **V and C preservation associated with less rhythmic speech, especially in σ range**
- **more rhythmic speech contains more deletion**
- **C and V deletion associated with lower and higher frequency rhythms, respectively.**

Conclusion / Speculations

- **There exists a frequency range in the rhythm spectrum—corresponding to fast Ft-timing—where the likelihood of deletion is lower.**
- **More rhythmic speech contains more deletion.**
- **Lower frequency (Ft-timescale) rhythmic speech contains more C-deletion, higher frequency (σ-timescale) rhythmic speech contains more V-deletion.**

Why is rhythmicity associated with deletion?

- ***Gestural phasing:*** **gestural systems are coupled to rhythmic systems; when metrical/rhythmic coupling becomes stronger, intergestural coupling is less autonomous and/or more variable, resulting in a greater likelihood of overlap/deletion. (rhythmic systems drive gestural systems)**
- ***Transcriber perceptual bias:*** **Perception of rhythm caused corpus transcribers not to perceive segments.**
- ***Emergent rhythm:*** **segmental deletion occurred randomly, the effect of this happens to be more rhythmic speech. Or perhaps, speakers employ deletion in order to make speech more rhythmic (the teleological version).**

Why do consonants and vowels pattern differently?

- **Some vowel deletions result in loss of syllable, others do not. Consonant deletions less often occur with loss of syllable.**

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