Acoustic Variability of Fricatives in Normal Adults

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Introduction 1

- Production-related parameters have been developed in order to compare fricatives – mechanical models vs. human speech[7,9], normal vs. clinical population[1,4,10,12], effect of size and gender[4,9], effect of voicing[3] and phonetic context[4,9,11], etc.
- When articulatory/aerodynamic data exist, assumptions underlying parameters are tested[2,7,9,12], strengthening predictions made from acoustic-only data [3,10]
- Study of /s/ in adolescents (typical and with RSSEs) [4,10] led to followup: record adults with same methods. **How much of variability is due to age, how much to characteristics of corpus, recording, etc.?**

Definition Of Parameters -- Sibilants

4 frequency bands: for /s/, male, Low = 1-3, mid = 3-7, high = 7-11, xhigh = 11-15 kHz

Low: find minimum; Mid: find maximum

F_M = frequency of max; related to Length of front cavity (place, lip rounding)

AmpD = difference between max and min. Degree of sibilance

Slope = fit line from F_M to 14 kHz. Related to noise source spectrum

Level = sound power level within mid, high, xhigh bands

-- Non-Sibilants

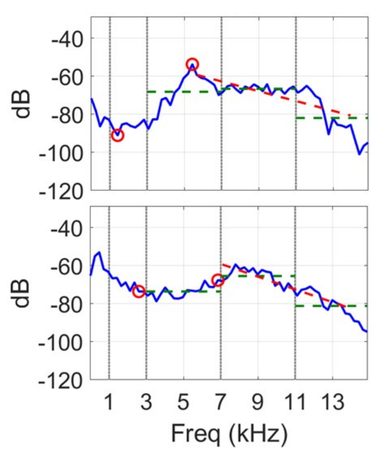
Use frequency bands as for /s/

Low-freq min, 1-7 kHz: FminA; Overall max, 1-13 kHz: FmaxA

AmpRange = difference between overall max and min

Max of broad peak, 5-12 kHz: F_h. Free jet noise spectrum

Slope, Levels as for /s/. Noise source – changes during fricative, & with stress



Method 2

CORPORA

Words were drawn from a study of children with residual speech sound errors (RSSEs) [6]

- Isolated words, elicited by picture naming: 65 words
- Rapid picture naming: name 6 words slowly, then rapidly in random order, 4-5 times each. Strawberries, spaghetti, elephant, thermometer, helicopter, umbrella
- Other tasks involving connected speech:
  - Recalling sentences: repeat 20 sentences that are successively longer
  - Grandfather Passage

PARTICIPANTS & PROCESSING

7 adults, ages 21 – 58; 3 men 4 women; Normal speech, hearing

Recorded in anechoic chamber

Shure WH30 headset Mic, Icicle Amplifier, recorded to Praat at 44 kHz; limiting frequency range is amplifier at 15 kHz

Speech is force-aligned [5] with manual correction

Analyzed each speaker separately

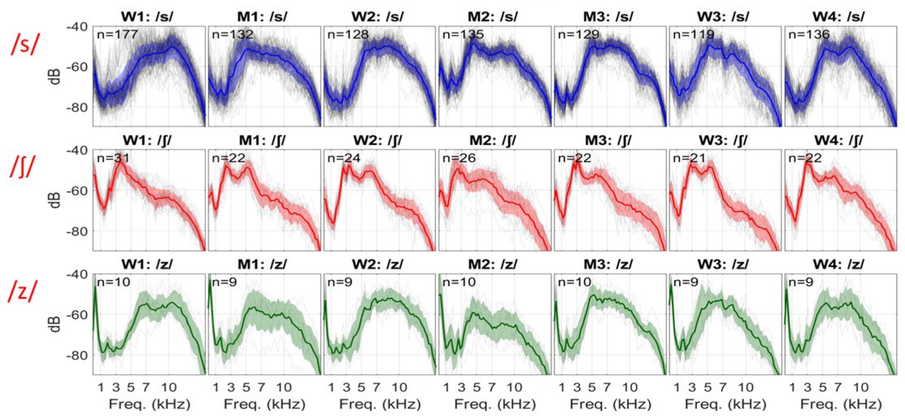
For some parameters, heuristic frequency bands differ for men and women

Multitaper spectra computed in 30 ms frames, 7 tapers, beginning, middle and end of each fricative [4]

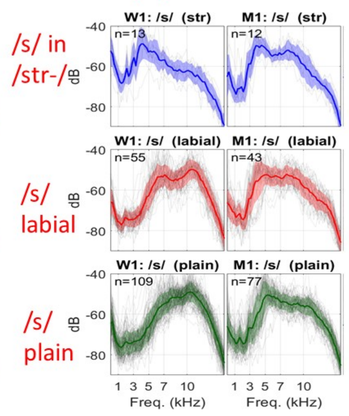
Parameters computed for each spectrum

Results -- sibilants 3

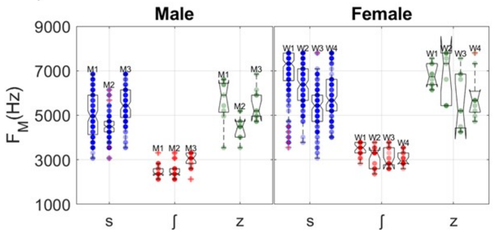
Mid-Fricative MT Spectra: Speakers



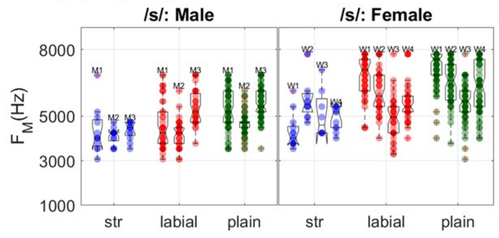
3 /s/ contexts



Graphs above: solid line = mean of all MT mid-fricative spectra; shaded area = +/- 1 std. dev. Note W1 /s/; she produced sound change in words such as "strap, strawberries". Upper right, /s/ separated into 3 phonetic contexts. Both W1 and M1 show difference in lowest peak for /s/ in /str-/.

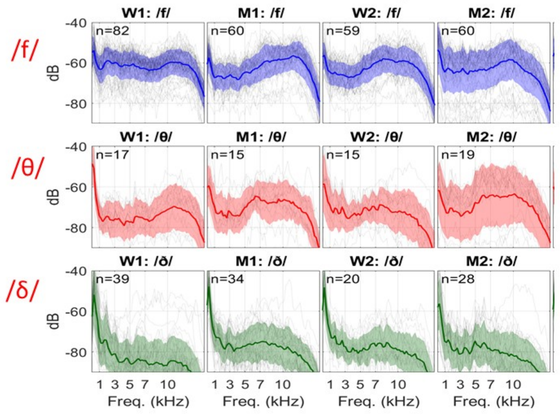


Left, note F_M – higher and more variable for /s/ than /ʃ/, for women than for men. Right, /s/ in /str-/ has lower F_M for W1 than other contexts.

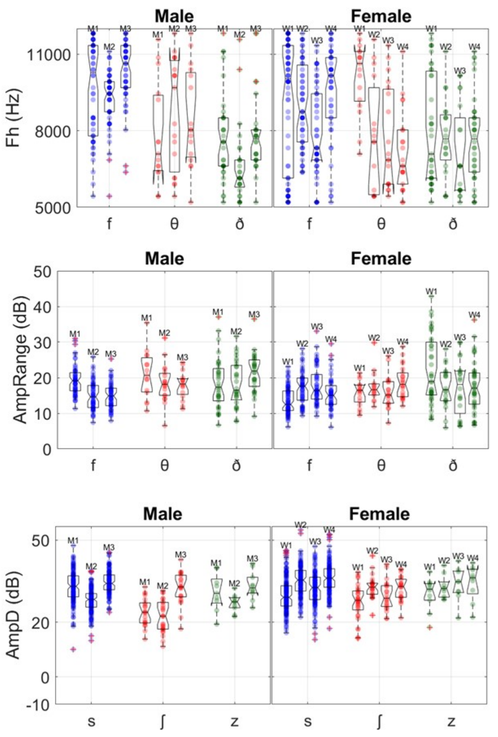


Results – non-sibilants 4

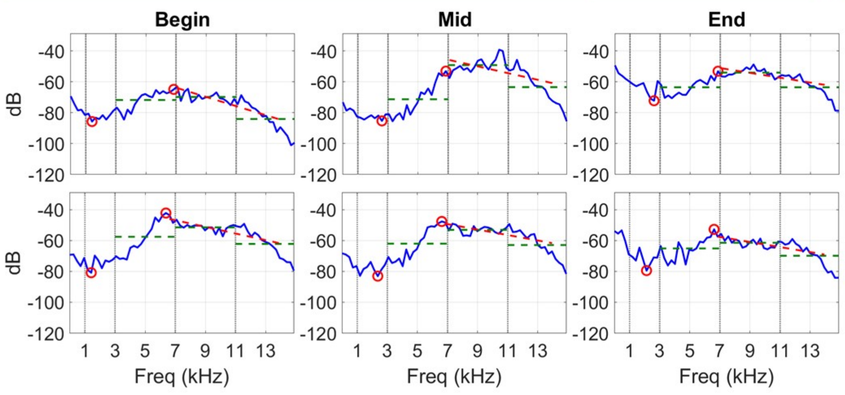
Mid-Fricative MT Spectra: Speakers



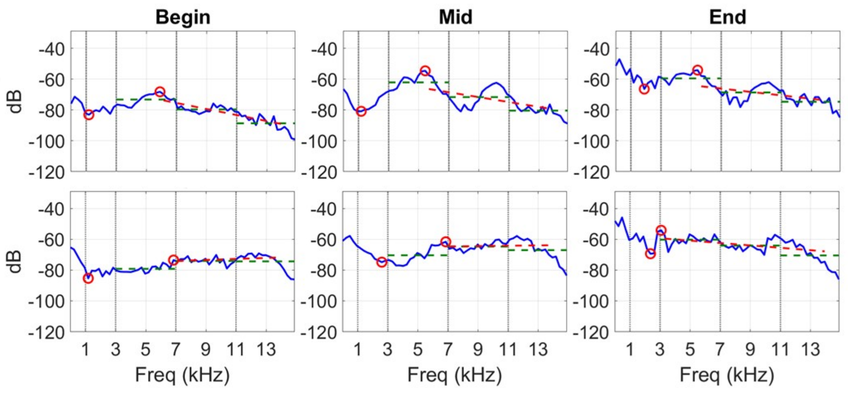
- F_h = max in range 5 -12 kHz
- Variable, but F_h (/f/) > F_h (/θ/) for most
- AmpRange = amp difference from 1 – 13 kHz
- AmpRange < AmpD as predicted; localized source for sibilants generates bigger difference



Results – speaking style 5



M1: /s/ in /s æ../
Top isolated word "sandwich"
Bottom connected speech "Saturday"
More high-frequency energy in isolated word
Slopes similar for all



M1: /θ/ in /θɝ../
Top isolated word "thirsty"
Bottom connected speech "thermometer"

AmpD > 20 dB isol. word – Sibilant-like for this context
Slopes similar for all

Conclusions 6

- Parameters F_M and AmpD work for sibilants even in these corpora; AmpD slightly smaller than past studies using sustained fricatives [3,11]
- Sound change demonstrated in two subjects with F_M parameter mid-/s/ in /str-/ words; F_M ([ʃtr-]) < F_M ([str-])
- For non-sibilants, AmpRange demonstrates relative flatness of spectra; AmpRange (f, θ) < AmpD (s, ʃ, z/), but in some contexts /θ/ appears more sibilant-like. F_h measures frequency of broad peak, not specific resonance. F_h (/f/) > F_h (/θ/) for most speakers
- Spectral slope without any amplitude intercept does not differentiate fricatives, or position within fricative
- Sound power spectrum levels in three bands shift as expected, though less in connected speech; need to devise ways of expressing that
- Production-related parameters offer way to characterize variability, for use in comparing adults to adolescents, normal to clinical populations, etc. Speaking style differences bear further scrutiny

References

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