Perceptual and Acoustic Assessment of Strained Voice Quality Using Synthetically Modified Voice Samples

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Introduction

Strained Voice Quality

- Voice quality: “attributes of a sound other than its pitch and loudness that allow a listener to judge that two sounds are the same or different” (ANSI, 1960)
- **Strain**: “perception of **excessive vocal effort** (hyperfunction)” (Kempster et al., 2009)
- One of the common features of hyperfunctional voice disorders (e.g., nodules, muscle tension dysphonia), laryngeal dystonia, etc.
- Mainly assessed with subjective, auditory-perceptual evaluation (Oates, 2009)
- **Lack of knowledge in acoustic features of strain**

Acoustic Features of Strain

- Increased perceived strain has been associated with:
  1) Increased spectral energies at higher harmonic frequencies (Anand et al., 2019; Bergan et al., 2004)
  2) Decreased **relative fundamental frequency** (**RFF**; more information on Appendix)
     - RFF quantifies the short-term variations of fundamental frequency (f_o) in voiced-voiceless consonant-voiced productions (e.g. /ifi/)
     - RFF was observed to be decreased in individuals with hyperfunctional voice disorders (Stepp et al., 2010, 2011)
  3) Increased **mid-to-high frequency noise** (Hirano, 1981; Klatt & Klatt, 1990; Lowell et al., 2012)
- **Not clear whether RFF and mid-to-high frequency noise directly contribute to strain**

Purpose and Hypotheses

To understand the effect of **RFF** and **mid-to-high frequency noise** on strain by **synthetically modifying** these features

Hypothesis 1: **Lowering RFF** in voice samples would **increase strain**

Hypothesis 2: **Raising RFF** in voice samples would **decrease strain**

Hypothesis 3: **Adding mid-to-high frequency noise** to voice samples would **increase strain**

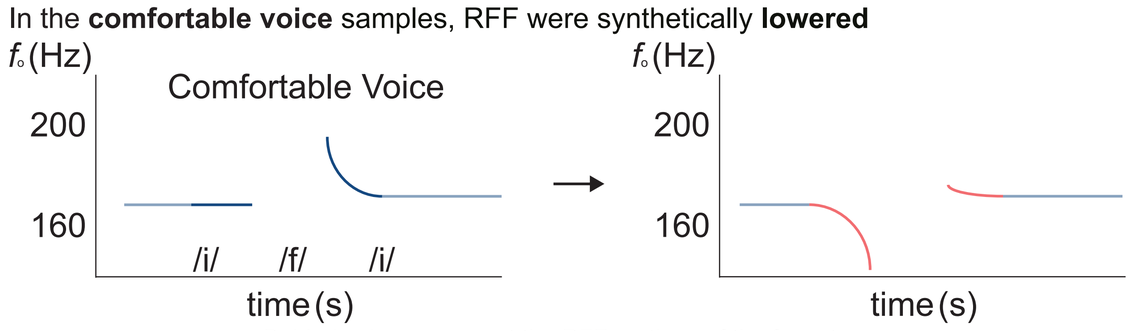
Methods

Original Voice Samples

- /ifi/ recordings of eight speakers (4 females; mean age = 32.6 years) with typical voices
- Both **comfortable voice** and **maximum vocal effort samples** for each speaker (8 speakers x 2 vocal effort levels = 16 original samples)

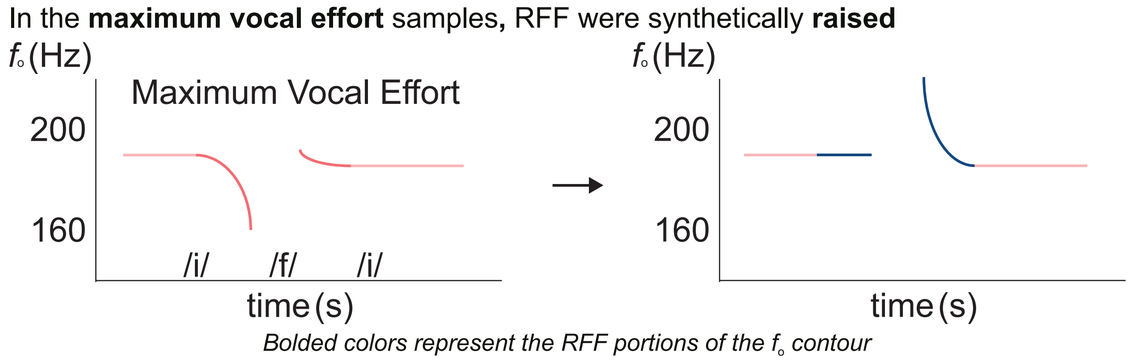
RFF Modification

- In the **comfortable voice** samples, RFF were synthetically **lowered**



Bolded colors represent the RFF portions of the f_o contour

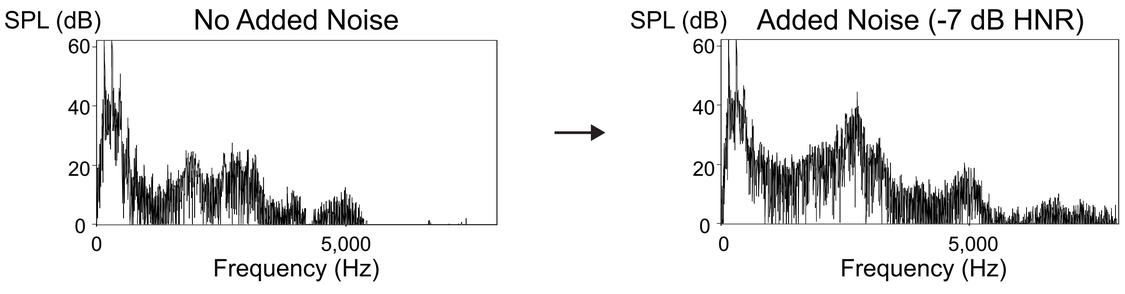
- In the **maximum vocal effort** samples**,** RFF were synthetically **raised**



Bolded colors represent the RFF portions of the f_o contour

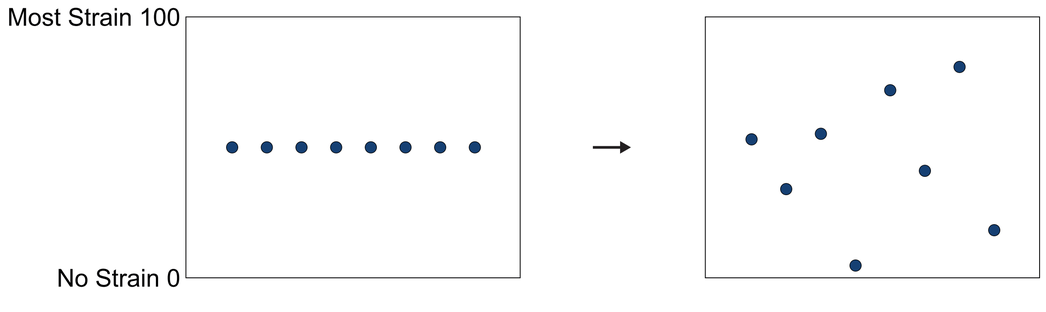
Mid-to-High Frequency Noise

Added to the sample to **decrease harmonics-to-noise ratio (HNR) by 7 dB**



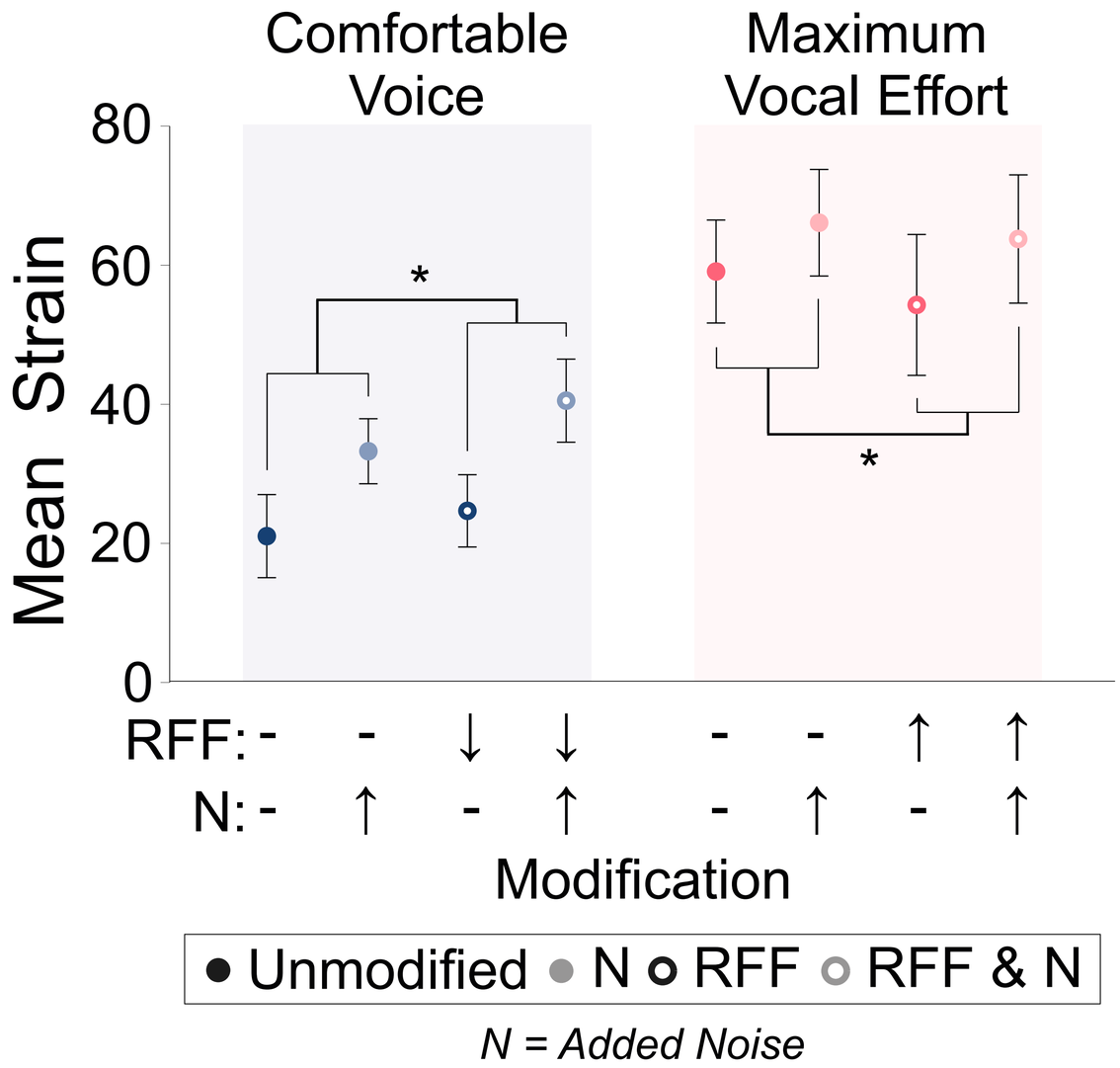
Visual Sort-and-Rate Task

- 20 listeners (10 females; mean age = 22.0 years)
- 64 stimuli = 16 unmodified + 16 RFF-modified + 32 added noise



Results

- The effect of **the interaction between RFF and vocal effort levels** (p = 0.003, η_p^2 = 0.74)
  - Lowering RFF increased strain (p < 0.001)
  - Raising RFF decreased strain (p = 0.003)
- The effect of **mid-to-high frequency noise** (p < 0.001, η_p^2 = 0.97)



N = Added Noise

Discussion

- Directly supports **RFF** and **mid-to-high frequency noise** as an **acoustic contributors to strain** using synthetically modified samples
- **Multiparametric tools** incorporating multiple acoustic features of strain

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NIDCD
National Institute on Deafness and Other Communication Disorders

Appendix

Relative Fundamental Frequency

Instantaneous f_os of the 10 voicing cycles before and after a voiceless consonant are normalized by the f_os of the cycles furtherst from the consonant (f_{ref}; offset cycle 1 and onset cycle 10) with the equation: RFF (ST) = 12 × $\log_2(f_o/f_{ref})$