Interaction between phonation mode and pharyngeal narrowing: A pilot EGG study

Donna Erickson[1] , Jihyeon Yun [2] , Jiayin Gao [3] , and Kerrie Obert [4]

1 Haskins Laboratories, U.S.A., 2 Chungnam National University, Korea, 3 Sophia University, Japan & University of Edinburgh, United Kingdom, 4 The Ohio State University, USA

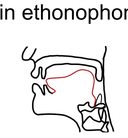
[1]ericksondonna2000@gmail.com, [2]yunjihyeon@gmail.com, [3]iayin.gao@gmail.com,[4]kerriebobert@gmail.com

Our study

- We use electrography (EGG) to investigate the interaction between (1) phonation mode and (2) pharyngeal area narrowing.
- Two laryngeal modes (based on cover-body theory of phonation, Hirano 1977 [1]);
  - Thin fold vibration (cover, upper edge of the folds only)

  - Thick fold vibration (cover & body)
- Three supralaryngeal settings
  - Normal/ No pharyngeal narrowing
    - As it is in normal speech

  - Lateral Medial Pharyngeal Narrowing
    - Lateral to medial narrowing of the pharynx (LMN) at the level of the oropharynx (a setting for "twang-style singing" [5], but also heard in ethonophonetic speech acts [6].
  - Anterior Posterlor Narrowing



    - Anteriorly to posteriorly narrowed pharynx (APN) at the level of the tongue root (a possible setting for "opera-style") [4]

Hypotheses

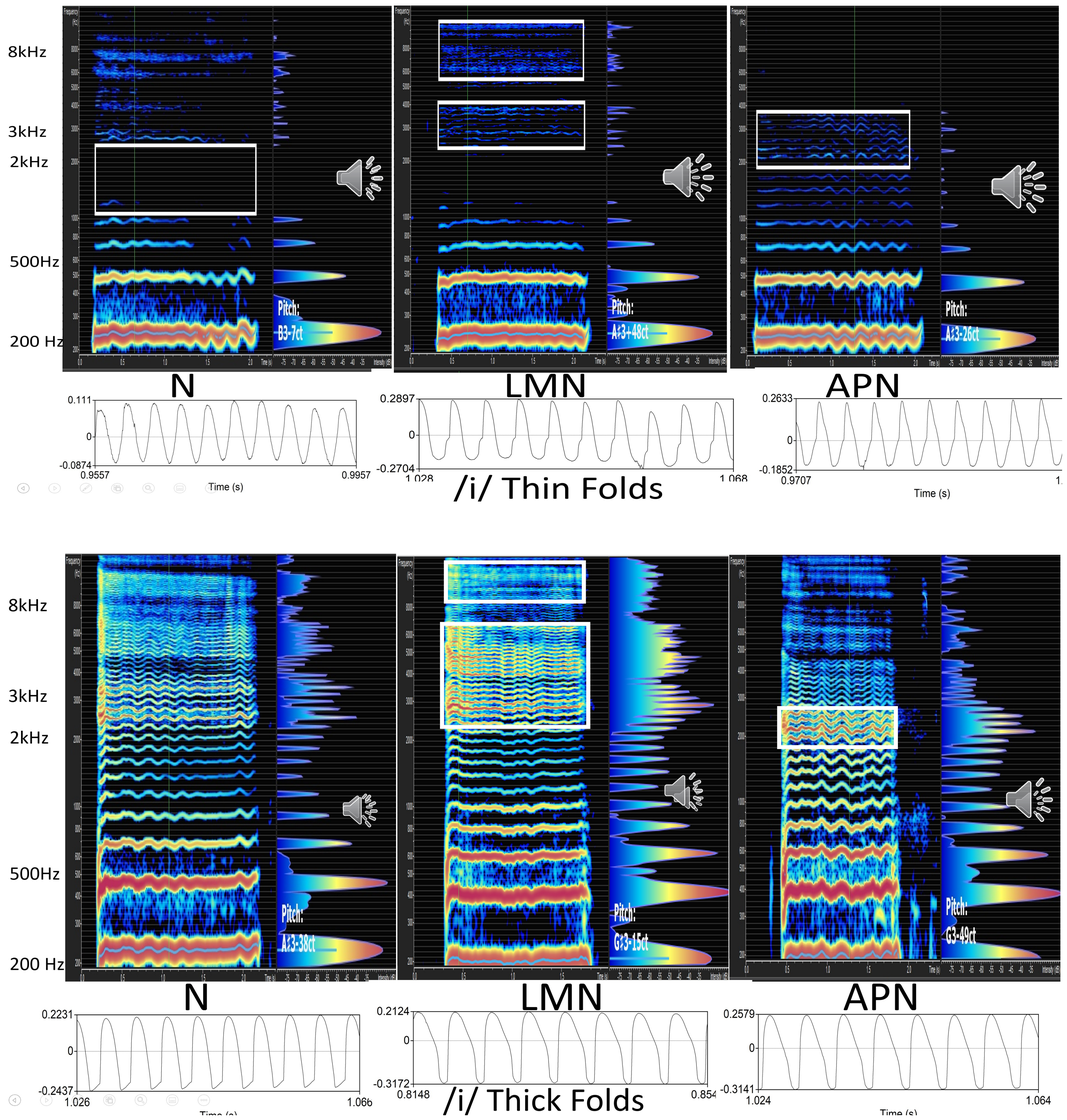
- 1. Open Quotient (OQ) of vowels produced with thin folds is larger than that produced with thick folds
- 2. EGG signals of thin folds will be more symmetrical than those of thick folds [3, 8]
- 3. Pharyngeal narrowing will affect symmetry of EGG signal
- 4. Pharyngeal narrowing will affect spectral information, i.e., increased energy in upper frequencies.
- 5. Vowel height affects OQ.

Methodology

- **EGG recordings:** soundproof room at Arai Lab at Sophia University with electroglottograph (Glottal Enterprises EG2-PCX2) and an electret condenser microphone (Sony ECM-MS957) connected to a laptop computer via an audio interface (Edirol UA-25EX). Acoustic and EGG signals were recorded simultaneously using Audacity at a 44.1 kHz sampling rate.
- **Speaker:** Phonetician trained in Estill Voice Production Method [2]
- **Sustained vowels: /i/, /e/, /a/** , Produced with 2 modes of phonation & 3 settings of pharyngeal narrowing, total of 18 vowels
- **EGG Analysis**: Praatdet (Kirby 2017, [7]). OQ estimated by detection of derivative of the EGG signal of closing and opening peaks
- **Acoustic Analysis**: Voce vista

Results

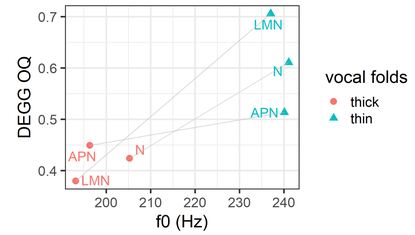
Acoustic spectrograms and EGG signals of 6 /i/ vowels



Comments

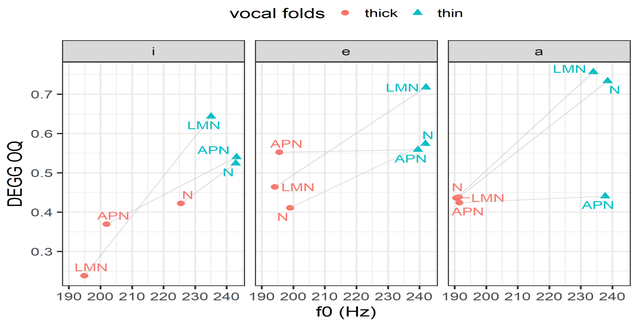
1. Thin folds have less energy in higher frequencies & EGG signal more symmetrical than thick folds
2. Pharyngeal narrowing increases energy in upper frequencies; EGG signal is less symmetrical, which suggests that pharyngeal narrowing increases vocal fold thickness..
3. Lateral Medial Narrowing increases energy primarily in 3-4kHz region, & also above 6kHz.
4. Anterior Posterior Narrowing increases energy primarily in 2-3 kHz region

OQ of vowels produced with thin folds > than those produced with thick folds



Mean OQ values of vowels produced with thick folds (red) vs thin folds (blue). Intervals measured were from 0.9 to 1.0 sec for all vowels except for 1.5 to 1.6 sec for LMN.

Interactions of vowel height, f0, vocal fold thickness, pharyngeal narrowing & OQ



1.As F0 rises, so does OQ.
2.Differences in OQ due to vowel quality
  As the vowel opens (becomes lower), OQ for thin folds increases. This finding is consistent with that reported in Figure 2 by Ingo Titze in his study about twang [9].
3. Differences in OQ due to vowel quality & pharyngeal narrowing
  a. For /a/ on thin folds, APN reduces OQ (increases CQ), even on high F0,
  b. For /i/ on thick folds, LMN helps reduce OQ/increase CQ)

References

1. Hirano, M. "Structure and vibratory behavior of the vocal folds," Dynamic Aspect of Speech Production, University of Tokyo Press, Tokyo, Japan, pp. 13–27, 1977.
2. Estill, J., Steinhauer, K., McDonald, M. "The Estill Voice Model: Theory and Translation". Estill Voice International, LLC: Pittsburgh PA. 2017.
3.Henrich, N., d'Alessandro, C., Doval, B., Castellengo, M. "On the use of the derivative of electroglottographic signals for characterization of nonpathological phonation". The Journal of the Acoustical Society of America 115(3):1321-32, DOI: 10.1121/1.1646401, 2004.
4. https://www.youtube.com/watch?v=KHjbqUYrb04
5.Perta, K., Bae, Y., and Obert, K. "A pilot investigation of twang quality using magnetic resonance imaging". Logopedics Phoniatrics Vocology, DOI:10.1080/14015439.2020.1757147. 2020.
6. Sadanobu, T., Zhu, C., Erickson, D., Obert, K. "Japanese 'street seller's voice'". Proc. Mtgs. Acoust. 29, 060003, doi: 10.1121/2.0000404, 2016.
7.Kirby, J. (2017). "Praatdet: Praat-based tools for EGG analysis." (version 0.1.1) https://github.com/kirbyj/praatdet. 2017.
8. Mayr, A. "Investigating the *Voce Faringea*: Physiological and Acoustic Characteristics of the Bel Canto Tenor's Forgotten Singing Practice". The Voice Foundation. Elsevier Inc. http://dx.doi.org/10.1016/j.jvoice.2016.06.010. 2017.
9. Titze, I. R., Bergan, C. C., Hunter, E.J. and Story, B. (2003) 'Source and filter adjustments affecting the perception of the vocal qualities twang and yawn', Logopedics Phoniatrics Vocology, 28:4, 147 – 155. DOI: 10.1080/14015430310018874.

Acknowledgments. This study was partially supported by a Grant-in-Aid for JSPS Fellows 17F17006 to Takayuki Arai and Jiayin Gao