Phonetic Realization and Phonological Representation of Voice Quality in Santiago Laxopa Zapotec

Mykel Loren Brinkerhoff

1 Proposal

My dissertation addresses how phonology and phonetics account for differences in voice quality. Voice quality describes how the larynx can be manipulated during speech to affect how the sounds are produced. Most commonly, in speech, these manipulations have a breathy or creaky voice quality (Esling et al. 2019). In some languages, like English, the amount of breathiness or creakiness produced when we speak does not significantly affect what we say. However, this is different in other languages across the world. For example, in many Mesoamerica and Southeast Asian indigenous languages, voice quality differences can drastically change a word's meaning (Esposito & Khan 2020). In the endangered Zapotec language Santiago Laxopa Zapotec (SLZ) spoken by approximately 1000 speakers in the municipality of Santiago Laxopa, Ixtlán, Oaxaca, Mexico (Adler & Morimoto 2016, Adler et al. 2018, Brinkerhoff, Duff & Wax Cavallaro 2021, Foley, Kalivoda & Toosarvandani 2018, *Santiago Laxopa* 2022, Sichel & Toosarvandani 2020, Silva-Robles et al. 2022) there are four unique voice qualities breathy, checked, rearticulated, and modal. Breathy vowels are realized with a breathy voice during any point of the vowel. Checked and rearticulated vowels are realized with creaky voice but in different locations within the vowel (i.e., checked vowels have creakiness at the end while rearticulated vowels have creakiness at the middle). Modal vowels, or the default vowel, do not have any laryngeal modification.

My dissertation will address several questions about how these voice quality distinctions are produced and what they can tell us about how these sounds are organized in the sound system of SLZ. The first concerns the phonetic realization or how SLZ makes these sounds. Initial investigations into these voice qualities by Adler & Morimoto (2016) and Brinkerhoff & McGuire (In Preparation) have revealed some information about this question, mainly what acoustic measures best capture the contrasts between these qualities. Adler & Morimoto (2016) showed that spectral tilt can account for the four voice quality distinctions in SLZ. This acoustic measure looks at the speech signal's relative amplitude of sound waves (Fischer-Jørgensen 1968). Adler & Morimoto found that two different spectral tilt measures can capture the distinctions. However, recent work in Brinkerhoff & McGuire (In Preparation) on ten SLZ speakers shows that most spectral tilt measures are not good at capturing the voice quality distinctions. Instead, we found that most spectral tilt measures could only catch some differences. Instead, the acoustic measure called Strength of Excitation, which measures how strongly the vocal folds are vibrating (Murty & Yegnanarayana 2008, Mittal, Yegnanarayana & Bhaskararao 2014), and a new acoustic measure

proposed by Chai & Garellek (2022), Residual H1, better capture the voice quality contrasts in SLZ. This aligns with more recent work by Chai & Garellek (2022) and Zhang (2016a,b), where they show and discuss how spectral tilt measures are not as robust as previously thought. My dissertation expands on this discussion about why spectral tilt measures fail to capture the contrasts in SLZ and the role that Strength of Excitation, residual H1, and other acoustic measures play in establishing and describing these voice quality distinctions. This phonetic knowledge is critical in explaining how these voice qualities are produced.

It is commonly accepted that the sounds used by language are organized and stored in an abstract language system we call the phonological component of mental grammar. Different linguistic theories argue that there is little to no phonetic input (Reiss 2017), whereas others say that phonetics and phonology are entirely unified with total overlap (Flemming 2001). One of the questions that my dissertation will address is to what extent the data from SLZ voice quality can shed light on this interaction, particularly how it relates to the representation of these sounds in the phonological component of mental grammar. These phonological representations form the building blocks from which our understanding of how sounds pattern and are organized into cohesive systems. There is debate about how information is stored in these phonological representations. Some linguists argue that only a single form is stored (e.g., Albright 2002). Others argue that instead, we have a set of multiple forms stored (e.g., Mascaró 2007) or all the actual forms spoken or heard (e.g., exemplar theory, Ernestus & Baayen 2007). Essentially, these views ask how abstract these phonological representations could be for the grammar to operate. My dissertation will contribute to the ongoing debate about the nature of these phonological representations.

2 Outline of dissertation

1. Introduction
    - Research Questions
    - Why tackle these problems
    - Roadmap of dissertation
2. Santiago Laxopa Zapotec phonetics and phonology
    - Brief overview and description of Santiago Laxopa Zapotec
        - SLZ is a member of the Zoogochan branch of Cojones Zapotec
        - Considered a dialect of Zoogocho (Smith-Stark 2003)

- Consonants
- Special focus on the vowels and their voice quality
  - Four or five vowels phonemes
  - Related languages are 4 vowel sytems with one extra vowel that only shows up in loanwords from Spanish (Aaron Huey Sonnenschein 2004, Aaron H. Sonnenschein 2005, Avelino 2004)
  - Four voice qualities
    * Talk about how modal, checked, rearticulated, and breathy vowels are produced.
    * SLZ is the only known Northern Zapotec language to develop breathy voice (c.f., Ariza-García 2018)

3. Phonetic realism and phonological representations

- Big question is about the nature of the Phonetics-Phonology Interface (Kennedy 2021)
- What is Phonetic Realism, its strengths and weaknesses?
  - Katz & Assmann 2019
  - Knight & Setter 2021
  - Fowler 1983
- Talk about Laryngeal Realism as a tie in to phonetic realism.
  - Iverson & Salmons 1995
  - Honeybone 2005
  - Beckman et al. 2011
  - Beckman, Jessen & Ringen 2013
- Discuss Phonological Representations
  - Different schools of thought ranging from no phonetic input to complete overlap (Albright 2002, Flemming 2001, Reiss 2017)

4. Phonetics and phonology of Voice Quality

- What is voice quality
  - History of voice quality studies
    * Spectral-tilt
      · Fischer-Jørgensen (1968) as the developer of spectral-tilt

        - Garellek 2022 gives a pretty good summary of the history of voice quality research
        - Problems with traditional measurements (Chai & Garellek 2022)
    - Other measurements for VQ (Garellek 2019, Keating et al. 2023)

5. Acoustics of voice quality in Santiago Laxopa Zapotec
    - This is essentially Brinkerhoff & McGuire (In Preparation)
    - Description of experiment
    - Description of results
    - Discussion of results.
6. Implications for voice quality
    - What the results of the previous chapter tell us about how voice quality is produced in SLZ.
    - What do the results tell us about the phonetics of voice quality
    - What do the results tell us about the phonology of voice quality
7. Conclusion

3 Timeline for dissertation

Milestone	Date
Finish theoretical research	May 2024
Start first draft of dissertation	May 2024
Conference presentation at LabPhon	June 2024
Potential research travel to Oaxaca	July 2024
Process additional data if needed	August–October 2024
First draft completed	December 2024
Revisions to dissertation	December 2024–January 2025
Present at LSA and SSILA	January 2025
Completed defense draft	February 2025
Defend Dissertation	March 2025
Revisions completed	May 2025
Submit Dissertation	May 2025

References

Adler, Jeff, Steven Foley, Jed Pizarro-Guevara, Kelsey Sasaki & Maziar Toosarvandani. 2018. The derivation of verb initiality in Santiago Laxopa Zapotec. In Jason Merchant, Line Mikkelsen, Deniz Rudin & Kelsey Sasaki (eds.), *A reasonable way to proceed: Essays in honor of Jim McCloskey*, 31–49. Santa Cruz, Berkeley, Chicago: University of California.

Adler, Jeffrey M. & Maho Morimoto. 2016. Acoustics of phonation types and tones in Santiago Laxopa Zapotec. *The Journal of the Acoustical Society of America* 140(4). 3109–3109. https://doi.org/10.1121/1.4969713.

Albright, Adam. 2002. *The Identification of Bases in Morphological Paradigms*. Los Angeles, CA: University of California, Los Angeles dissertation.

Ariza-García, Andrea. 2018. Phonation types and tones in Zapotec languages: A synchronic comparison. *Acta Linguistica Petropolitana* XIV(2). 485–516. https://doi.org/10.30842/alp2306573714220.

Avelino, Heriberto. 2004. *Topics in Yalálag Zapotec, with particular reference to its phonetic structures*. Los Angeles, CA: University of California, Los Angeles dissertation. 315 pp.

Beckman, Jill, Pétur Helgason, Bob McMurray & Catherine Ringen. 2011. Rate effects on Swedish VOT: Evidence for phonological overspecification. *Journal of Phonetics* 39(1). 39–49. https://doi.org/10.1016/j.wocn.2010.11.001.

Beckman, Jill, Michael Jessen & Catherine Ringen. 2013. Empirical evidence for laryngeal features: Aspirating vs. true voice languages. *Journal of Linguistics* 49(2). 259–284. https://doi.org/10.1017/S0022226712000424.

Brinkerhoff, Mykel Loren, John Duff & Maya Wax Cavallaro. 2021. Downstep in Santiago Laxopa Zapotec and the prosodic typology of VSO languages. In *Manchester Phonology Meeting*. Manchester, England.

Brinkerhoff, Mykel Loren & Grant McGuire. In Preparation. On residual H1 as a measure of voice quality. Manuscript. Santa Cruz, CA.

Chai, Yuan & Marc Garellek. 2022. On H1–H2 as an acoustic measure of linguistic phonation type. *The Journal of the Acoustical Society of America* 152(3). 1856–1870. https://doi.org/10.1121/10.0014175.

Ernestus, Mirjam & R. H. Baayen. 2007. Intraparadigmatic effects on the perception of voice. In Jeroen van deWeijer & Erik Jan van derTorre (eds.), *Voicing in Dutch: (De)voicing phonology, phonetics, and psycholinguistics*, vol. 286, 153–174. Amsterdam: John Benjamins Publishing Company. https://doi.org/10.1075/cilt.286.07ern.

Esling, John H., Scott R. Moisik, Allison Benner & Lise Crevier-Buchman. 2019. *Voice Quality: The Laryngeal Articulator Model*. 1st edn. (Cambridge Studies in Linguistics 162). Cambridge University Press. https://doi.org/10.1017/9781108696555.

Esposito, Christina M. & Sameer ud Dowla Khan. 2020. The cross-linguistic patterns of phonation types. *Language and Linguistics Compass* 14(12). https://doi.org/10.1111/lnc3.12392.

Fischer-Jørgensen, Eli. 1968. Phonetic Analysis of Breathy (Murmured) Vowels in Gujarati. *Annual Report of the Institute of Phonetics University of Copenhagen* 2. 35–85. https://doi.org/10.7146/aripuc.v2i.130674.

Flemming, Edward. 2001. Scalar and categorical phenomena in a unified model of phonetics and phonology. *Phonology* 18(1). 7–44. https://doi.org/10.1017/S0952675701004006.

Foley, Steven, Nick Kalivoda & Maziar Toosarvandani. 2018. Forbidden clitic clusters in Zapotec. In Daniel Edmiston, Marina Ermolaeva, Emre Hakgüder, Jackie Lai, Kathryn Montemurro, Brandon Rhodes, Amara Sankhagowit & Michael Tabatowski (eds.), *Proceedings of the Fifty-third Annual Meeting of the Chicago Linguistic Society*, 87–102.

Fowler, Carol A. 1983. Realism and unrealism: a reply. *Journal of Phonetics* 11(4). 303–322. https://doi.org/10.1016/S0095-4470(19)30832-0.

Garellek, Marc. 2019. The phonetics of voice. In William F. Katz & Peter F. Assmann (eds.), *The Routledge handbook of phonetics* (Routledge Handbooks in Linguistics), 75–106. Abingdon, Oxon ; New York, NY: Routledge.

Garellek, Marc. 2022. Theoretical achievements of phonetics in the 21st century: Phonetics of voice quality. *Journal of Phonetics* 94. 101155. https://doi.org/10.1016/j.wocn.2022.101155.

Honeybone, Patrick. 2005. Diachronic evidence in segmental phonology: the case of obstruent laryngeal specifications. In Marc van Oostendorp & Jeroen van de Weijer (eds.), *The Internal Organization of Phonological Segments*, 317–352. Berlin, Boston: DE GRUYTER. https://doi.org/10.1515/9783110890402.317.

Iverson, Gregory K. & Joseph C. Salmons. 1995. Aspiration and laryngeal representation in Germanic. *Phonology* 12(3). 369–396. https://doi.org/10.1017/S0952675700002566.

Katz, William F. & Peter F. Assmann (eds.). 2019. *The Routledge handbook of phonetics* (Routledge Handbooks in Linguistics). Abingdon, Oxon ; New York, NY: Routledge.

Keating, Patricia, Jianjing Kuang, Marc Garellek, Christina M. Esposito & Sameer ud Dowla Khan. 2023. A cross-language acoustic space for vocalic phonation distinctions. *Language* 99(2). 351–389. https://doi.org/10.1353/lan.2023.a900090.

Kennedy, Robert. 2021. The Phonetics/Phonology Interface. In Rachael-Anne Knight & Jane Setter (eds.), *The Cambridge Handbook of Phonetics*, 1st edn., 682–706. Cambridge University Press. https://doi.org/10.1017/9781108644198.028.

Knight, Rachael-Anne & Jane Setter (eds.). 2021. *The Cambridge Handbook of Phonetics*. 1st edn. (Cambridge Handbooks in Language and Linguistics). Cambridge: Cambridge University Press. https://doi.org/10.1017/9781108644198.

Mascaró, Joan. 2007. External Allomorphy and Lexical Representation. *Linguistic Inquiry* 38(4). 715–735. https://doi.org/10.1162/ling.2007.38.4.715.

Mittal, Vinay Kumar, B. Yegnanarayana & Peri Bhaskararao. 2014. Study of the effects of vocal tract constriction on glottal vibration. *The Journal of the Acoustical Society of America* 136(4). 1932–1941. https://doi.org/10.1121/1.4894789.

Murty, K. Sri Rama & B. Yegnanarayana. 2008. Epoch Extraction From Speech Signals. *IEEE Transactions on Audio, Speech, and Language Processing* 16(8). 1602–1613. https://doi.org/10.1109/TASL.2008.2004526.

Reiss, Charles. 2017. Substance Free phonology. In *The Routledge Handbook of Phonological Theory*. Routledge.

Santiago Laxopa. 2022. *Santiago Laxopa: Economy, Employment, Equity, Quality of Life, Education, Health and Public Safety*. Data México. https://datamexico.org/en/profile/geo/santiago-laxopa (25 April, 2022).

Sichel, Ivy & Maziar Toosarvandani. 2020. The featural life of nominals. lingbuzz/005523.

Silva-Robles, Fe, Felipe Lopez, John Duff & Carolyn Anderson. 2022. Eliciting Associated Motion Constructions in Two Zapotec Languages. *Semantic Fieldwork Methods* 4(3). 1–51.

Smith-Stark, Thomas. 2003. Algunas isoglosas zapotecas. In *Proceedings of the III Coloquio de Mauricio Swadesh*. Mexico City: UNAM: Instituto de Investigaciones Antropológicas.

Sonnenschein, Aaron H. 2005. *A descriptive grammar of San Bartolomé Zoogocho Zapotec*. Munich: Lincom Europa.

Sonnenschein, Aaron Huey. 2004. *A descriptive grammar of San Bartolomé Zoogocho Zapotec*. Los Angeles, CA: University of Southern California dissertation.

Zhang, Zhaoyan. 2016a. Cause-effect relationship between vocal fold physiology and voice production in a three-dimensional phonation model. *The Journal of the Acoustical Society of America* 139(4). 1493–1507. https://doi.org/10.1121/1.4944754.

Zhang, Zhaoyan. 2016b. Mechanics of human voice production and control. *The Journal of the Acoustical Society of America* 140(4). 2614–2635. https://doi.org/10.1121/1.4964509.