Nasalization and voiceless obstruents in Yoloxóchitl Mixtec: an aerodynamic analysis

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Outline

Nasal harmony

- "[C]omes about when an underlyingly nasal segment... triggers the nasalization of an adjacent string of segments in a predictable and phonologized way" (Walker 2000: 3).

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/daba-$\tilde{i}$/ $\rightarrow$ [$\tilde{n}\tilde{a}\tilde{m}\tilde{e}$] (schematic)

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/CVCV-Ṽ/ → [C̃Ṽ C̃Ṽ]
/daba-ĩ/ → [nãmẽ] (schematic)

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Example (Leftward nasal harmony, blocked)

/CV̥CV-Ṽ/ → [CV̥C̃Ṽ]

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Example (Leftward nasal harmony, blocked)

/CV̥CV-Ṽ/ → [CV̥C̃Ṽ]
/dapa-ĩ/ → [dapẽ] (schematic)

Nasal harmony in Mixtec

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  - can become nasalized in nasal harmonic spans (Coatzospán Mixtec).

Nasal harmony in Ocotepec

- Marlett (1992), based on data from a personal communication, claims that the feature [+NASAL] is applied to entire CVCV lexemes regardless of the nature of the consonants.
- He asserts, however, that nasalization would not be realized phonetically.

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Example (Schematics based on Marlett (1992))

/CVCV-$\tilde{\text{V}}$/ $\rightarrow$ [C$\tilde{\text{V}}$C$\tilde{\text{V}}$]

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/CVCV-Ṽ/ → [CṼCṼ]
/dasa-ĩ/ → [dãsẽ] ...
/dasa-ĩ/ → *[nãsẽ]

▸ Go to (real) Ocotepec Data

Nasal harmony in Coatzospán Mixtec

- Gerfen (2001) used aerodynamic evidence from three speakers to argue that nasalization is realized on voiceless fricatives (though not on other voiceless obstruents) in nasal harmonic spans.
- This, despite the fact that fricatives are phonologically opaque to nasal harmony (i.e., the vowel to the left of the fricative is not nasalized).

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/apa-ĩ/ → [apẽ] — voiceless stop oral, opaque

Aerodynamics of Coatzospán Mixtec

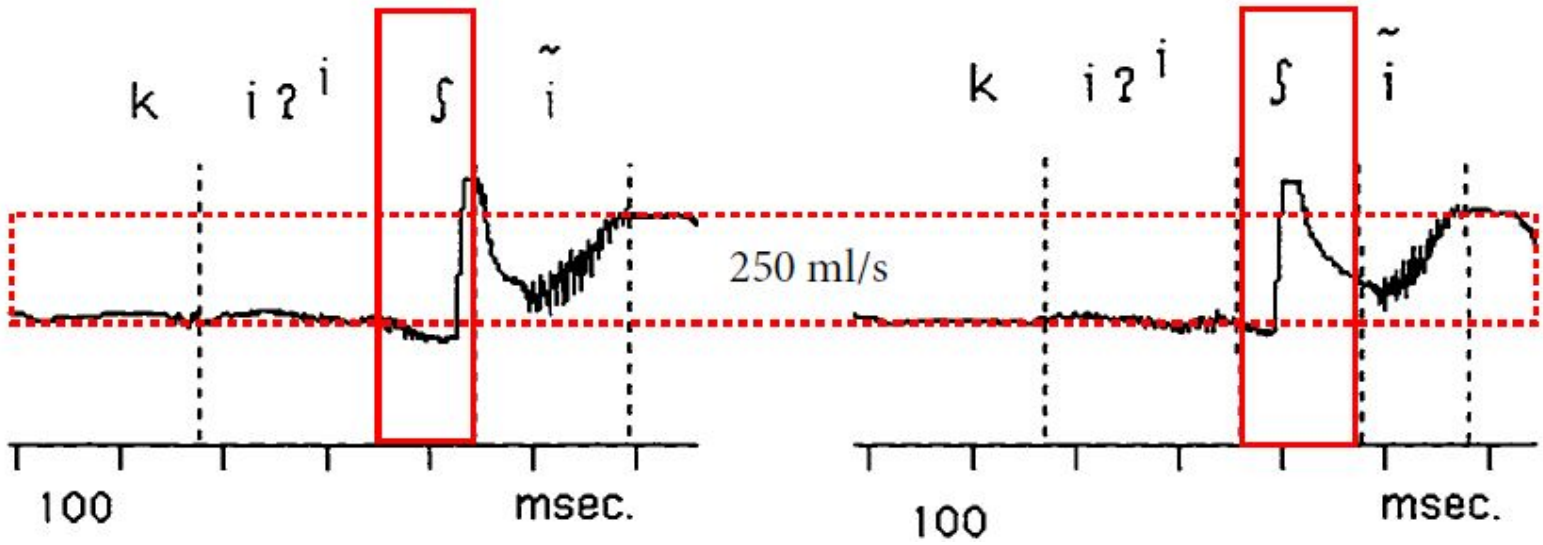

Figure: [kiʔⁱʃ̰ĩ] 'you.FAM' will come' (from Gerfen 1996: 425; red marks our own). Note our use of the diacritic for 'nasal escape' [ʃ̰] (Extended IPA, 1994), reminiscent of the voiceless portion in a voiceless nasal.

▸ More aerodynamics of Coatzospán

*Nasalized buccal obstruents

- Gerfen's findings challenge Ohala & Ohala (1993: 227):

Theorem

"The velic valve must be closed (i.e., the soft palate must be elevated) for an obstruent articulated further forward than the point where the velic valve joins the nasal cavity and the oral cavity."

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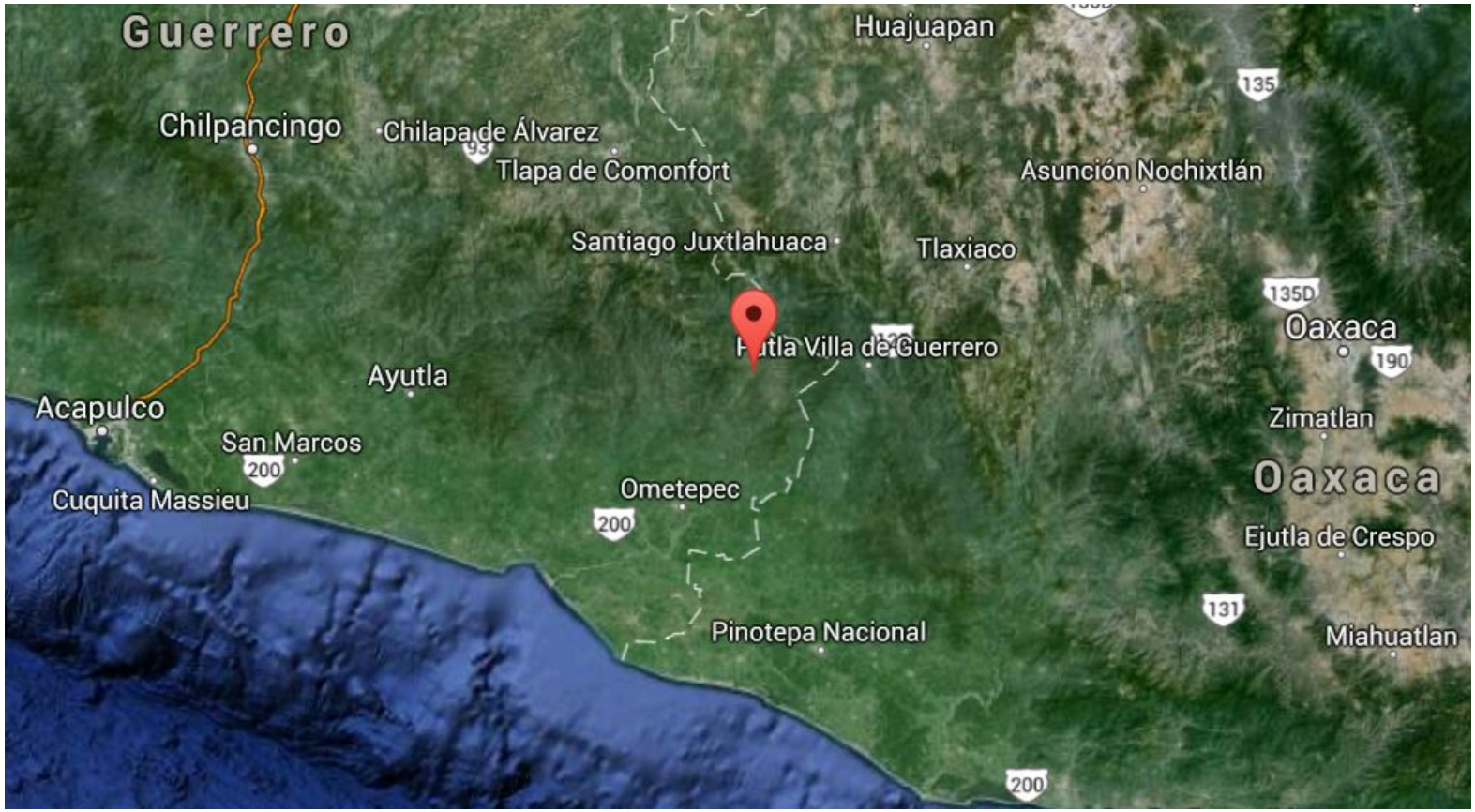
- Modeling by Shosted (2006) explored how nasalization might debilitate the acoustic characteristics of fricatives.
- Demolin (2011) partially corroborated Shosted (2006) with Guarani, a language in which voiceless obstruents are transparent to nasal harmony (like Ocotepec?).

Our project goals

- To further consider the phonetic realization of segments that are phonologically transparent or opaque to nasal harmony.
- To further consider the phonetic realization of nasalization on buccal obstruents.
- To characterize the phonetics of nasal harmony in Yoloxóchitl Mixtec using a relatively large corpus of aerodynamic data.

Speakers

- Nine male speakers from Yoloxóchitl, Guerrero, Mexico (one excluded) ▸ Go to Statistical Analysis



Materials 1

- 341 test items embedded in a carrier phrase, repeated three times ≈ 8K tokens.
- Data were collected in one carrier phrase with a few exceptions.

Example ('I yelled *undeveloped* father')

ni1-nda?1yu1-ra1 **li4sũ2** *ta4ta2*

- Nasal/oral pairs were generally matched for identical or similar tonal patterns to avoid confounds between high tone (possibly resulting from higher subglottal pressure) and higher airflow.

Materials 2

Test items have the following phonological structure:

- List 1: monomorphemic CVCV and CVC$\tilde{V}$ = monomorphemic
- List 2: monomorphemic CVV and CV?V plus oral and nasal enclitics = polymorphemic
- List 3: monomorphemic CV1NV2 and NV1NV2 words plus oral and nasal enclitics; monomorphemic CVV and CV?V words plus oral and nasal enclitics = polymorphemic
- List 4: monomorphemic C1VC2VV and C1VC2V$\tilde{V}$ words plus oral and nasal enclitics = polymorphemic

▸ More on Materials

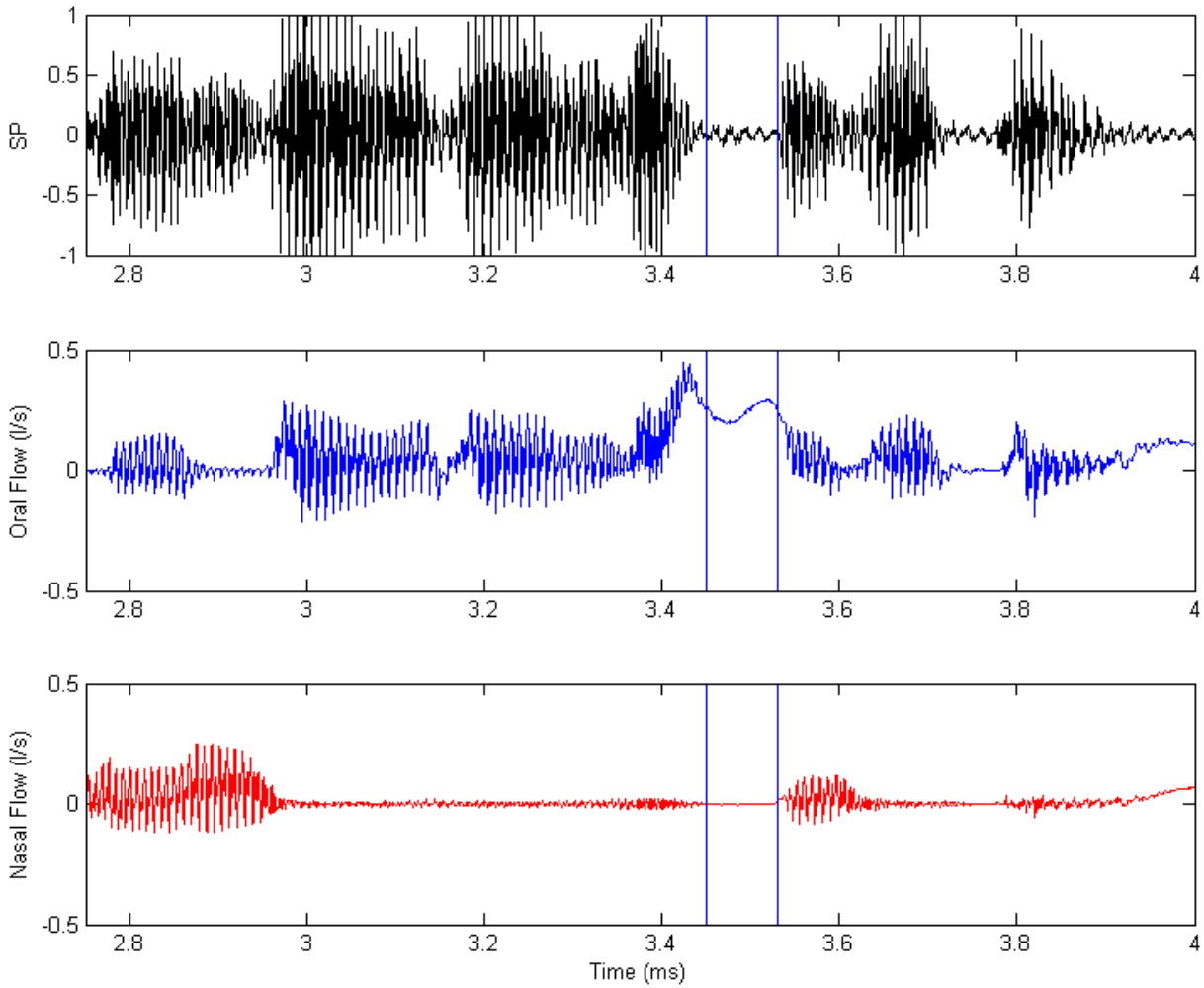
Instrumentation

- Data were gathered using a split-flow air mask fitted with calibrated pneumotachometers.
- Simultaneous audio and airflow signals were gathered at a sampling frequency of 2 kHz.
- Boundaries between consonants and vowels were annotated by hand by two research assistants who had access to the audio signal (sound pressure and spectrogram).
- Airflow signals were zero-phase filtered in Matlab (bandpass 20–200 Hz) ▸ Filter details
- Median absolute and proportional (Nasal/Oral) airflow values during particular segments, e.g., C1 or V2.
- Annotation and analysis are ongoing...

▸ More on instrumentation

Example acquisition

li4sũ1, [s] demarcated



▸ See TextGrid in Praat ▸ See filtered version

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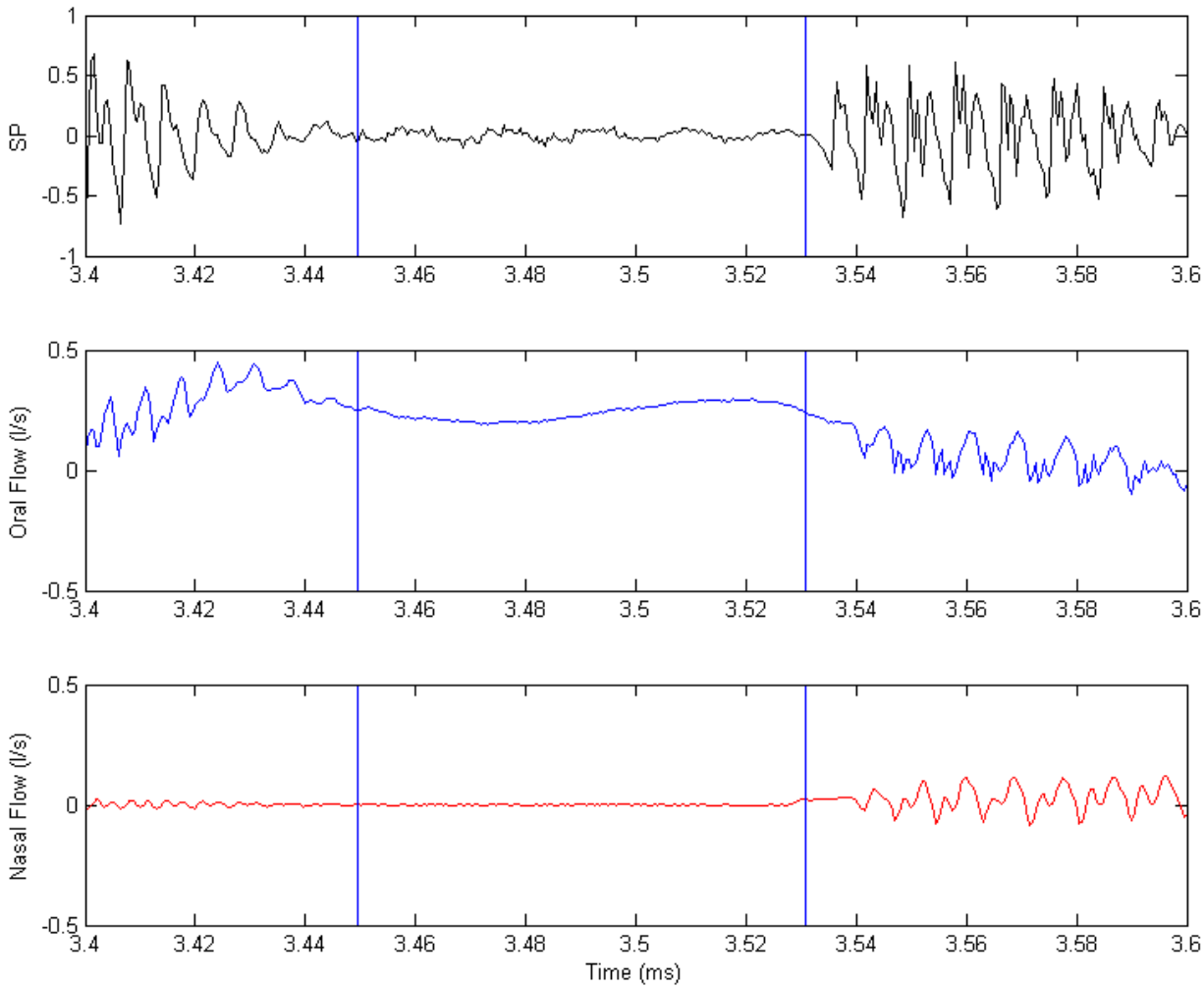

▸ See TextGrid in Praat

Statistical analysis

- One speaker (MSF515) was excluded for his inability to concentrate on the nasal / oral distinction, which resulted in numerous production errors. This left eight (8) speakers in the analysis. ◂ Go back to speakers
- Of three repetitions, only the second was used in the results reported for CVCV (List 1); all repetitions were used for polymorphemic CV=V (List 2).
- Linear mixed effects models using the *nlme* package in R 3.0.2 (Pinheiro et al. 2013).
- Median nasal flow (abs. or prop.) during a particular segment were dep. vars. with trigger nasality as ind. var.
- Speaker and item were both included as random effects.
- We report estimated p-values extracted from the output of `lme.r` and visually inspected confidence intervals for the effect with `intervals(lme.object)`.

▸ See some example code

Monomorphemic CVCV
List 1

- The proportional and absolute nasal flow of V2 was significantly related to the phonological nasality of V2, lending some support to our methodology. ▸ See detailed results
- The proportional and absolute nasal flow of C2 was *not* significantly related to the phonological nasality of V2. For proportional flow, in particular, this was equally true of a subset of fricatives only. ▸ See detailed results
- The proportional and absolute nasal flow of V1 was *not* significantly related to the phonological nasality of V2, either. ▸ See detailed results

Polymorphemic CV=V
List 2

- The proportional and absolute nasal flow of the first half of an oral stem vowel was significantly ($p<0.0001$) related to the phonological nasality of the vowel enclitic.
  ▸ See detailed results
- The proportional and absolute nasal flow of the first half of an oral stem vowel was significantly ($p<0.0001$) related to the phonological nasality of the vowel enclitic, even when the stem vowel contained a glottal stop, i.e., CV?V=V. ▸ See detailed results

Polymorphemic CV=V
List 2

- The proportional nasal flow of the first half of a *nasal* stem vowel was significantly ($p<0.0001$) related to the phonological nasality of the vowel enclitic, meaning that an oral enclitic is capable of reducing (proportional) stem vowel nasality by 20–30%. ▸ See detailed results
- The proportional and absolute nasal flow of the preceding consonant was *not* significantly related to the phonological nasality of the vowel enclitic. ▸ See detailed results

Discussion: Monomorphemic CVCV

List 1

- There is no phonetic evidence of synchronic nasal harmony in CVC̥V items where V varies between oral and nasal.
- C2 (C̥) is neither transparent to nasal harmony nor is it nasalized in the presence of a phonologically nasal vowel.
- This can be taken as evidence that, as in Coatzospán Mixtec, voiceless obstruents block nasal harmony in Yoloxóchitl Mixtec. However, unlike in Coatzospán Mixtec, there is no evidence that voiceless obstruents are nasalized or experience nasal escape in Yoloxóchitl Mixtec.
- To the extent that nasal harmony occurs in CVCV spans where C2 is not a voiceless obstruent, our findings confirm the theorem of Ohala & Ohala 1993 regarding buccal obstruents. ◂ Back to the Theorem

Discussion: Polymorphemic CV=V
List 2

- There is evidence that in Yoloxóchitl Mixtec, nasal harmony takes place with the addition of a nasal vowel enclitic.
- So far, we can best characterize this process as leading to the nasalization of preceding vocalic material, including material leftward of an intervening (phonological) glottal stop. Some thoughts on the glottal stop
- We still have no evidence that a preceding voiceless (buccal) obstruent can be nasalized due to the presence of a nasal enclitic.

Example (xi'4i4=un4 'take.2PSG', 'tomas')

/xi?i=ũ/ → [xĩ?ĩũ] or [xḭ̃ḭ̃ũ]

Discussion: Polymorphemic CV=V
List 2

- There is some evidence for oralization as a morphophonological process in Yoloxóchitl Mixtec.
- When an oral enclitic is added to a stem with a nasal vowel, the first half of the vocalic material shows significantly less nasal flow, both in absolute and proportional terms.
- The vowel in the stem is still nasal, but it experiences significantly less nasality than in the case of a nasal enclitic.

Some conclusions

- We find evidence in Yoloxóchitl Mixtec broadly supporting standard claims regarding the nasalization of osbtruents: buccal obstruents may not allow nasalization but non-buccals (here, glottal stop) may do so. Further, we find evidence of nasal harmony in adjoining vowels.

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- Data from Yoloxóchitl Mixtec do not falsify the observations of Gerfen (2001; 1996), who studied a different, albeit related, language. Our findings highlight the importance and potential rarity of his observations.

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- Data from Yoloxóchitl Mixtec do not falsify the observations of Gerfen (2001; 1996), who studied a different, albeit related, language. Our findings highlight the importance and potential rarity of his observations.
- Among Mixtec languages, Coatzospán Mixtec (and perhaps Ocotepec) may be peculiar in either allowing nasal harmony to occur across voiceless obstruents (Ocotepec) or permitting the nasalization of one category of voiceless obstruents (fricatives in Coatzospán Mixtec).

Acknowledgments

- Our patient speakers
- Graduate research assistant: Li-Hsin Ning (Ph.D., Linguistics, U of Illinois, 2014)
- Undergraduate research assistants: Hannah Greening (B.A., Linguistics, U of Illinois, 2013); Collin Friedemann, Laeh Ragans, Ruchi Tekriwal, and Laura Woelfle.
- NSF-DEL 0966462: Corpus and lexicon development: Endangered genres of discourse and domains of cultural knowledge in T**u**'un ísaví (Mixtec) of Yoloxóchitl, Guerrero

7 The Appendix

- Introduction+
- Methods+
- Results+
- Discussion+

Full definition of nasal harmony

- Nasal harmony "comes about when an underlyingly nasal segment, such as a phonemic nasal stop or vowel, triggers the nasalization of an adjacent string of segments in a predictable and phonologized way" (Walker 2000: 3).

◂ Back to Nasal Harmony

Marlett's Rule 2

Marlett (1992: 426) Rule 2

A segment adjacent to a nasalized segment becomes nasalized; Obstruents cannot be nasalized. Back to Ocotepec

Ocotepec: A personal communication

- "In Ocotepec Mixtec, a nonbranching feature [+nasal] also does not occur, but the facts are different from Tezoatlán Mixtec. Compare the following words from Atatlahuca Mixtec (which follows the typical pattern) and Ocotepec Mixtec (both sets of data provided by Ruth Mary Alexander)" (Marlett 1992: 430).

◂ Back to Ocotepec

▸ To Ocotepec Data

Ocotepec: Phonetic interpertation of [+NASAL]

- On Ocotepec: [T]here would be no phonetic interpretation of [the nasal feature] when it combines with obstruents (Marlett 1992: 431). ◂ Back to Ocotepec

Ocotepec data: Marlett (1992: 431)

(5)

Atatlahuca	Ocotepec	Underlying Forms and Glosses
suk^{w}ã	*sũk^{w}ã*	*suk^{w}a^{N}* 'thus'
n^{d}ixẽ	nĩxĩ	*nixe^{N}, nixi^{N}* 'wing'
n^{d}ixẽ	nĩxã	*nixe^{N}, nixa^{N}* 'sandal'
žɨkɨ̃	ñĩkĩ	*yɨkɨ^{N}, yiki^{N}* 'squash'
žuN^{n}ũ	*ñũtũ*	*yutu^{N}* 'tree'
žuk^{w}ã	*ñũk^{w}ã*	*yuk^{w}a^{N}* 'there'
žaN^{n}ĩ	ñãtĩ	*yati^{N}* 'be near'
žaxĩ	ñãxĩ	*yaxi^{N}* 'gourd'
žukũ	*ñũkũ*	*yuku^{N}* 'furrow'

- "To account for the Ocotepec data, rule (2) must be revised. One possibility would be to allow the autosegmental feature [+nasal] to spread freely to any segment, but there would be no phonetic interpretation of this feature when it combines with obstruents. This version of spreading would ensure that all sonorants in a given morepheme are either oral or nasal, regardless of the presence of obstruents."

Back to Ocotepec

Segmentation of Coatzospán data

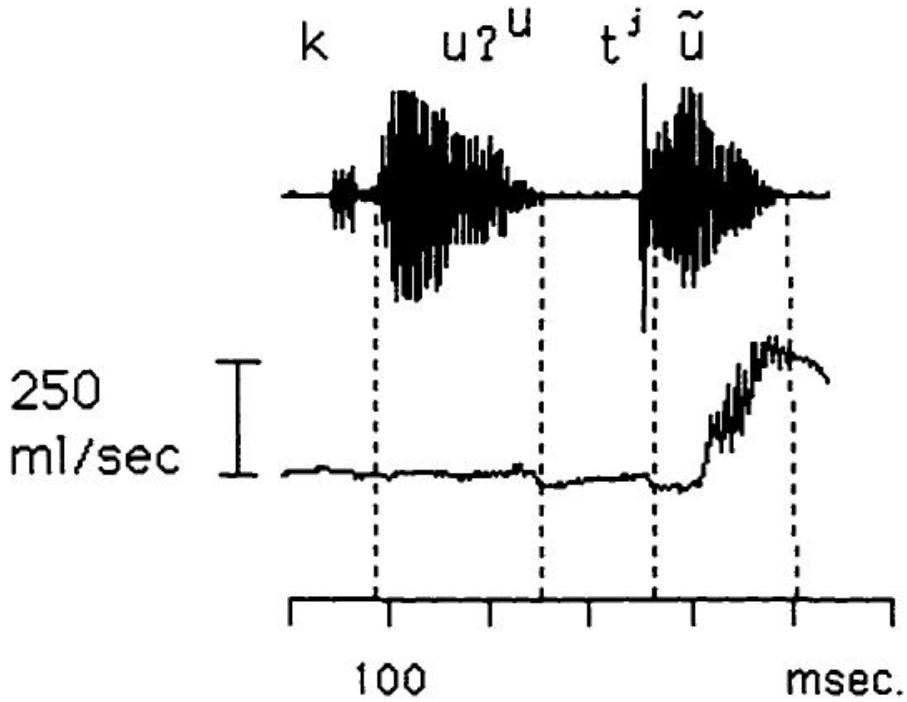

Figure: Typical data segmentation (Gerfen 1996: 45): "[T]he data were segmented by hand, using the waveform and, in more difficult cases, spectrograms to aid in the decision making process."

◂ Back to Coatzospán

More aerodynamics of Coatzospán

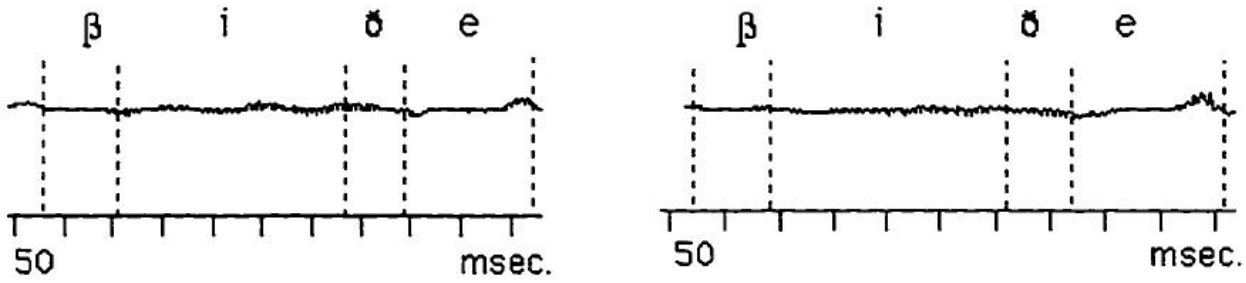

Figure: [βiðe] 'wet'

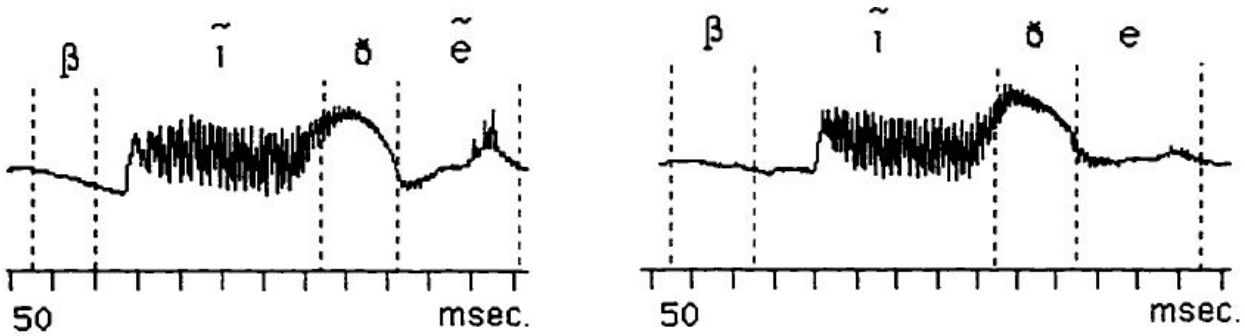

Figure: [β̃ĩð̃ẽ] 'you.FAM are wet'. Note [ð] can be nasalized and is transparent to nasal harmony.

Back to Coatzospán aerodynamics

Materials: List 1

- monomorphemic CVCV vs. CVCVn
- C2 ranges between oral obstruents /s x ch t k/
- controlled for final vowel /u i a un in an/
- Tonal patterns are 1.1, 1.4, 3.2, 3.3. 3.4, 4.1, 4.2, 4.3, 4.4, 13.2, 14.2, 14.3, 14.4.

◂ Back to Materials

Materials: List 1—Research questions

- In disyllabic monomorphemic words, is nasalization present on V1 if V2 is underlyingly nasal (regressive nasalization)?
- Is the presence/degree of nasalization in V1 related to the kind of obstruent C2 (anterior vs. posterior fricative / fricative vs. stop)?
- What are the differences in degree of nasalization between V1 and (nasal) V2?

◂ Back to Materials

Materials: List 2

- monomorphemic CVV and CV? plus oral and nasal enclitics
- V ranges between /uu ii aa uun iin aan/
- enclitics range between /e o a en on an/
- Tonal patterns are 1.1, 1.,3, 1.4, 3.2, 3.3, 3.4, 4.2, 1.1.1, 1.1.4, 1.4.3, 1.4.4, 3.3.3, 3.3.4, 3.4.4, 4.2.2, 4.2.4

◂ Back to Materials

Materials: List 2—Research questions

- When nasal enclitics are added to disyllabic monomrphemic words, what is the degree and timecourse of nasalization on preceding segmental material?
- Does this nasalization spread through glottalization/glottal stop?
- For disyllabic monomorphemic words, is the presence/degree of nasalization in V1 conditioned by intervening glottalization / glottal stop?
- Does vowel length affect the degree / timecourse of nasalization?

◂ Back to Materials

Materials: List 3

- monomorphemic CV1NV2 and NV1NV2 words plus oral and nasal enclitics
- V2 ranges between /u i a/; N ranges between /m n ñ/; enclitics range between /e o a en on an/ (some items have two enclitics)
- monomorphemic CVV and CV?V words plus oral and nasal enclitics
- V ranges between /uu aa ii/
- Tonal patterns are 1.1, 1.3, 1.4, 3.2, 3.3, 3.4, 4.1, 4.2, 4.4, 1.1.1, 1.1.4, 1.1.4.3, 1.3.3, 1.3.4, 1.4.3, 1.4.4, 3.2.2, 3.2.4, 3.3.3, 3.3.4, 4.3, 4.3.4, 4.4, 4.4.4, 4.4.3, 3.3.3, 3.3.4, 4.1.1, 4.1.4, 4.2.2, 4.2.4, 4.4.3, 4.4.4

◂ Back to Materials

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- When nasal enclitics are added to disyllabic monomrphemic words, what is the degree and timecourse of nasalization on preceding segmental material?
- Does this nasalization spread through glottalization/glottal stop?
- For disyllabic monomorphemic words, is the presence/degree of nasalization in V1 conditioned by intervening glottalization / glottal stop?
- Does the presence of a nasal consonant condition an increase in either progressive or regressive nasalization?

◂ Back to Materials

Materials: List 4

- monomorphemic C1VC2VV and C1VC2VVn words plus oral and nasal enclitics (4 words lack C1; these were coded with a false C1 during the word boundary for ease of analysis – 04/25/14)
- C2 ranges between /x kw s m kw ñ k nd/; V1 ranges between /a i u/ ; V2 ranges between /aa ii uu aan iin uun/
- Tonal patterns are 1.1.1, 1.1.1.1, 1.1.1.4, 1.1.4, 1.1.4.3, 1.1.4.4, 3.1.1, 3.2.2, 3.2.2.2, 3.2.2.4, 3.2.2.4.3, 3.3.3, 3.3.3.4, 3.3.3.4.3, 3.3.4, 3.3.4.3, 3.3.4.4, 3.3.4.4.3, 3.3.4.4.3, 4.3.3., 4.3.3.4, 4.3.4, 4.3.4.3, 4.3.4.4,
- Some items have two enclitics

◂ Back to Materials

Materials: List 4—Research questions

- When nasal enclitics are added to disyllabic monomrphemic words, what is the degree and timecourse of nasalization on preceding segmental material?
- Does this nasalization spread through glottalization/glottal stop?
- For disyllabic monomorphemic words, is the presence/degree of nasalization in V1 conditioned by intervening glottalization / glottal stop?
- Does the presence of a nasal consonant condition an increase in either progressive or regressive nasalization?
- Does vowel length affect the degree / timecourse of nasalization?

◂ Back to Materials

Instrumentation

- Simultaneous nasal and oral flow were collected using a Glottal Enterprises OroNasal airflow mask fitted with Biopac TSD137 pneumotachometers attached via rubber cannulae to Biopac TSD160 pressure transducers.
- Audio was sampled using an AKG-C520 head-mounted condenser microphone.
- Signals were recorded using Biopac AcqKnowledge software in order to monitor signals in real-time.
- Software limitations allowed for a maximum sampling rate of 2 kHz.
- Oral flow, nasal flow, and audio were all sampled at 2 kHz.
- Oral and nasal pneumotachometers were calibrated using a 600 ml calibration syringe.

Back to Instrumentation

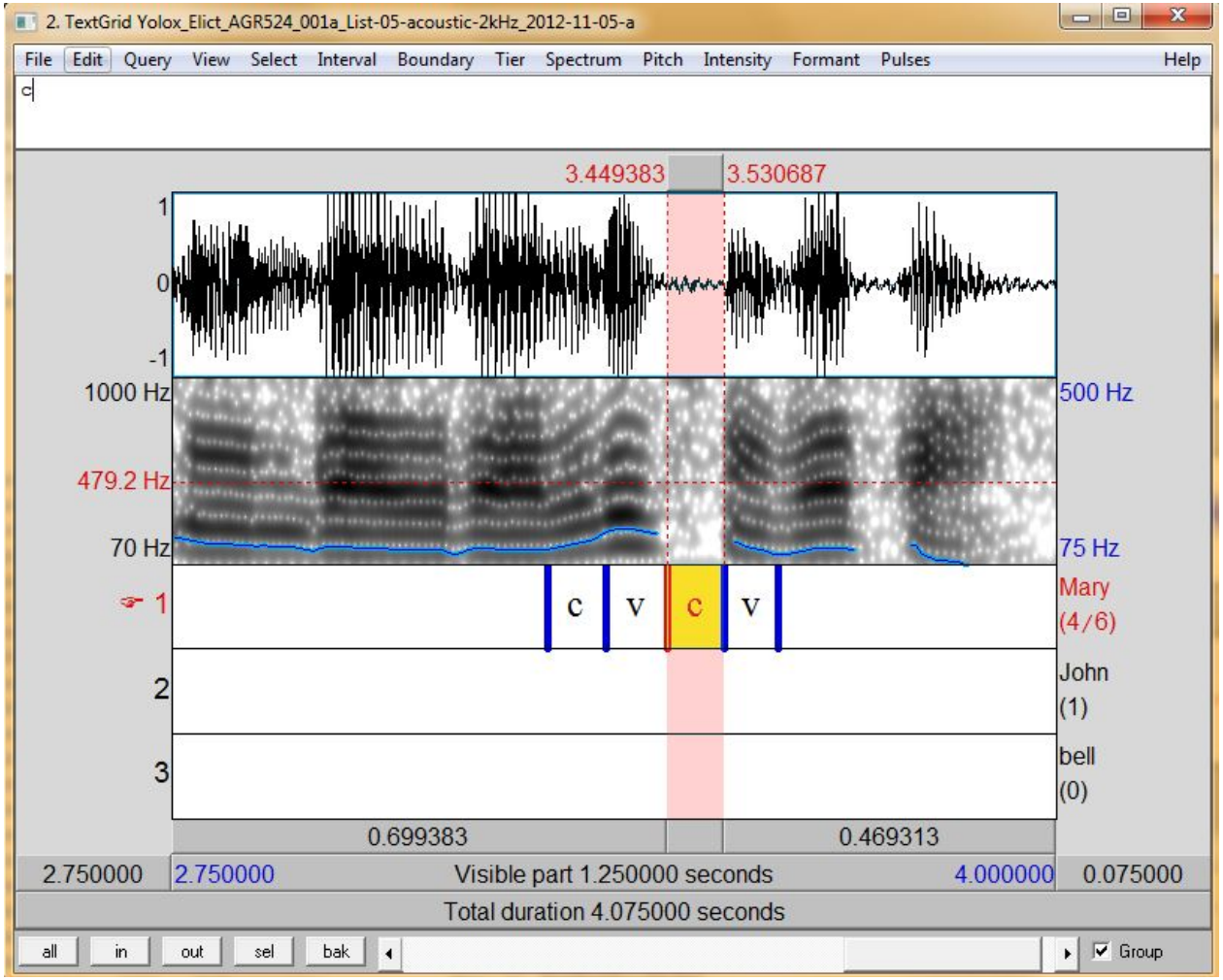
Filter details

- `h = fdesign.lowpass('Fp,Fst,Ap,Ast',0.01,...`
  `1/10,1,60);`
- `d = design(h,'equiripple');`
- `nasflow = filtfilt(d.Numerator,1,CalMat(:,1));`
- `oraflow = filtfilt(d.Numerator,1,CalMat(:,2));`

Back to Instrumentation

Example TextGrid

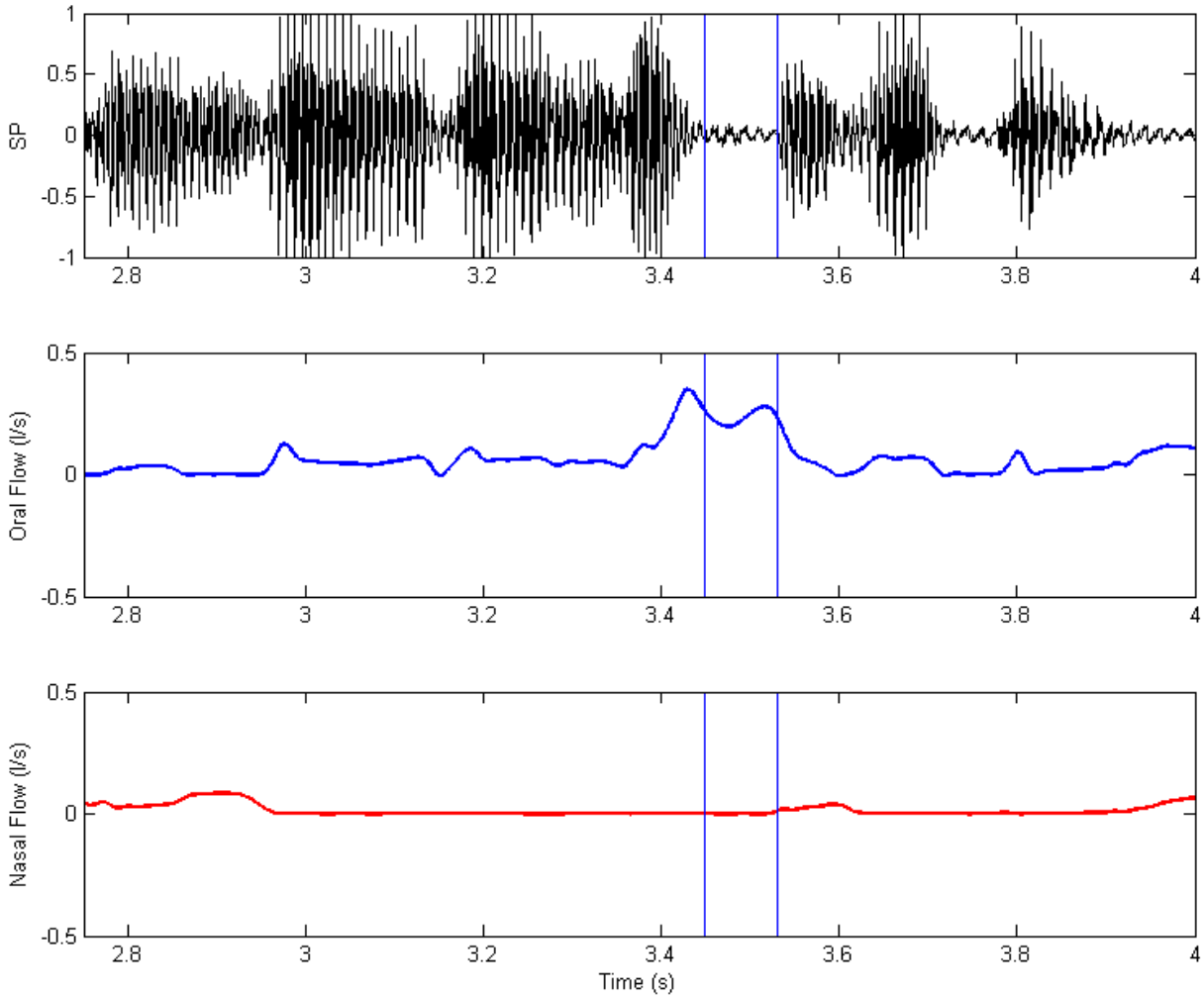
li4sũ2, [s] highlighted



◂ Go back to example acqusition

Example Acquisition—Filtered version

lis4sũ2, [s] demarcated



Go back to example acqusition

Code example for linear mixed effects models

nlme package, R 3.0.2

- Monomorphemic CVCV (List 1)
  - `C2.pnf.lme <- lme(c2.pnf~nasality,...`
    `data=subset(mix1,rep==2),random=...`
    `~1|speaker/serial)`
  - `summary(C2.pnf.lme)$tTable`

Code example for linear mixed effects models

nlme package, R 3.0.2

- Monomorphemic CVCV (List 1)
  - `C2.pnf.lme <- lme(c2.pnf~nasality,... data=subset(mix1,rep==2),random=... ~1|speaker/serial)`
  - `summary(C2.pnf.lme)$tTable`
- Polymorphemic CV=V (List 2)
  - mix2.v1a.anf.lme <- lme(v1a.anf~nasal.clitic,... data=subset(subset(mix2,polymorphemic==1),... nasal.stem.vowel=="oral"), random=~1—speaker/serial)
  - `summary (mix2.v1a.anf.lme)$tTable`

Go back to statistical analysis

Absolute Nasal Flow (anf) on V2

List 1: CVC**V**

v2.anf	Value	StdErr	DF	t	p
(Intercept)	0.0272	0.0021	317		
v2.nasalityOral	-0.0266	0.0013	317	-20.5	$< .0001$

Table: Mixed model (lme) contrast table for *v2.anf* (model v2.anf $\sim$ v2.nasality). The value in row (Intercept) gives the reference value for v2.nasality = Nasal.

◂ Go back to results summary (List 1)

Proportional Nasal Flow (pnf) on V2

List 1: CVC**V**

v2.pnf	Value	StdErr	DF	t	p
(Intercept)	0.41	0.03	317		
v2.nasalityOral	-0.391	0.018	317	-22.2	$< .0001$

Table: Mixed model (lme) contrast table for *v2.pnf* (model v2.pnf $\sim$ v2.nasality). The value in row (Intercept) gives the reference value for v2.nasality = Nasal.

◂ Go back to results summary (List 1)

Absolute Nasal Flow (anf) on C2

List 1: CV**C**V

c2.anf	Value	StdErr	DF	t	p
(Intercept)	0.0008	0.0004	317		
v2.nasalityOral	-0.0002	0.0003	317	-0.5	0.5855

Table: Mixed model (lme) contrast table for *c2.anf* (model c2.anf ~ v2.nasality). The value in row (Intercept) gives the reference value for v2.nasality = Nasal.

◂ Go back to results summary (List 1)

Proportional Nasal Flow (pnf) on C2

List 1: CV**C**V

c2.pnf	Value	StdErr	DF	t	p
(Intercept)	0.15	0.029	317		
v2.nasalityOral	-0.021	0.017	317	-1.2	0.2156

Table: Mixed model (lme) contrast table for *c2.pnf* (model c2.pnf ~ v2.nasality). The value in row (Intercept) gives the reference value for v2.nasality = Nasal.

◂ Go back to results summary (List 1)

Proportional Nasal Flow (pnf) on C2

List 1: CV**C**V, fricatives only

c2.pnf	Value	StdErr	DF	t	p
(Intercept)	0.013	0.005	110		
v2.nasalityOral	-0.002	0.005	110	-0.5	0.5971

Table: Mixed model (lme) contrast table for *c2.pnf* (model c2.pnf ~ v2.nasality). The value in row (Intercept) gives the reference value for v2.nasality = Nasal.

◂ Go back to results summary (List 1)

Absolute Nasal Flow (anf) on V1

List 1: C**V**CV, fricatives only

v1.anf	Value	StdErr	DF	t	p
(Intercept)	0.00079	0.00026	317		
v2.nasalityOral	1e-05	0.00019	317	0	0.9604

Table: Mixed model (lme) contrast table for *v1.anf* (model v1.anf ~ v2.nasality). The value in row (Intercept) gives the reference value for v2.nasality = Nasal.

◂ Go back to results summary (List 1)

Proportional Nasal Flow (pnf) on V1

List 1: C**V**CV, fricatives only

v1.pnf	Value	StdErr	DF	t	p
(Intercept)	0.017	0.005	317		
v2.nasalityOral	-0.001	0.004	317	-0.2	0.8398

Table: Mixed model (lme) contrast table for *v1.pnf* (model v1.pnf ~ v2.nasality). The value in row (Intercept) gives the reference value for v2.nasality = Nasal.

◂ Go back to results summary (List 1)

Absolute nasal flow (anf) on V1a

List 2: C**V**=V (polymorphemic)

v1a.anf	Value	StdErr	DF	t	p
(Intercept)	0.0052	0.0011	352		
nasal.cliticoral	-0.0045	0.0009	167	-5.2	$< .0001$

Table: Mixed model (lme) contrast table for *v1a.anf* (model v1a.anf $\sim$ nasal.clitic). The value in row (Intercept) gives the reference value for nasal.clitic = nasal.

◂ Go back to results summary (List 2)

Proportional nasal flow (pnf) on V1a

List 2: C**V**=V (polymorphemic)

v1a.pnf	Value	StdErr	DF	t	p
(Intercept)	0.216	0.023	352		
nasal.cliticoral	-0.158	0.018	167	-8.9	$< .0001$

Table: Mixed model (lme) contrast table for *v1a.pnf* (model v1a.pnf $\sim$ nasal.clitic). The value in row (Intercept) gives the reference value for nasal.clitic = nasal.

◂ Go back to results summary (List 2)

Absolute nasal flow (anf) on V1a

List 2: C**V**?V=V (polymorphemic), with glottal stop in stem

v1a.anf	Value	StdErr	DF	t	p
(Intercept)	0.0021	0.0006	176		
nasal.cliticoral	-0.0017	0.0005	79	-3.7	3e-04

Table: Mixed model (lme) contrast table for *v1a.anf* (model v1a.anf $\sim$ nasal.clitic). The value in row (Intercept) gives the reference value for nasal.clitic = nasal.

◂ Go back to results summary (List 2)

Proportional nasal flow (pnf) on V1a

List 2: C**V**ʔV=V (polymorphemic), with glottal stop in stem

v1a.pnf	Value	StdErr	DF	t	p
(Intercept)	0.237	0.028	176		
nasal.cliticoral	-0.163	0.023	79	-7.1	$< .0001$

Table: Mixed model (lme) contrast table for *v1a.pnf* (model v1a.pnf $\sim$ nasal.clitic). The value in row (Intercept) gives the reference value for nasal.clitic = nasal.

◂ Go back to results summary (List 2)

Proportional nasal flow (pnf) on C1

List 2: **C**V=V (polymorphemic)

c1.anf	Value	StdErr	DF	t	p
(Intercept)	0.0008	0.0005	352		
nasal.cliticoral	0.0001	0.0004	167	0.3	0.7364

Table: Mixed model (lme) contrast table for *c1.anf* (model c1.anf ~ nasal.clitic). The value in row (Intercept) gives the reference value for nasal.clitic = nasal.

◂ Go back to results summary (List 2)

Proportional nasal flow (pnf) on C1

List 2: **C**V=V (polymorphemic)

c1.pnf	Value	StdErr	DF	t	p
(Intercept)	0.106	0.016	352		
nasal.cliticoral	-0.002	0.014	167	-0.1	0.9076

Table: Mixed model (lme) contrast table for *c1.pnf* (model c1.pnf ~ nasal.clitic). The value in row (Intercept) gives the reference value for nasal.clitic = nasal.

◂ Go back to results summary (List 2)

Absolute nasal flow (anf) on V1a

List 2: C$\tilde{\mathbf{V}}$=V (polymorphemic), nasal stem vowels only

v1a.anf	Value	StdErr	DF	t	p
(Intercept)	0.021	0.004	397		
nasal.cliticoral	-0.004	0.0024	191	-1.7	0.1006

Table: Mixed model (lme) contrast table for *v1a.anf* (model v1a.anf $\sim$ nasal.clitic). The value in row (Intercept) gives the reference value for nasal.clitic = nasal.

◂ Go back to results summary (List 2)

Proportional nasal flow (pnf) on V1a

List 2: C$\tilde{\mathbf{V}}$=V (polymorphemic), nasal stem vowels only

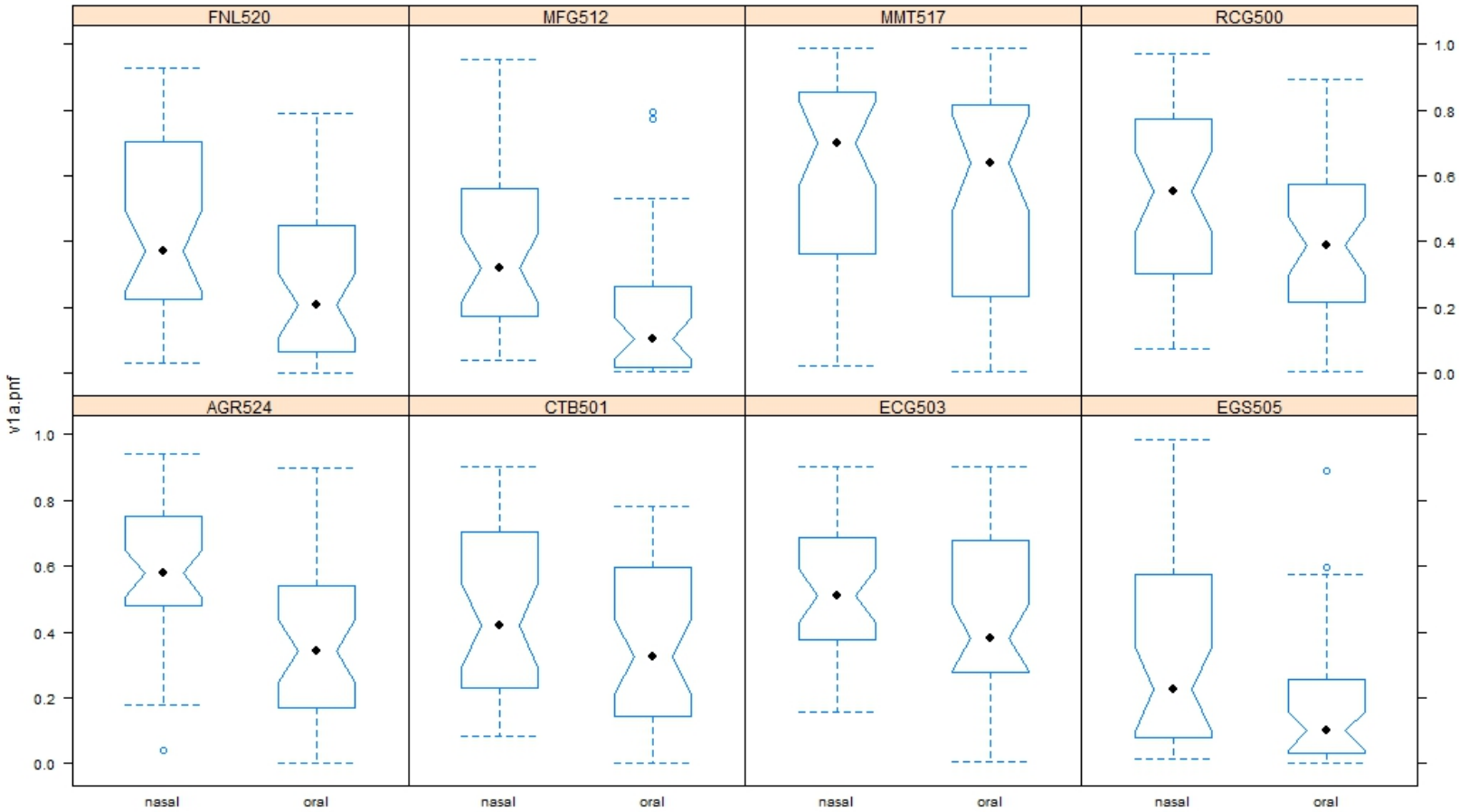
v1a.pnf	Value	StdErr	DF	t	p
(Intercept)	0.49	0.04	397		
nasal.cliticoral	-0.139	0.028	191	-4.9	$< .0001$

Table: Mixed model (lme) contrast table for *v1a.pnf* (model v1a.pnf $\sim$ nasal.clitic). The value in row (Intercept) gives the reference value for nasal.clitic = nasal.

◂ Go back to results summary (List 2)

Proportional nasal flow (pnf) on V1a

List 2: C$\tilde{\mathbf{V}}$=V (polymorphemic), nasal stem vowels only



Glottal stop

- Glottal stop appears to be realized very often as a modulation in voice quality, e.g., creaky voice.
- For this reason, it may be unwarranted to claim that the glottal obstruent (or, more to the physiological point, its release) may be nasalized in Yoloxóchitl Mixtec.
- With access to oral flow data, it should be possible to examine the phonetic nature of the phonological glottal stop in Yoloxóchitl Mixtec: a sharp decrease in flow (e.g., to zero l/s) would suggest a stop.
- Creaky voice will be relatively more difficult to identify positively.

◂ Go back to discussion of CV=V (List 2)