⟨'⟩ in Tsimane': a Preliminary Investigation

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Introduction

Tsimane' Community and Language

- Mosetenan language (Ritchie et al. 2023)
  - Mosetén ($<$ 3,000 speakers)
  - Tsimane' ($\sim$ 17,000 speakers)
- Few descriptions
  - Wayne Gill (1960s)
  - Eusebia H. Martin (1990s)
  - Sandy Ritchie (2010s)
- **Little focus on phonetics or phonology**

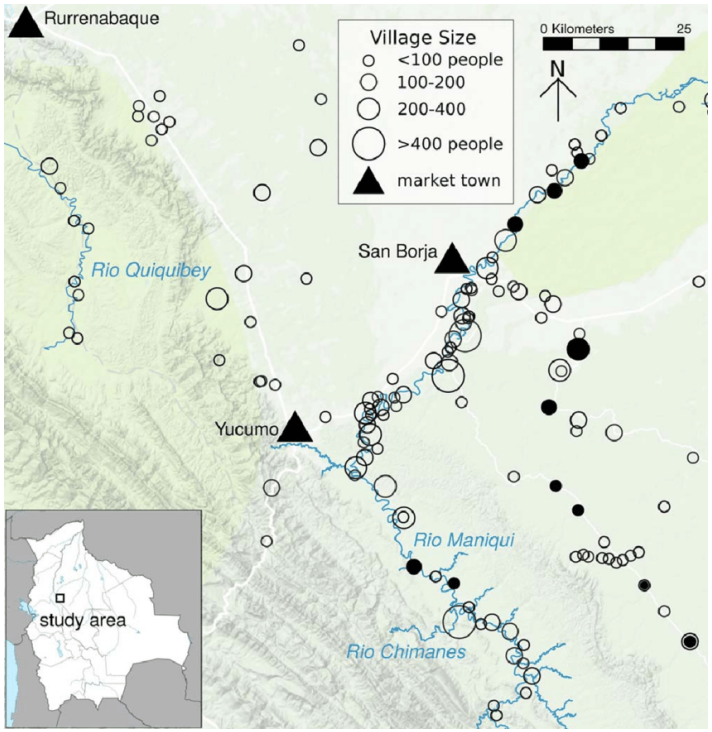

Figure 1: Map of Tsimane' territory (borrowed from Gurven et al. 2017)

Research Questions

Focus on the **realisation** of the **sound written ⟨'⟩**

Traditionally **described as a glottal stop**

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Focus on the **realisation** of the **sound written ⟨'⟩**

Traditionally **described as a glottal stop**

- Is ⟨'⟩ a glottal stop?
  - Is ⟨'⟩ realised as a **stop**?
  - If not, has it other *traditional* **features of glottal stops**?

⟨'⟩ in Tsimane'

- Phonemic
  - ä'äm' (**female** owl) v. ä'äm (**male** owl)
- Distribution
  - **only as a coda**
  - 78.94% after an oral vowels /a, ə, e, i, o, u/
  - 8.61% after a nasal vowels /ã, ə̃, ẽ, ĩ, õ, ũ/
  - 12.4% after a nasal consonant /m, n/ (& occasionally /r, ʊ/)
- Tsimane' does not allow complex onsets and codas
  - ⟨'⟩ after a consonant is itself unusual in Tsimane'

Methodology

Stimuli

- Minimal Pairs
  - Validated by 2 native male Tsimane' speakers

#	Word 1	Word 2	#	Word 1	Word 2
1	ä'ä**m'**	ä'ä**m**	10	fó'jeya**qui'**	fó'jeya**qui**
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3	ajá**'**	á**ja**	12	**jä'**mij	**jä**míj
4	án'dye**m'**	án'dye**m**	13	**já'**na'	**ja**ná'
5	bǫ́rịc**ǫ'**	bǫ́rịc**ǫ**	14	**jí'**ĉun	**ji**ĉún
6	bubá**qui'**	bubá**qui**	15	jí'**jun'**taqui	jí'**jun**taqui
7	**ĉó'**chaqui	**ĉo**cháqui	16	jí'junta**qui'**	jí'junta**qui**
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9	**có'**co'	**co**có'	**18**	**jí'**jun'**tye'**	**jí**jun'**te**

Table 1: Recording Stimuli

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  - Tsimane'/English dictionary
    - Under-specified orthography
    - e.g. /n/ v. /ɲ/ v. /nʲ/ → ⟨n⟩

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    - Palatal/Palatalised consonants ✗

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  - Attention to
    - Palatal/Palatalised consonants ✗
    - Nasal vowels ✗
    - Stress ✓ **(I will get back to this point later)**
  - Total: **97** (+ 7 quasi) minimal pairs
- **Preliminary analysis**
  17 (+ **1 quasi**) minimal pairs

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Table 1: Recording Stimuli

Recording Procedure

- Recording Contexts
  - Isolation
  - 1 natural sentence
  - 3 carrier sentences (Table 2)

Begin	TARGET-WORD mo' nash peyacdye' yu yi
	TARGET-WORD is the word I am saying
Middle	yu ra' yi TARGET-WORD jeñej peyacdye'
	I will say TARGET-WORD as a word
End	yu ra' yi mo' peyacdye' TARGET-WORD
	I will say the word TARGET-WORD

Table 2: Carrier sentences

Recording Procedure

- Recording Contexts
  - Isolation
  - 1 natural sentence
  - 3 carrier sentences (Table 2)
- Data
  - 2h13 recordings
  - Preliminary analysis
    380 sentences (20mn)

Begin	TARGET-WORD mo' nash peyacdye' yu yi
	TARGET-WORD is the word I am saying
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Table 2: Carrier sentences

Annotation

Annotations

- Manual Segmentation & Annotation
  1. Phonetic Realisation
  2. Phoneme
  3. Syllable
  4. Word
  5. Sentence

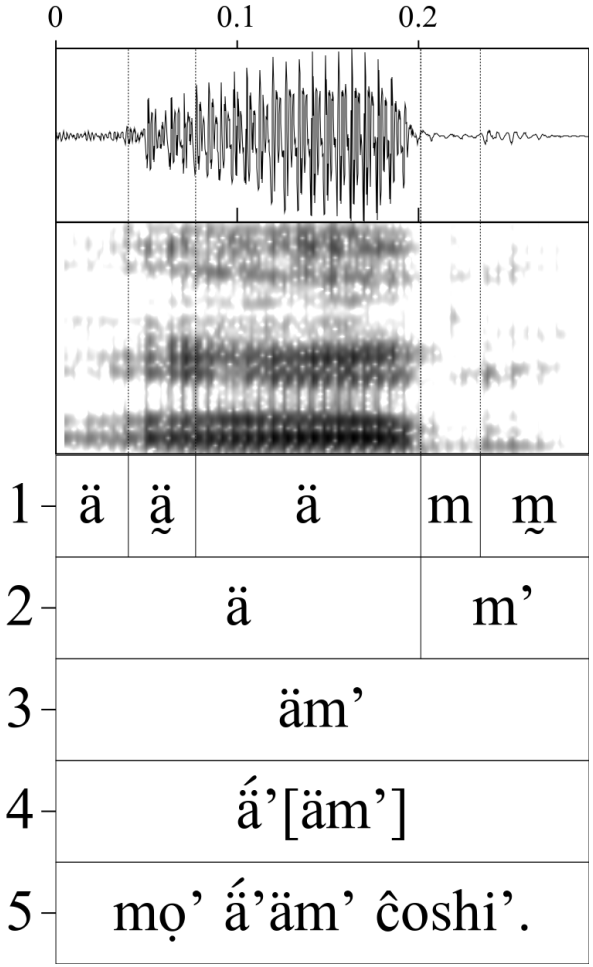


Figure 2: Annotated example
“The [female owl] sleeps”

Annotations

- Coarse grained phonetic annotation for ⟨'⟩
  1. **clos** perceptible silence (Figure 3)

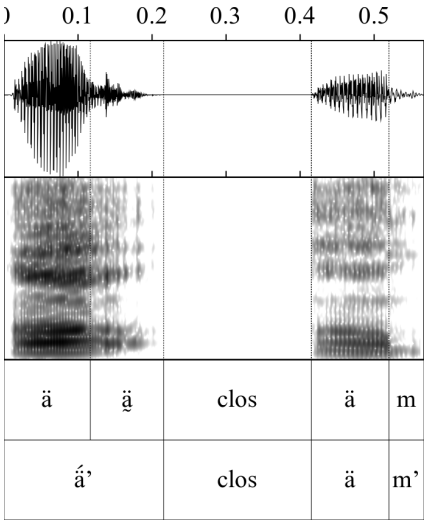
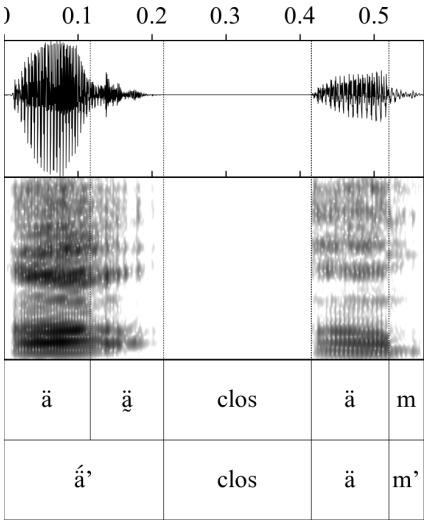


Figure 3: **clos**
ä'äm' (*female owl*)

Annotations

- Coarse grained phonetic annotation for ⟨'⟩
  1. **clos** perceptible silence (Figure 3)

  3. ◌̰ glottal constriction with **amodal** voicing where is ◌ is the sound preceding ⟨'⟩



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ä'äm' (*female owl*)

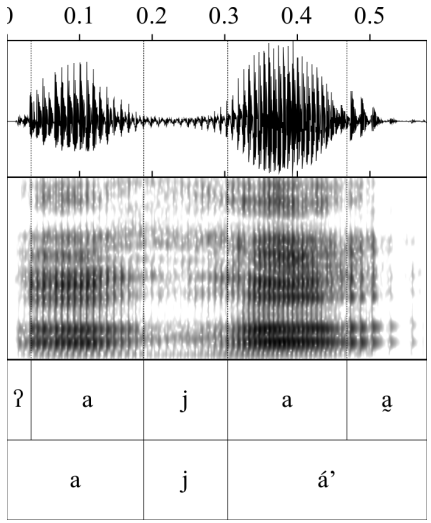
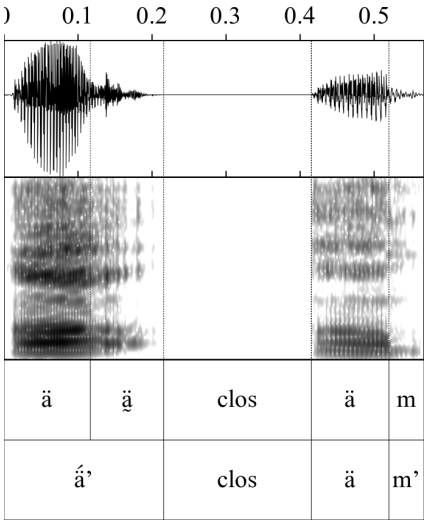


Figure 6: ◌̰
ajá' (*flu*)

Annotations

- Coarse grained phonetic annotation for ⟨'⟩
  1. **clos** perceptible silence (Figure 3)
  2. **ʔ** glottal constriction without **amodal** voicing
  3. ◌̰ glottal constriction with **amodal** voicing where is ◌ is the sound preceding ⟨'⟩



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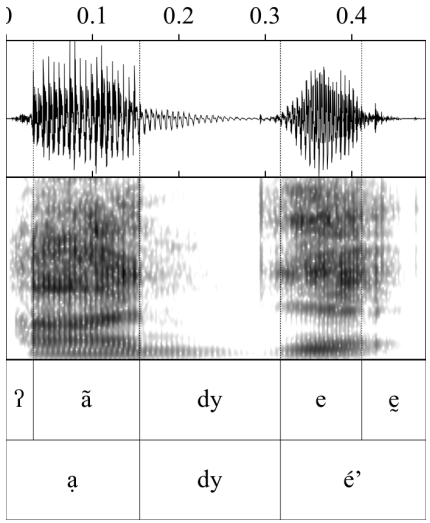

Figure 4: Initial **ʔ**
adyé' (*coal*)

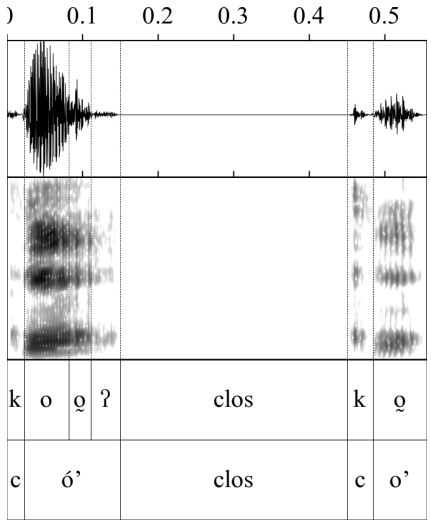

Figure 5: Final **ʔ**
có'co'(*mite*)

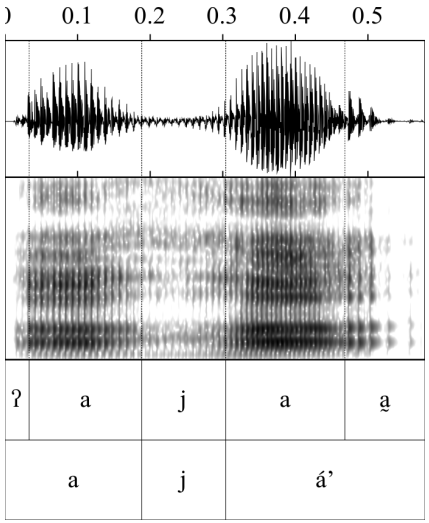

Figure 6: ◌̰
ajá' (*flu*̰)

Results

Analysis (1)

1. Is ⟨'⟩ systematically realised with a full closure?

- Full closure = Presence of silence
- 7 minimal pairs with **word-internal ⟨'⟩**
- Silence can be attributed to closure and not boundary pause

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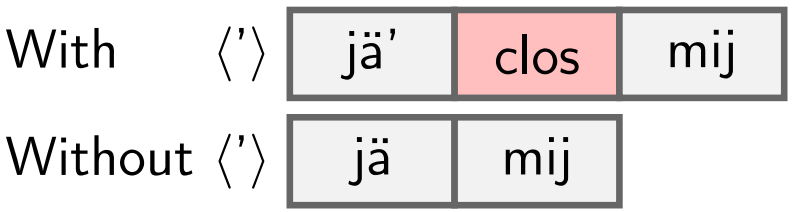
(a) Non-occlusive context

#	Word 1	Word 2
12	**jä'**mij	**jä**míj
13	**já'**na'	**ja**ná'
18	**jí'**jun'tye'	**jí**jun'te

- **Presence** of silence



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- **Presence** of silence

With ⟨'⟩: jä' | clos | mij

Without ⟨'⟩: jä | mij

(b) Occlusive context

#	Word 1	Word 2
7	**ĉó'**chaqui	**ĉo**cháqui
9	**có'**co'	**co**có'
14	**jí'**ĉun	**ji**ĉún
15	jí'**jun'**taqui	jí'**jun**taqui

- **Duration** of silence

With ⟨'⟩: có' | clos | co'

Without ⟨'⟩: co | clos | có'

Analysis (1a) Non-Occlusive Context

- **Presence** of a silence
- 3 pairs $\times$ 5 context $\times$ 2 spk. $=$ 60 obs

#	Word 1	Word 2
12	**jä'**mij	**jä**míj
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Analysis (1a) Non-Occlusive Context

- **Presence** of a silence
- 3 pairs × 5 context × 2 spk. = 60 obs
  - → 4/30 obs. with intended ⟨'⟩
  - → 1/30 obs. without intended ⟨'⟩

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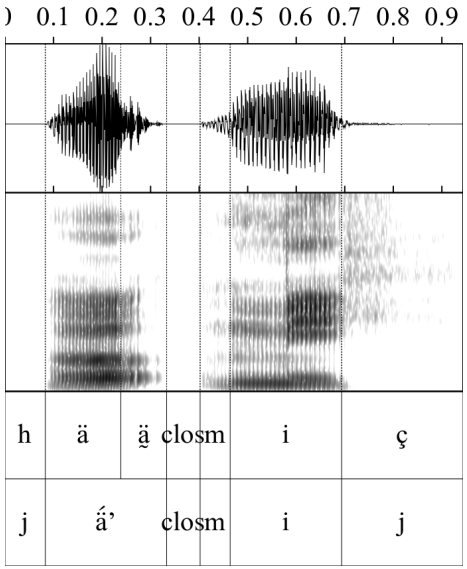

Figure 7: Perceptible silence (intended ⟨'⟩) jä'mij (*to hurry up*)

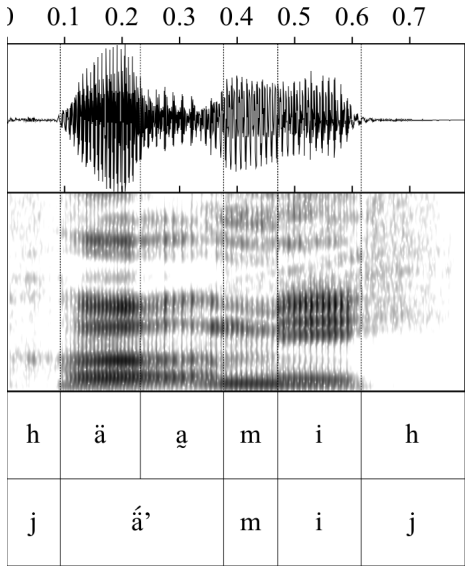

Figure 8: No silence (intended ⟨'⟩) jä'mij (*to hurry up*)

Analysis (1a) Non-Occlusive Context

- **Presence** of a silence
- 3 pairs × 5 context × 2 spk. = 60 obs
  - → 4/30 obs. with intended ⟨'⟩
  - → 1/30 obs. without intended ⟨'⟩
  - → **Low incidence**

#	Word 1	Word 2
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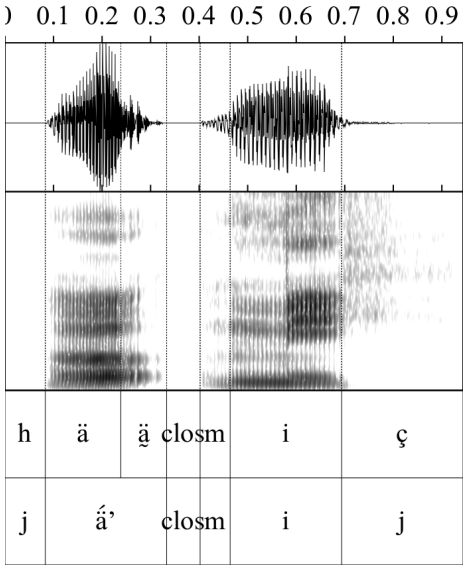

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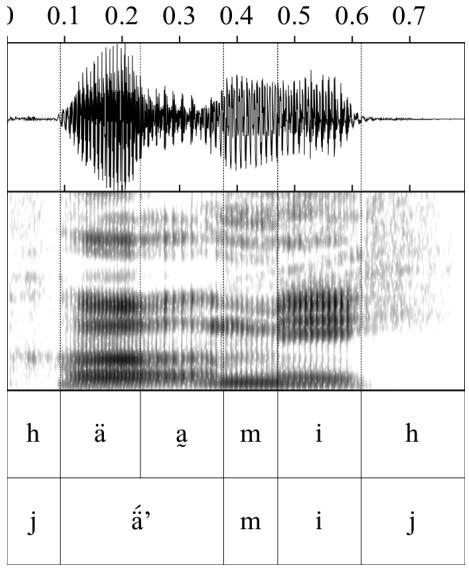

Figure 8: No silence (intended ⟨'⟩) jä'mij (*to hurry up*)

Analysis (1b) Occlusive Context

- **Duration** of a silence
- 4 pairs $\times$ 5 context $\times$ 2 spk. $=$ 80 obs

#	Word 1	Word 2
7	**ĉó'**chaqui	**ĉo**cháqui
9	**có'**co'	**co**có'
14	**jí'**ĉun	**ji**ĉún
15	jí'**jun'**taqui	jí'**jun**taqui

Analysis (1b) Occlusive Context

- **Duration** of a silence
- 4 pairs × 5 context × 2 spk. = 80 obs
  - → 0.127ms with intended ⟨'⟩
  - → 0.103ms without intended ⟨'⟩

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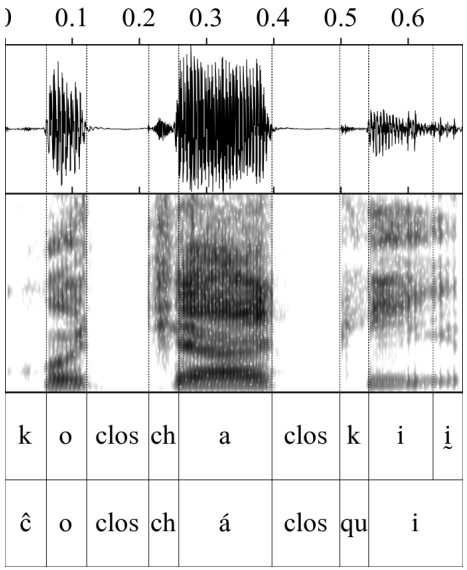


Figure 9: Short occlusion (no intended ⟨'⟩) ĉocháqui (*to grind*)

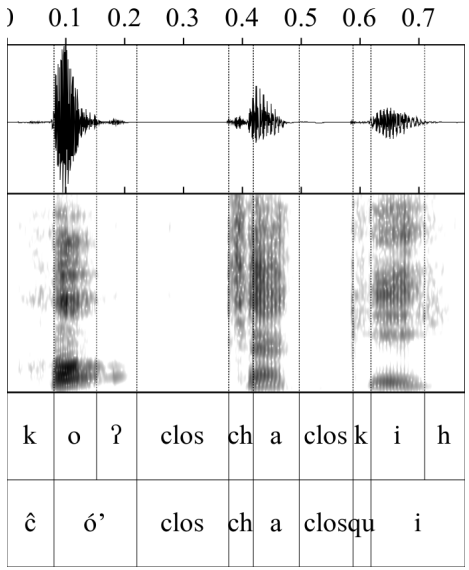
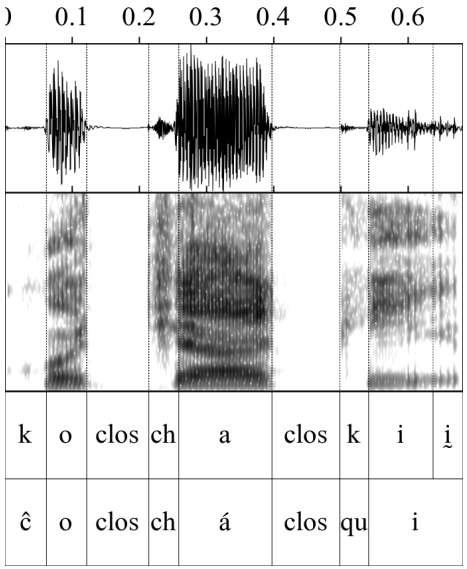


Figure 10: Long occlusion (intended ⟨'⟩) ĉó'chaqui (*to jab*)

Analysis (1b) Occlusive Context

- **Duration** of a silence
- 4 pairs × 5 context × 2 spk. = 80 obs
  - → 0.127ms with intended ⟨'⟩
  - → 0.103ms without intended ⟨'⟩
  - → **significant**, paired t-test, $p < 0.01$

#	Word 1	Word 2
7	**ĉó'**chaqui	**ĉo**cháqui
9	**có'**co'	**co**có'
14	**jí'**ĉun	**ji**ĉún
15	jí'**jun'**taqui	jí'**jun**taqui



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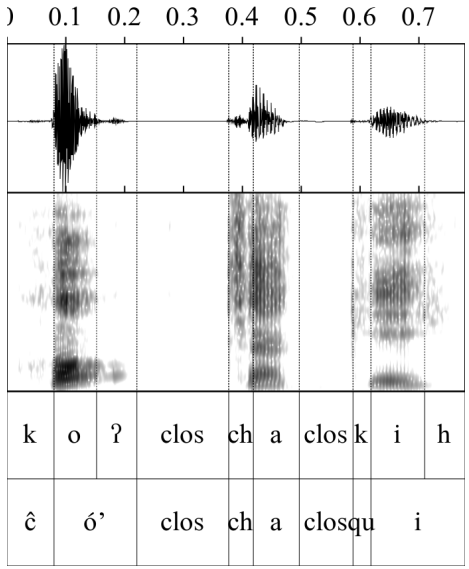


Figure 10: Long occlusion (intended ⟨'⟩) ĉó'chaqui (*to jab*)

Analysis (2)

2. Is ⟨'⟩ realised with glottal approximant ??

- Narrowing of the vocal tract
- **Without creak**
- 18 pairs × 5 context × 2 spk. = 380 obs
  - 7% of intended ⟨'⟩

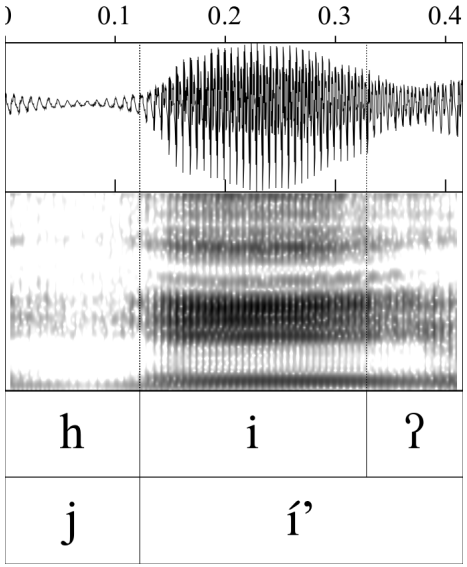


Figure 11: **ji'**jun'taqui *(to employ)*

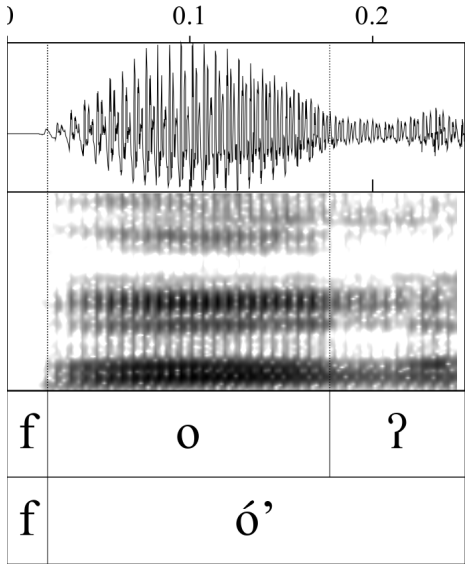


Figure 12: **fo'**jeyaqui' *(to empty)*

Analysis (3)

3. Is ⟨'⟩ realised with non-modal voicing?

- Narrowing of the vocal tract
- **With creak**

Analysis (3)

3. Is ⟨'⟩ realised with non-modal voicing?

- Narrowing of the vocal tract
- **With creak**

(a) Vowels

16 pairs × 5 context × 2 spk. = 160 obs

Analysis (3)

3. Is ⟨'⟩ realised with non-modal voicing?

- Narrowing of the vocal tract
- **With creak**

(a) Vowels	**(b) Consonants**
16 pairs × 5 context × 2 spk. = 160 obs	3 pairs × 5 context × 2 spk. = 60 obs

Analysis (3a) Creaky Vowels

- 16 pairs × 5 context × 2 spk. = 160 obs
  - → 125/160 obs. with intended ⟨'⟩
  - → 12/160 obs. without intended ⟨'⟩

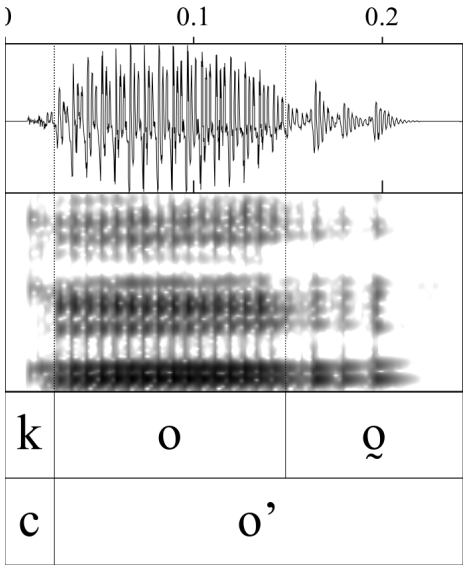


Figure 13: **co'**co' *(type of bird)*

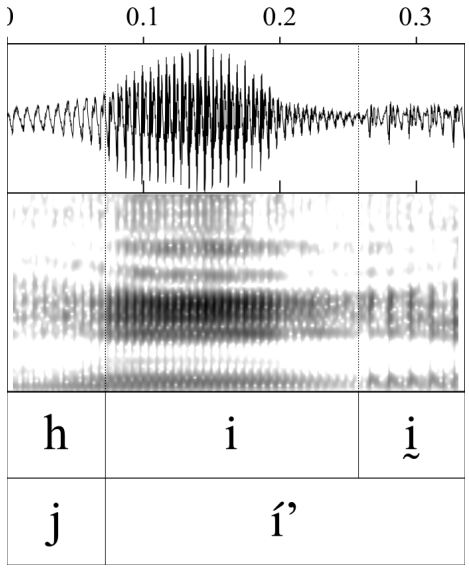
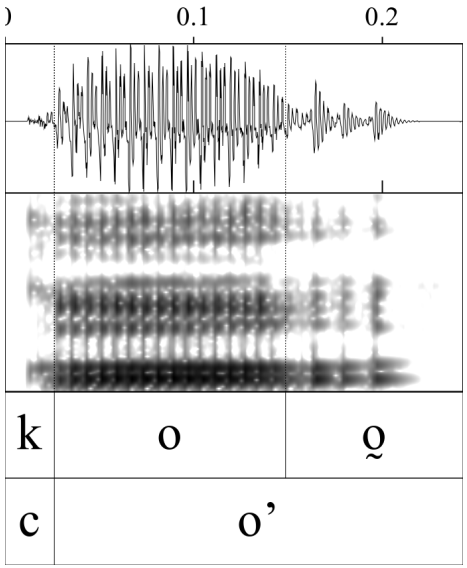


Figure 14: **ji'**jun'taqui *(to employ)*

Analysis (3a) Creaky Vowels

- 16 pairs × 5 context × 2 spk. = 160 obs
  - → 125/160 obs. with intended ⟨'⟩
  - → 12/160 obs. without intended ⟨'⟩
  - → **significant**, Chi-squared, $p < 0.001$



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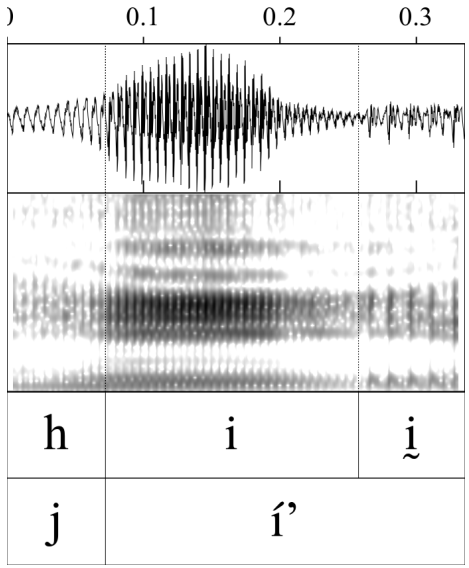


Figure 14: **ji'**jun'taqui *(to employ)*

Analysis (3b) Creaky Consonants

- 3 pairs × 5 context × 2 spk. = 60 obs
  - → 6/30 obs. with intended ⟨'⟩
  - → 3/30 obs. without intended ⟨'⟩

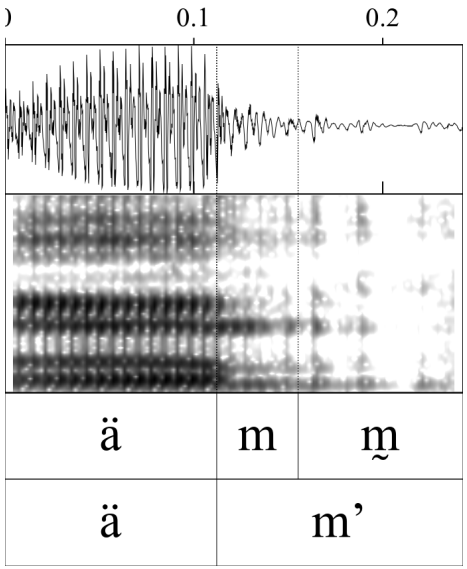


Figure 15: Creaky intended ⟨'⟩
ä'**äm'** (*female owl*)

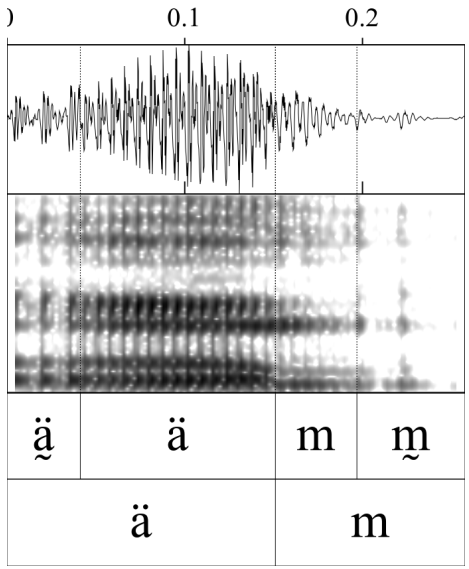
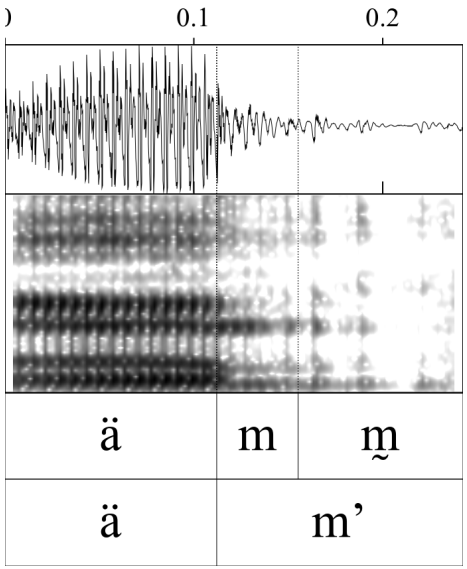


Figure 16: Creaky non-intended ⟨'⟩
ä'**äm** (*male owl*)

Analysis (3b) Creaky Consonants

- 3 pairs × 5 context × 2 spk. = 60 obs
  - → 6/30 obs. with intended ⟨'⟩
  - → 3/30 obs. without intended ⟨'⟩
  - → **non significant**, Chi-squared, $p > 0.01$



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ä'**äm'** (*female owl*)

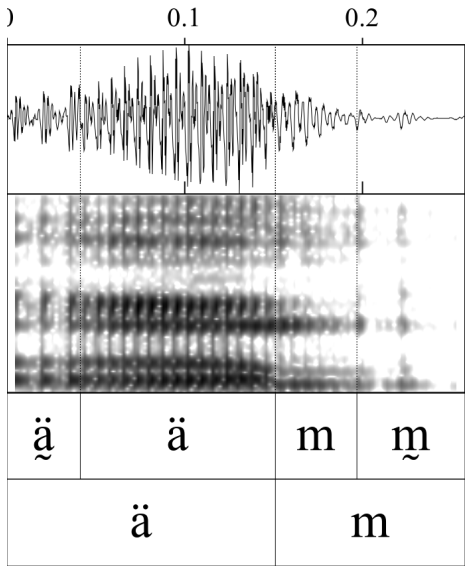
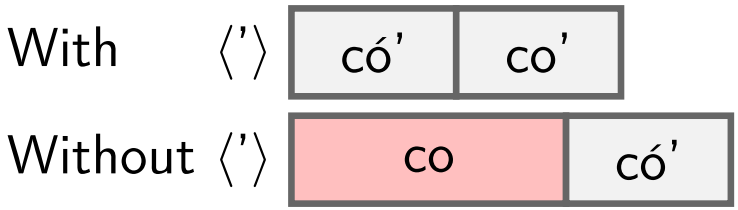


Figure 16: Creaky non-intended ⟨'⟩
ä'**äm** (*male owl*)

Analysis (4)

4. Is ⟨'⟩ cued by duration?



Analysis (4)

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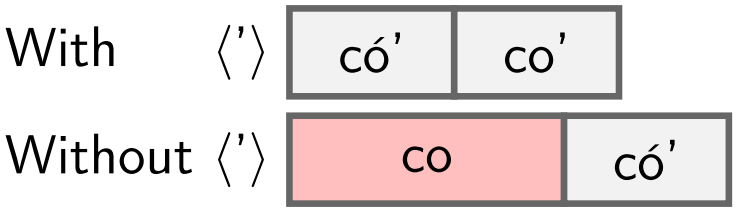

(a) Vowels

16 pairs × 5 context × 2 spk. = 160 obs

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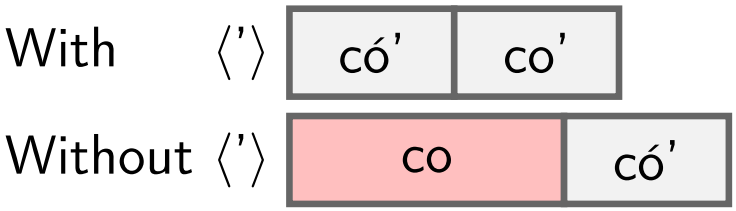

(a) Vowels

16 pairs × 5 context × 2 spk. = 160 obs

- Duration is **not significant**
- Mean with ⟨'⟩ = 0.170
- Mean without ⟨'⟩ = 0.159

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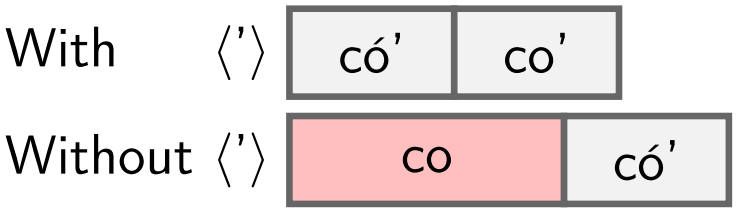

(a) Vowels

16 pairs × 5 context × 2 spk. = 160 obs

- Duration is **not significant**
- Mean with ⟨'⟩ = 0.170
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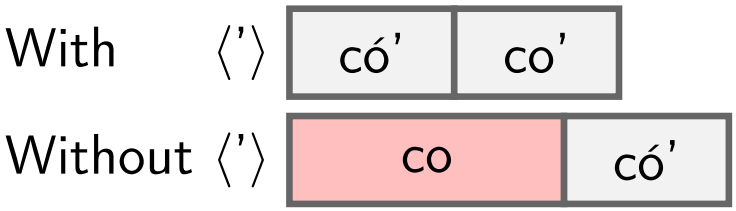
(b) Consonants

3 pairs × 5 context × 2 spk. = 60 obs

Analysis (4)

4. Is ⟨'⟩ cued by duration?



(a) Vowels

16 pairs × 5 context × 2 spk. = 160 obs

- Duration is **not significant**
- Mean with ⟨'⟩ = 0.170
- Mean without ⟨'⟩ = 0.159

(b) Consonants

3 pairs × 5 context × 2 spk. = 60 obs

- Duration is **significant**
- Mean with ⟨'⟩ = 0.070
- Mean without ⟨'⟩ = 0.099

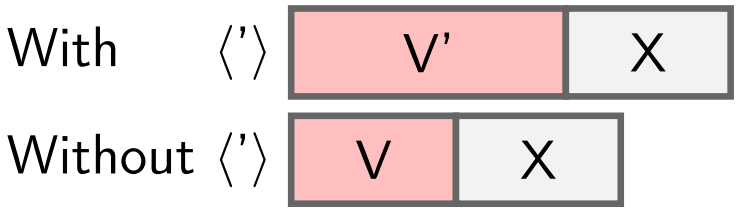
Analysis (4)

4. Is ⟨'⟩ cued by duration?

(a) Vowels

16 pairs × 5 context × 2 spk. = 160 obs

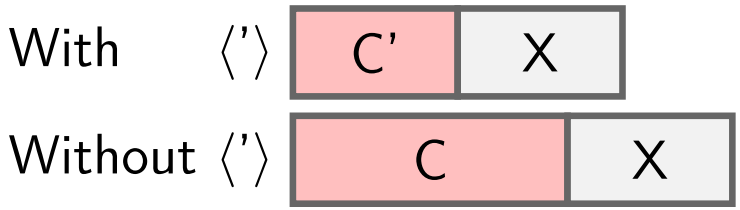
- Duration is **not significant**



(b) Consonants

3 pairs × 5 context × 2 spk. = 60 obs

- Duration is **significant**



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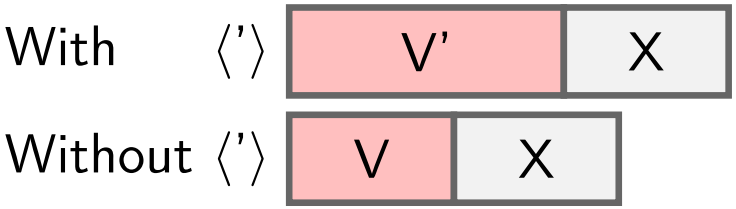

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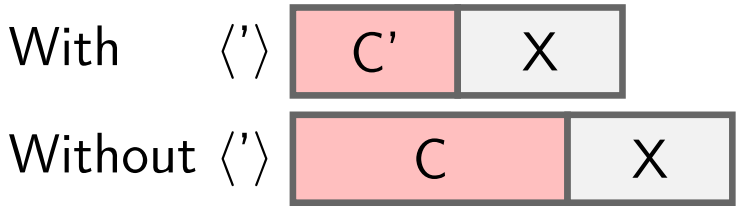


- Opposite directions?

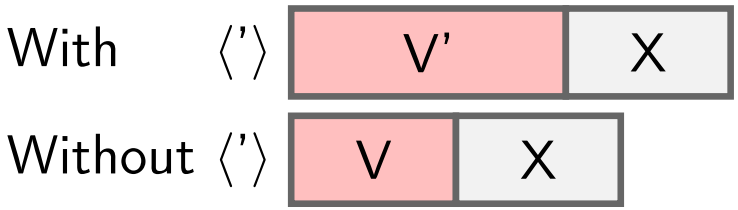
Analysis (4)

4. Is ⟨'⟩ cued by duration?

(a) Vowels

16 pairs × 5 context × 2 spk. = 160 obs

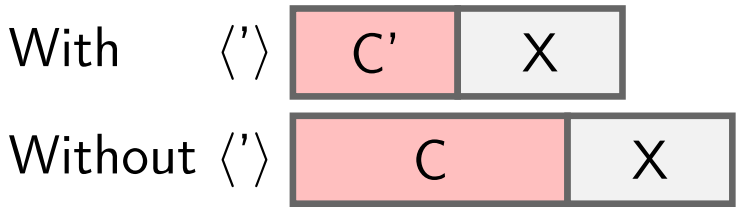
- Duration is **not significant**



(b) Consonants

3 pairs × 5 context × 2 spk. = 60 obs

- Duration is **significant**



- Opposite directions?
  - Glottal vowels are **generally stressed**
  - Stressed vowels are generally longer
  - **Need more data do disentangle** stress/glottal production

Summary

- ⟨'⟩ primarily realised via **non-modal phonation**
  - 69% of obs. with ⟨'⟩ feature non-modal voicing

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- ⟨'⟩ primarily realised via **non-modal phonation**
  - 69% of obs. with ⟨'⟩ feature non-modal voicing
- Full closure (silence) is **very rare**
  - 7% of obs. with ⟨'⟩ feature a silence
- Vowel & Consonant **duration might serve as a cue**
  - Limited data
  - **Conflation of stress and presence of glottal**

Conclusion & Future Works

Summary

- Is ⟨'⟩ a glottal stop?
  - Yes!
  - "In the great majority of languages [...], *glottal stops are apt to fall short of complete closure* [...]. In place of a true stop, a very **compressed form of creaky voice** or some less extreme form of **stiff phonation** may be superimposed on the vocalic stream." Ladefoged et al. 1995 cited by Rose 2022.
  - Whalen et al. 2016 and Davidson 2021 (both cited by DiCanio 2021) report that glottal stops are realised with a creaky voice respectively **62 and 73%** of the time in Arapaho and Hawaian

Future Works

- **Finer annotation**
  - Split the ʔ category
  - Types of creakiness (Keating et al. 2023)
- **Psycholinguistic status**: one unit v. two units?
- **Interaction of stress and glottal stops**
- **Perceptual cues** used by speakers
  - Duration
  - Full closures
  - Stiff voicing
  - Creakiness/Breathiness

Thank you! Yoshoropaij!

Open Data & Code

https://gin.g-node.org/William-N-Havard/tsimane-glottal-public

https://gin.g-node.org/William-N-Havard/tsimane-glottal-interspeech23

Onset

- Realisation of ⟨'⟩ are found in onset positions
- Non-phonemic at this position
- Speakers appear to be **unconscious they produce this sound**

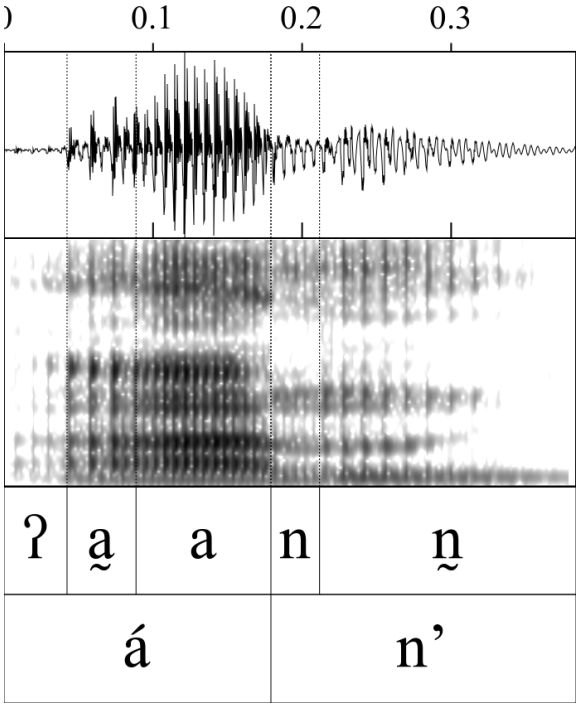

Figure 17: **an'**dyem (*to enjoy*)

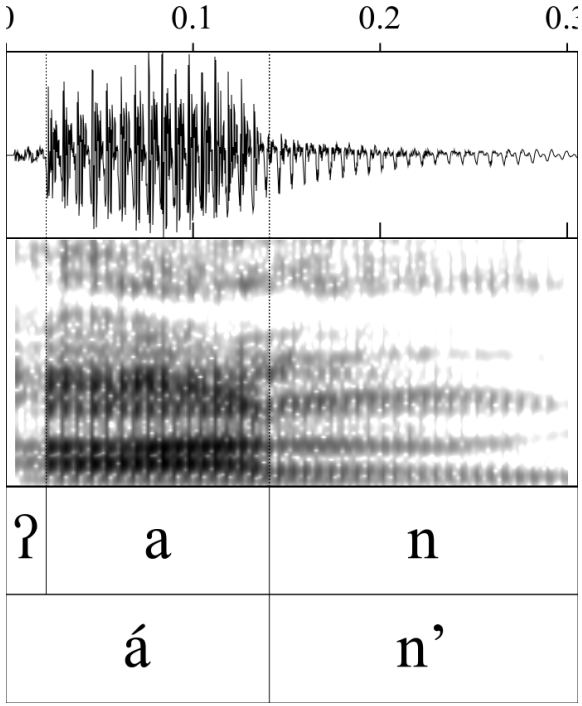

Figure 18: **an'**dyem (*to enjoy*)

Hiatus Avoidance

- ⟨'⟩ in onset position is also used to avoid hiatuses
- Function documented in many language (e.g. British English Fuchs 2015)

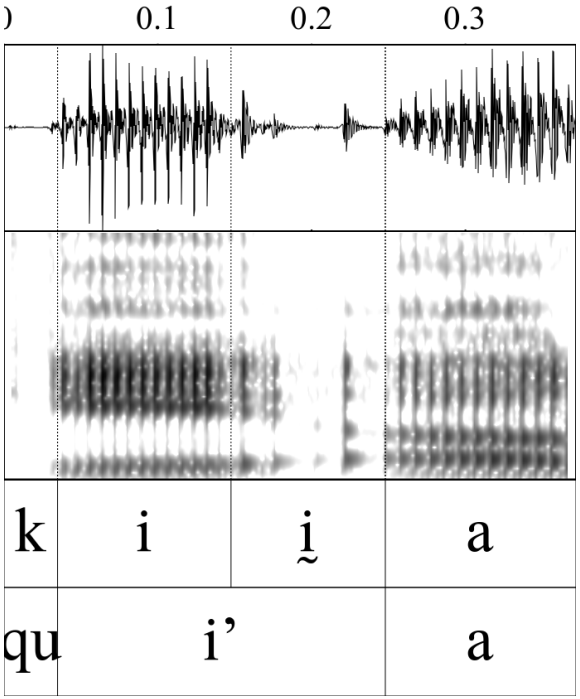

Figure 19: *fo'jeyaqui' arosh*
*(**she** throws the rice away)*

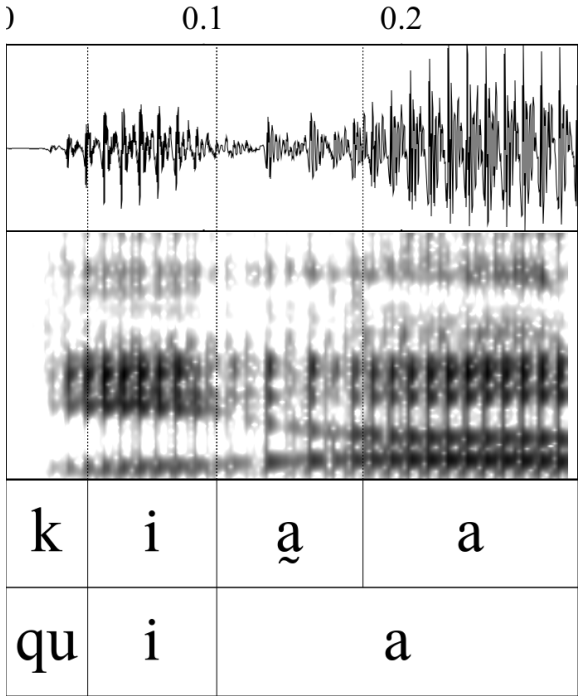

Figure 20: *fo'jeyaqui arosh*
*(**he** throws the rice away)*