Acoustic Correlates of Stress in Mankiyali

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Background

Mankiyali is an understudied Indo-Aryan language spoken in the Khyber Pakhtunkhwa Province of Pakistan.

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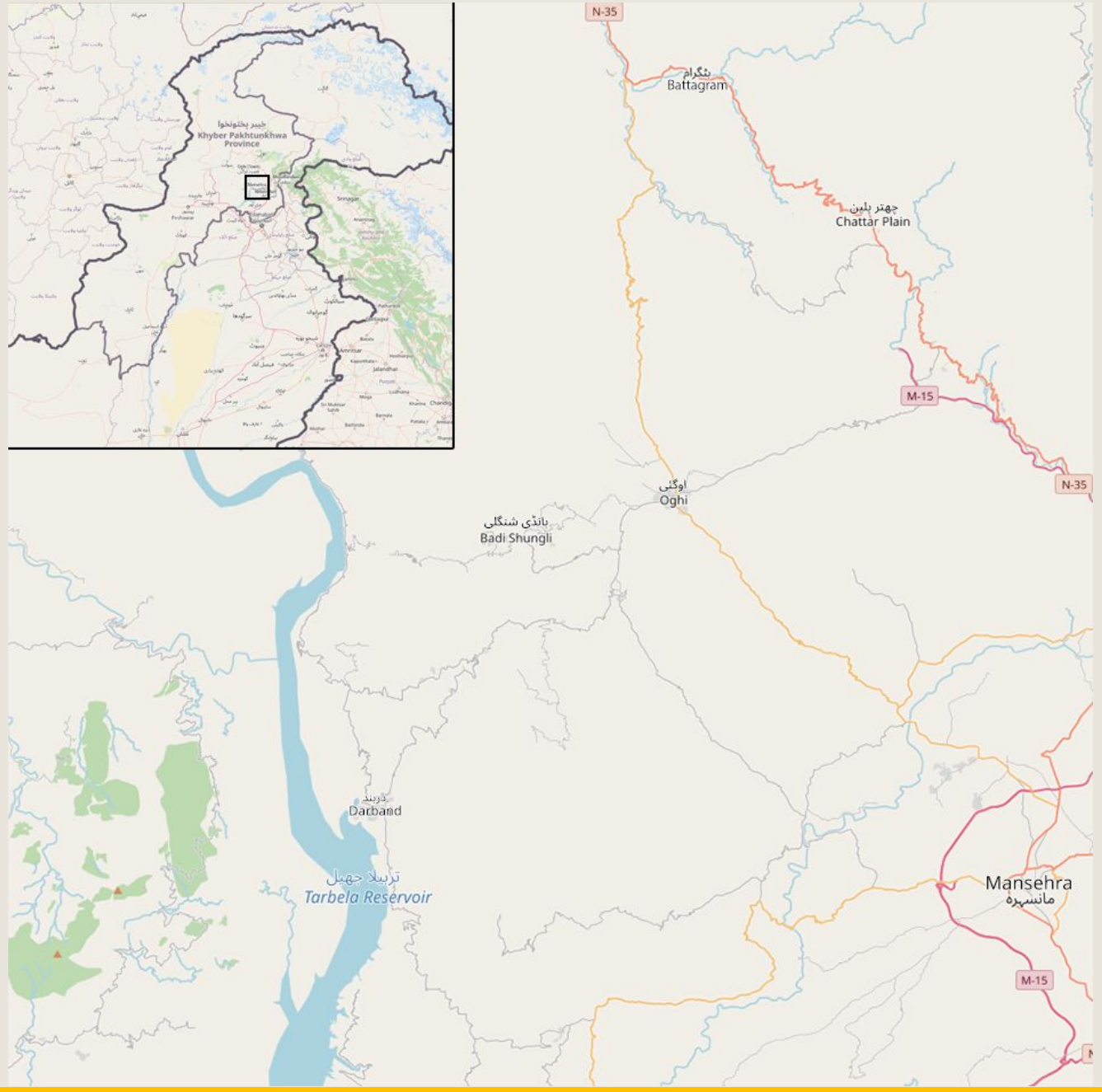
Background



Primarily spoken in the villages of **Danna** and **Dameka.**

Located in **Mansehra District**, about a 4 hour drive from Islamabad.

Background

Roughly 500 speakers.

Endangered: children are beginning to learn Hindko as their first language.

Overview of Talk

- Background on Mankiyali Phonology
- Previous studies examining the acoustic correlates of stress
- The Present Study
  - Research Questions
  - Methodology
  - Results
- Conclusion

Mankiyali Phonology

- 17 phonemic vowels

		Front			Central			Back		
		short	**long**	**long nasal**	**short**	**long**	**long nasal**	**short**	**long**	**long nasal**
High	tense	i	ii	ĩĩ				u	uu	ũũ
	lax	ɪ	ɪɪ	ɪ̃ɪ̃						
Mid	tense	e	ee					o	oo	õõ
	lax									
Low	tense				a	aa	ãã			
	lax									

Mankiyali Phonology

Five **relevant syllable types for stress**: CV, CVC, CVCC, CVV, and CVVC

- **CV**, **CVC**, and **CVV** are widespread and appear in initial, medial, and word-final positions.
- **CVVC** is less common but still appears in all positions.
- **CVCC** is relatively rare and somewhat restricted in its distribution.

Mankiyali Stress

Default penultimate primary stress.

- *a.na.* ˈ***gu****.gu* “owl”
- *dʒan.* ˈ***dar****.yoz* “locks”
- ˈ***kaa****.rɪɪ* “millet”

Weight-sensitive stress system: CVVC, CVV > CVCC, CVC > CV

- CVVC, CVV > CVCC, CVC, CV
  - *muk.* ˈ***lee*** “open (IMP)” *gand.* ˈ***gii*** “dirtiness”
  - *luŋ.* ˈ***gaaɽ*** “fox” *ma.* ˈ***sĩĩ*** “fly”
- CVCC, CVC > CV
  - ˈ***baŋg****.su.va* “buckle” *ma.* ˈ***čʰɪr*** “mosquito”

The relationship between **CVVC ~ CVV** and **CVCC ~ CVC** is undetermined.

Previous Research

- There is a significant body of work analyzing the acoustic correlates of word-level stress on the world's languages.
    - Gordon & Roettger (2017) survey previous work on the subject.
        - 110 studies on 75 languages.
        - Only two Indo-Aryan languages (Sindhi and Urdu) in the survey.

Previous Research

- Duration is generally considered the most salient acoustic correlate of word-level stress (van Heuven & Turk, 2021).
    - **Functional Load Hypothesis (FLH)**: the use of an acoustic property in other areas of the phonology of a language prevents it from being used as an acoustic correlate to stress.
        - Berinstein, 1979; Hayes, 1995; Gordon & Applebaum, 2010
    - Other studies contradict the FLH.
        - van Heuven & turk, 2021; Lunden et. al., 2017

Previous Research

- Previous studies argued for f0 as a very reliable acoustic correlate to word-level stress.
  - e.g., Gordon, 2004; Garellek & White, 2015; among many others

- Recent work argues that most acoustic studies of stress have failed to disentangle **word-level stress** from **phrase-level stress.**
  - **Phrase-level stress**: prominence on the primary stressed syllable of the focused word in a phrase.
  - **Word-level stress**: prominence on the primary stressed syllable of every word that has stress (focus or non-focus).

This Study - Research Questions

- What are the acoustic correlates of word-level stress?
  - Does the FLH prevent duration from being an acoustic correlate to word-level stress?

- What are the acoustic correlates of phrase-level stress?
  - Do these correlates differ from those of word-level stress?

Participants

30 native speakers of Mankiyali.

Ages 20-51.

All participants are **at least trilingual** in Mankiyali, Hindko, and Urdu.

Speech Materials

- Compares the acoustic properties of stressed syllables vs. unstressed syllables.
- Disyllabic words.
- Penultimate target syllables
- Grouped into near minimal pairs.
  - e.g., ˈ***ya****.ka* ~ ya.ˈ**kaɾ**
- **CVVC** tokens targeted the word-final syllable.

Target σ stressed	**Target σ unstressed**
ˈ**CV**.CV	**CV**.ˈCVC
ˈ**CVC**.CV	**CVC**.ˈCVV
ˈ**CVV**.CVV	**CVV**.ˈCVVC
ˈ**CVCC**.CV	**CVCC**.ˈCVV
CVV.ˈ**CVVC**	ˈCVVC.**CVVC**

Speech Materials

- Five word pairs for each syllable type = **50 tokens.**

CV		CVC		CVV		CVCC		CVVC	
ˈ**kʰa**.ba	**kʰa**.ˈbaaɽ	ˈ**gaɽ**.ku	**gaɽ**.ˈkuu	ˈ**bẽẽ**.ɣĩĩ	**bẽẽ**.ˈɣĩĩz	ˈ**saŋg**.yõ	**saŋg**.ˈtoob	laŋ.ˈ**gaar**	ˈɖaaŋ.**gaar**
ˈ**ma**.za	**ma**.ˈzar	ˈ**mus**.ki	**mus**.ˈkii	ˈ**pee**.kii	**pee**.ˈkiiz	ˈ**gand**.yõ	**gand**.ˈgii	ka.ˈ**daar**	ˈkaar.**daar**
ˈ**ka**.ca	**ka**.ˈcar	ˈ**bel**.ti	**bel**.ˈtiiz	ˈ**kaa**.ɣaa	**kaa**.ˈɣaaz	ˈ**mist**.ri.yo	**mist**.ˈrii	go.ˈ**daaɽ**	ˈdʒoon.**daar**
ˈ**ya**.ka	**ya**.ˈkaɽ	ˈ**kut**.re	**kut**.ˈreez	ˈ**ɖee**.kii	**ɖee**.ˈkiiz	ˈ**ist**.ri.yõ	**ist**.ˈrii	maz.ˈ**daar**	ˈdaaɣ.**daar**
ˈ**cu**.ki	**cu**.ˈkiiɳ	ˈ**patʰ**.re	**patʰ**.ˈreez	ˈ**čee**.bii	**čee**.ˈbiiz	ˈ**dʒant**.ri.yõ	**dʒant**.ˈrii	baz.ˈ**vaaɳ**	ˈaaz.**vaaɳ**

Speech Materials

Sentence 1 (target sentence to analyze **phrase-level stress**)
Miŋi saŋgi **[token]** mandʒu
My friend **[token]** said
"my friend said **[token]**"

Sentence 2
Miŋi saŋgi du var **[token]** mandʒu
My friend two times **[token]** said
"my friend said **[token]** two times"

Sentence 3 (target sentence to analyze **word-level stress**)
Miŋi saŋgi coor var **[token]** mandʒu
My friend four times **[token]** said
"My friend said **[token]** four times"

Tokens embedded in **carrier sentences.**

Carrier sentences inserted into 3-sentence **mini-monologues.**

50 target mini-monologues
+ 34 filler mini-monologues
= 84 mini-monologues

Elicitation Procedure

Sessions took place in quiet homes in Danna and Dameka.

Zoom H5 4-track recorder.

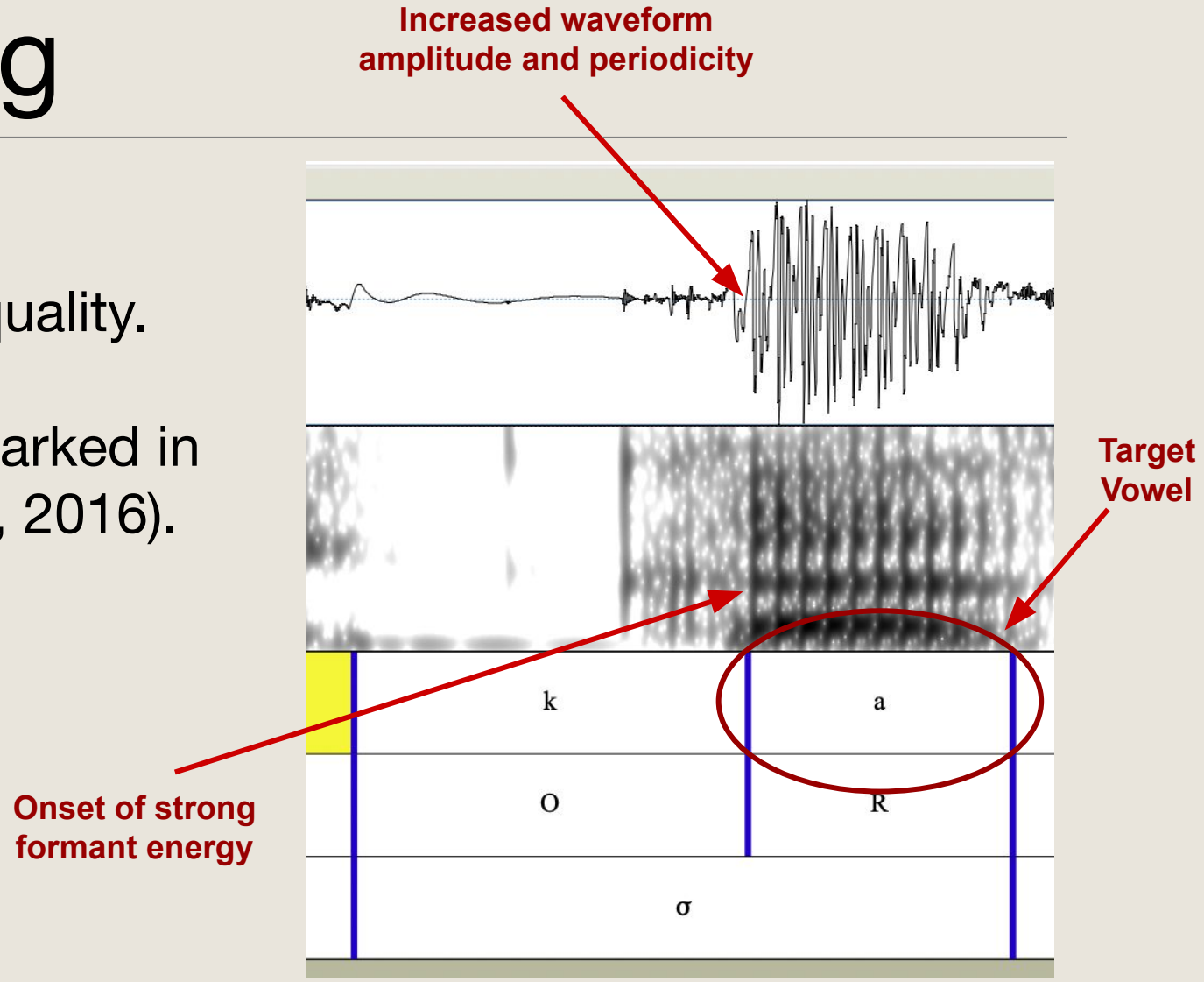
Audio-Technica BP894X **Cardioid Condenser Mic**.

Elicitation Procedure

- Participants given oral **instructions in Mankiyali**.
  - Instructed to read mini-monologues out loud at a normal pace.
- Mini-monologues presented **in a random order** on a laptop in Microsoft Word.
- Roughly 5 minutes to read through the materials before recording.
  - Presented in **Urdu script.**
- Halfway through the mini-monologues, participants took a 5-minute break.
- 2 days later, participants returned for a second recording.

Data Processing

- Monologues analyzed for quality.
- Target vowel boundaries marked in Praat (Boersma & Weenink, 2016).



Total Tokens

- Total **projected number of tokens** (N).
  50 tokens **x** 30 speakers **x** 2 repetitions **x** 2 stress-level conditions
  N = **6,000 tokens** (3,000 word-level and 3,000 phrase-level)

- 351 tokens discarded due to poor quality.
  N = **5,649 tokens** (2,821 word-level and 2,828 phrase-level)

Acoustic Measurements

3 acoustic properties extracted from each target vowel.

- **Duration**: Total time (ms) between vowel boundaries.
- **f0**: average pitch (Hz) over middle 60% of the vowel.
- **Intensity**: average energy (dB) over middle 60% of the vowel.

Statistical Measurements

3 Linear mixed-effects models for **word-level** stress

- Fixed effects
  - STRESS (primary, unstressed)
  - SYLLABLE TYPE (CV, CVC, CVCC, CVV, CVVC)
- Random effects
  - SPEAKER, WORD, REPETITION

❖ What are the acoustic correlates of word-level stress?

Statistical Measurements

3 LME models comparing **phrase-level** to **word-level** stressed syllables

- Fixed effects
  - STRESS LEVEL (phrase-level, word-level)
  - SYLLABLE TYPE (CV, CVC, CVCC, CVV, CVVC)
- Random effects
  - SPEAKER, WORD, REPETITION

❖ What are the acoustic correlates of phrase-level stress?

Results - Summary

- Models examining acoustic correlates of **word-level** stress.
  - A significant effect of STRESS on duration.
  - Generally no effect of STRESS on f0 or Intensity.
  - Effects don’t seem to differ significantly across syllable types.

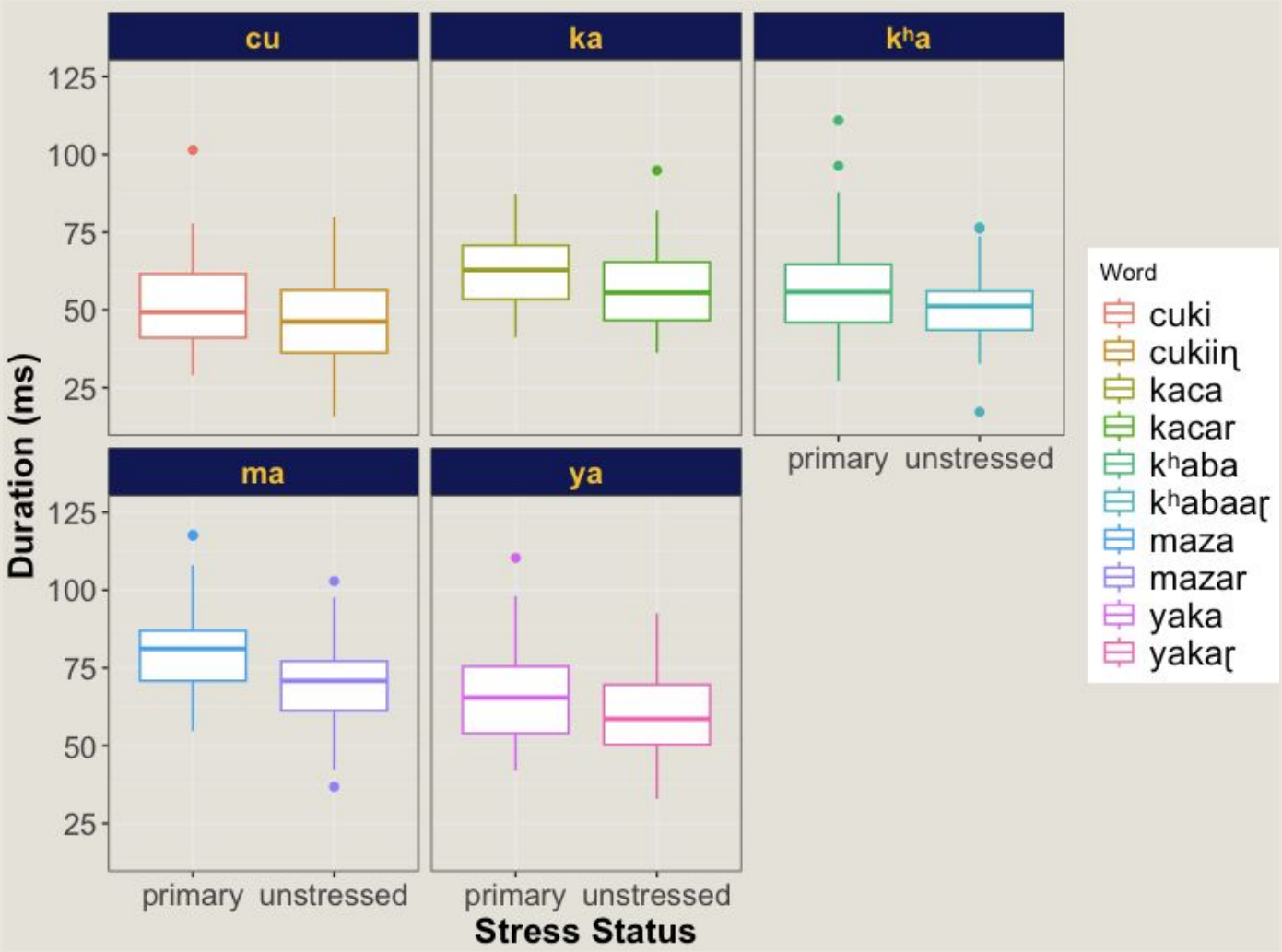
- Models examining acoustic correlates of **phrase-level** stress.
  - A significant effect of STRESS on all three acoustic properties.

Results - CV syllables duration

Boxplots showing mean duration of word-level stressed vs. unstressed **CV syllables**

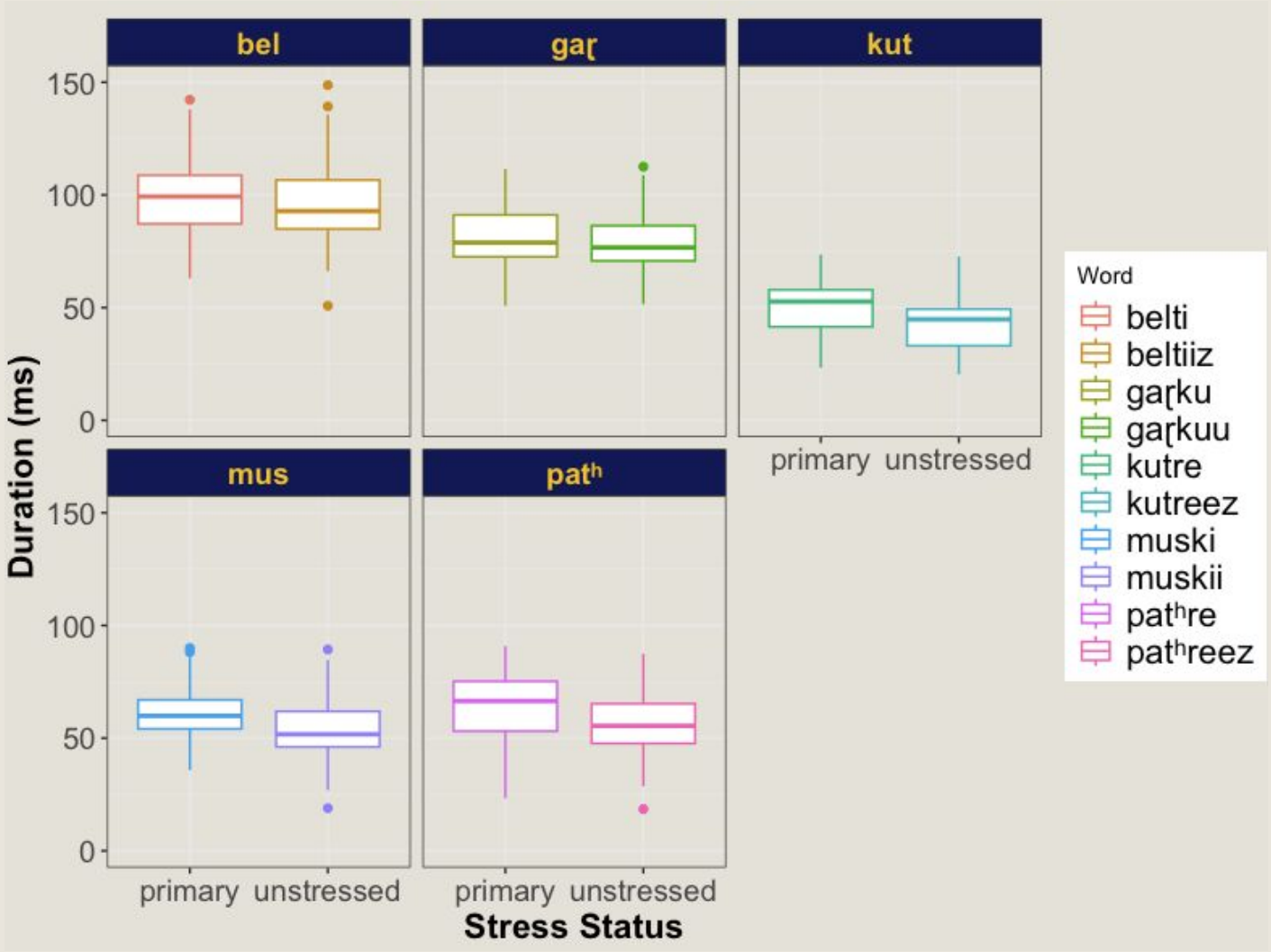
Is **duration** an acoustic correlate of word-level stress for **CV** syllables?

β = -6.9032	p < 0.0001	t = -7.012



Results - CVC syllables duration

Boxplots showing mean duration of word-level stressed vs. unstressed **CVC syllables**



Is **duration** an acoustic correlate of word-level stress for **CVC** syllables?

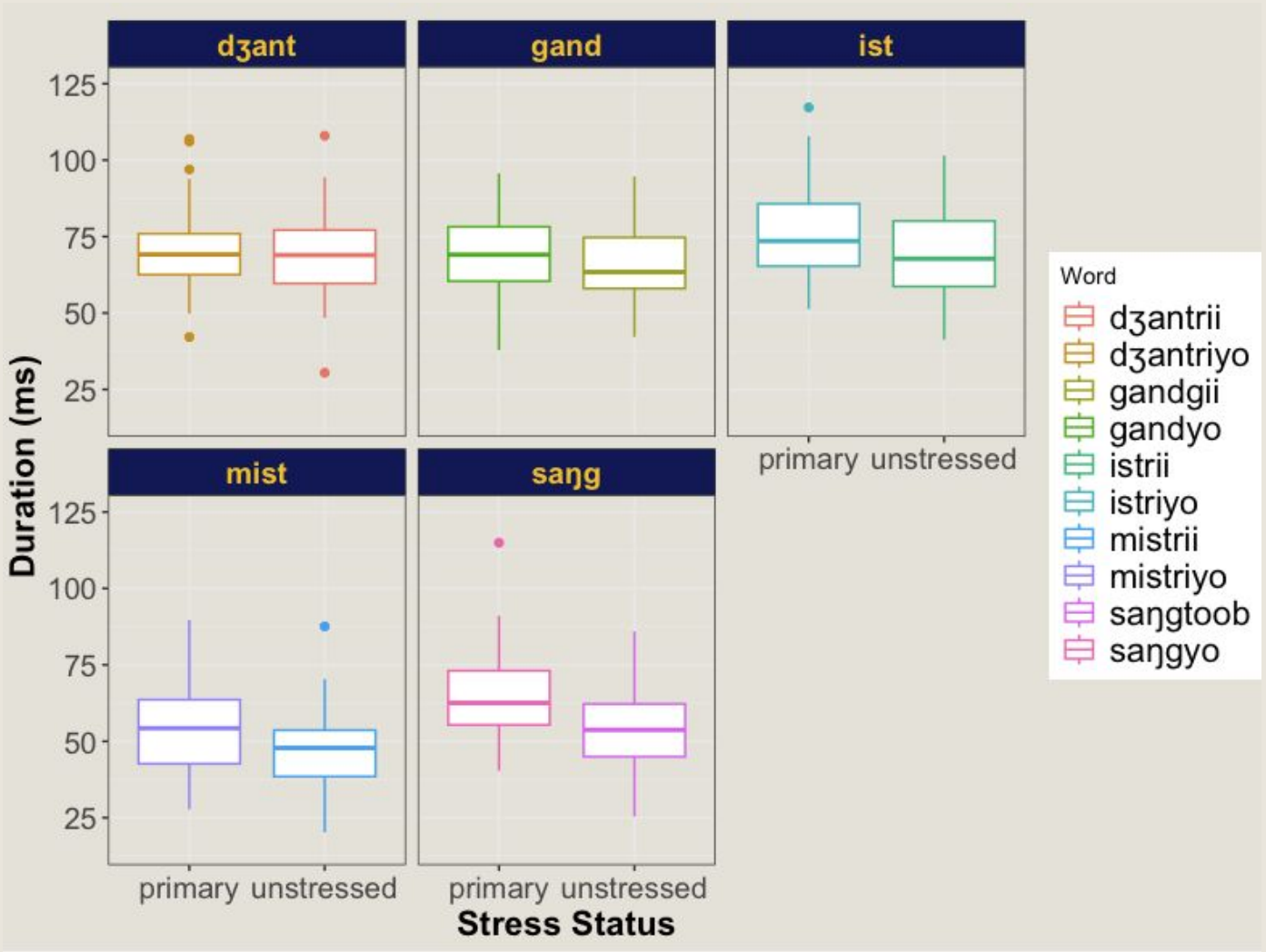
$\beta = -6.3230$	$p < 0.0001$	$t = -6.631$

Results - CVCC syllables duration

Boxplots showing mean duration of word-level stressed vs. unstressed **CVCC syllables**

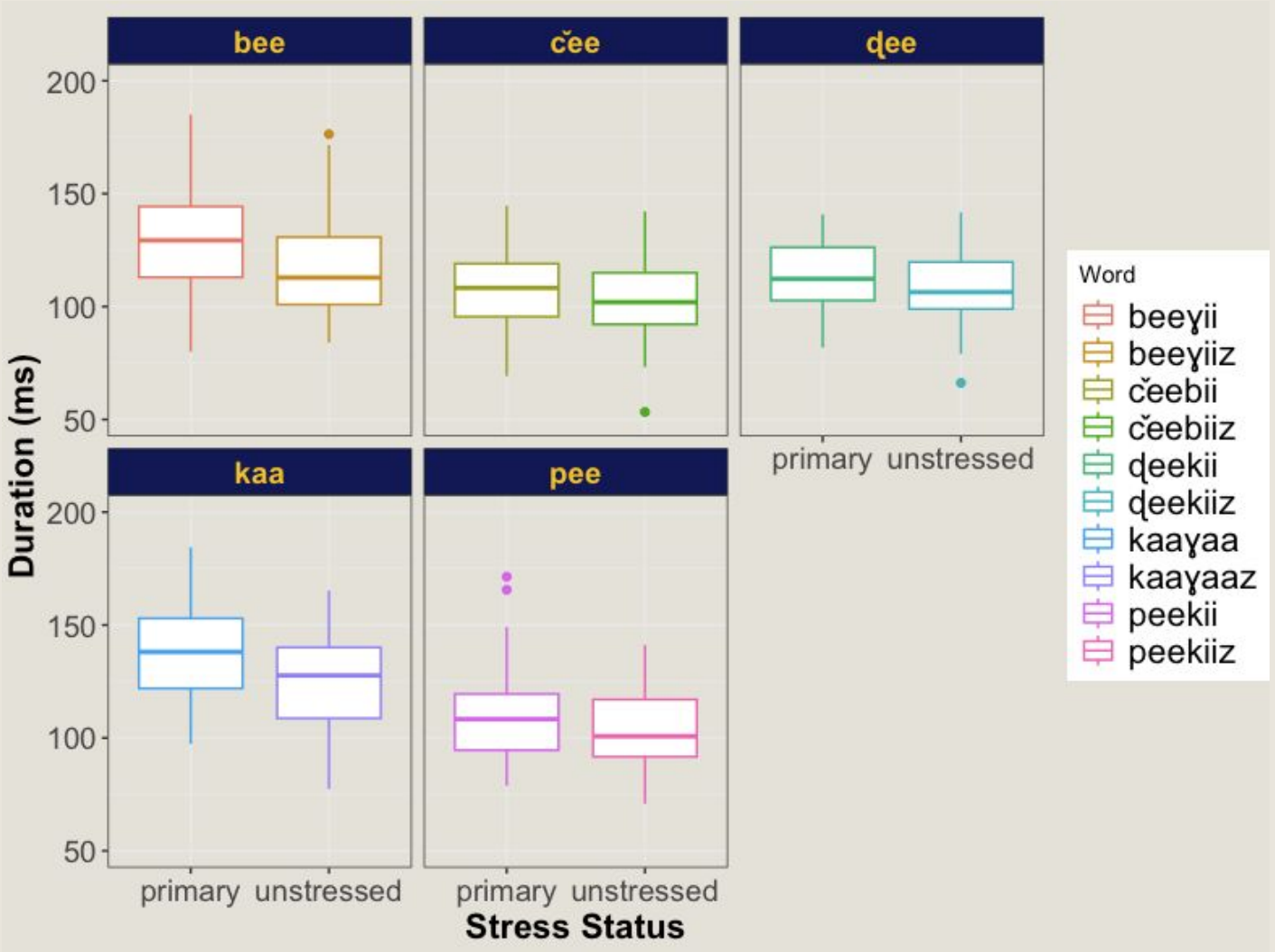
Is **duration** an acoustic correlate of word-level stress for **CVCC** syllables?

β = -6.1269	p < 0.0001	t = -6.676



Results - CVV syllables duration

Boxplots showing mean duration of word-level stressed vs. unstressed **CVV syllables**



Is **duration** an acoustic correlate of word-level stress for **CVV** syllables?

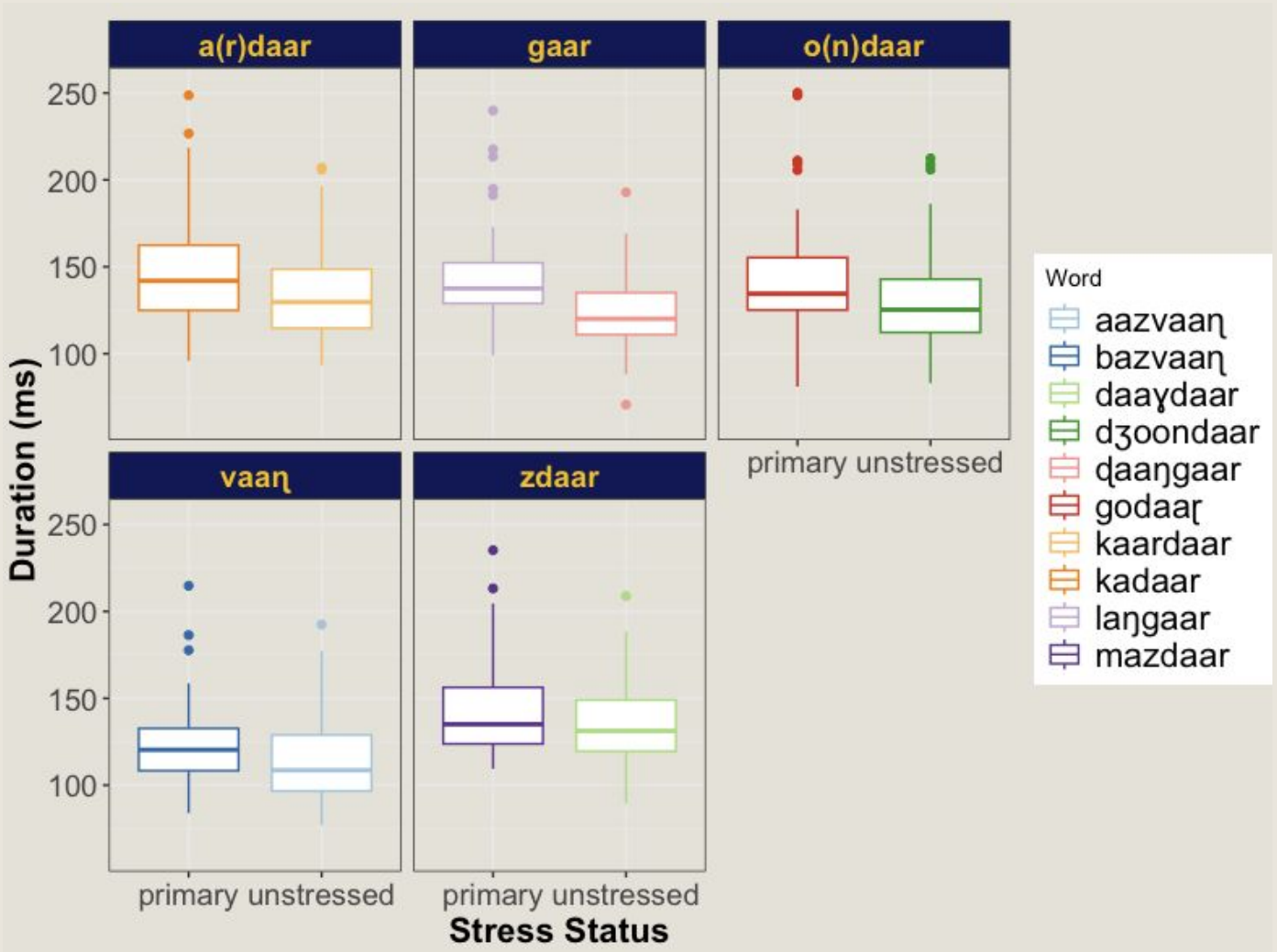
β = -8.137	**p < 0.0001**	**t = -7.584**

Results - CVVC syllables duration

Boxplots showing mean duration of word-level stressed vs. unstressed **CVVC syllables**

Is **duration** an acoustic correlate of word-level stress for **CVVC** syllables?

β = -11.317	p < 0.0001	t = -9.874



Results: word-level duration

Is **duration** an acoustic correlate of word-level stress?

➢ Does this differ across syllable type?

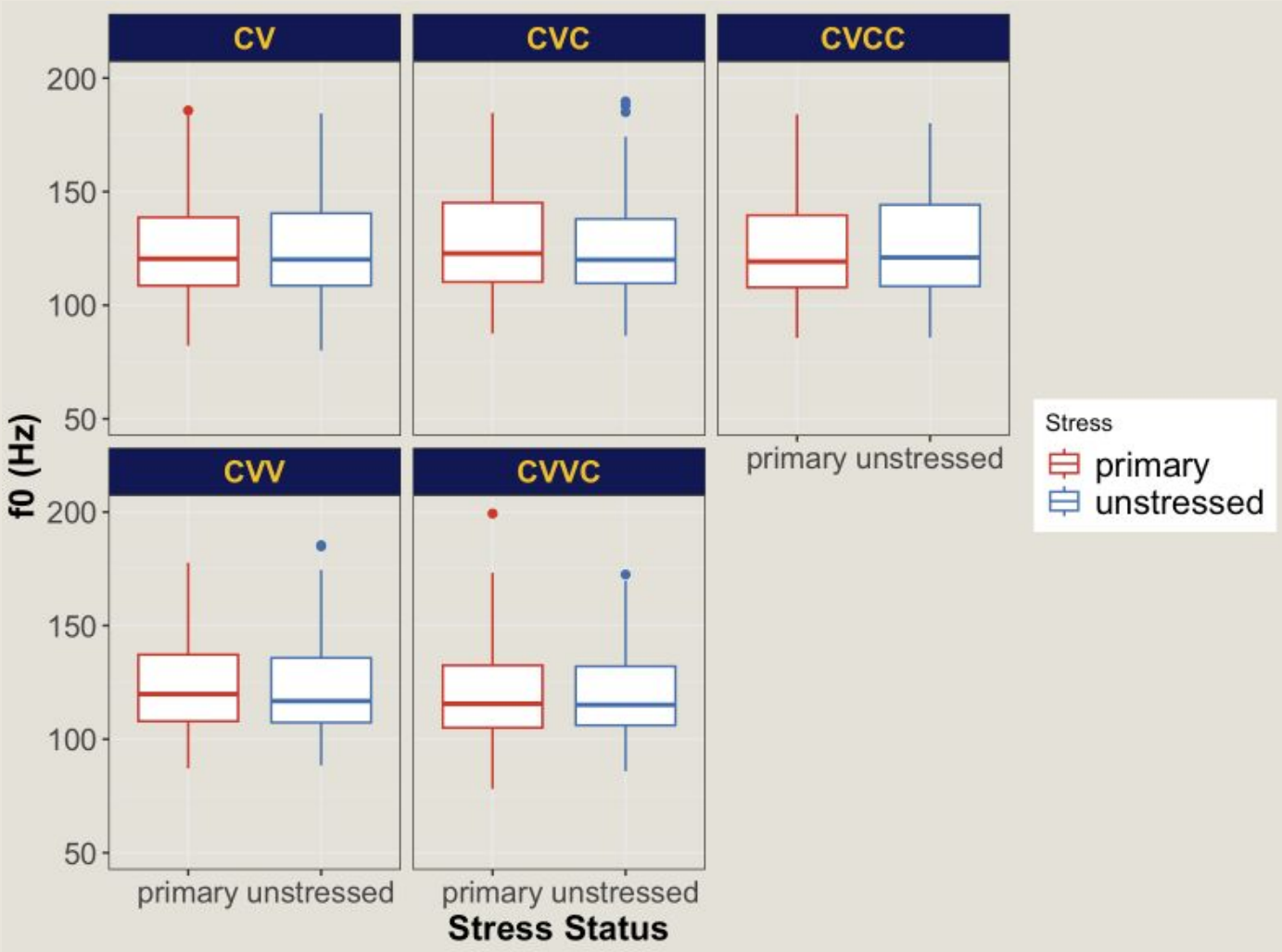
Syllable Type	Coefficient	p-value	t-value
CV	$\beta = -6.9032$	$p < 0.0001$	$t = -7.012$
CVC	$\beta = -6.3230$	$p < 0.0001$	$t = -6.631$
CVCC	$\beta = -6.1269$	$p < 0.0001$	$t = -6.676$
CVV	$\beta = -8.137$	$p < 0.0001$	$t = -7.584$
CVVC	$\beta = -11.317$	$p < 0.0001$	$t = -9.874$

Results: word-level f0

Is **f0** an acoustic correlate of word-level stress?

Syllable	Coefficient	p-value	t-value
CV	β = 0.323	p = 0.87	t = 0.164
CVC	**β = -6.491**	**p < 0.01**	**t = -3.138**
CVCC	β = 1.568	p = 0.276	t = 1.089
CVV	β = 0.7055	p = 0.473	t = 0.718
CVVC	β = 0.1203	p = 0.867	t = 0.168

Boxplots showing **average f0** of word-level stressed vs. unstressed syllables by syllable type

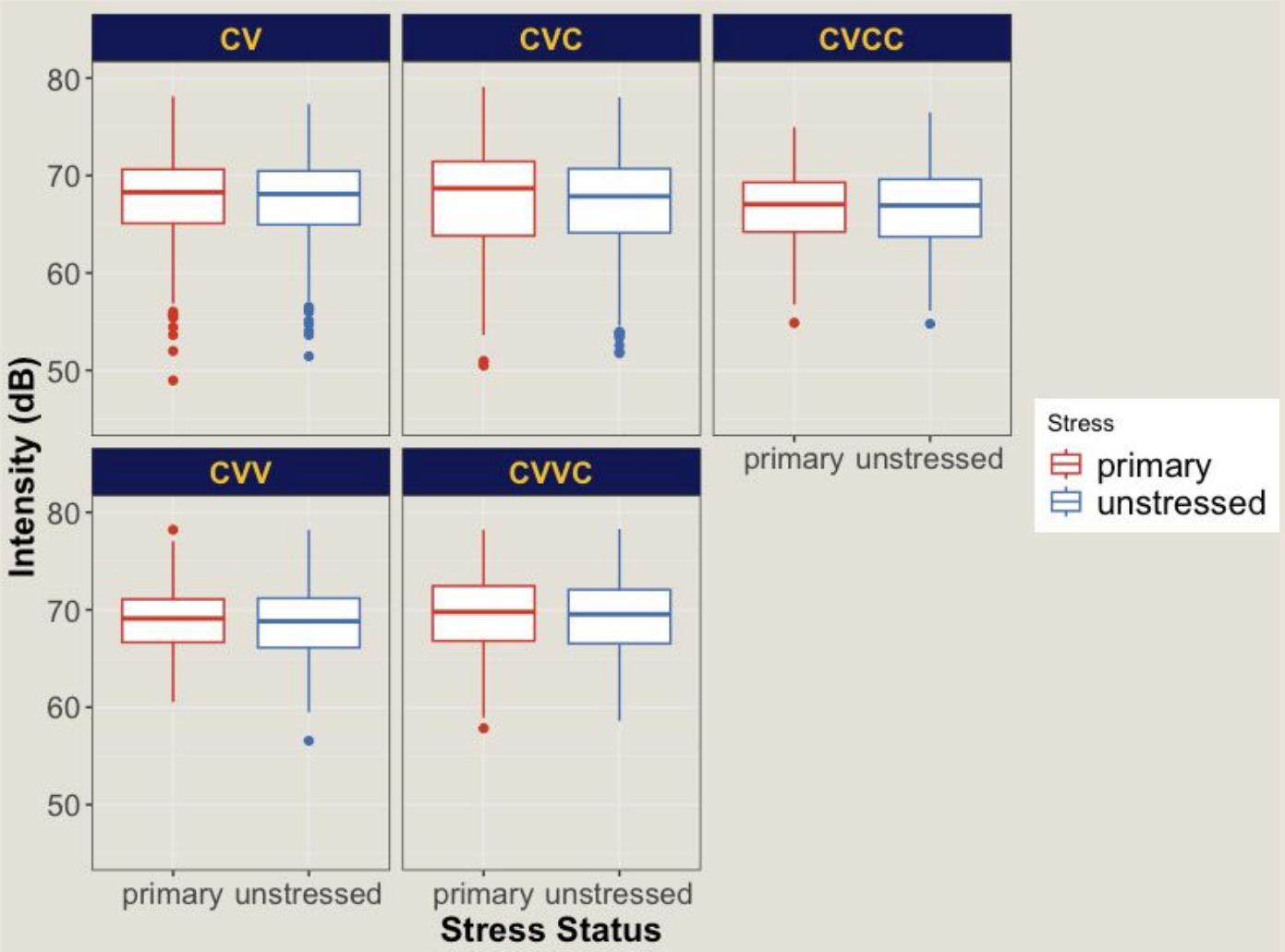


Results: word-level intensity

Is **intensity** an acoustic correlate of word-level stress?

Syllable	Coefficient	p-value	t-value
CV	β = -0.01349	p = 0.96	t = -0.05
CVC	**β = -0.6717**	**p < 0.05**	**t = -2.33**
CVCC	β = 0.05694	p = 0.829	t = 0.216
CVV	β = -0.1688	p = 0.397	t = -.848
CVVC	β = 0.00670	p = 0.975	t = 0.031

Boxplots showing **average intensity** of word-level stressed vs. unstressed syllables by syllable type

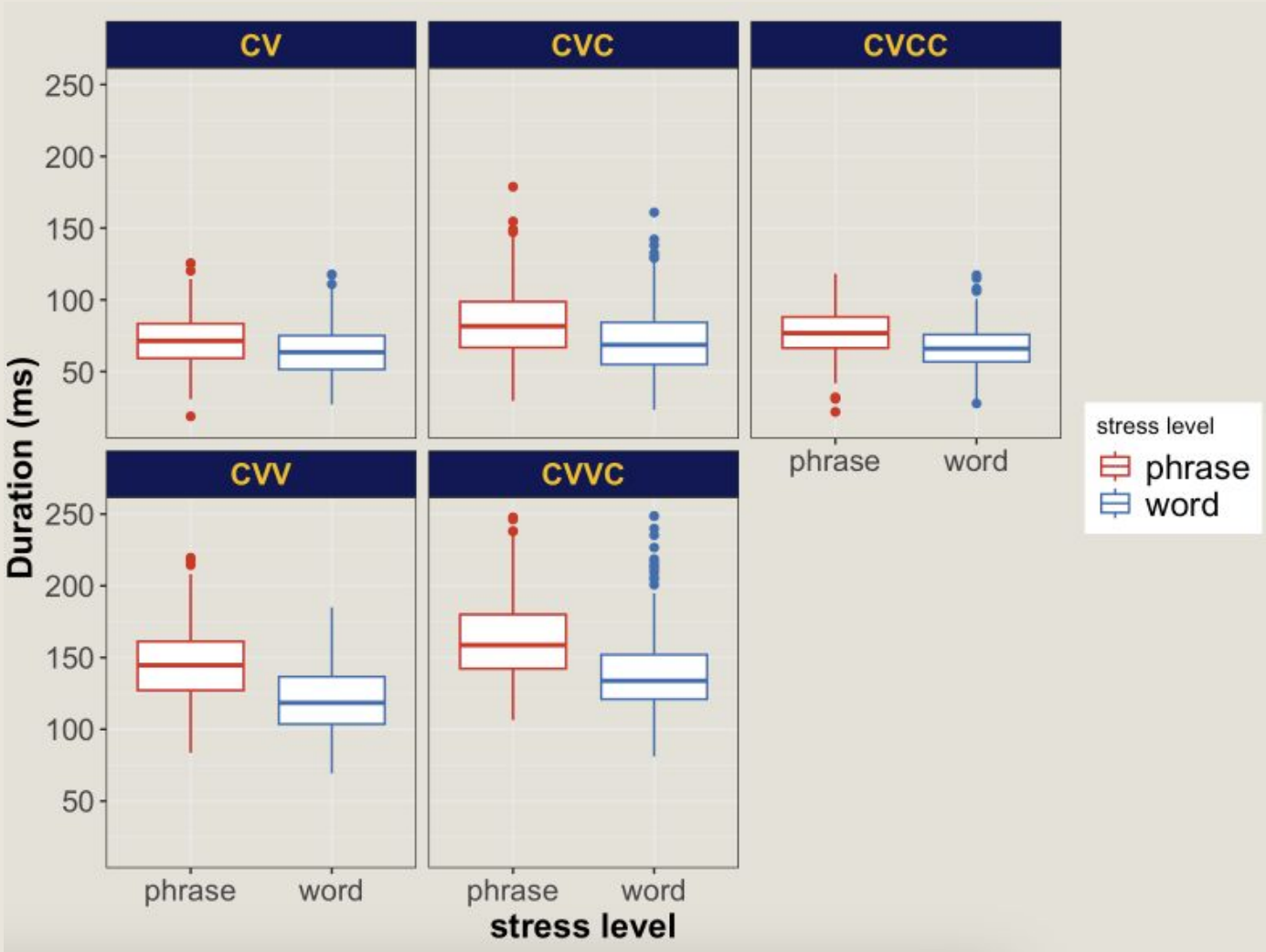


Results: phrase-level duration

Is **duration** an acoustic correlate of **phrase-level stress**?

Syllable	Coefficient	p-value	t-value
CV	β = -8.3417	p < 0.0001	t = -9.775
CVC	β = -12.8367	p < 0.0001	t = -13.138
CVCC	β = -10.204	p < 0.0001	t = -9.935
CVV	β = -24.552	p < 0.0001	t = -19.45
CVVC	β = -25.294	p < 0.0001	t = -21.02

Boxplots showing **average duration** of **stressed phrase-level vs. stressed word-level syllables**

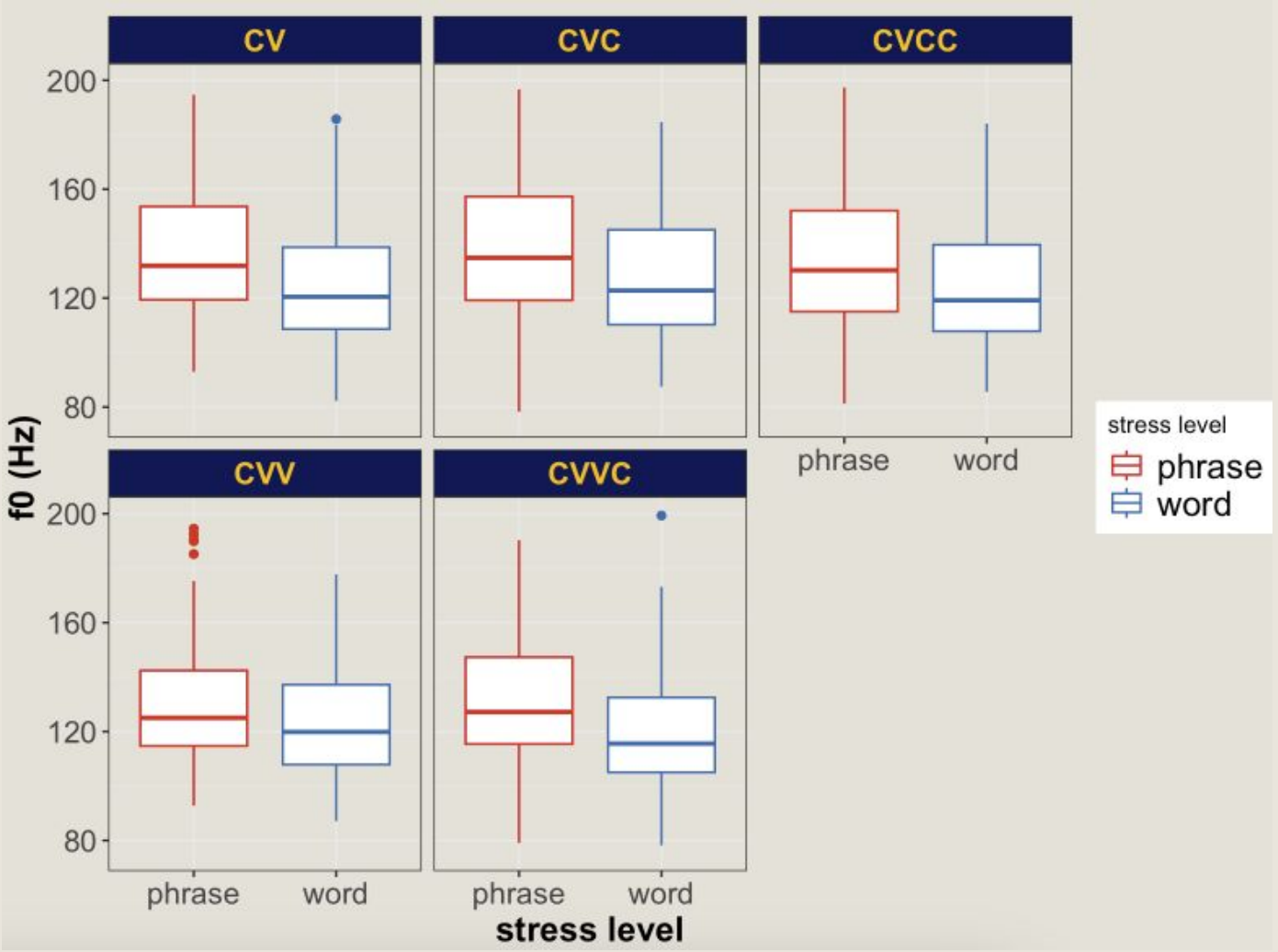


Results: phrase-level f0

Boxplots showing **average f0** of **stressed phrase-level vs. stressed word-level syllables**

Is **f0** an acoustic correlate of **phrase-level stress**?

Syllable	Coefficient	p-value	t-value
CV	β = -16.079	p < 0.0001	t = -9.548
CVC	β = -12.827	p < 0.0001	t = -8.342
CVCC	β = -11.566	p < 0.0001	t = -8.196
CVV	β = -8.2913	p < 0.0001	t = -8.788
CVVC	β = -13.4577	p < 0.0001	t = -18.61

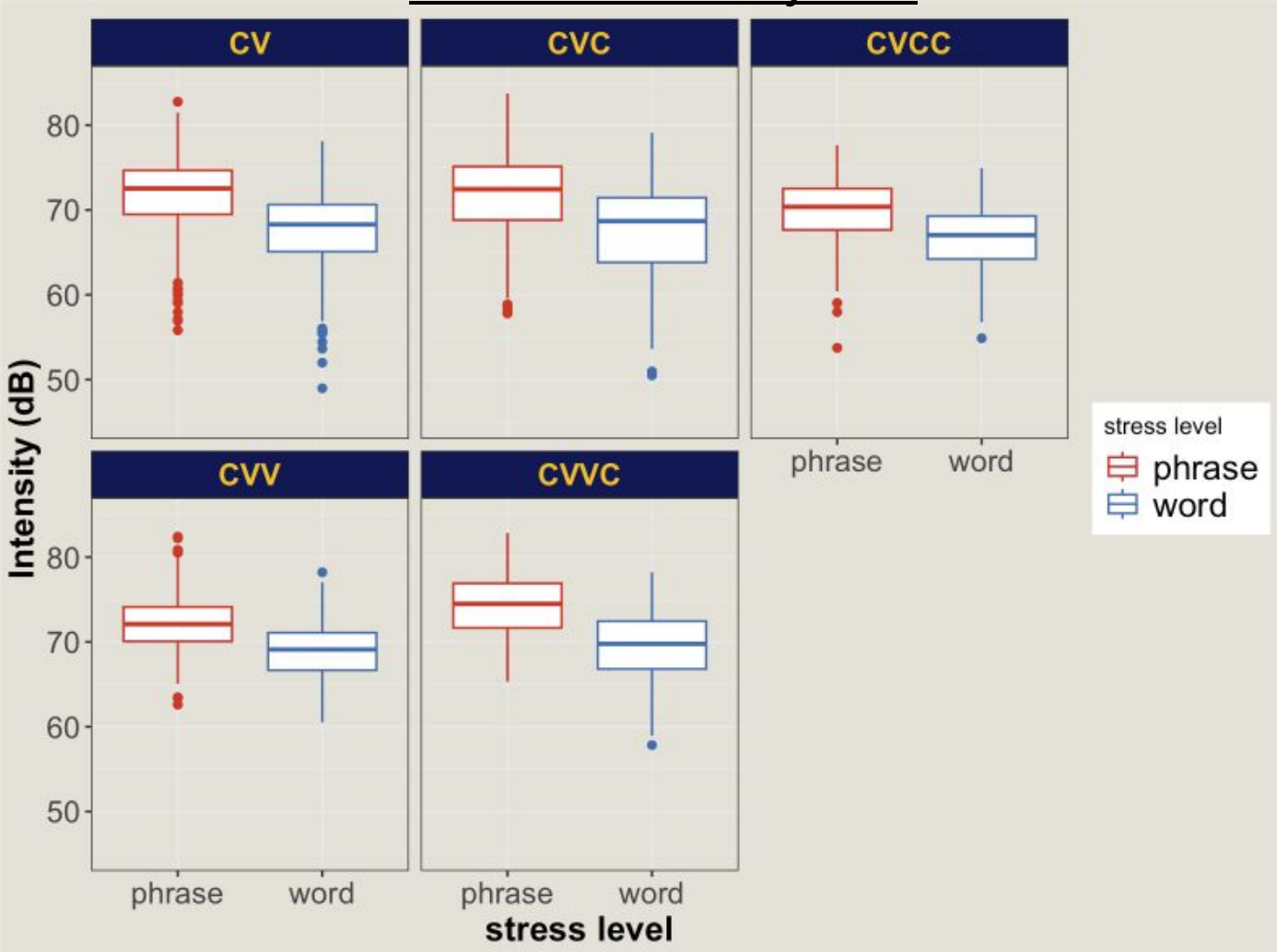


Results: phrase-level intensity

Is **intensity** an acoustic correlate of **phrase-level stress**?

Syllable	Coefficient	p-value	t-value
CV	β = -4.1828	p < 0.0001	t = -15.89
CVC	β = -4.0198	p < 0.0001	t = -13.13
CVCC	β = -3.169	p < 0.0001	t = -11.27
CVV	β = -3.4589	p < 0.0001	t = -17.26
CVVC	β = -4.8317	p < 0.0001	t = -21.76

Boxplots showing **average intensity** of **stressed phrase-level vs. stressed word-level syllables**



Conclusion

- **Duration** is the only acoustic correlate for word-level stress, of the the properties we measured, indicating that the FLH does not hold, at least in Mankiyali.
  - Duration can distinguish vowel phonemes **and** act as an acoustic correlate to stress.

- All three acoustic properties measured act as acoustic correlates to **phrase-level** stress.
  - This is interesting, given that most studies suggest f0 is the sole acoustic correlate to phrase-level stress.

Thank you!

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