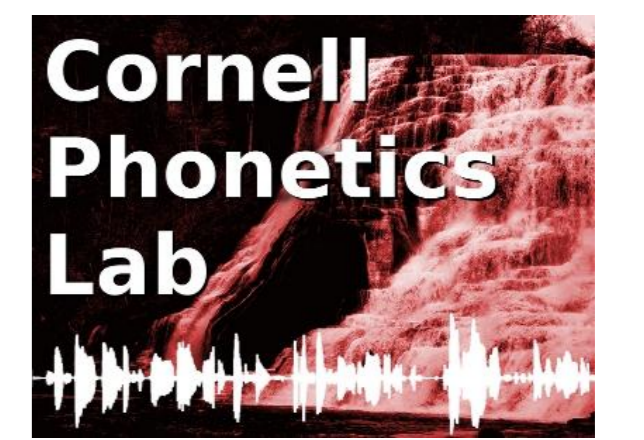


Intrusive Schwa in Khmer

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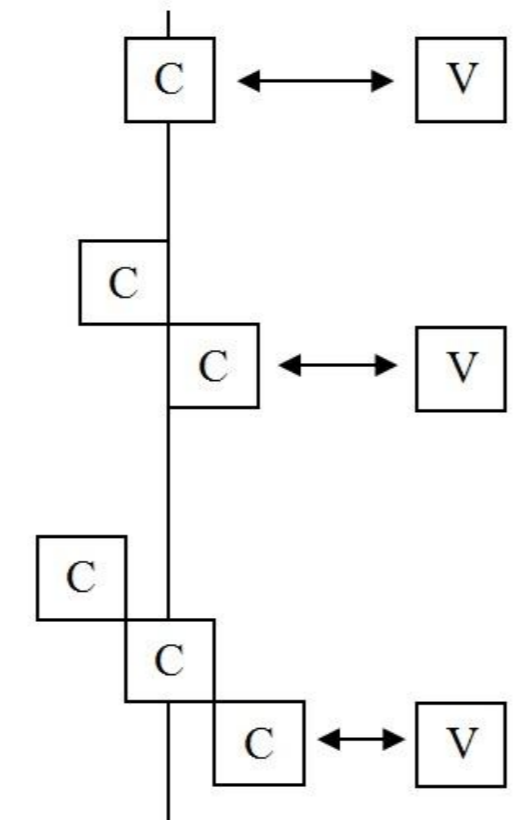
LabPhon 13
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1 Consonantal Phasing Relations

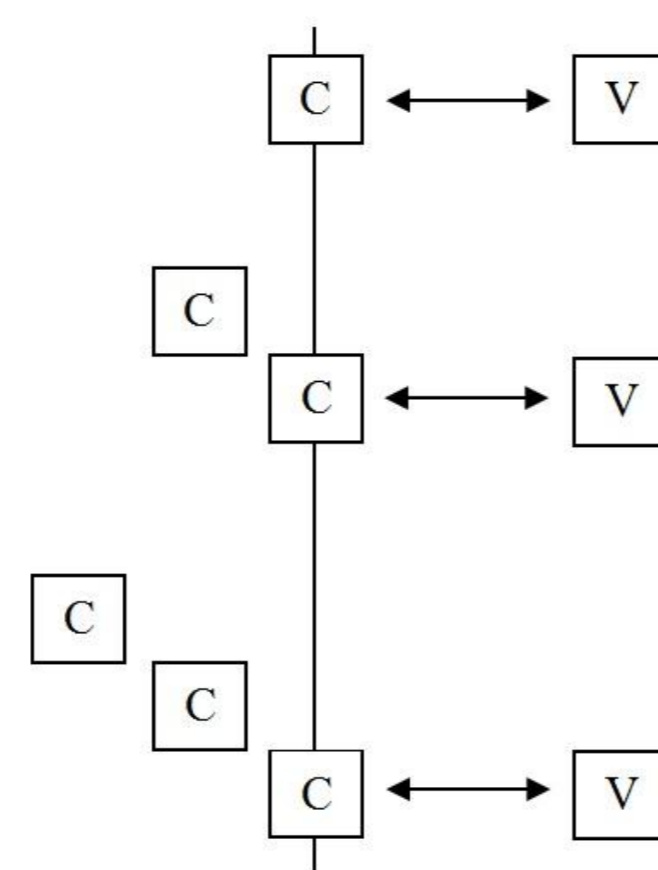
C-center Languages

- Consonants are anti-phased with each other
- All consonants are in-phase with the following vowel
- Vowel onset is aligned with the durational midpoint of the consonants.
- Timing lag between the rightmost consonant and the following vowel becomes shorter (Goldstein et al. 2007).



Simplex-timed Languages

- Consonants are anti-phased with each other
- Only the rightmost consonant is in-phase with the following vowel
- Vowel onset is aligned with the durational midpoint of the rightmost consonant only.
- Lag between the rightmost consonant and the following vowel remains constant, no matter the number of word-initial consonants.
- Schwa-like material often intervenes between the consonants, e.g. Tashlihyt Berber (Ridouane and Fougeron 2011)



Adapted from Hermes (2008)

2 Khmer

- Contains class of words that are claimed to have intrusive schwas

Word Types

Word Types	[mAt]	'dash away'	ម៉ីត
Monosyllables	[mAt]	'dash away'	ម៉ីត
Disyllables and longer	[mAt.'pot]	'stretch one's back'	ម៉ីតពត់
Sesquisyllables	[mteh]/[møteh]	'pepper'	ម្លើស

- Has a large inventory of word-initial consonant sequences, which are claimed to be produced in various ways (Huffman 1972)

Khmer Consonant Clusters

C2 \ C1	s	h	r	l	p	t	c	k	m	n	ɲ	ʔ	b	d
p	ps	ph	pr	pl	pt	pc	pk	pn	pp	pɲ	pʔ		pb	pd
t	ts	th	tr	tl	tt	tc	tk	tn	tt	tɲ	tʔ		tb	td
c	cs	ch	cr	cl	ct	cc	ck	cn	cc	cɲ	cʔ		cb	cd
k	ks	kh	kr	kl	kt	kc	kk	kn	kk	kɲ	kʔ		kb	kd
s		sh	sr	sl	st	sc	sk	sn	ss	sɲ	sʔ		sb	sd
m	ms	mh	mr	ml	mt	mc		mn	mm	mɲ	mʔ		mb	md
l	ls	lh	lr	ll	lt	lc	lk	ln	ll	lɲ	lʔ		lb	ld

□ Intrusive [ə] ◻ Intrusive [ɤ] ■ No intrusive material

★ What is the nature of intrusive schwa in Khmer?

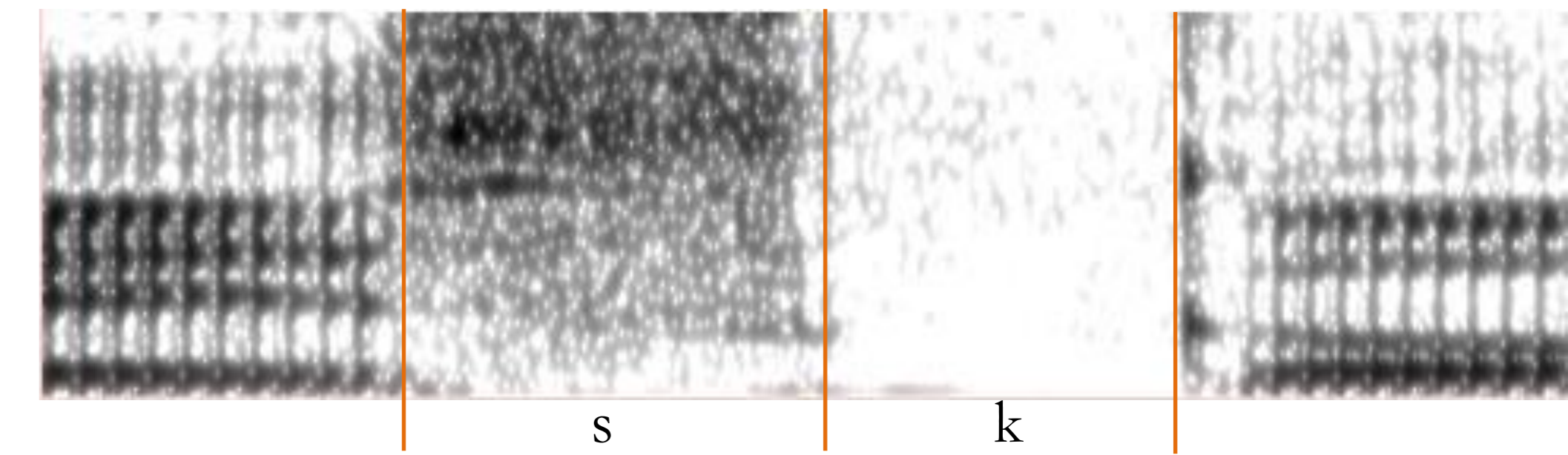
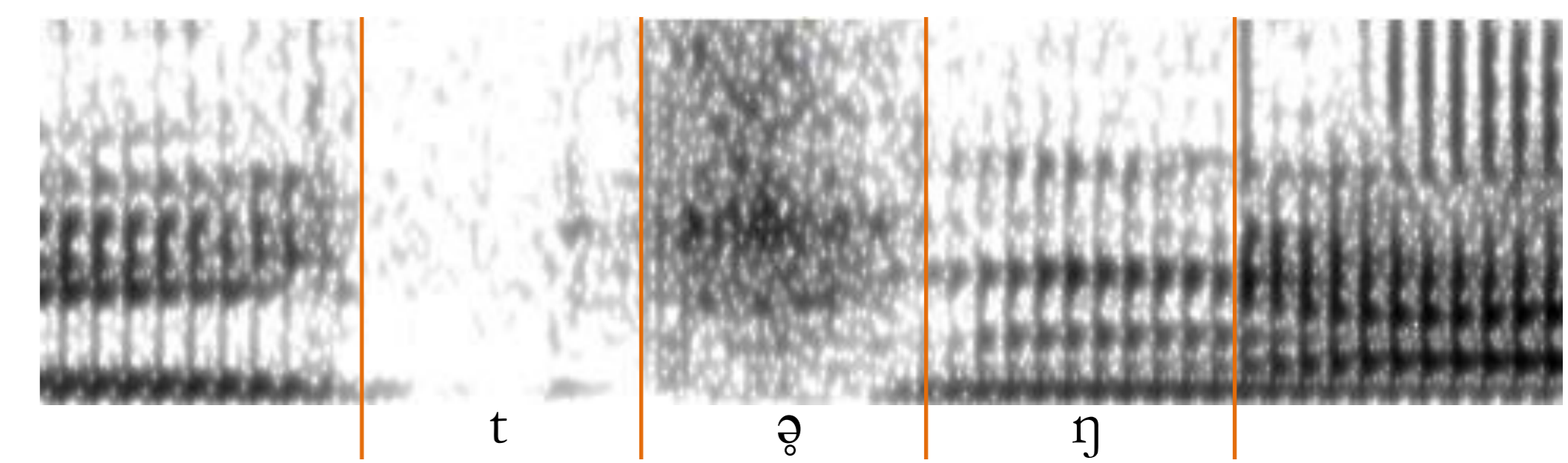
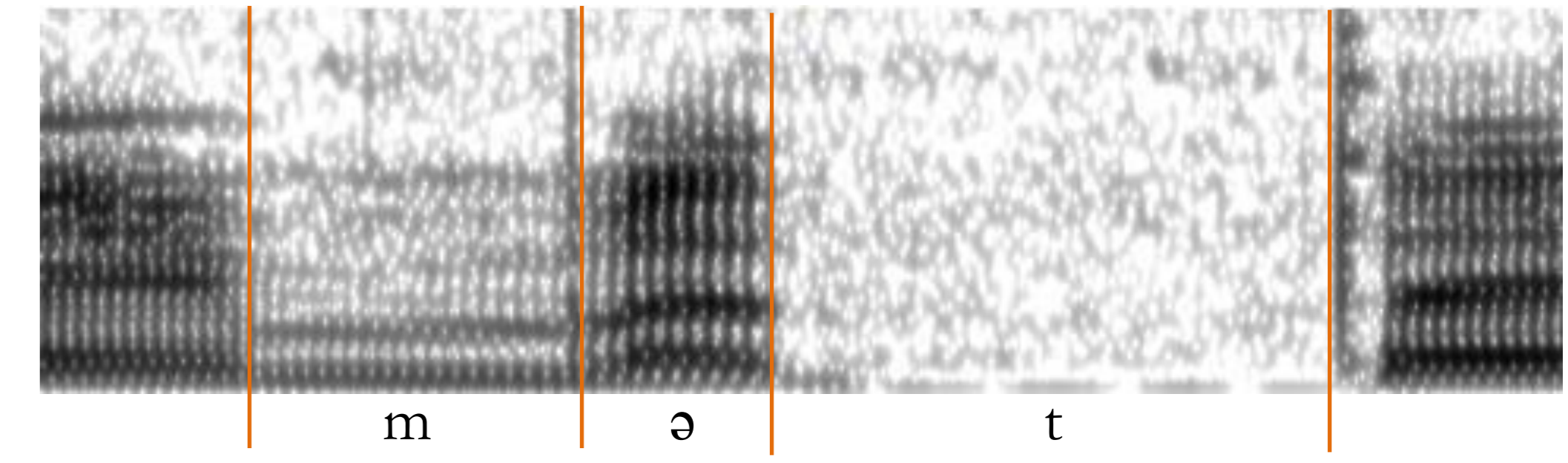
3 Experimental Methods and Predictions

3.1 Method

- 18 Khmer speakers, ages 18 – 44 ($\mu = 27$), recorded in Phnom Penh
- Word types include: CCVC/CəCVC/CɤCVC: 20
CAC.CVC: 4
CAC: 13
- Randomized and produced in frame: [nijj] ____ m'dong tɔət
- 3 repetitions, 2nd repetition analyzed

3.2 Possible Outcomes

- Voiced Underlap: Produced with an intrusive schwa ([ə]) between C1 and C2, which is characterized by a voiced period with formant structure between the two consonants.
- Voiceless underlap: Produced with non-harmonic material ([ɤ]) between C1 and C2, (referred to in Huffman (1972) as aspiration). Note that this can be obscured in the context of fricative noise.
- No underlap: Gestures are overlapping or adjacent such that nothing intervenes between C1 and C2.



4 Results

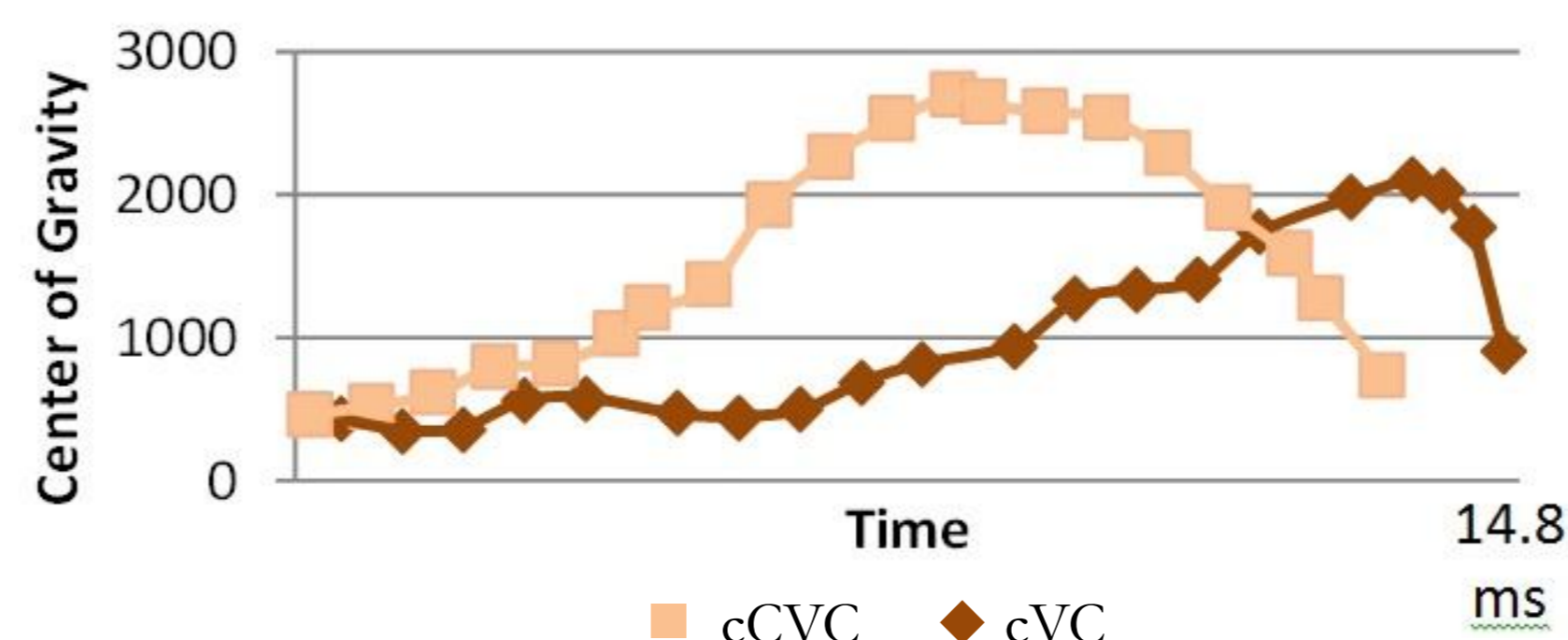
4.1 Distribution of Intrusive Schwa

For non-sibilant C1s:

- All voiceless underlap follows a voiceless C1, except for [pr] sequences
- All voiced underlap follows a voiced C1,

C2 \ C1	r	t	c	k	m	n	ŋ	b
p	100, 100		89, 0	100, 0		89, 0	94, 0	
t							100, 0	
m		72, 100				89, 100		
l				94, 100	94, 100		94, 100	100, 100

Percentage underlap (left); percentage of underlap which is voiced (right)



Aspirated [c] C1s are followed by [ə] in about 28% of tokens with C2 [b]. Otherwise, affricate C1 sequences have voiceless underlap. In cases where underlap is obscured by fricative noise, center of gravity measurements show it is still present. [s]-initial sequences are less conclusive.

4.2 Duration

- Differences in consonantal context were controlled for using residuals resulting from a regression of durations by consonant types.
- Durations of voiced and voiceless underlap were compared with each other and with underlying unstressed [A].

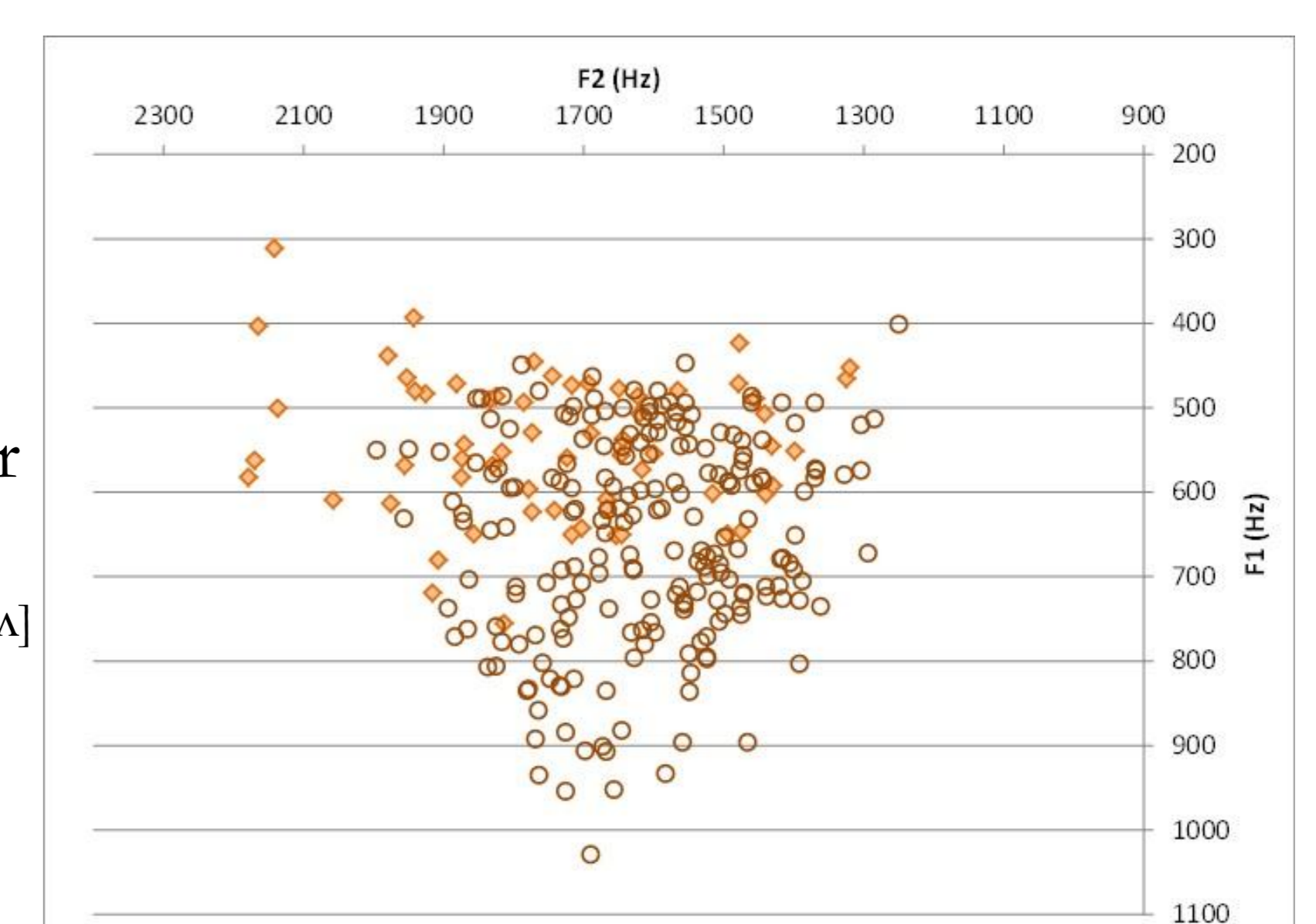
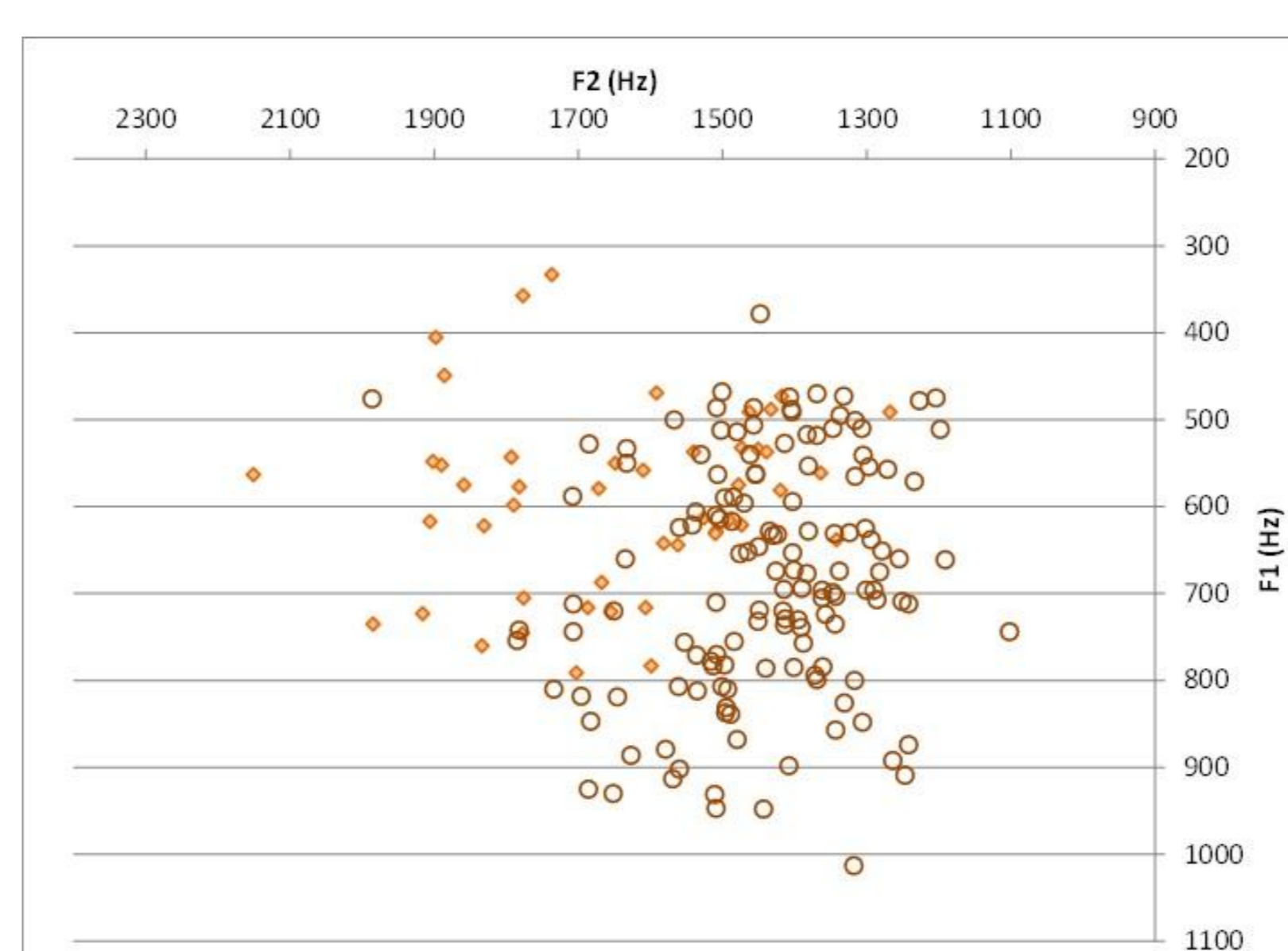
Voiced UL x Voiceless UL (CəCVC x CɤCVC)	
UL Dur x Total Dur	< 0.0001
UL Type x UL Dur	0.7565
UL Type x Total Dur	0.9934

- Underlap type is correlated neither with underlap duration nor the total duration of the CC sequence.
- In general, underlap is significantly shorter than [A].

Underlap x Unstressed [A] (CəCVC/CɤCVC x CAC.'CVC)	
Total Dur UL > Total Dur A	< 0.0001
[A] > UL (Obstruent initial)	< 0.0001
[A] ≠ UL (Sonorant initial)	0.3899

4.3 Formants

- F1 values are significantly lower for voiced [ə] than for [A] ($p < 0.0001$), although some overlap is present.
- F2 values for [ə] have a wider distribution than F2 values for [A].
- Formant values for [ə] are more affected by the preceding consonant than are formant values for [A].



5 Conclusions

- Intrusive schwa in Khmer is not durationally distinct from inter-consonantal aspiration, and its presence is highly predictable from consonantal context. This suggests that it is a voiced transition period, or underlap.
- Underlying [A] vowels are longer than intrusive schwa. Their F1 values are higher and their F2 values are less variable. This is consistent with intrusive schwa's status as a transition state without a gestural target.
- The pervasive presence of intrusive schwa/underlap suggests that Khmer is a simplex-timed language that does not exhibit the C-center effect, although articulatory tests are needed to verify this claim.

Khmer intrusive schwa
= voiced underlap