Effect of word position on stop bursts in Pitjantjatjara.

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Pitjantjatjara

- Spoken in Central Australia (around 2000 speakers), a dialect of the greater Western Desert language.
- Learnt as a first language.

From Dixon (2002).

		apical		laminal	
	bilabial	alveolar	retroflex	palatal	velar
stop	p	t	ʈ	c	k
nasal	m	n	ɳ	ɲ	ŋ
lateral		l	ɭ	ʎ	

Pitjantjatjara

/ca/	*tjaa*	mouth	caa
/ci/	*tjina*	foot	cina
/cu/	*tjulpu*	bird	culpu
/ta/	*tali*	sandhill/dune	tali
/ti/	*tili*	flame	tili
/tu/	*tupunpa*	sandhill country	tupunpa
/ʈa/	*kaṯaṉi*	to cut	kaʈaɳi
/ʈi/	*iṯi*	baby	iʈi
/ʈu/	*kuṯuṯu*	heart	kuʈuʈu

Introduction

- Word-initial position is prosodically prominent in Pitjantjatjara (Tabain, Fletcher & Butcher, under revision).
  - ✓ It is marked by greater duration, a word boundary tone aligned with the left edge, and by greater spectral energy.
  - ✓ Little evidence for vowel reduction, and no evidence for effects of spectral tilt on the vowel.
  - ✓ No evidence for secondary stress.

- Initial position is prosodically strong (Fletcher 2010)
- Place of articulation imperative in Australian languages (Butcher 2006).

Introduction

1. However, the alveolar vs. retroflex contrast is neutralized in initial position /T/
2. Velars in Australian languages are more back than in European languages (Butcher & Tabain 2004). How does this interact with the alveo-palatal contrast?
3. For completeness, we look at the five places of articulation: /p t ʈ c k/. Note that there is no voicing contrast.

Recordings

- 9 speakers:

• 3 from Areyonga (NT) recorded at La Trobe Uni. in 2010. Recorded direct to computer and sampled at 44.1 kHz.

• 6 from Ernabella (SA) recorded in the community in 1990. Recorded onto tape, subsequently digitized.

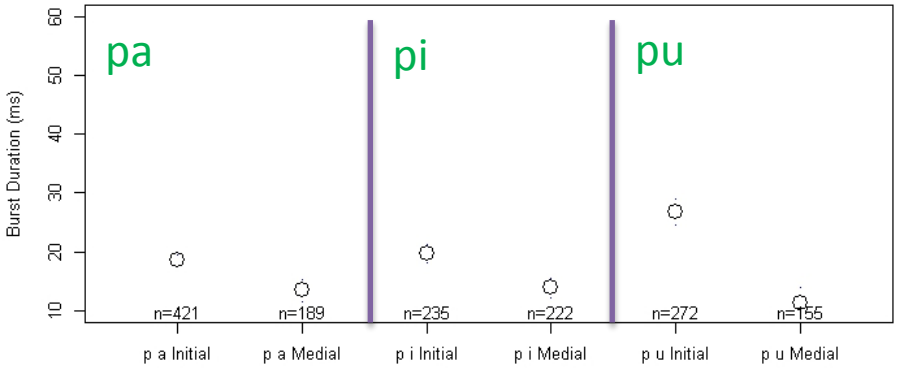
•All female, except for one male speaker from Ernabella.

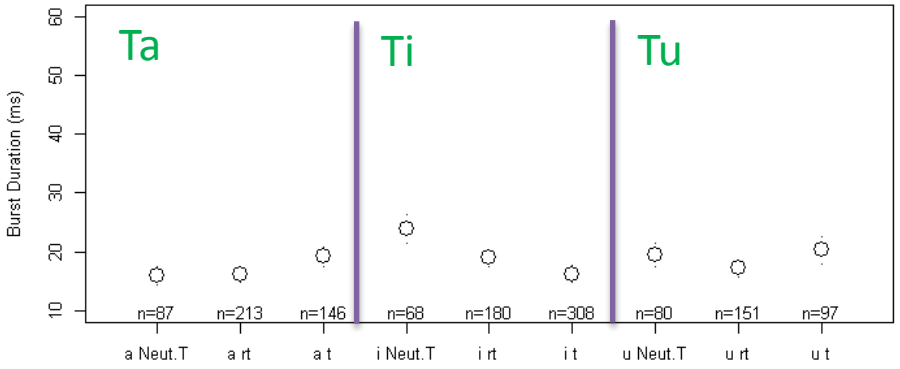
Stimuli

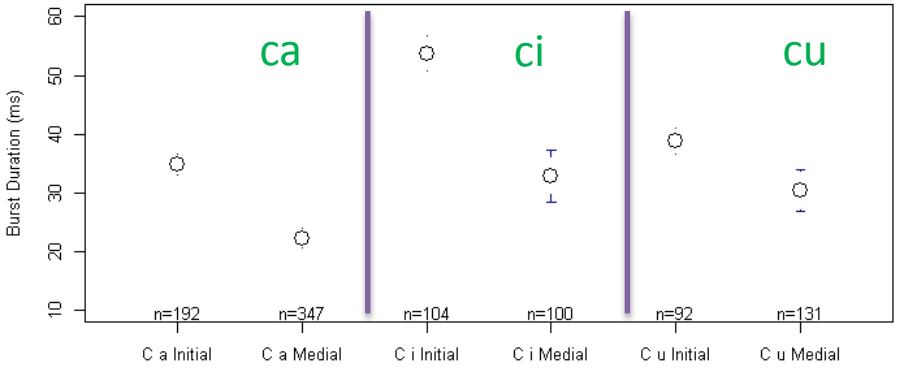
- Real words illustrating the consonant sounds in initial and medial position (no word-final consonants).
- Each consonant combined with each of the three vowels /a, i, u/.
- Each word repeated three times, without carrier phrase.
- Labelling and analysis in EMU/R.
- Labelled according to language orthography (even where apical quality was different).
- A total of **5956** tokens.

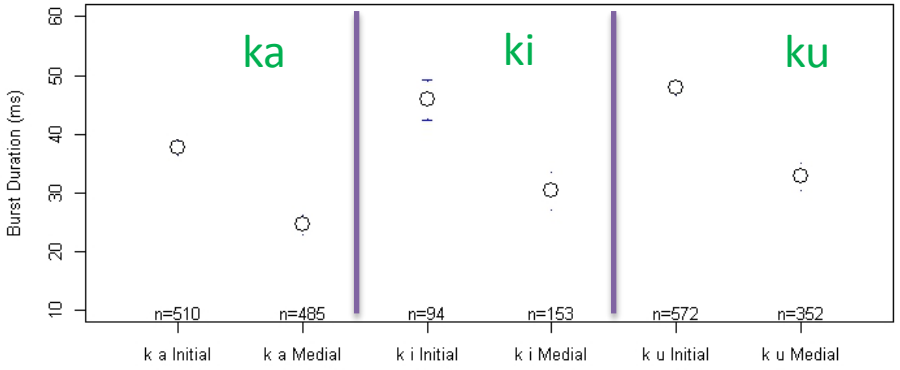
Measures & Stats

- 10 ms Hamming-windowed FFT, centred at stop release.
- Calculated using 1-6 kHz range:
  - ✓ Spectral moments (Forrest et al.1988) – CoG, SD, Skewness and Kurtosis.
  - ✓ Spectral Tilt.
  - ✓ F2, F3 and F4 (ESPS Pitch & Formant Tool – 5 ms frame shift)
- Duration
- LME analyses using *nmle*() package in R (R Core Team 2012). Prosodic (Initial vs. Medial), with Speaker set as a random factor. Significance was set at $p < 0.0056$.

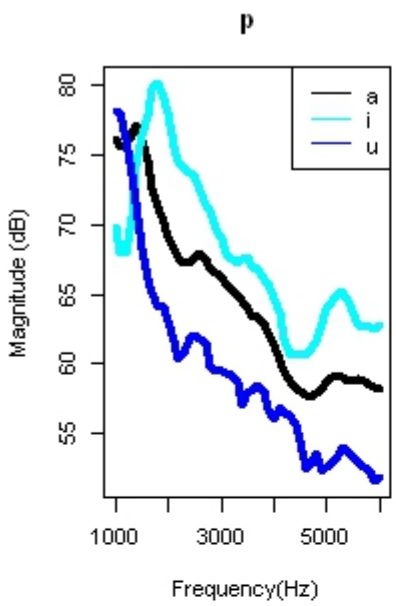


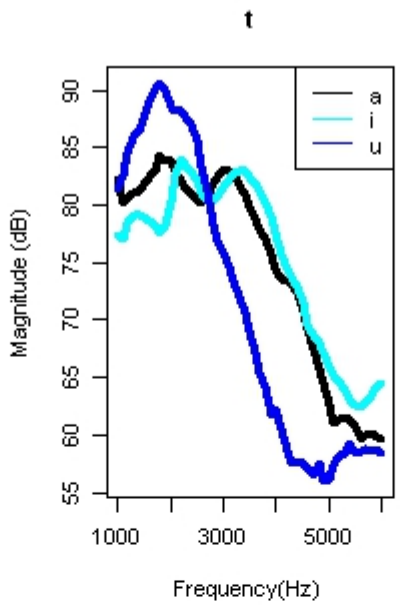


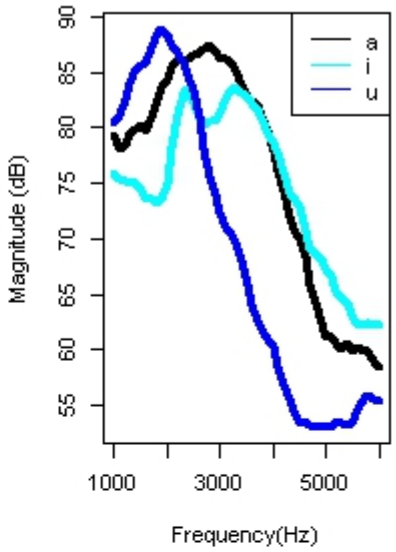


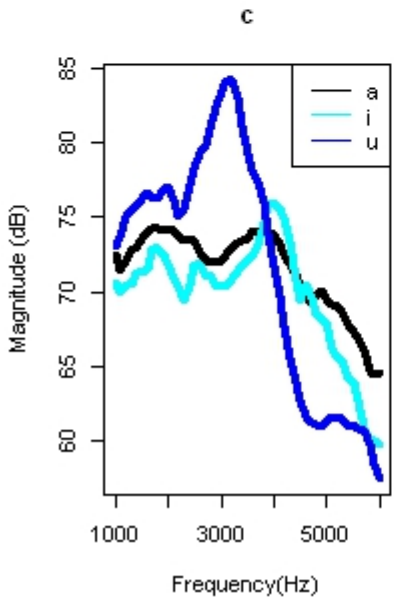


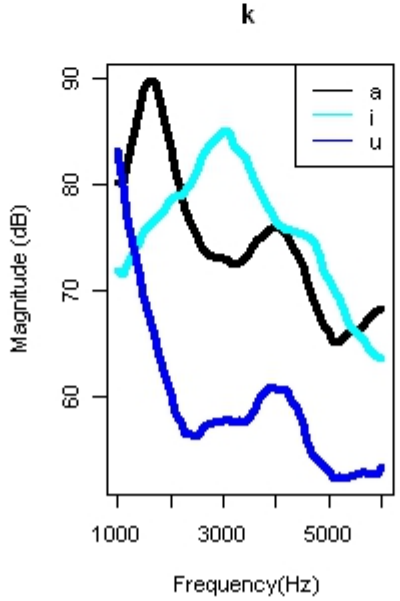
Burst Duration



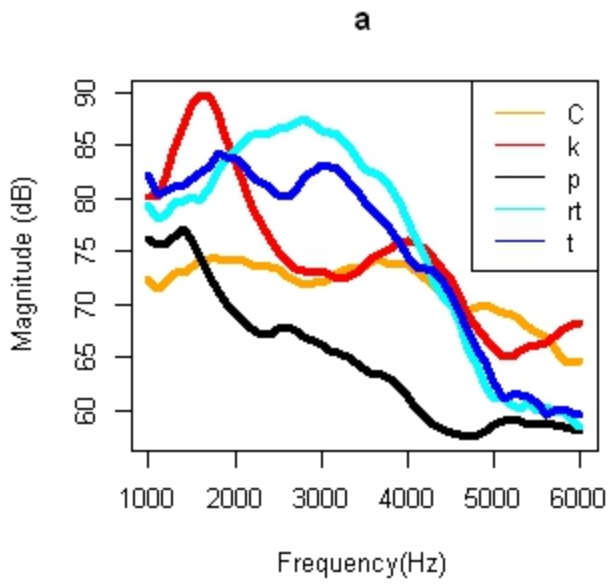


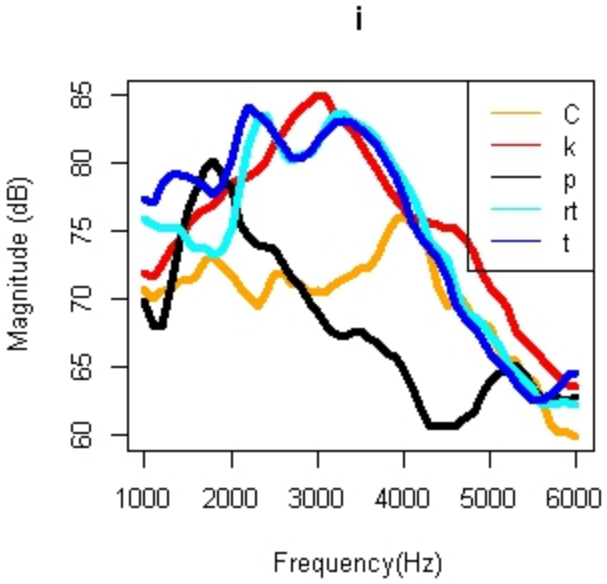


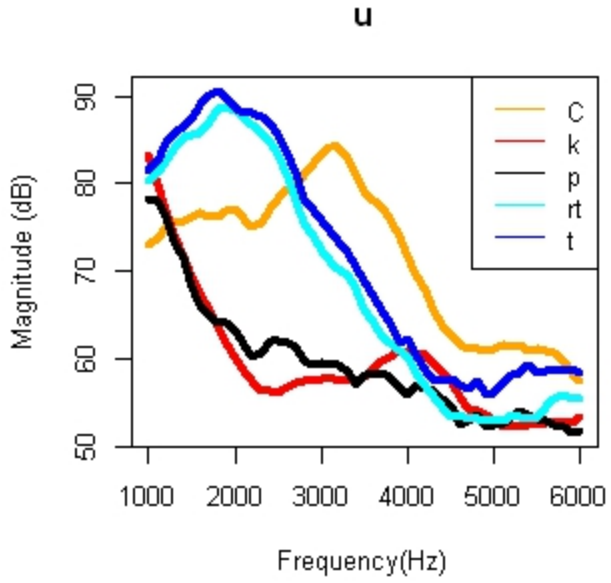




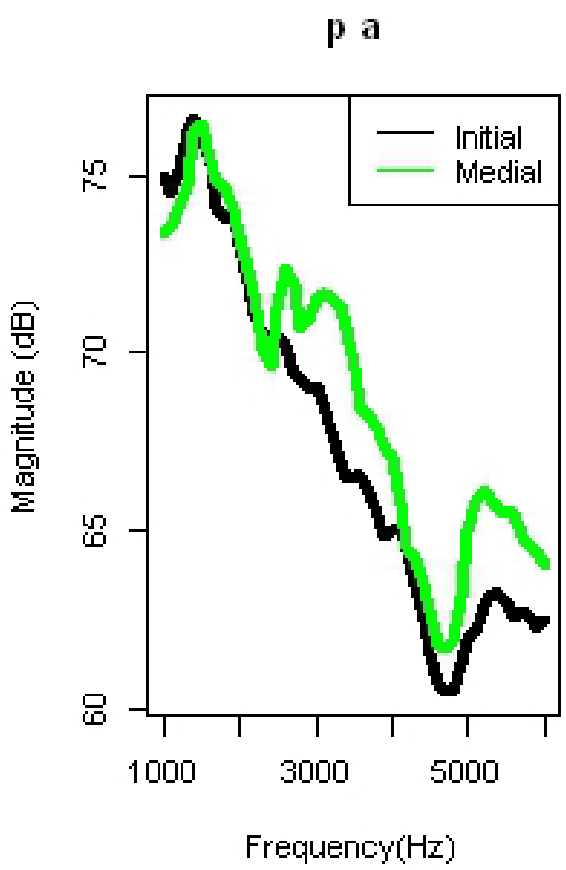
Areyonga – Word Medial Only

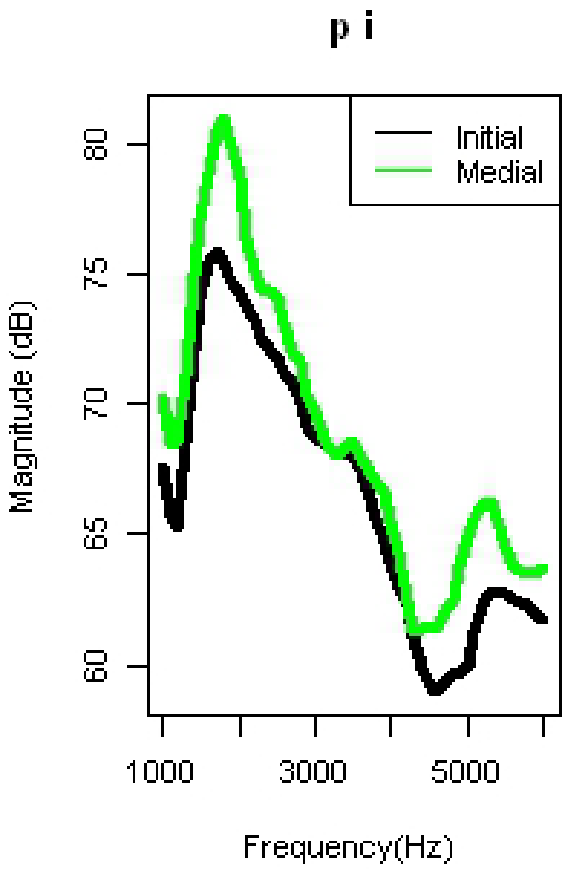


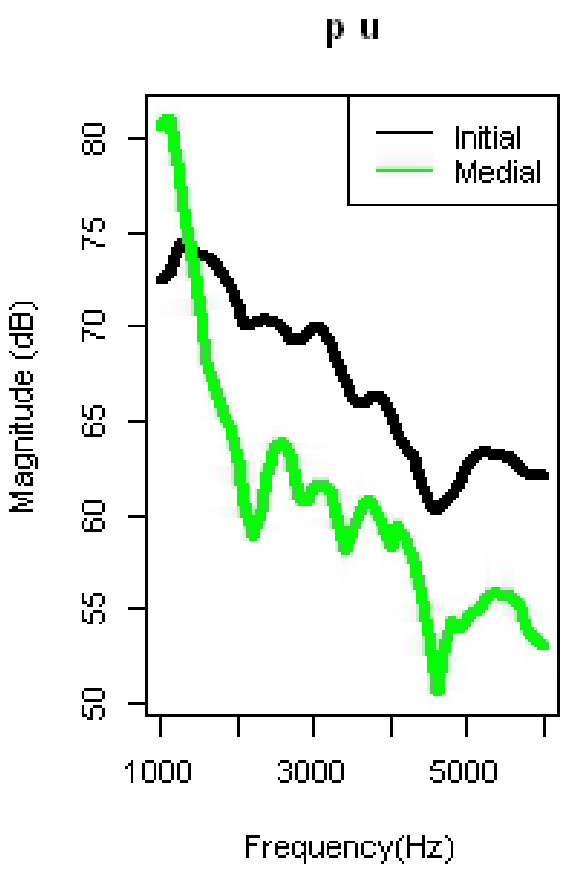




Areyonga – Word Medial Only







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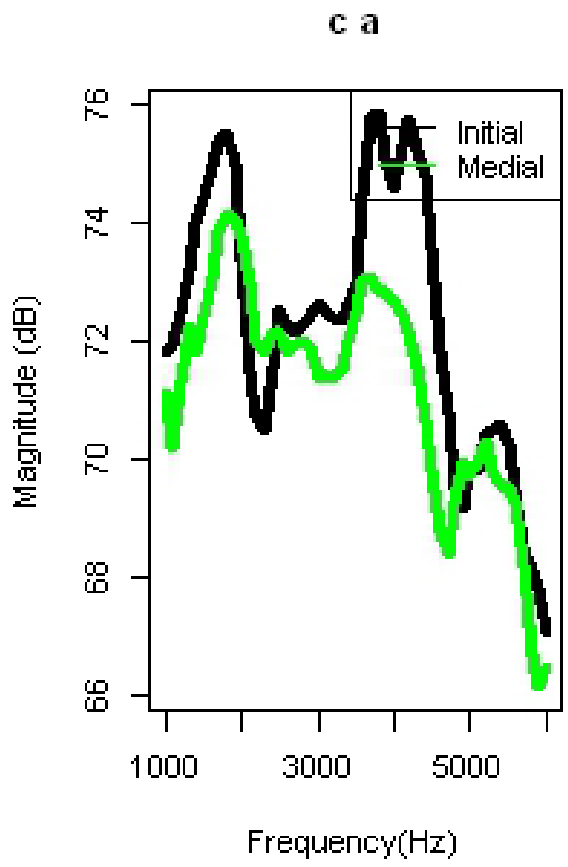
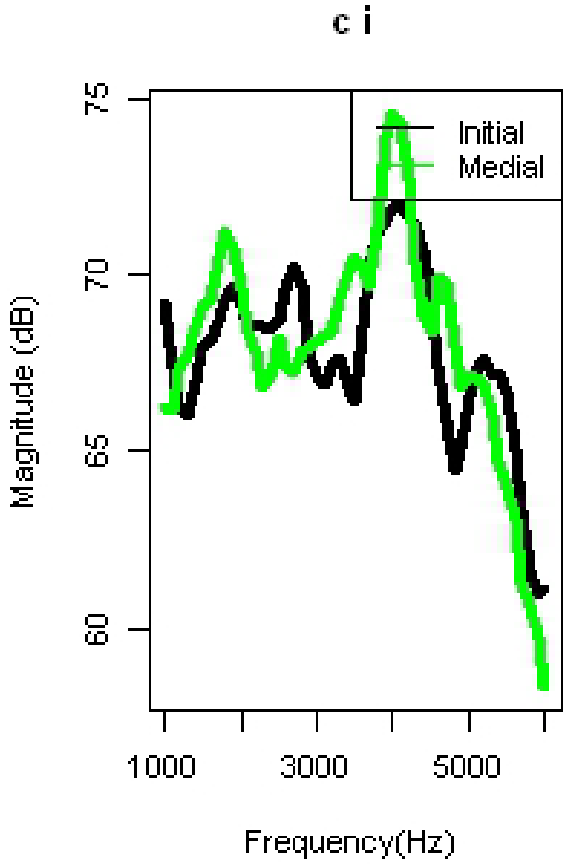
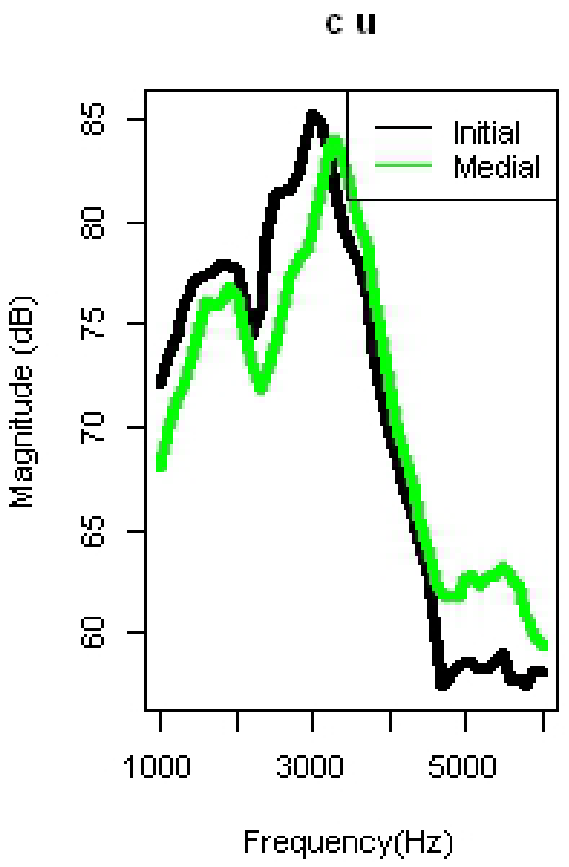
F3 Lower

SD Lower

Kurtosis Higher



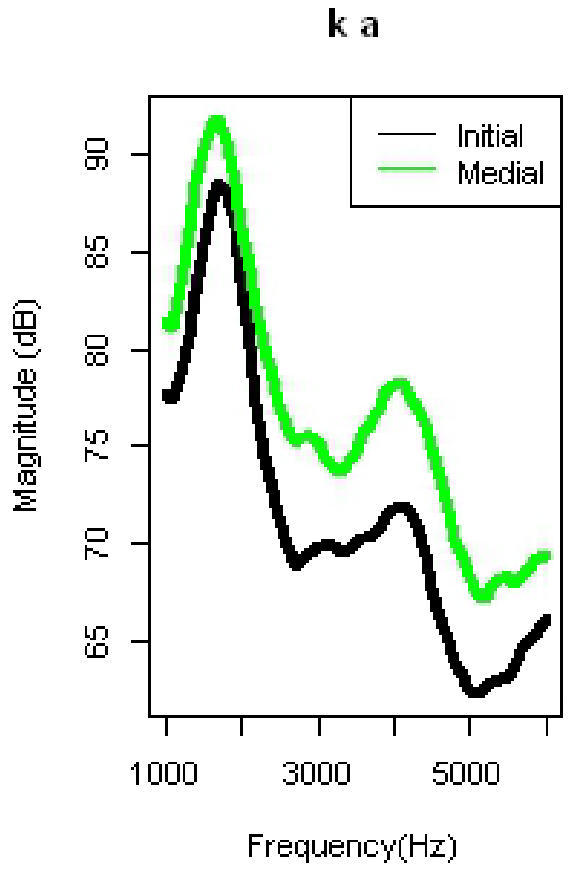


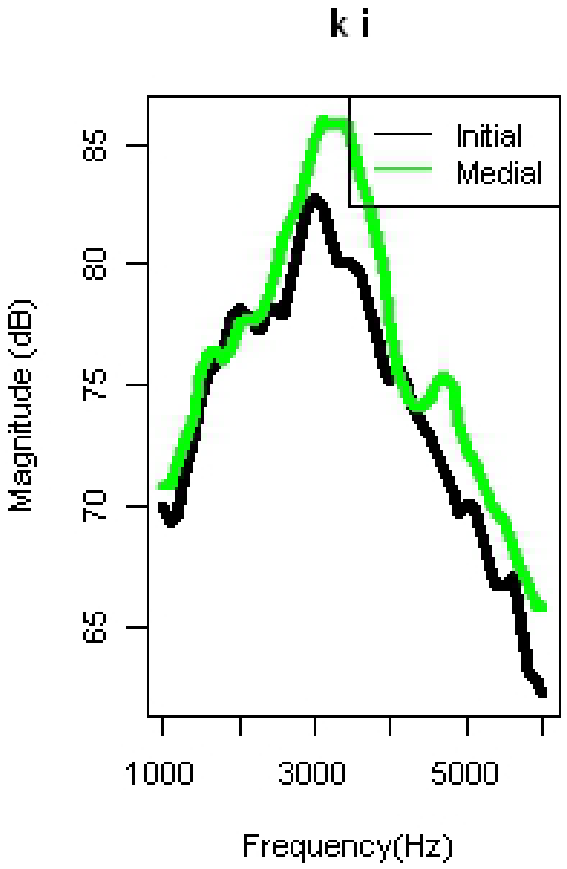


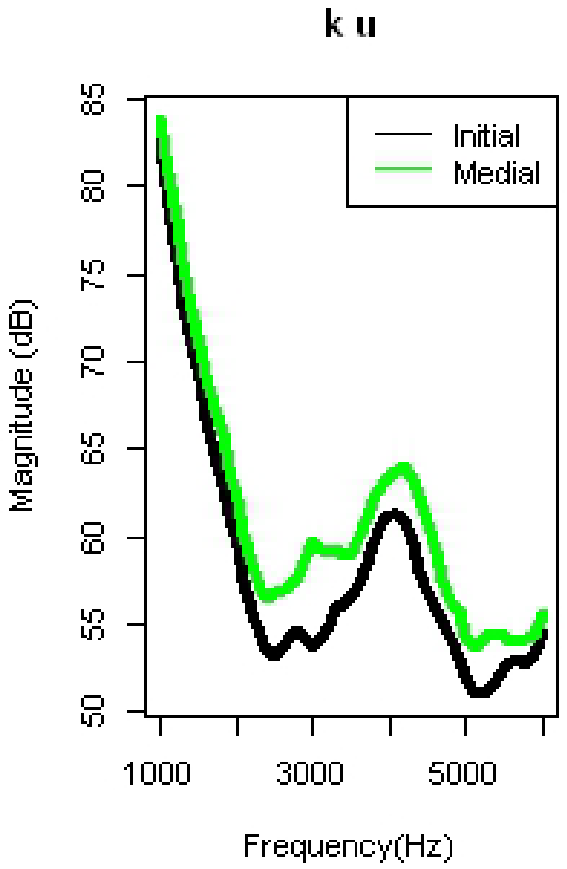
F2	Lower
Skew	Lower

F2	Lower
F4	Lower

Tilt	Lower
CoG	Lower
Skew	Higher
Kurtosis	Higher



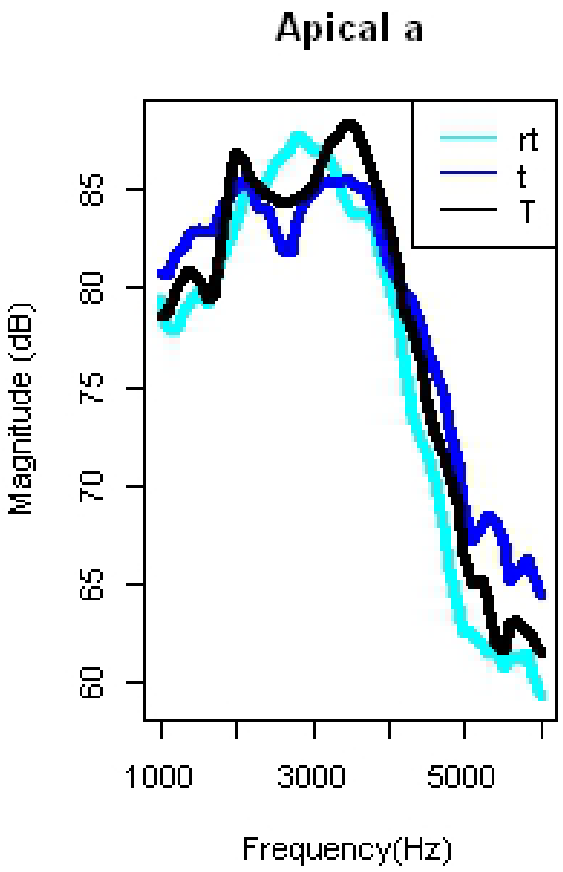


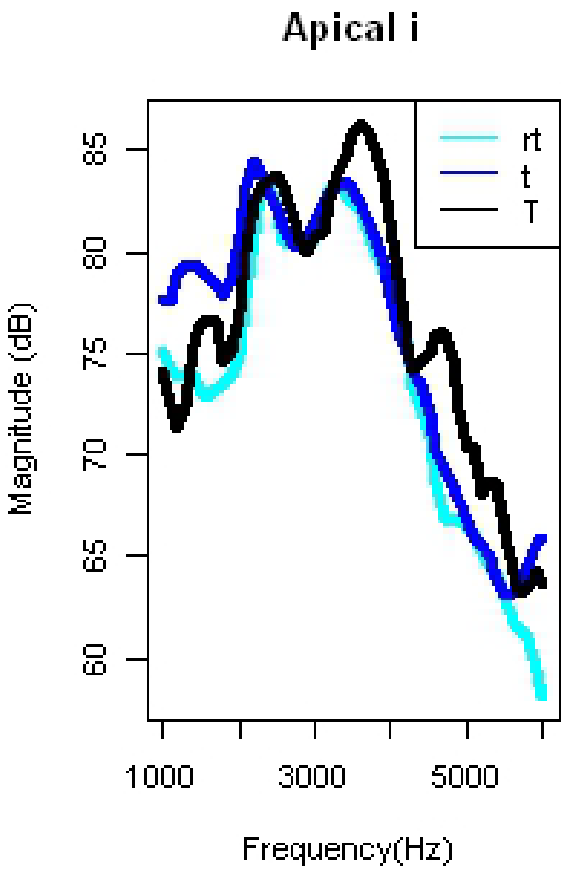


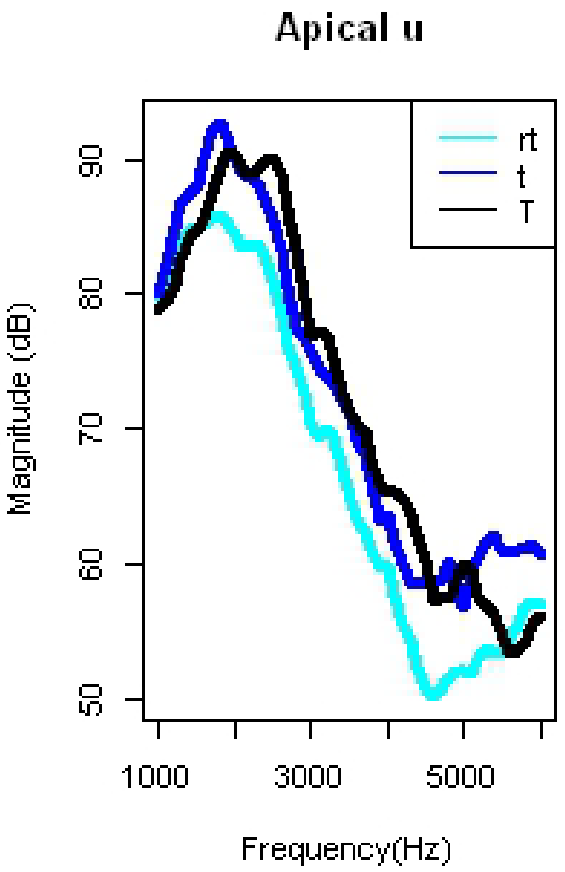
Tilt	Lower
CoG	Lower
Skew	Higher

F2	Lower
F3	Lower
Tilt	Lower
CoG	Lower
Skew	Higher

Tilt	Lower
SD	Higher
Kurtosis	Higher





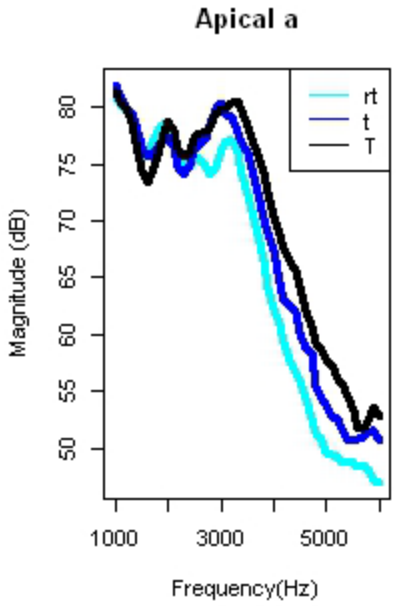


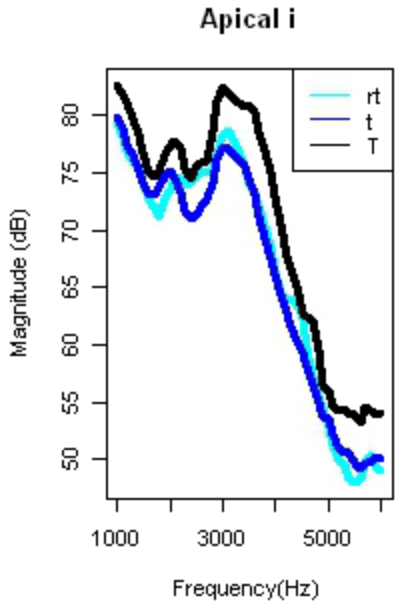
Tilt	Higher
Skew	Lower
F3	Higher
F4	Higher
Tilt	Higher
CoG	Higher
Skew	Lower
Kurtosis	Lower

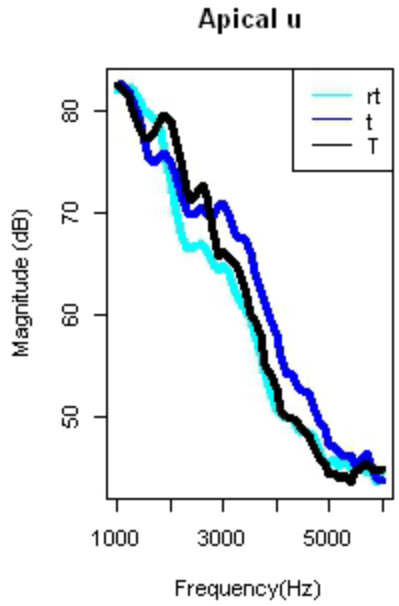
Tilt	Higher
CoG	Higher
Skew	Lower
Tilt	Higher
Kurtosis	Lower

-

F2	Higher
SD	Lower


Apical a
rt
t
T
Magnitude (dB)
50
55
60
65
70
75
80
1000
3000
5000
Frequency(Hz)


Apical i
rt
t
T
Magnitude (dB)
50
55
60
65
70
75
80
1000
3000
5000
Frequency(Hz)


Apical u
rt
t
T
Magnitude (dB)
50
60
70
80
1000
3000
5000
Frequency(Hz)

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Summary

1. In general, the bilabial /p/ is not affected by position in Word. Some effects in context of /u/ (duration and spectral).
2. Neutralized Initial /T/ seems more alveolar: it has higher Tilt and CoG, and lower Skewness, in Initial position. Are tactile and visual cues relevant?
3. Neutralized Initial /T/ does not have a longer stop burst in Initial position – part of consonant identity (very short at about 15 ms).

Summary cont.

4. There appears to be a darkening of the velar /k/ in Initial position.
5. Overall, not many effects for palatal /c/. Some effects for /cu/, with lower frequencies enhanced. Resistance to coarticulation.
6. Overall, not many effects on formants (but note F2 moves in same direction for /ci/ and /ki/).

Conclusion

- Spectral balance moves to higher frequencies in Initial position for apicals, but to lower frequencies for (/c/ and) /k/.
- Do the observed effects of Word-initial position enhance the contrast between different places of articulation?
- Or do they simply serve to mark the Word-initial stressed syllable in the same way that spectral tilt marks the stressed vowel in certain Germanic languages?
- Or is it both?

Thanks for listening!

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References

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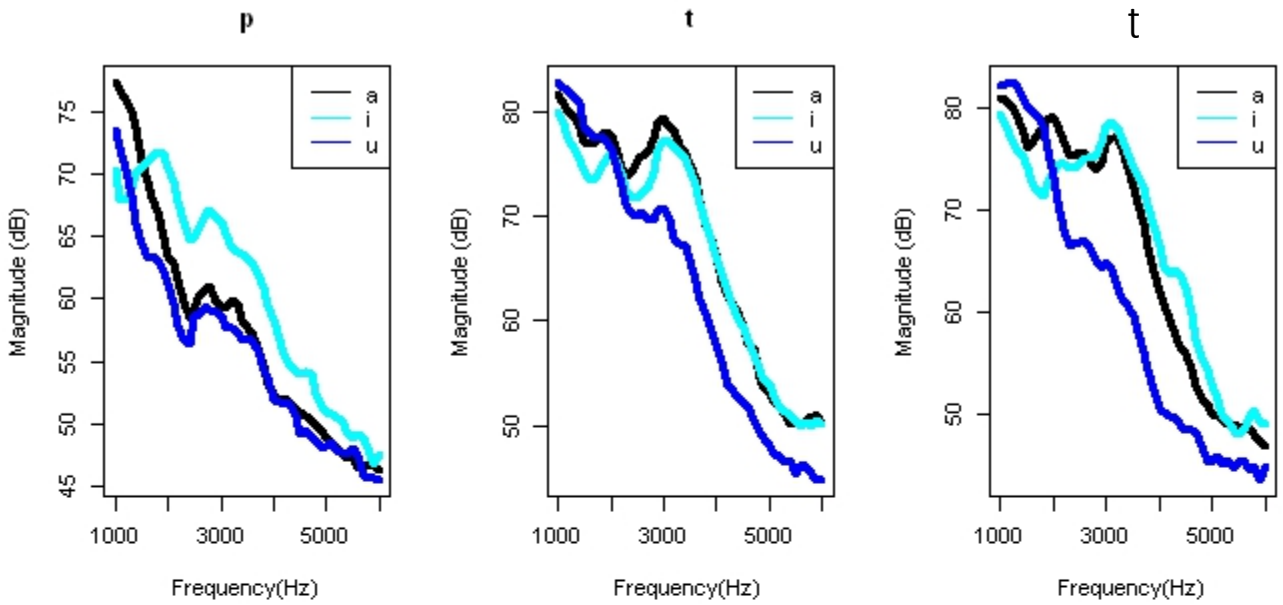
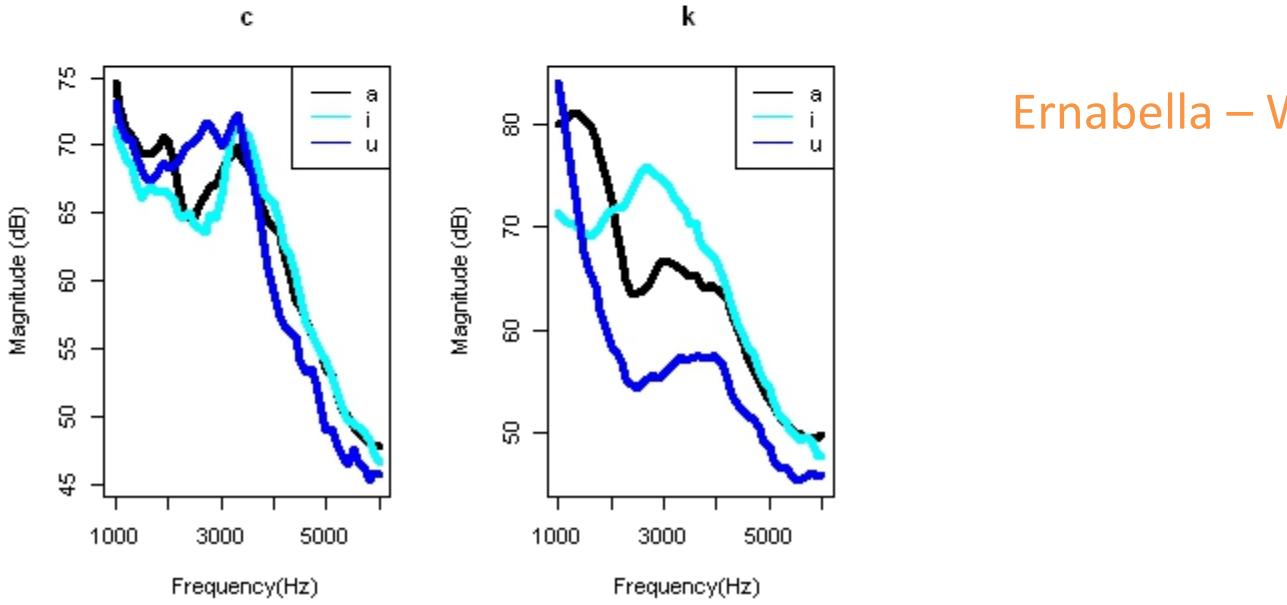
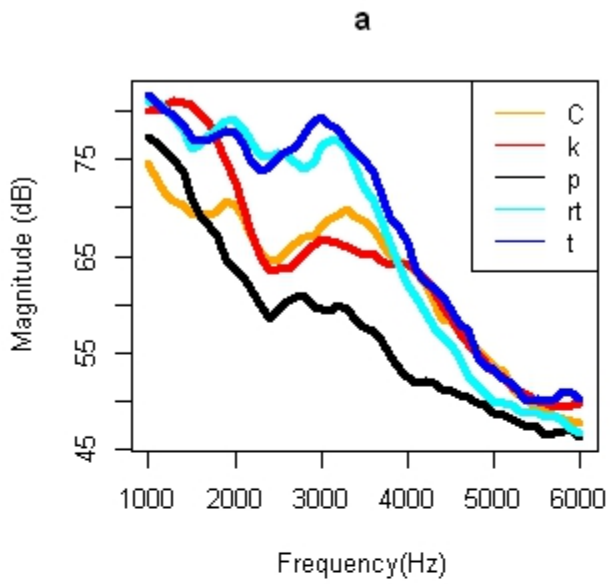
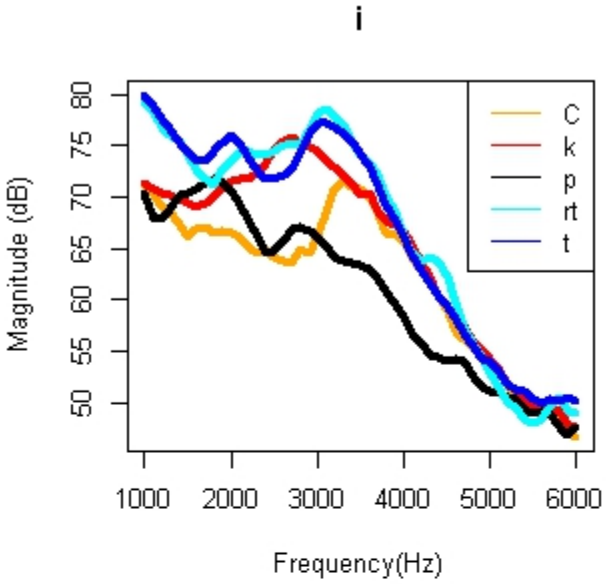
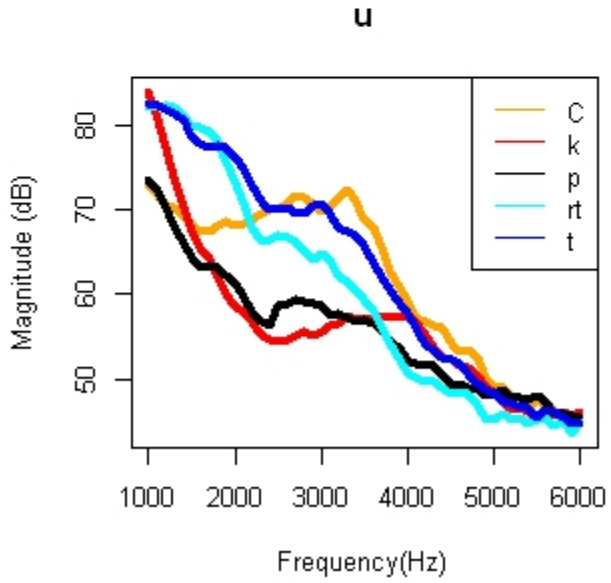




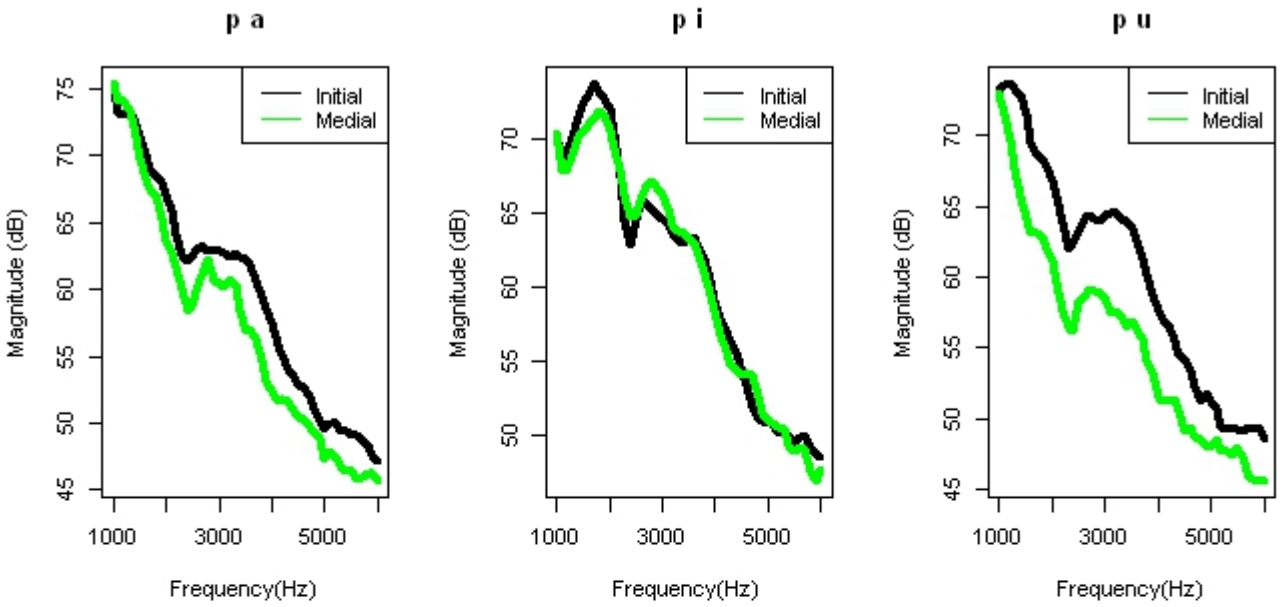
Ernabella – Word Medial Only

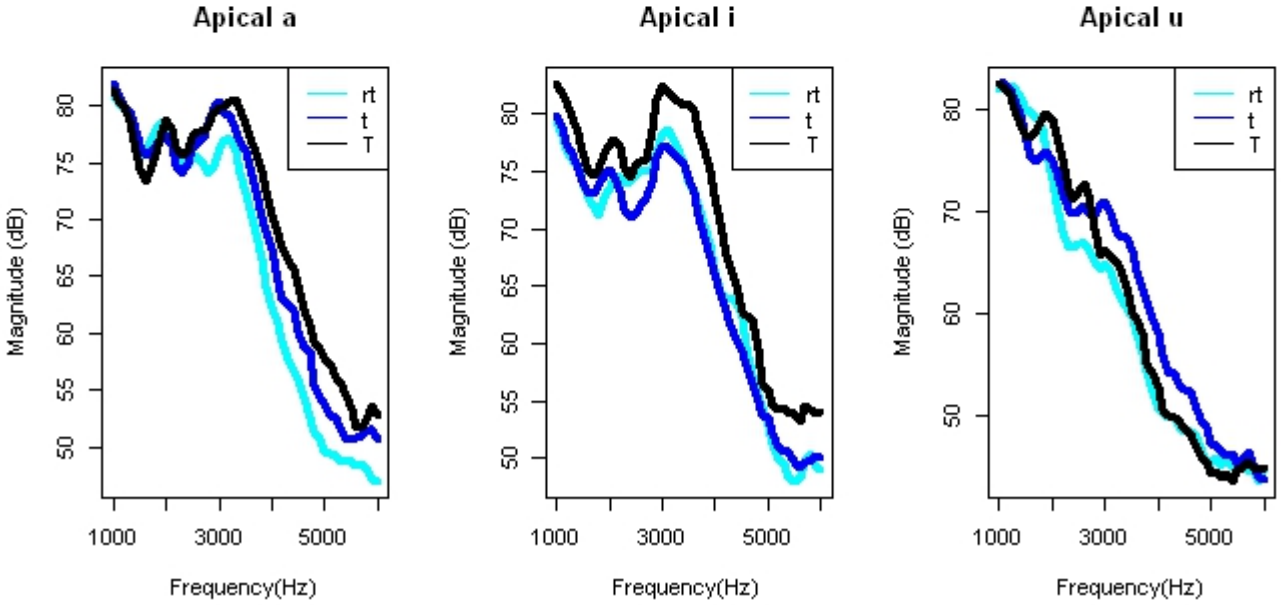




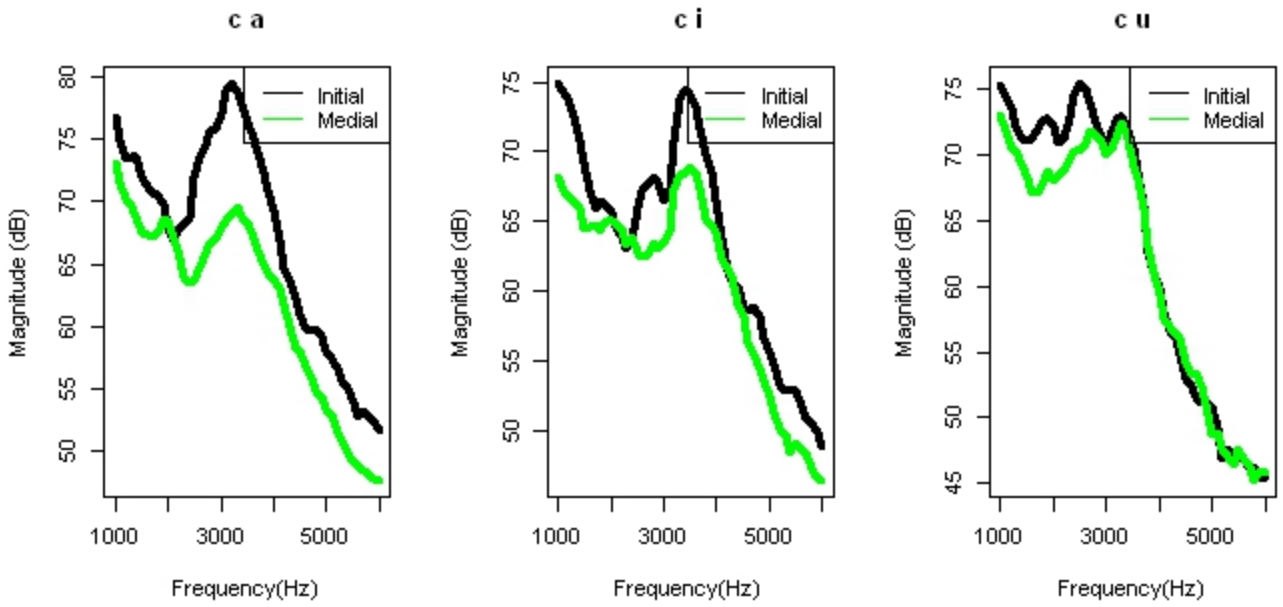


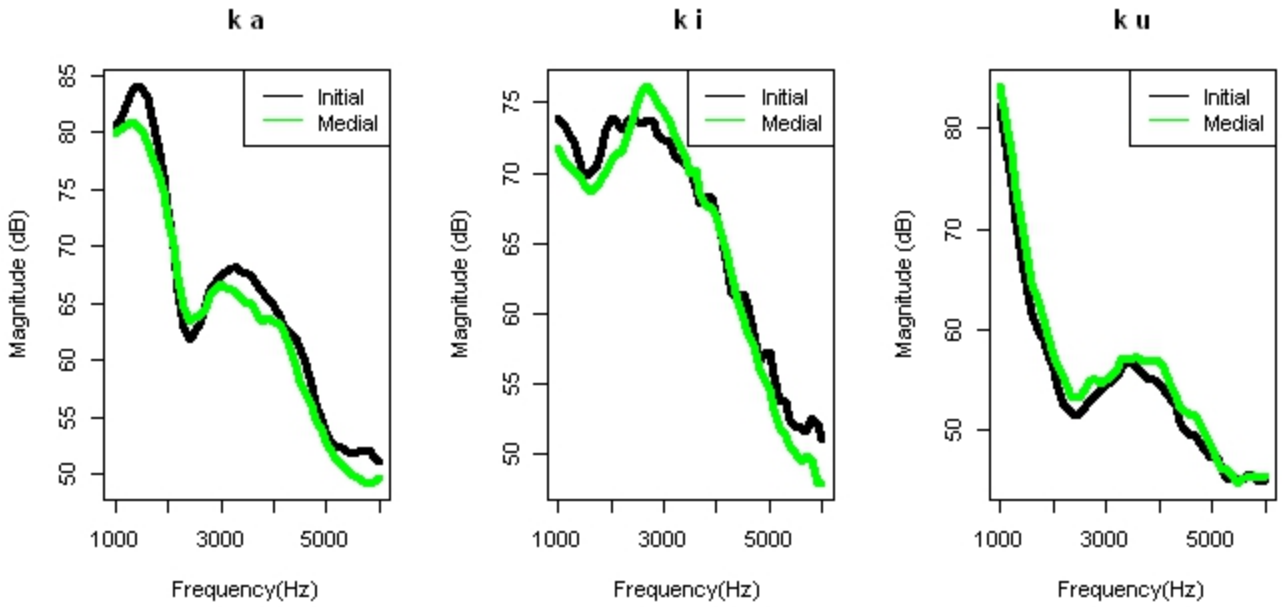
Ernabella – Word Medial Only


p a
p i
p u
Initial
Medial
Magnitude (dB)
Frequency(Hz)
1000
3000
5000

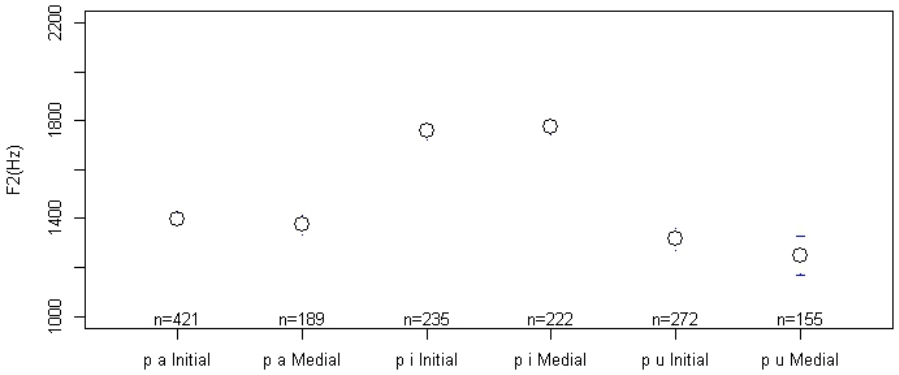

Apical a
Apical i
Apical u
rt
t
T
Magnitude (dB)
Frequency(Hz)
1000
3000
5000

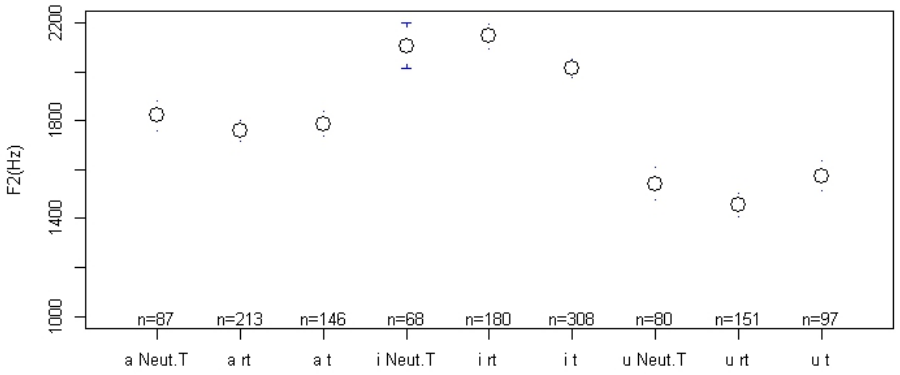
ERNABELLA

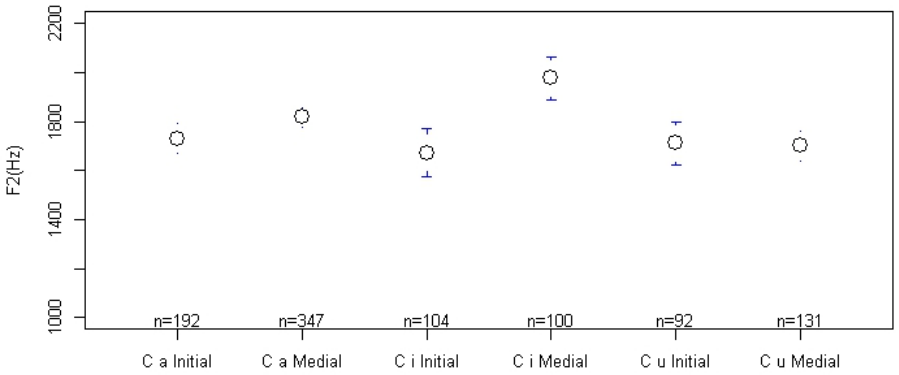

c a
c i
c u
Initial
Medial
Magnitude (dB)
Frequency(Hz)
1000
3000
5000

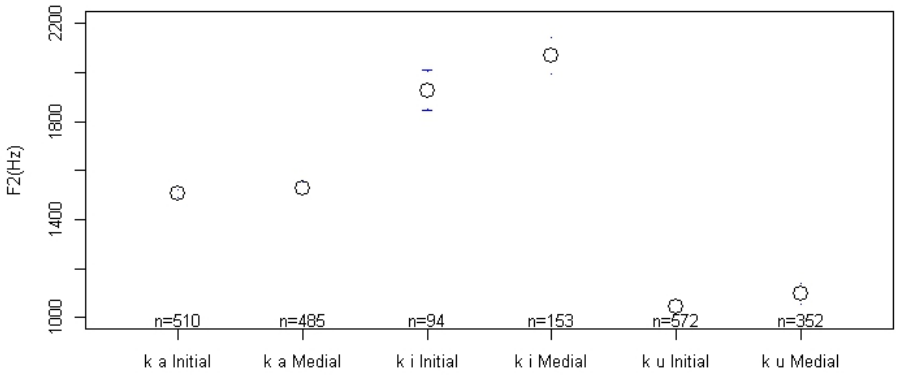

k a
k i
k u
Initial
Medial
Magnitude (dB)
Frequency(Hz)
1000
3000
5000

ERNABELLA

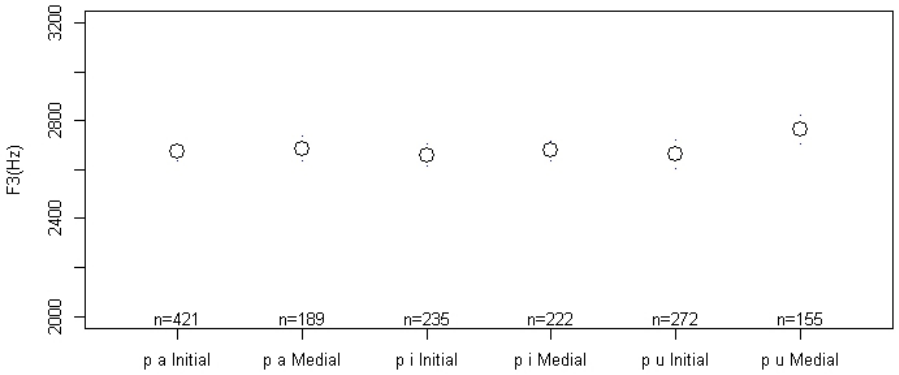

F2(Hz)
2200
1800
1400
1000
n=421
n=189
n=235
n=222
n=272
n=155
p a Initial
p a Medial
p i Initial
p i Medial
p u Initial
p u Medial

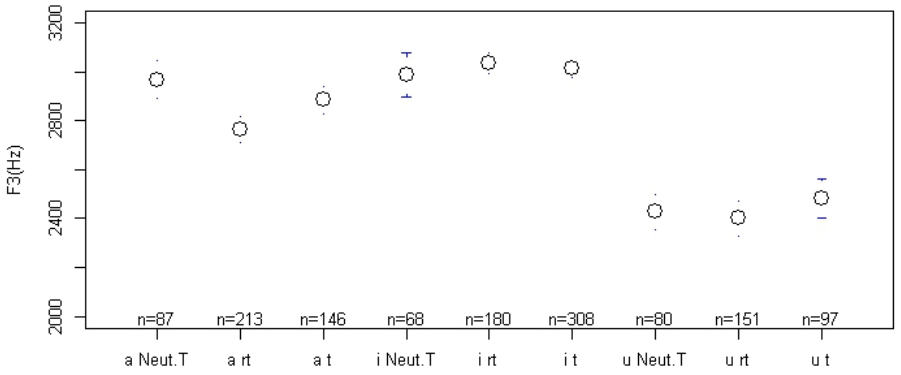

F2(Hz)
2200
1800
1400
1000
n=87
n=213
n=146
n=68
n=180
n=308
n=80
n=151
n=97
a Neut.T
a rt
a t
i Neut.T
i rt
i t
u Neut.T
u rt
u t

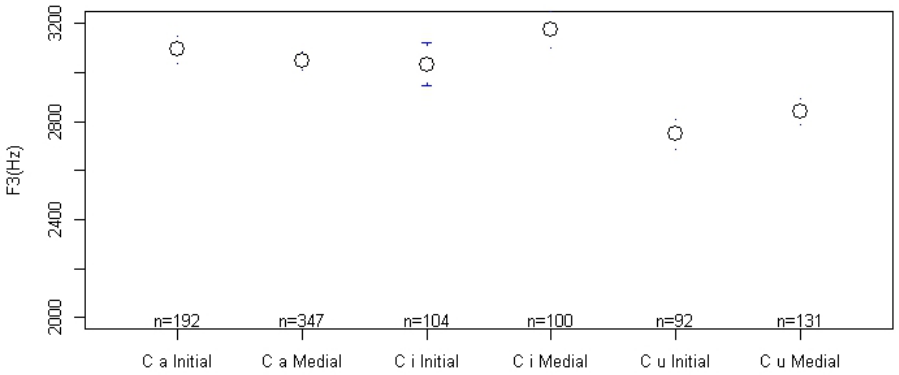

F2(Hz)
2200
1800
1400
1000
n=192
n=347
n=104
n=100
n=92
n=131
C a Initial
C a Medial
C i Initial
C i Medial
C u Initial
C u Medial

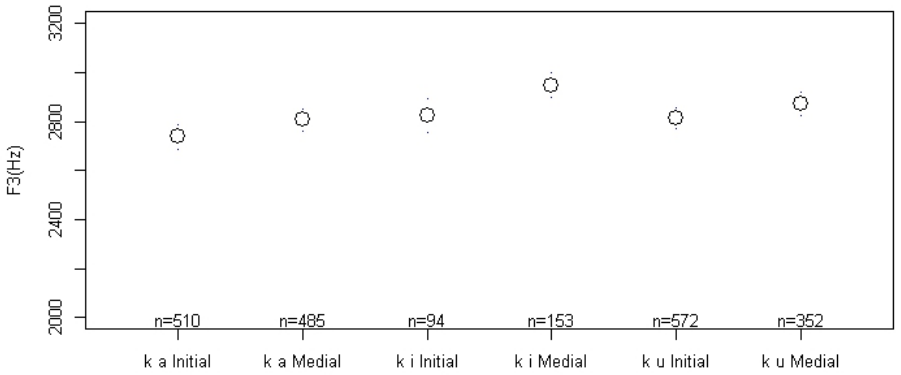

F2(Hz)
2200
1800
1400
1000
n=510
n=485
n=94
n=153
n=572
n=352
k a Initial
k a Medial
k i Initial
k i Medial
k u Initial
k u Medial

F2

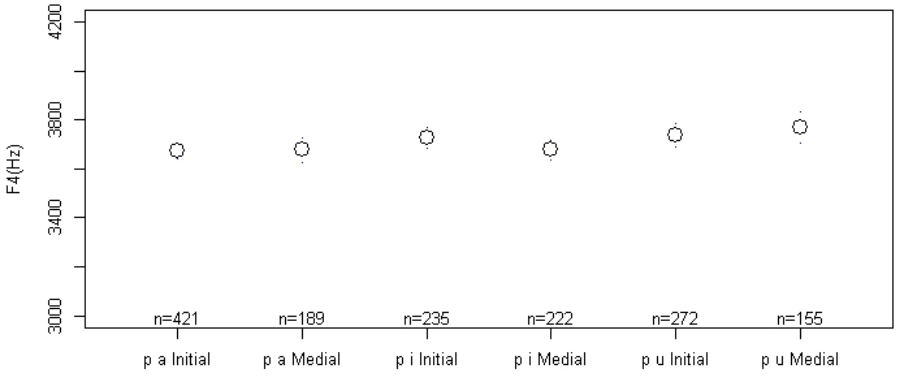

F3(Hz)
3200
2800
2400
2000
n=421
n=189
n=235
n=222
n=272
n=155
p a Initial
p a Medial
p i Initial
p i Medial
p u Initial
p u Medial

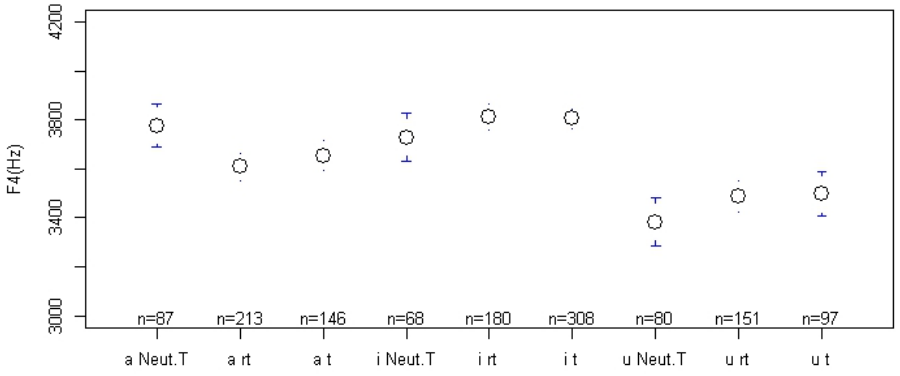

F3(Hz)
3200
2800
2400
2000
n=87
n=213
n=146
n=68
n=180
n=308
n=80
n=151
n=97
a Neut.T
a rt
a t
i Neut.T
i rt
i t
u Neut.T
u rt
u t

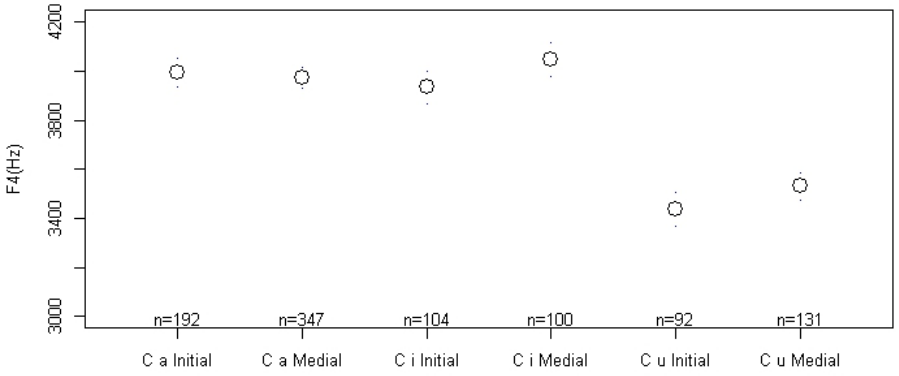

F3(Hz)
3200
2800
2400
2000
n=192
n=347
n=104
n=100
n=92
n=131
C a Initial
C a Medial
C i Initial
C i Medial
C u Initial
C u Medial

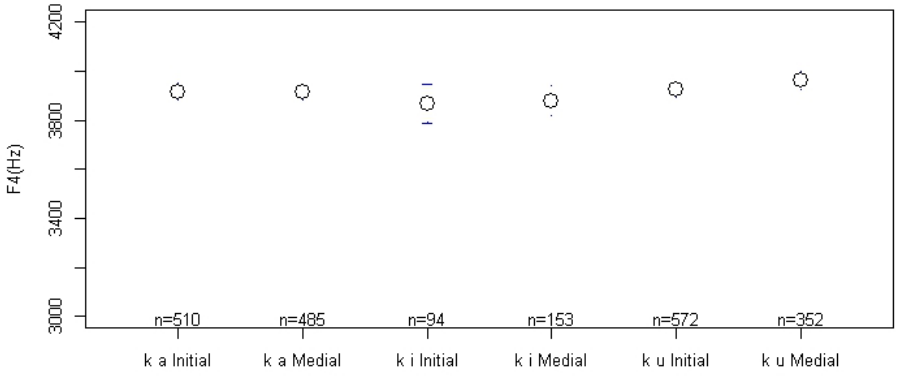

F3(Hz)
3200
2800
2400
2000
n=510
n=485
n=94
n=153
n=572
n=352
k a Initial
k a Medial
k i Initial
k i Medial
k u Initial
k u Medial

F3

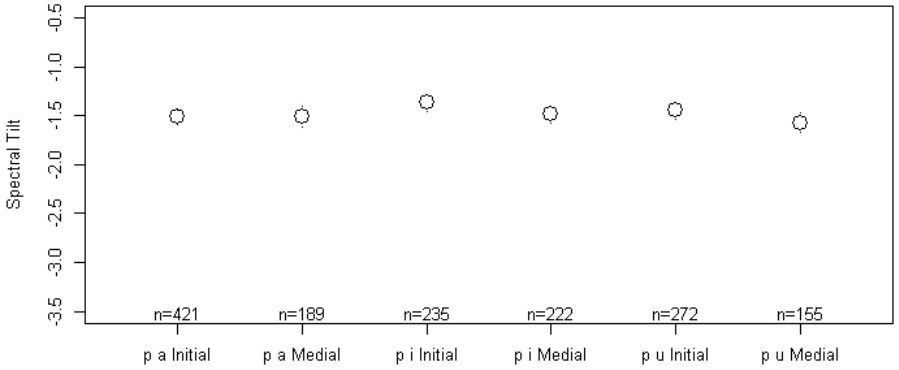

F4(Hz)
4200
3800
3400
3000
n=421
n=189
n=235
n=222
n=272
n=155
p a Initial
p a Medial
p i Initial
p i Medial
p u Initial
p u Medial

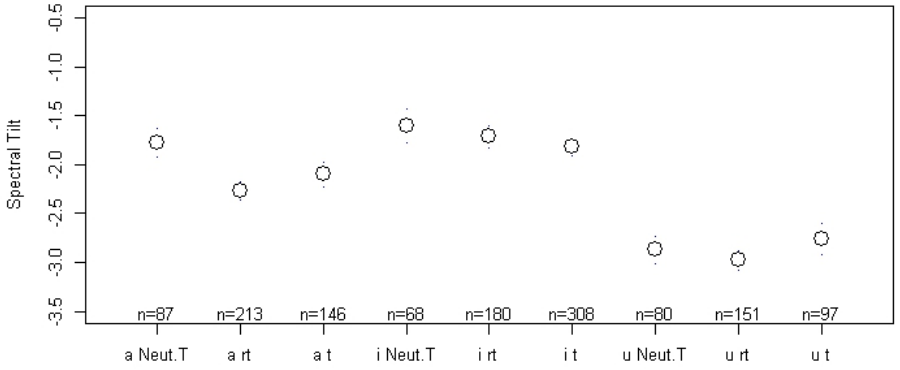

F4(Hz)
4200
3800
3400
3000
n=87
n=213
n=146
n=68
n=180
n=308
n=80
n=151
n=97
a Neut.T
a rt
a t
i Neut.T
i rt
i t
u Neut.T
u rt
u t

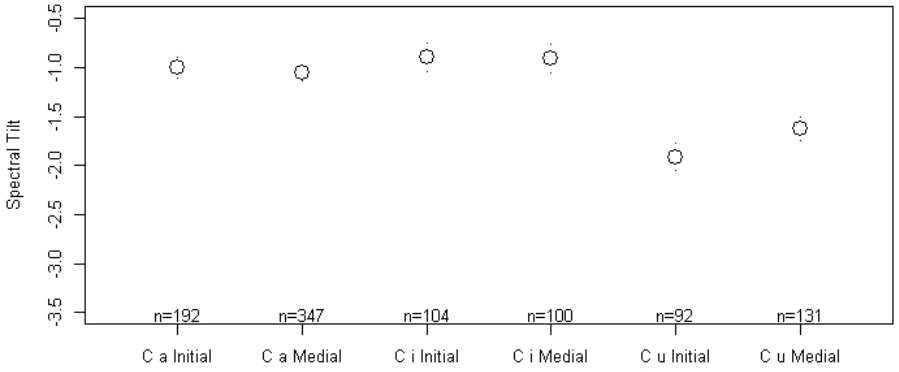

F4(Hz)
4200
3800
3400
3000
n=192
n=347
n=104
n=100
n=92
n=131
C a Initial
C a Medial
C i Initial
C i Medial
C u Initial
C u Medial

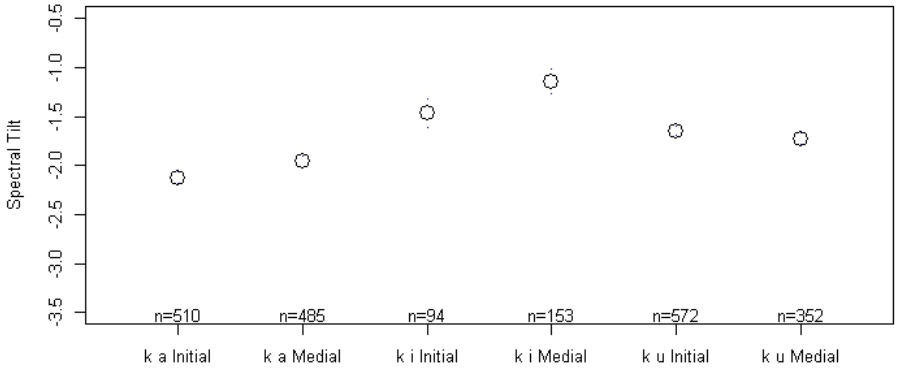

F4(Hz)
4200
3800
3400
3000
n=510
n=485
n=94
n=153
n=572
n=352
k a Initial
k a Medial
k i Initial
k i Medial
k u Initial
k u Medial

F4

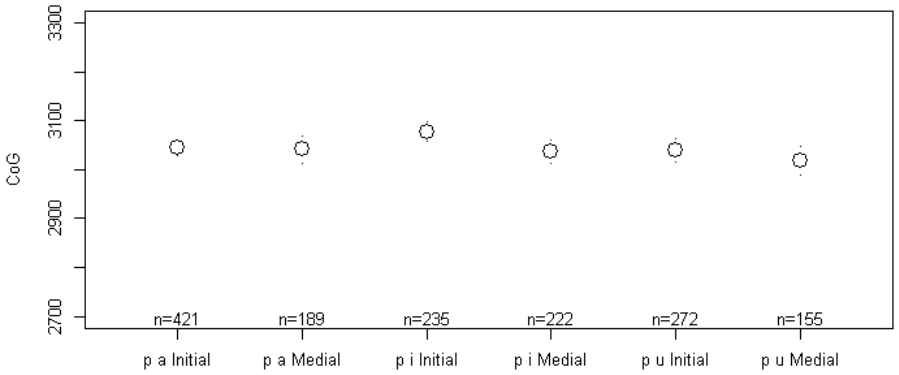


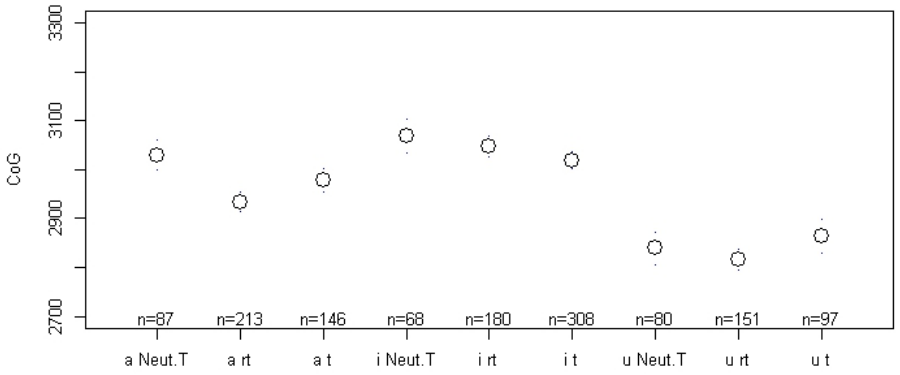


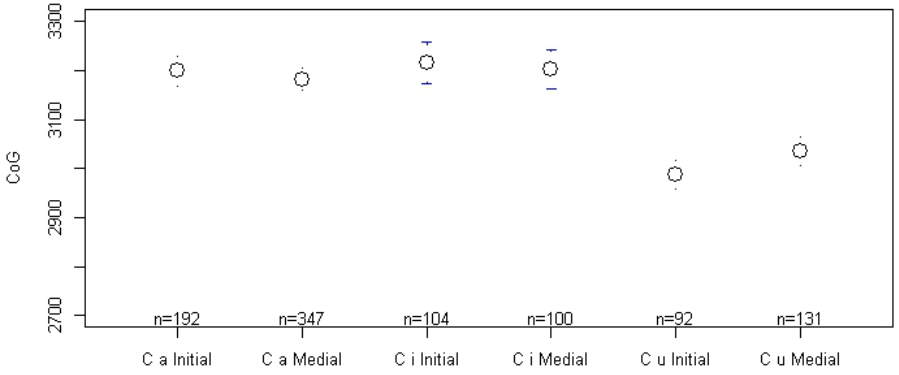


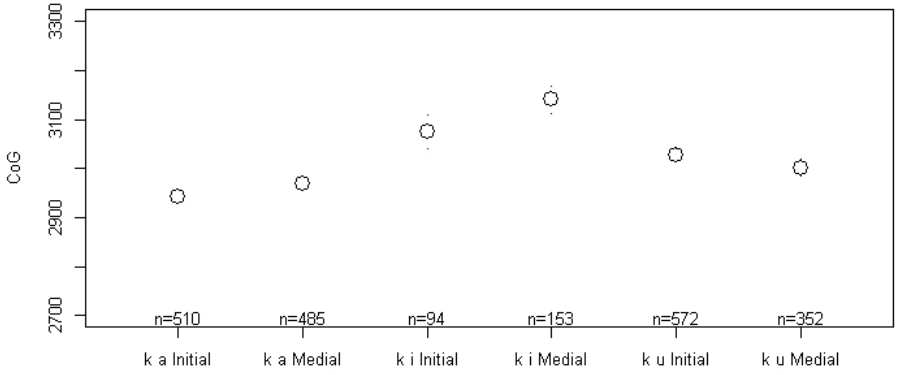


Spectral Tilt

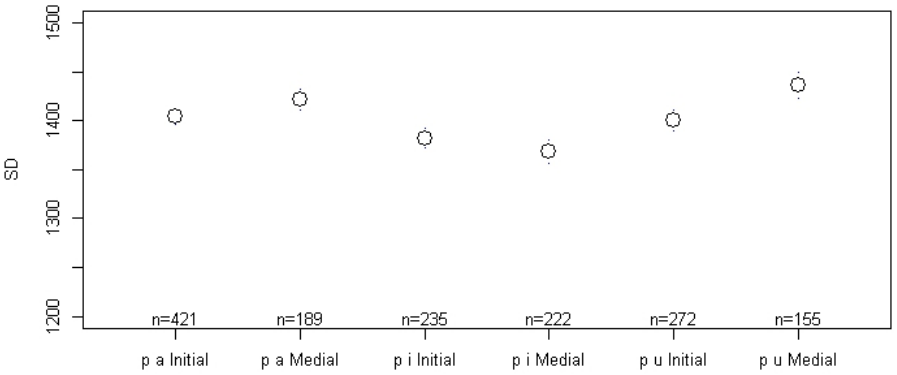


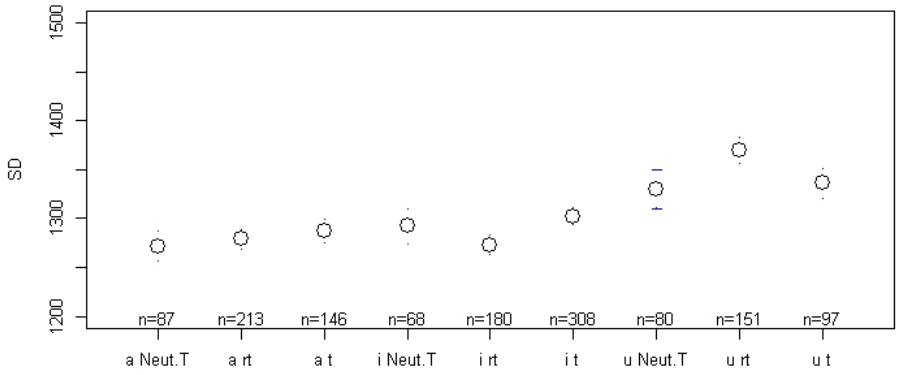


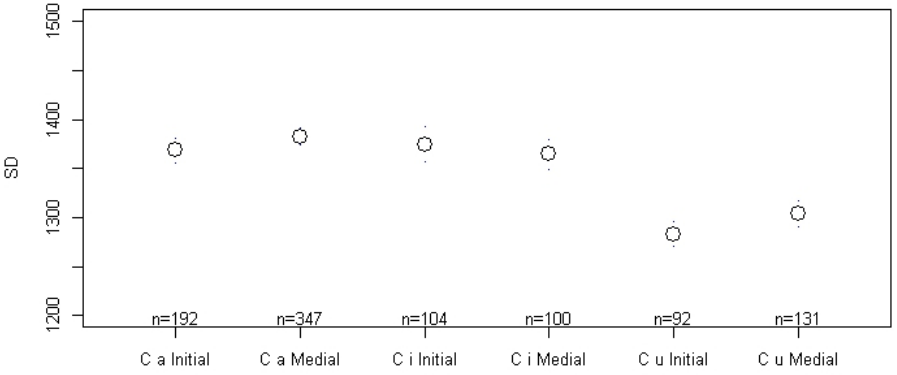


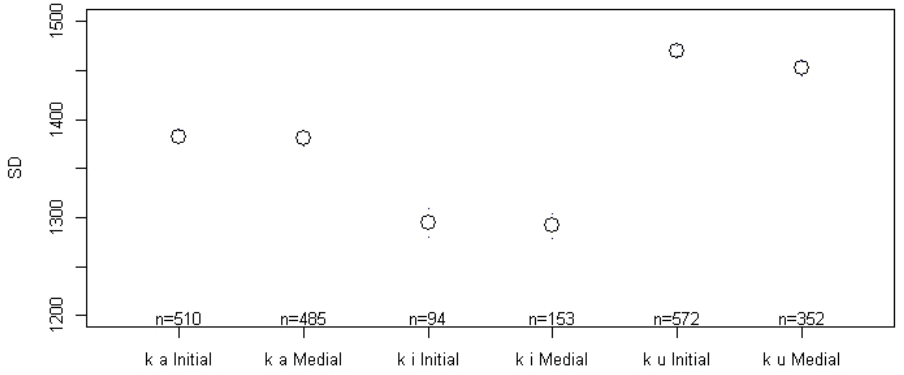


Centre of Gravity

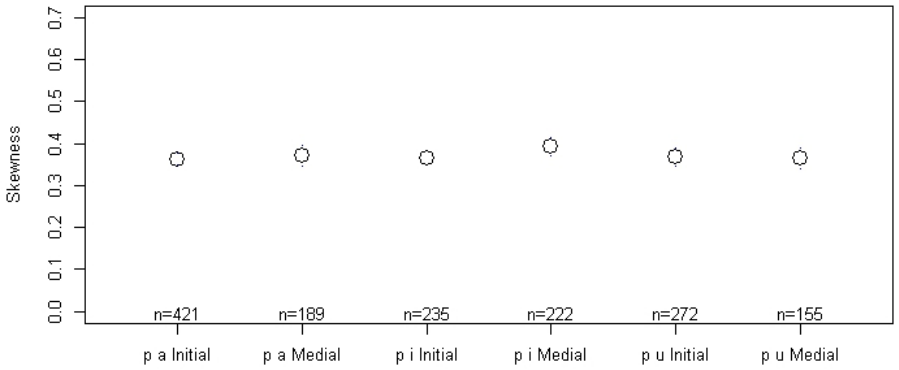


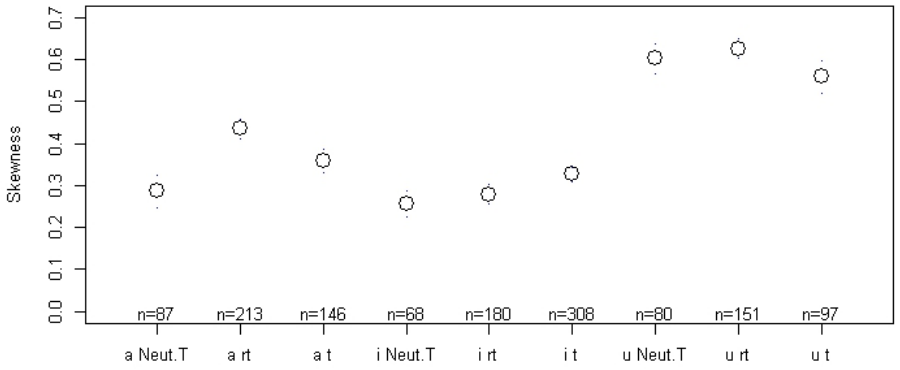


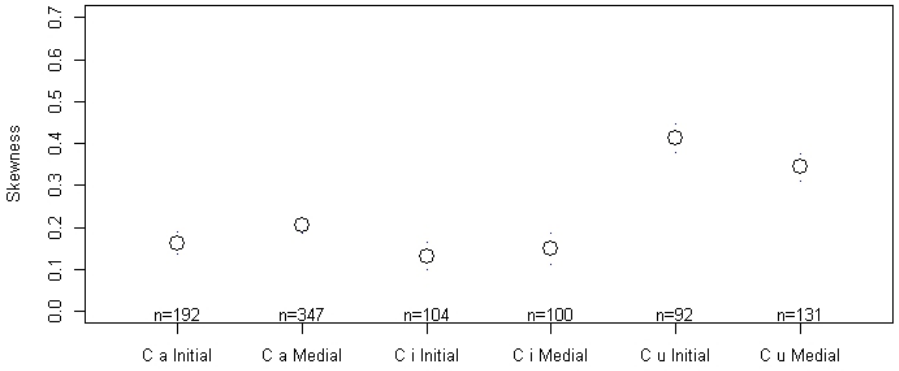


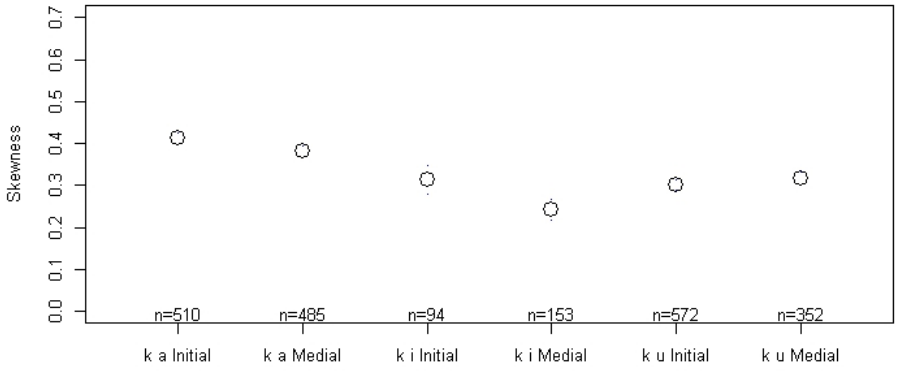


Standard Deviation

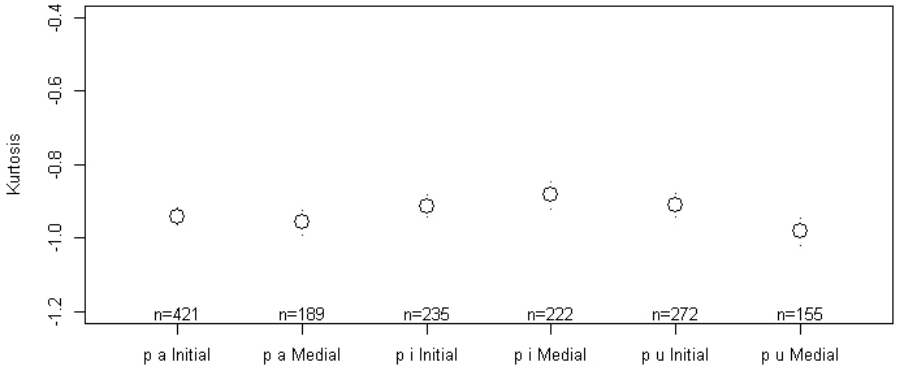

Skewness
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
n=421 n=189 n=235 n=222 n=272 n=155
p a Initial
p a Medial
p i Initial
p i Medial
p u Initial
p u Medial

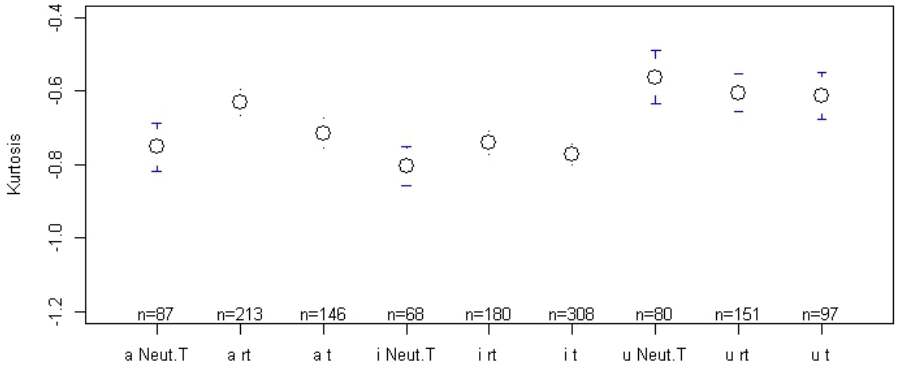

Skewness
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
n=87 n=213 n=146 n=68 n=180 n=308 n=80 n=151 n=97
a Neut.T
a rt
a t
i Neut.T
i rt
i t
u Neut.T
u rt
u t

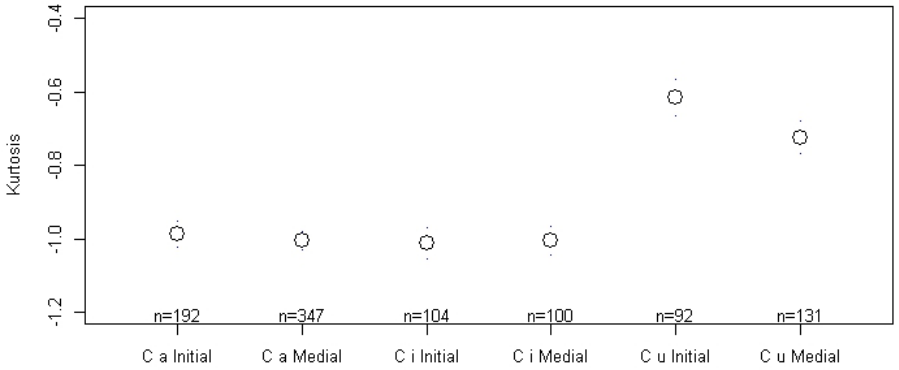

Skewness
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
n=192 n=347 n=104 n=100 n=92 n=131
C a Initial
C a Medial
C i Initial
C i Medial
C u Initial
C u Medial

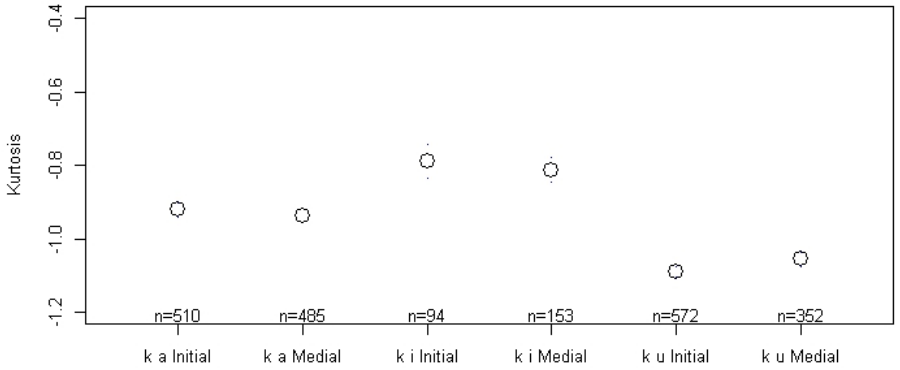

Skewness
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7
n=510 n=485 n=94 n=153 n=572 n=352
k a Initial
k a Medial
k i Initial
k i Medial
k u Initial
k u Medial

Skewness


Kurtosis
-0.4
-0.6
-0.8
-1.0
-1.2
n=421
n=189
n=235
n=222
n=272
n=155
p a Initial
p a Medial
p i Initial
p i Medial
p u Initial
p u Medial

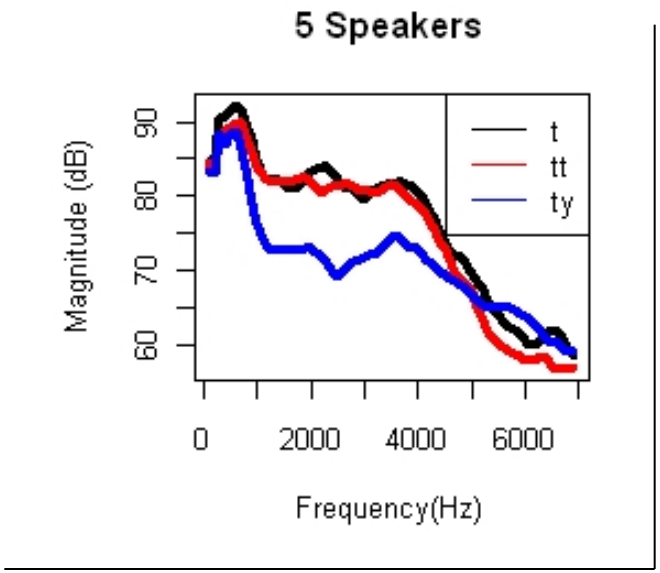

Kurtosis
-0.4
-0.6
-0.8
-1.0
-1.2
n=87
n=213
n=146
n=68
n=180
n=308
n=80
n=151
n=97
a Neut.T
a rt
a t
i Neut.T
i rt
i t
u Neut.T
u rt
u t

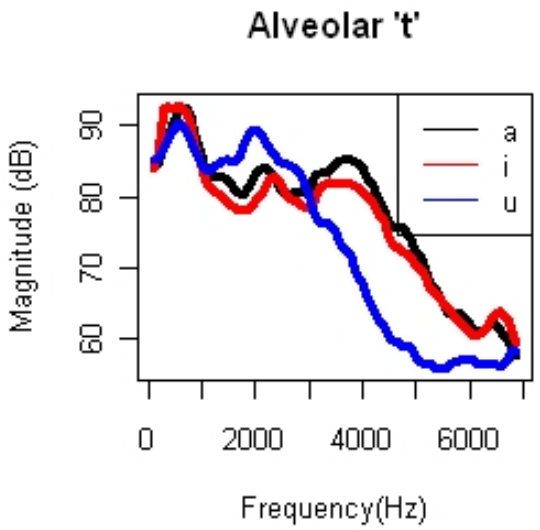

Kurtosis
-0.4
-0.6
-0.8
-1.0
-1.2
n=192
n=347
n=104
n=100
n=92
n=131
C a Initial
C a Medial
C i Initial
C i Medial
C u Initial
C u Medial

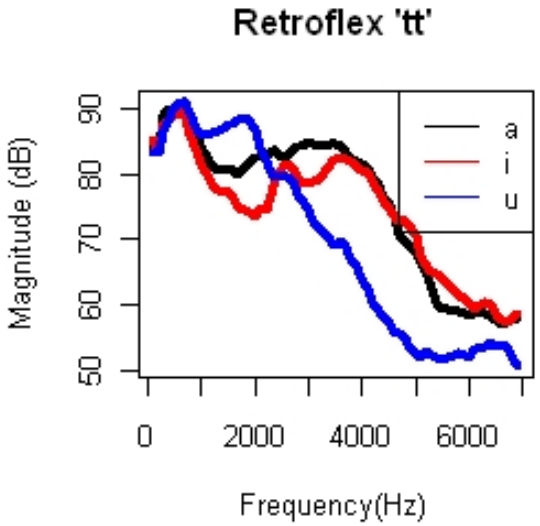

Kurtosis
-0.4
-0.6
-0.8
-1.0
-1.2
n=510
n=485
n=94
n=153
n=572
n=352
k a Initial
k a Medial
k i Initial
k i Medial
k u Initial
k u Medial

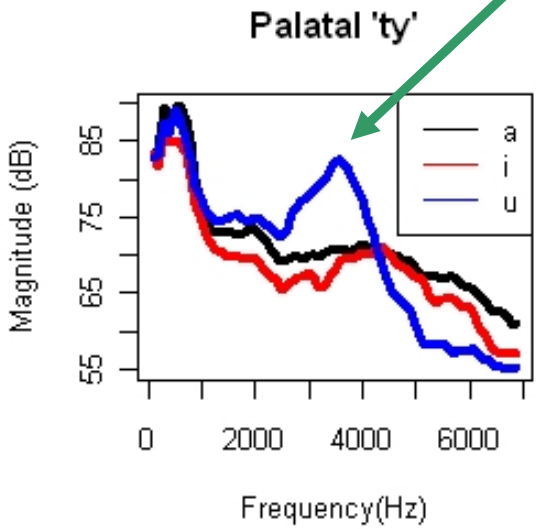
Kurtosis

Spectra from 5 speakers only…

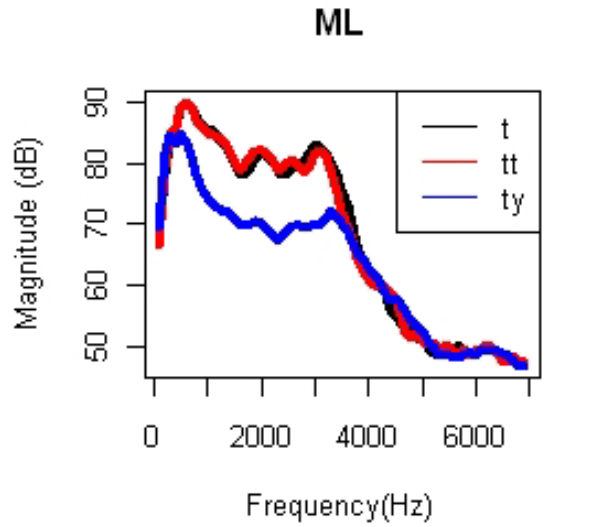


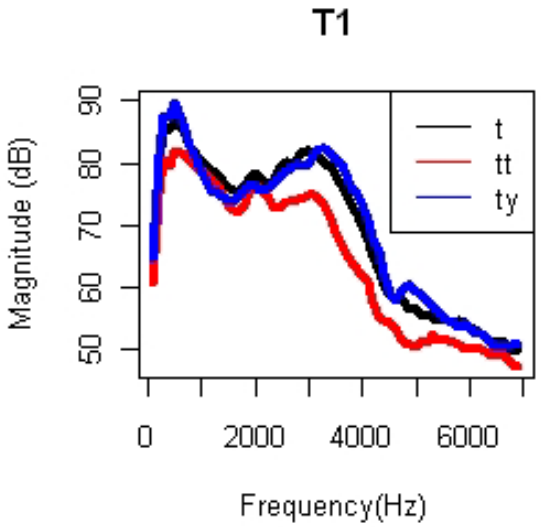


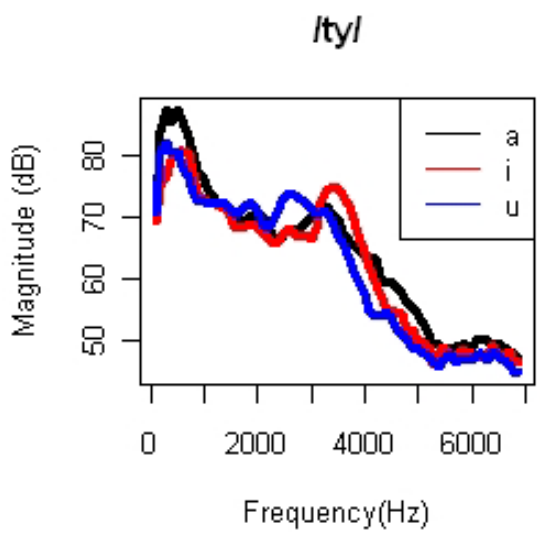


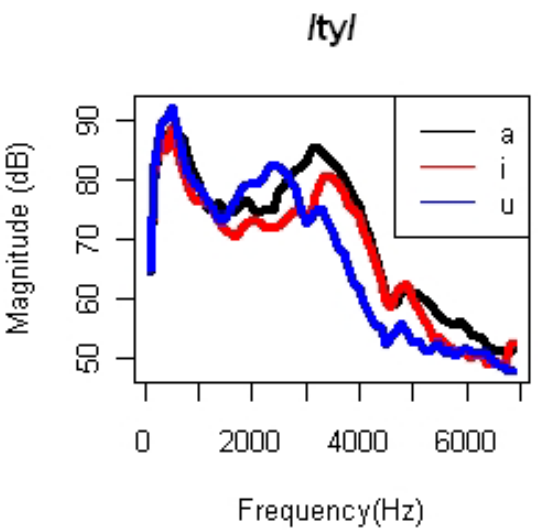


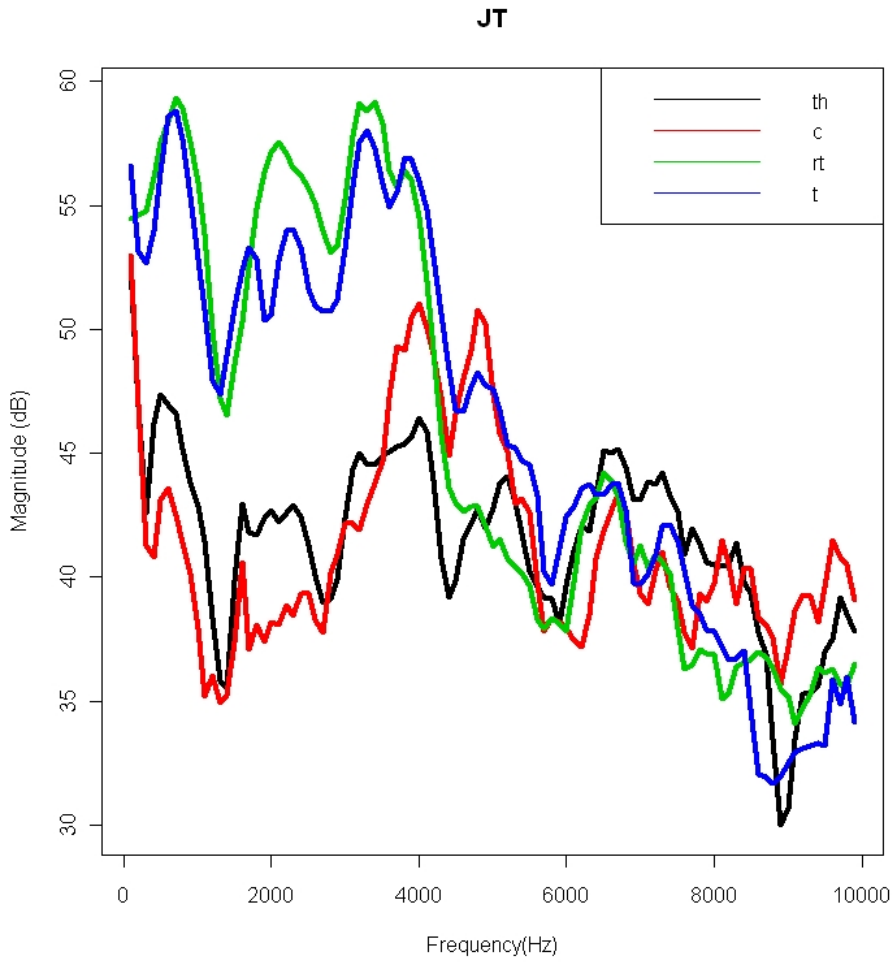
Spectra from the other two speakers…

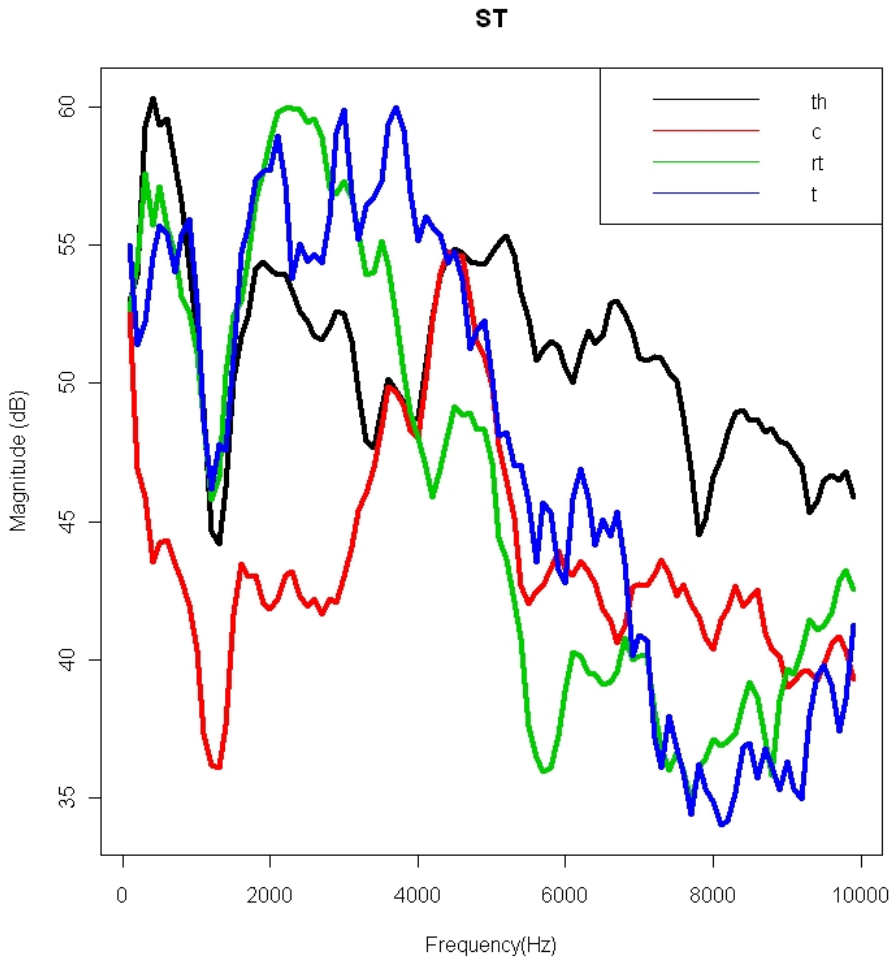




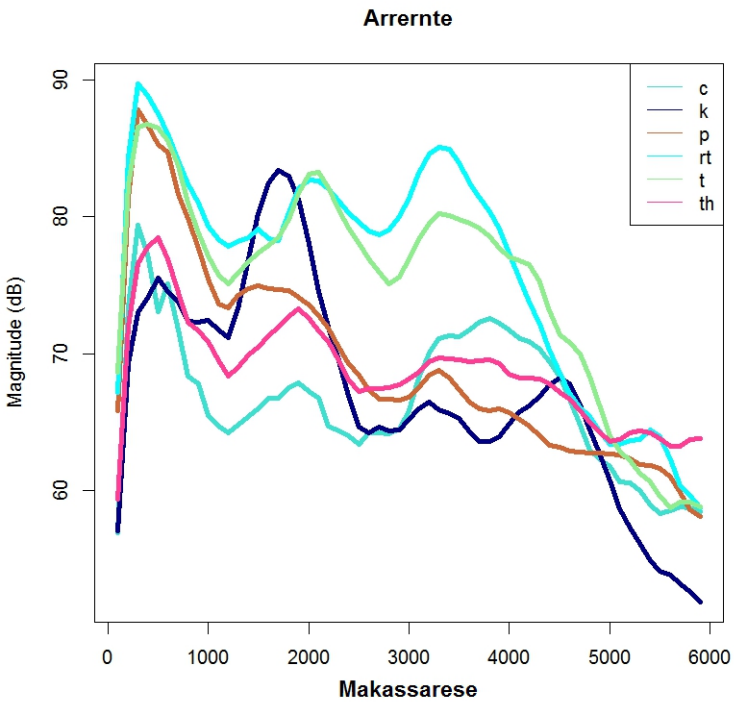


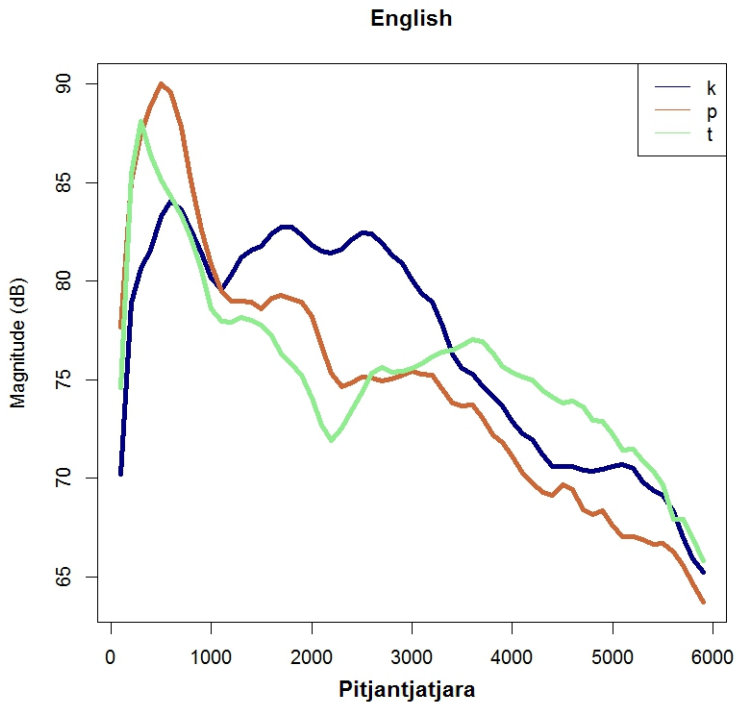


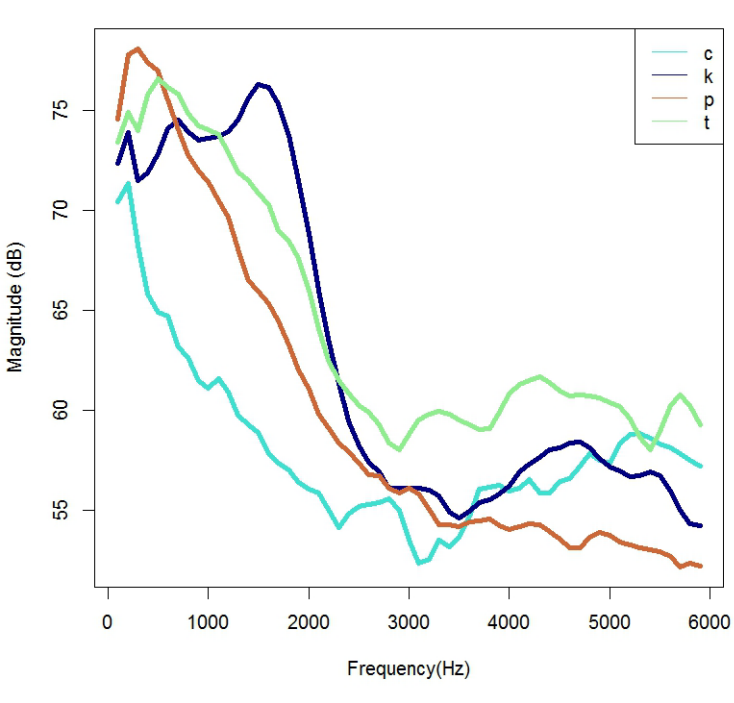


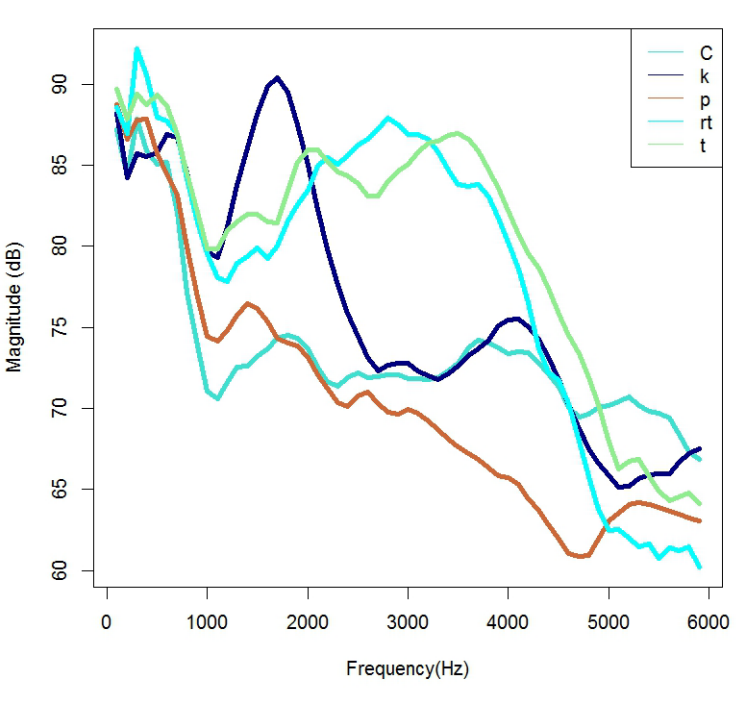


Coronal Stop Spectra for two female speakers of Arrernte


Arrernte
Magnitude (dB)
90
80
70
60
0
1000
2000
3000
4000
5000
6000
c
k
p
rt
t
th


English
Magnitude (dB)
90
85
80
75
70
65
0
1000
2000
3000
4000
5000
6000
k
p
t


Makassarese
Magnitude (dB)
75
70
65
60
55
0
1000
2000
3000
4000
5000
6000
Frequency(Hz)
c
k
p
t


Pitjantjatjara
Magnitude (dB)
90
85
80
75
70
65
60
0
1000
2000
3000
4000
5000
6000
Frequency(Hz)
C
k
p
rt
t