Lexical Stress in Singing: a pilot study

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Introduction

Observation of linguistic and acoustic aspects of singing is proposed in order to understand its relation to speech production. The focus of this work are syllable length differences and vowel formant patterns in singing.

Background

• Massini-Cagliari (1992): lexical stressed syllables in Brazilian Portuguese are longer than the others in the same word;
• Kelso (1995): The problem of pattern complexity*;*
•Articulatory Phonology: speech as a dynamic phenomenon:, i.e., occurring in space (the vocal tract) and time.

Purpose

• This study purpose is to observe the realization of stressed, pre-stressed , pos-stressed syllables in singing compared to speech.
• Syllable length and F1, F2 of three extreme vowels were measured.

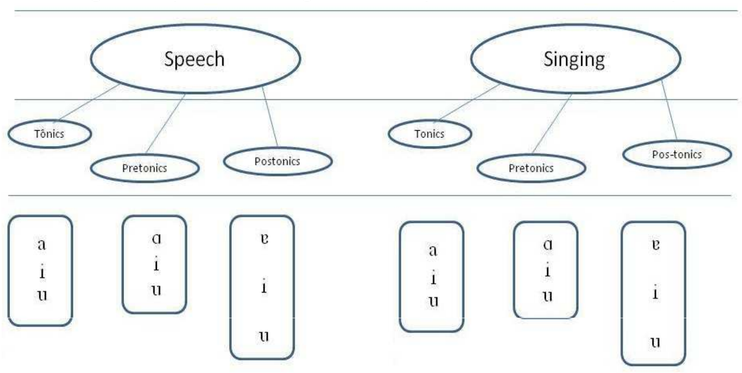
Questions

• Does syllable length in a song follow the musical structure (half notes, quarter notes, eighth notes) or does it follow the linguistic structure (stressed and unstressed syllables)?
• Based on *The problem of pattern complexity* (Kelso, 1995): to this study, we ask “how is the vocal tract set to sing?”

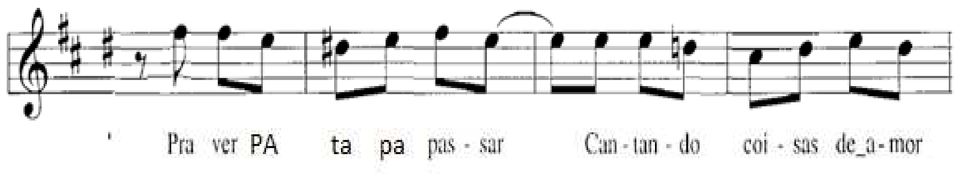
Methodology

• A pilot study with 1 male professional singer;
• Recordings done in sound attenuated booth with Shure head-mounted microphones.
• A Factorial experiment with two factors is proposed, each one with three levels:

Figure 1. Experimental design for the complete data collection and analyses.



• Third and fourth verses of the song *A Banda* (The marching band), by Chico Buarque, with some non-sense words:



The table shows the non-sense words:

Table 1: non-sense words used in this pilot study.

Stressed	Pos-stressed	Pre-stressed
/'pa.tɐ/	/'pa.tɐ/	/pa.'ta.pɐ/
/'pi.tɐ/	/'pa.tɪ/	/pi.'ta.pɐ/
/'pu.tɐ/	/'pa.tʊ/	/pu.'ta.pɐ/

Hypotheses

• Syllable length: syllable length in singing is influenced by both the music and the language.
• Resonances: the resonances rather than the durations characterizes vowels in singing.

Results

The table below shows the ratio between the syllable length and the sentence length:

Table 2: Mean (in milliseconds) duration of stressed and non-stressed syllables. Percentage refers to the measured syllable length in relation to sentence length

	Singing			Speech		
	SyllableDur (ms)	SentenceDur (ms)	%	SyllableDur (ms)	SentenceDur (ms)	%
Stressed	238	1694	14	208	1334	16
PreStressed	191	1805	11	156	1424	11
PosStressed	202	1811	11	130	1368	10

The means of F1 and F2 below can be compared horizontally and vertically:

Table 3: Mean (in hertz) of F1 and F2 and a comparison of F1 in speech and singing, as F2.

		Speech		Singing		Comparison between singing and speech	
		F1	F2	F1	F2	F1	F2
Stressed	a	714	1254	656	1283	v	^
	i	278	2074	318	2139	^	^
	u	254	682	308	669	^	=
Pre-stressed	a	725	1311	624	1294	v	=
	i	243	1896	327	2030	^	^
	u	265	796	305	756	^	v
Pos-Stressed	ɐ	616	1208	574	1292	v	^
	ɪ	-	-	-	-	-	-
	ʊ	351	837	350	817	=	v

The /i/ could not be measured due to the presence of the palatalization with /t/; and F1 and F2 values of /u/ were manually obtained via LPC.

Figure 3: Spectrogram of /pa/ of /ˈpa.tɐ/ in speech.

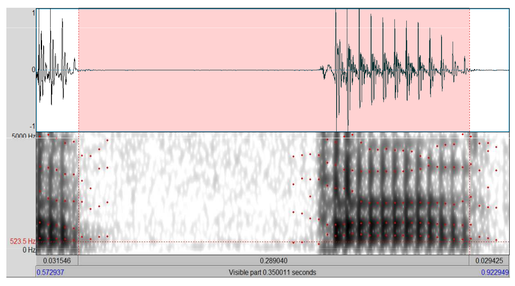


Figure 4: Spectrogram of /pa/ of /ˈpa.tɐ/ in singing.

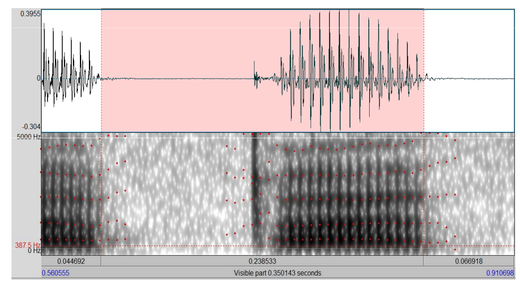


Figure 5: Spectrogram of /ta/ of /ˈpa.tɐ/ in speech.

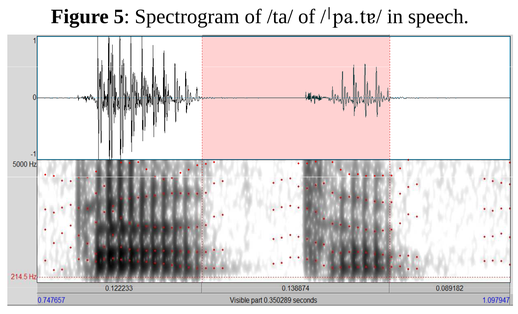
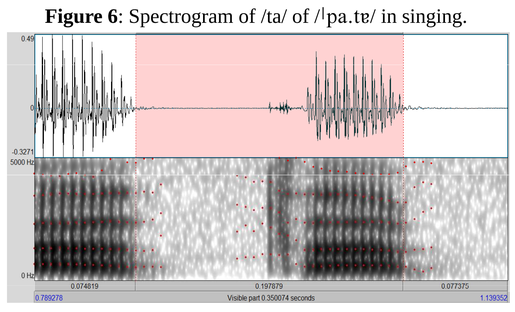


Figure 6: Spectrogram of /ta/ of /ˈpa.tɐ/ in singing.



Discussion

Comparing singing to speech, the mean of F1 in /a/, /ɑ/ and /ɐ/ have decreased; while the means of the another vowels have risen or were similar to the speech. These results may indicate more restrained movements in singing than in speech.

Future steps

• To submit found differences to further analysis: can we say that the relation between syllable duration and resonances is narrower in singing than in speech?
• To consider using a metronome.

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