Rui Rothe-Neves

Phonetics

FALE-UFMG, Brazil

Some Facts about Brazilian Portuguese Nasal Vowels

Nasal vowels in BP – a few examples

minto 'I lie' [mĩ:tʊ] [mĩⁿtʊ]   *mito* 'mith' [mitʊ]

cadente 'falling' [kadẽ:tʃɪ] [kadẽⁿtʃɪ] *cadete* * [kadetʃɪ]

canta 's/he sings' [ka:tɐ] [kaⁿtɐ]   *cata* 's/he picks' [katɐ]

bomba 'bomb' [bõ:bɐ] [bõᵐbɐ]   *boba* 'silly' [bobɐ]

mundo 'world' [mũ:dʊ] [mũⁿdʊ]   *mudo* 'dumb' [mũdʊ]

cama 'bed' [kɐ̃mɐ]; *cama*+inha 'little bed' [kɐ̃'mĩɲɐ]

caminha 'walk!' [kɐ̃'mĩɲɐ] ~ [ka'mĩɲɐ]

punhado 'handful' [pũ'ɲadʊ], ?[pu'ɲadʊ]

calma+*mente* 'easily' *[kawmɐ̃'mẽtʃɪ]

Contrastive nasalization – Interpreting the facts

Câmara Jr. (1970) proposed that there are no NV in BP, they emerge from a (phonetically unrealized) nasal archiphoneme

Subsequent generative approaches have offered different interpretations on why this is so

Comprehensive reviews in Bisol (1998); Wetzels (1997); D'Angelis (2002)

The status of NV as not underlyingly represented is not much in dispute

(1) $v \Rightarrow \tilde{v}$ / _N

   $N \Rightarrow \emptyset$ / $\tilde{v}$_

   $\emptyset \Rightarrow N$ / $\tilde{v}$_C

(2) /kaNta/ /kaNta/ /kaNta/
    | | | | | | |/+| | |/| |
    [kaNtɐ]   [kãNtɐ] [kã tɐ]
         \|
    [+nas]

If (2), then ṽ longer than V

Conclusion (!):

Compensatory lengthening

Pitfalls:

1. Sample size

2. "Mediu-se a duração do segmento vocálico, do apêndice consonântico (nasal), quanto existente (duração essa que foi computada juntamente com a do segmento vocálico), e da consoante subseqüente." (p.159)

3. ṽ + C ≈ V + C

|	M & W (1992) – Duration of [a] (ms)		
	Tauto N	Hetero N	Oral
I	208	132	146
II	189	156	166
M	198	144	156

- Dellatre (1954, also Dellatre & Monnot, 1981):

  - Transition => C

  - Formants => V

  - No formants (appendix) => N

- "The articulatory feature of velopharyngeal opening accompanied by oral cavity obstruction is linked to an acoustic feature of a nasal murmur. The murmur is the acoustic segment associated with an exclusively nasal radiation of sound energy." (Kent & Read, p.130)

- This choice is not trivial: if you measure different things, you will probably end up with different results

N=15 male subjs.
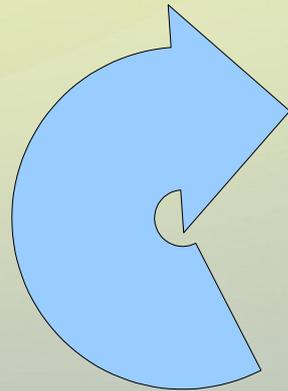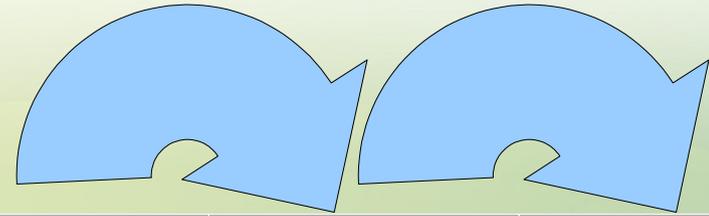
|	Oral	Tauto N	Hetero N
a	CATA	CANTA	CANA
i	PITO	PINTO	PINO
u	LUTO	UNTO	UNO
a	CAÇA	CANSA	
i	PIÇO	PINÇO	/_s
u	SÚCIA	NÚNCIO	

File View Corpus Help

Arial   30   ☑ Random   1/60

Diga unto para ela.

Ready   NUM

Iniciar   corpus - CorpusViewer   PT   22:54

Vogal

T0 T1   T2 T3

Vocábulo: Pinto
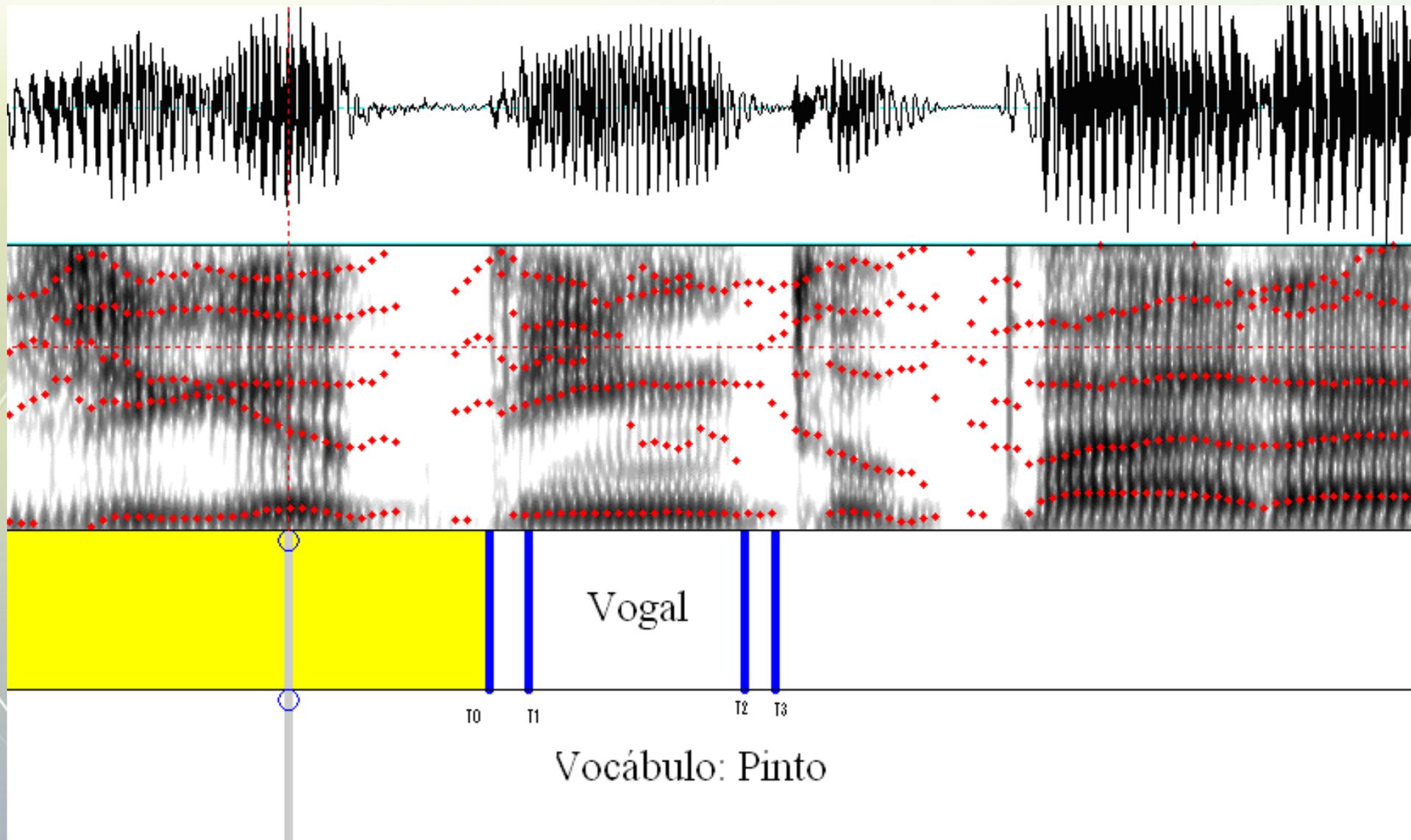
Difficult cases (e.g. Hyperspeech) discussed until consensus was reached

[pĩsʊ]

Visible part 0.476515 seconds

2.089207   2.565722

[pĩsʊ]
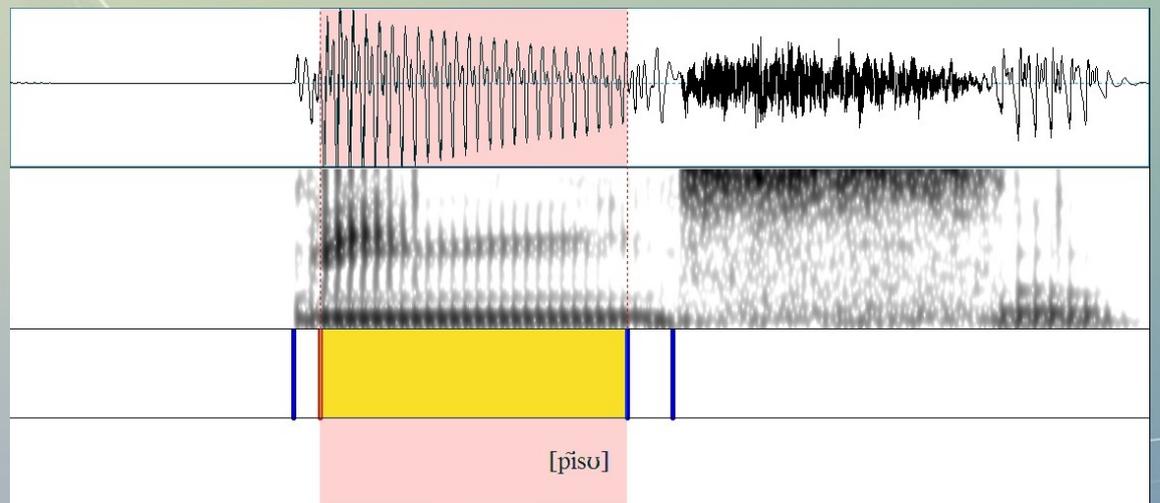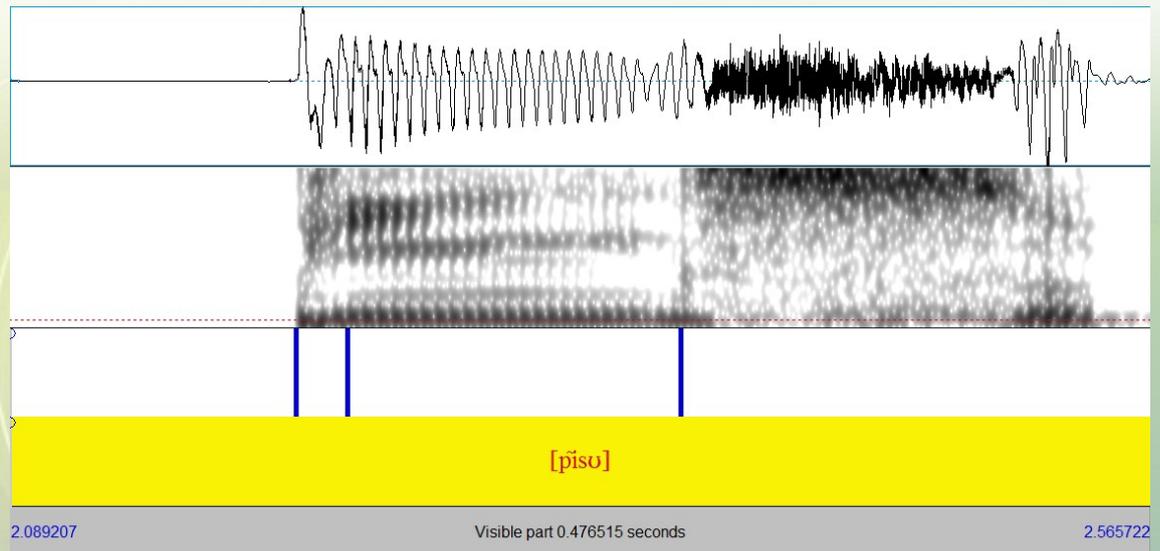
	Cata	Cana	Canta	Pito	Pino	Pinto	Luto	Uno	Unto
S1	2	3	3	2	3	3	3	3	3
S10	3	3	3	3	3	2	3	3	3
S11	3	3	3	3	3	3	3	2	3
S12	3	3	3	3	3	3	3	3	3
S13	3	3	3	3	3	3	3	3	3
S14	3	3	3	3	3	3	3	3	3
S15	3	3	3	3	3	2	3	3	2
S2	3	3	3	2	3	3	3	3	3
S3	3	3	3	3	3	3	3	3	3
S4	3	3	3	3	3	3	3	3	3
S5	3	3	3	3	3	2	3	3	3
S6	3	3	3	3	3	3	3	3	3
S7	3	3	3	3	3	2	3	3	3
S8	3	3	3	3	3	3	3	3	3
S9	3	3	3	3	3	3	3	2	3
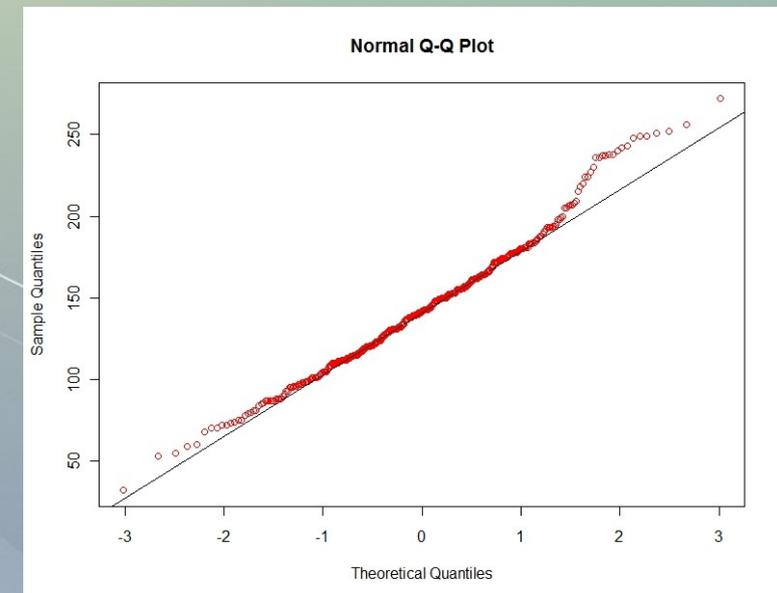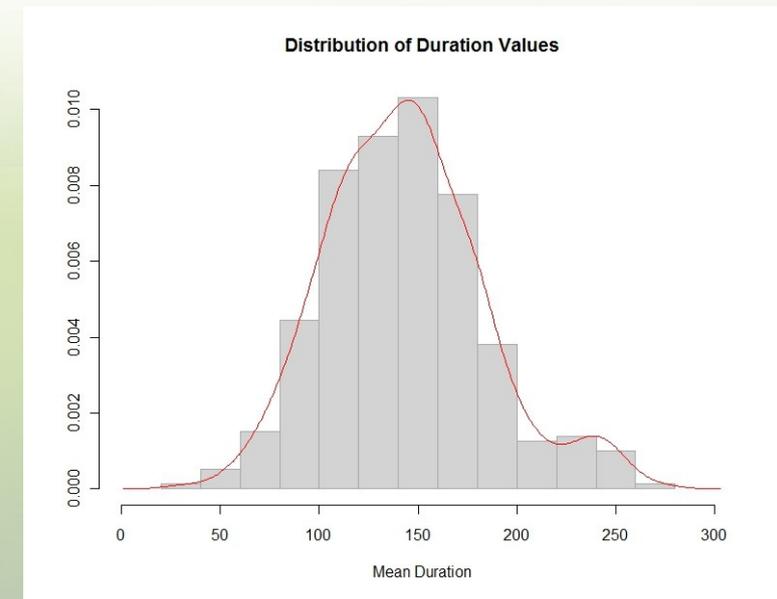
(n=393)	Control	Hetero N	Tauto N
a	44	44	45
i	42	45	41
u	45	43	44

Distribution of Duration Values

Normal Q-Q Plot

Mean duration as a function of context
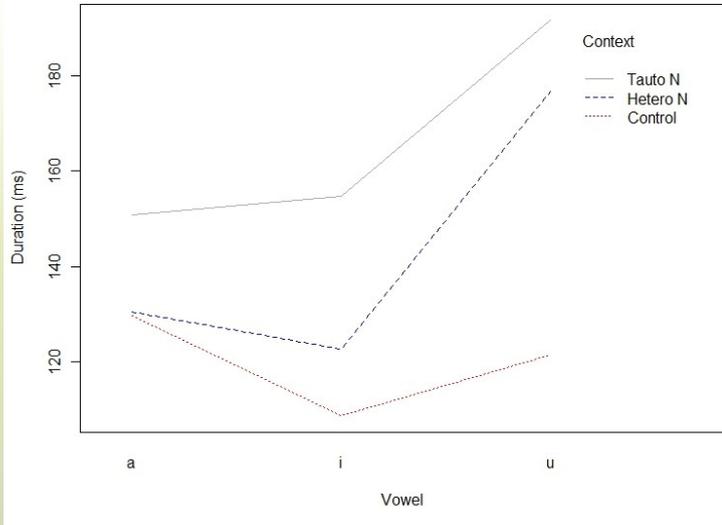
	a	i	u
Tauto N	151±30	155±28	191±32
Hetero N	130±30	123±30	177±34
Control	129±26	109±21	121±30

Subject Variation in a linguistically Neutral Model (r²=.35)

Vowel Duration predicted by the best model (r²=.81)

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Linear mixed model fit by REML
Formula: Duration ~ Context * Vowel + (1 + Context | Subj)
   Data: nasal
  AIC  BIC logLik deviance REMLdev
 3483 3547  -1726     3492    3451
Random effects:
 Groups   Name            Variance Std.Dev. Corr
 Subj     (Intercept)     555.25   23.564
          ContextHetero N 100.72   10.036   0.015
          ContextTauto N  161.21   12.697   0.016 0.105
 Residual                 345.17   18.579
Number of obs: 393, groups: Subj, 15

Fixed effects:
                         Estimate Std. Error t value
(Intercept)             130.2741      6.6989  19.447
ContextHetero N           0.7218      4.7365   0.152
ContextTauto N           20.8814      5.1260   4.074
Voweli                  -20.9813      4.0112  -5.231
Vowelu                   -8.4741      3.9407  -2.150
ContextHetero N:Voweli   14.1854      5.6231   2.523
ContextTauto N:Voweli    24.6194      5.6778   4.336
ContextHetero N:Vowelu   53.9229      5.6081   9.615
ContextTauto N:Vowelu    49.2487      5.5734   8.836
```

```
Data: nasal
Models:
neutro: Duration ~ (1 | Subj)
d11: Duration ~ Context * Vowel + (1 + Context | Subj)
        Df  AIC    BIC   logLik  Chisq Chi Df Pr(>Chisq)
neutro   3 3905 3916.9 -1949.5
d11     16 3524 3587.6 -1746.0 406.95     13  < 2.2e-16 ***
```

Before [t] — Duration (ms) vs Vowel (a, i, u); Context: Tauto N (solid), Control (dashed)

Before [s] — Duration (ms) vs Vowel (a, i, u); Context: Tauto N (solid), Control (dashed)
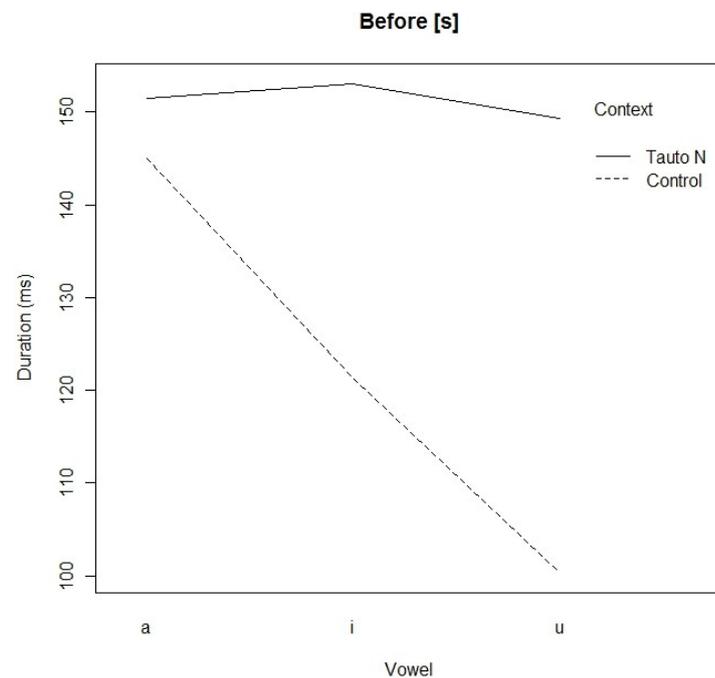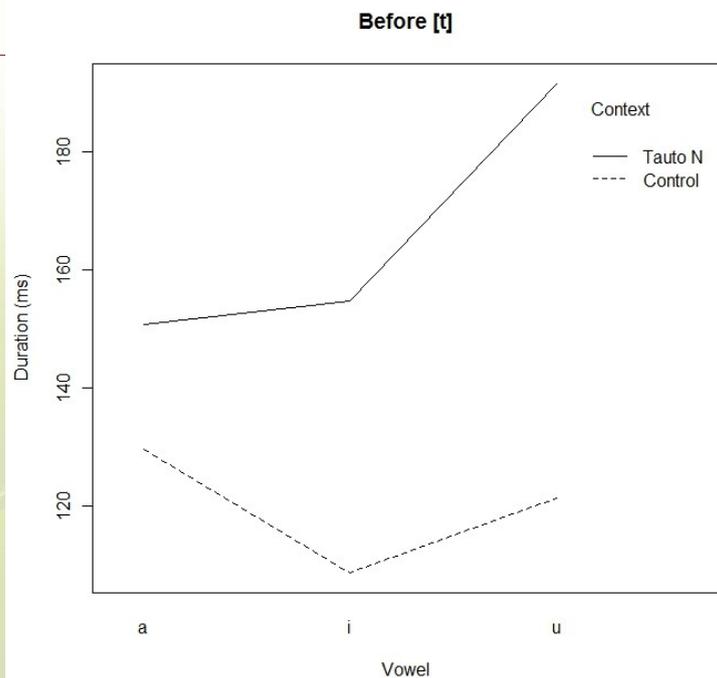
/_t	a	i	u	/_s	a	i	u
Control	129±36	109±21	121±30	Control	145±28	121±30	100±21
Tauto N	151±30	155±28	191±32	Tauto N	151±32	153±24	149±26

```
Models:
(1) Duration ~ Context * Vowel * ClassSubsC + (1+Context|Subj)
(2) Duration ~ Context * Vowel + Vowel * ClassSubsC + (1+Context|Subj)
        Df    AIC     BIC   logLik  Chisq Chi Df Pr(>Chisq)
(2)     13 4554.0 4609.2 -2264.0
(1)     16 4531.7 4599.6 -2249.8 28.274     3  3.182e-06 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Model	R^2
1)	.7934
2)	.7806

```
                            Correlation tests
                            Call:r.test(n = 393, r12 = 0.7934, r34 = 0.7806, twotailed = T)
                            Test of difference between two independent correlations
                             z value 0.47    with probability  0.64>
```

Analysis of Variance Table

	Df	Sum Sq	Mean Sq	F value
Context	1	63310	63310	199.7180
Vowel	2	7624	3812	12.0248
ClassSubsC	1	5741	5741	18.1101
Context:Vowel	2	45729	22864	72.1280
Context:ClassSubsC	1	8478	8478	26.7442
Vowel:ClassSubsC	2	42672	21336	67.3068
Context:Vowel:ClassSubsC	2	332	166	0.5234

Linear mixed model fit by REML
Model: Duration ~ Context * Vowel * ClassSubsC + (1+Context|Subj)

AIC	BIC	logLik	deviance	REMLdev
4481	4549	-2224	4500	4449

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
Subj	(Intercept)	494.636	22.240	
	ContextTauto N	69.438	8.333	0.263
Residual		316.997	17.804	

Number of obs: 516, groups: Subj, 15

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	130.283	6.339	20.551
ContextTauto N	20.873	4.346	4.803
Voweli	-20.956	3.843	-5.453
Vowelu	-8.483	3.776	-2.247
ClassSubsC	14.327	3.845	3.726
ContextTauto N:Voweli	24.740	5.438	4.550
ContextTauto N:Vowelu	49.379	5.340	9.248
ContextTauto N:ClassSubsC	-13.541	5.389	-2.513
Voweli:ClassSubsC	-1.472	5.490	-0.268
Vowelu:ClassSubsC	-35.638	5.373	-6.633
ContextTauto N:Voweli:ClassSubsC	-1.278	7.767	-0.165
ContextTauto N:Vowelu:ClassSubsC	-7.281	7.586	-0.960

Vowel Duration predicted by Subject Variation (r²=.62)

78% of explained variation

Vowel Duration by Best Model

Summary
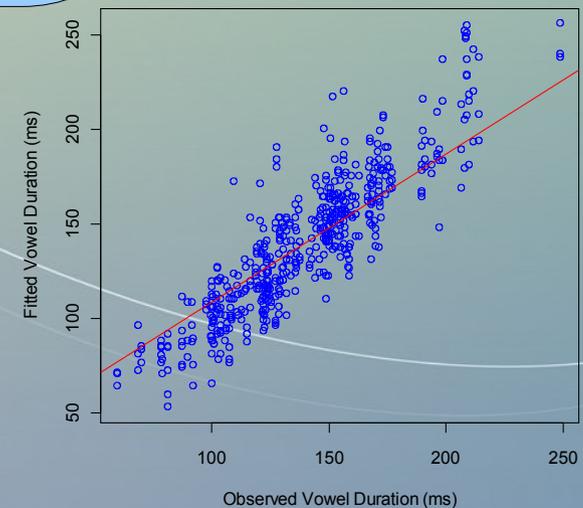
As vowel duration is a consequence of a process that happen in time, those factors could perhaps be translated into:

- N context (velum opening movement in or out of phase), and

- subsequent C (oral tract constriction), "concur" in changing

- vowel quality (oral area configuration)

The huge variation due to the subjects could be perhaps attributed to speech rate
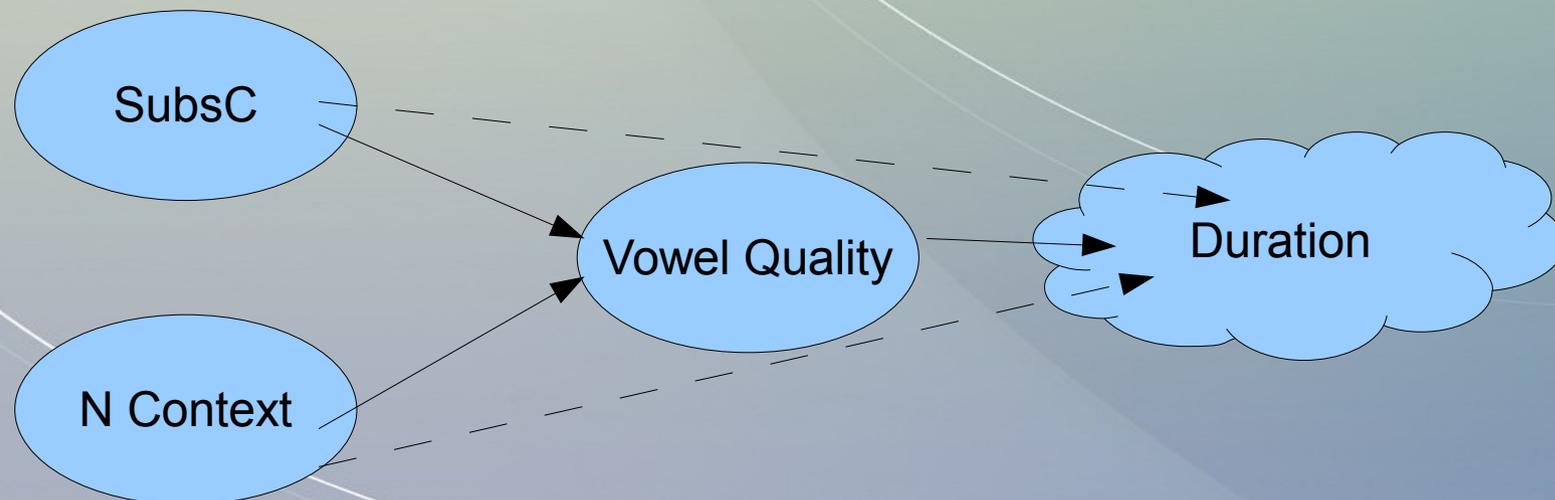
Albano (1999, p.32):

AV – velum opening

GCCL – TBCD

LCCL – TBCL

AL – Lip aperture
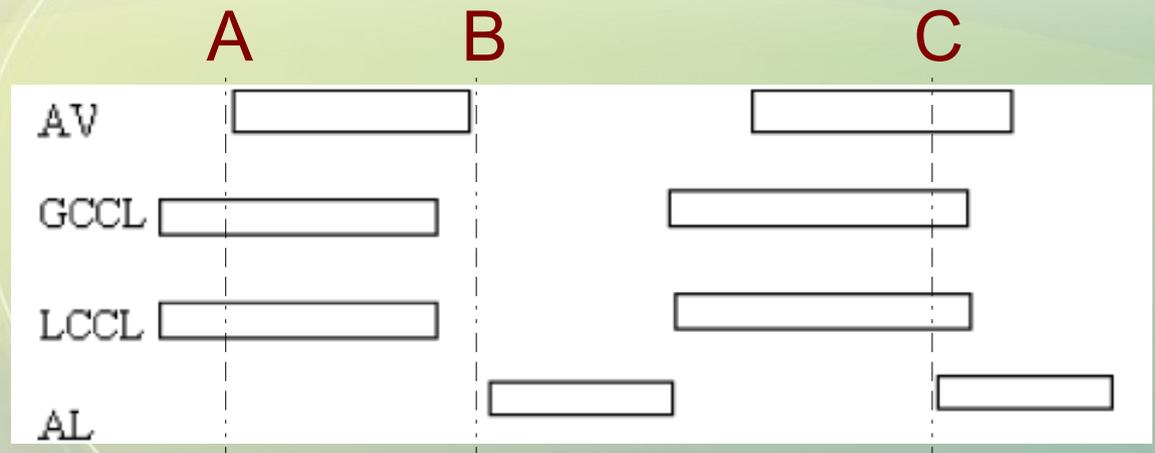
- a velum opening gesture in coda position is not aligned to the vocalic gesture

- before homorganic oral closure, the superposition of velar and consonantal gestures may be heard as a murmur

Oral and nasal airflow measures of VN
Raquel Medeiros (2009)

„Experiment" 1 – sentences from Souza (1994)

	Oral	Nasal
i	CATA	CANTA
e	CADETE	CADENTE
a	PITA	PINTA
o	BOBA	BOMBA
u	TUBA	TUMBA

„Experiment" 3 – Vowel [a] in different contexts

Context	
Oral /_t	CATA
Oral /_s	CAÇA
Nasal /_t	CANTA
Nasal /_s	CANÇA
Hetero N	CANA
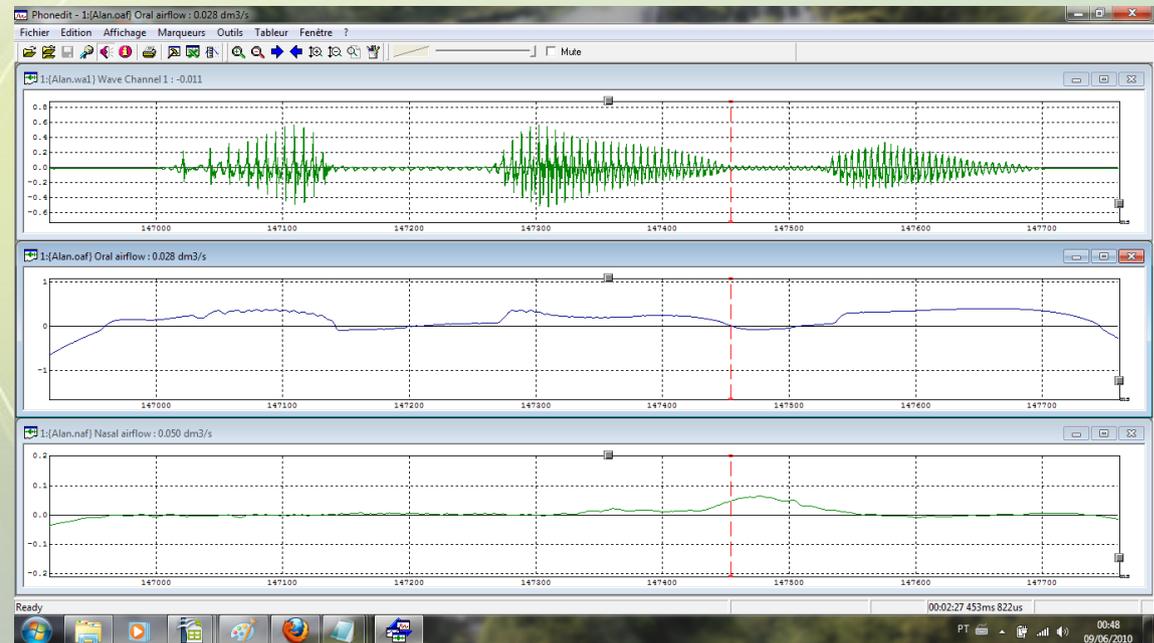
Measures: ⟶ Combined in several ways, e.g. nasal portion (%)
Oral and nasal airflow
Air volume
Vowel duration
Nasal airflow onset (5%) and peak

VN on oral and nasal airflow measures
Raquel Medeiros (2009)
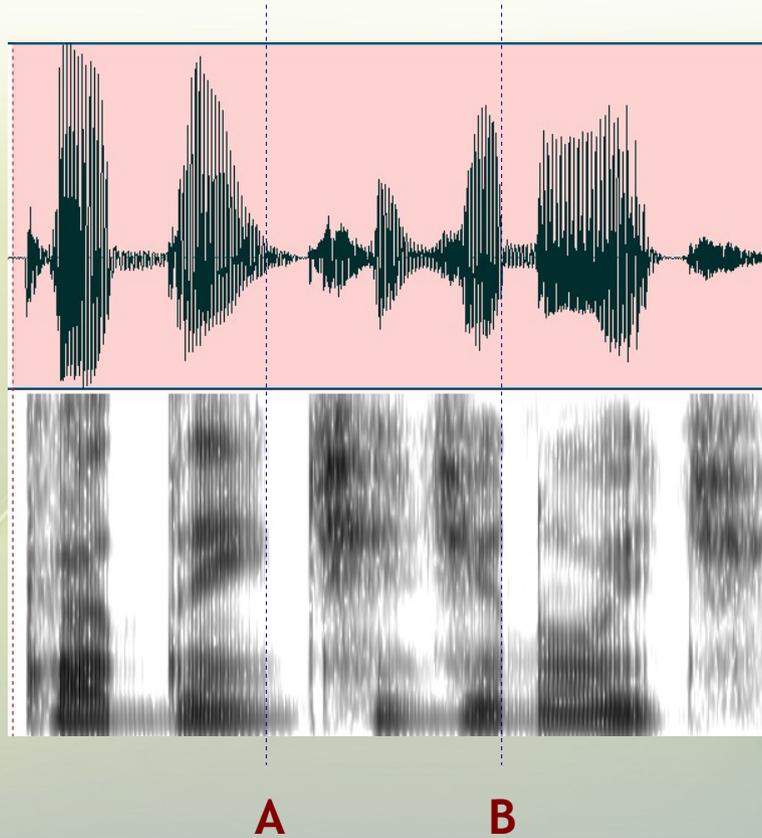
Oral closure and velum opening are either out of phase (A) or in phase (B)

Nasalância média (%)

Duração total da vogal (ms)

Duração proporcional da parte oral da vogal nasal (ms)

Duration of velum movement (onset-peak) as a function of relative vowel length

Error bars: +/- 1,00 SD; Vertical dotted line represents 100% of vowel length, or vowel end point.

Duration of velum opening (onset-peak) as a function of relative vowel length

Error bars: +/- 1,00 SD; Vertical dotted line represents 100% of vowel length, or vowel end point.
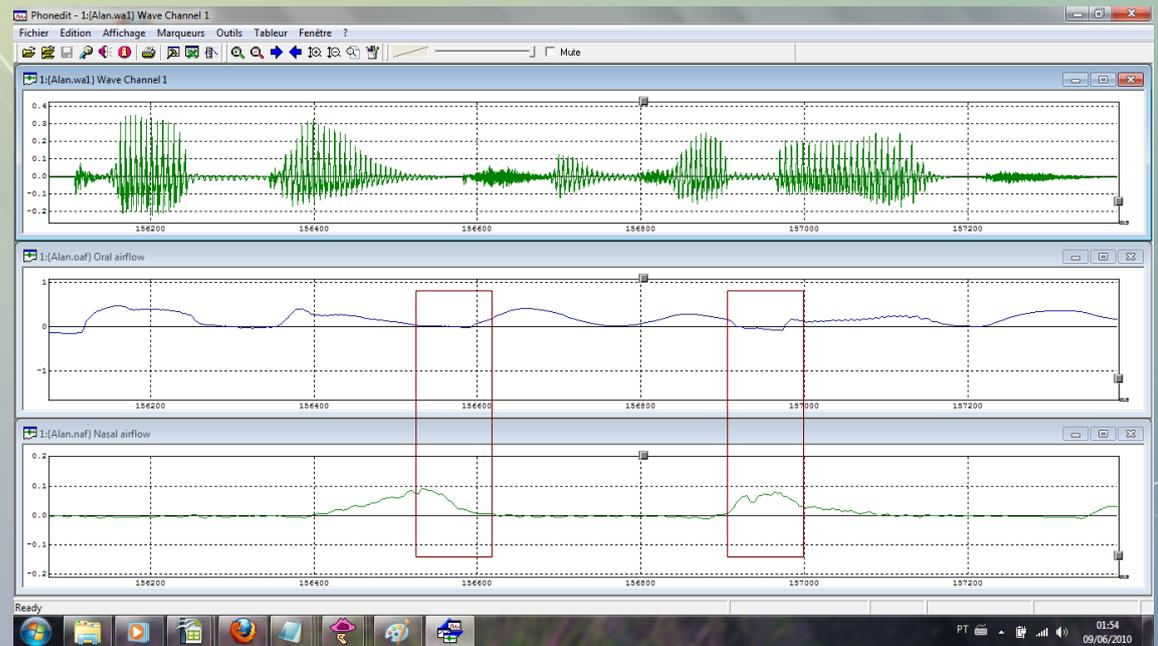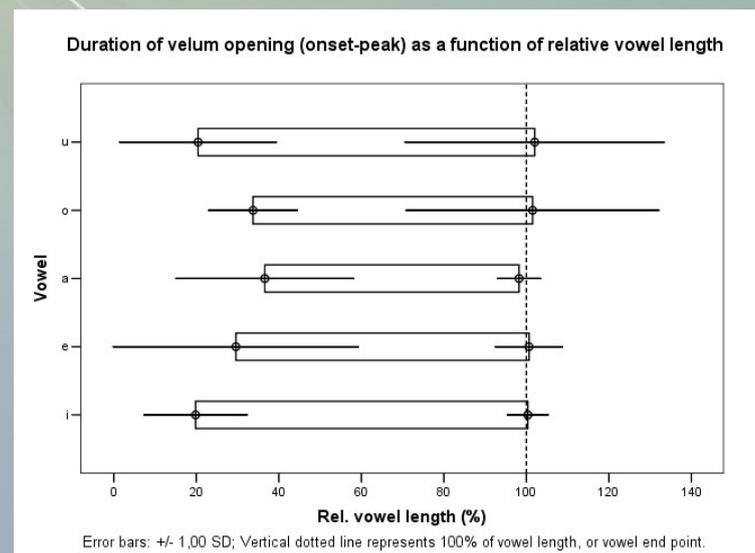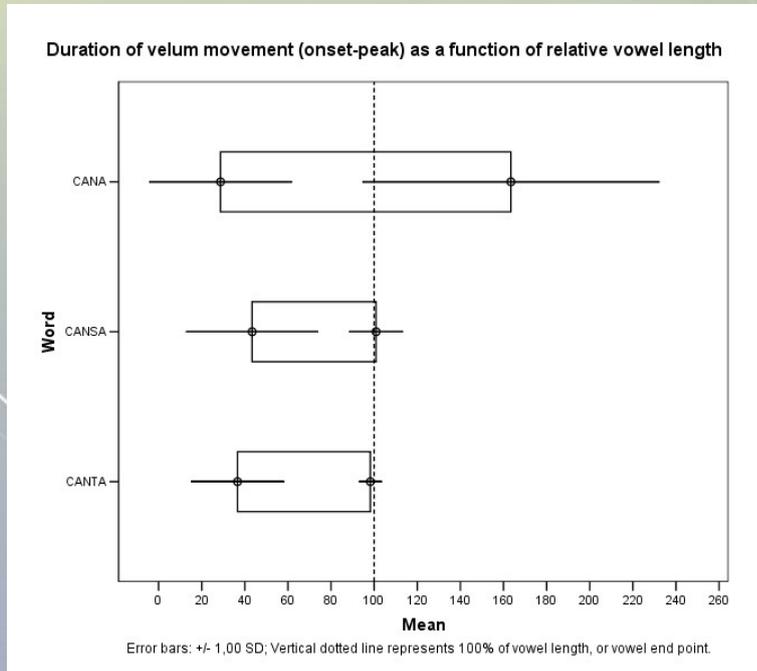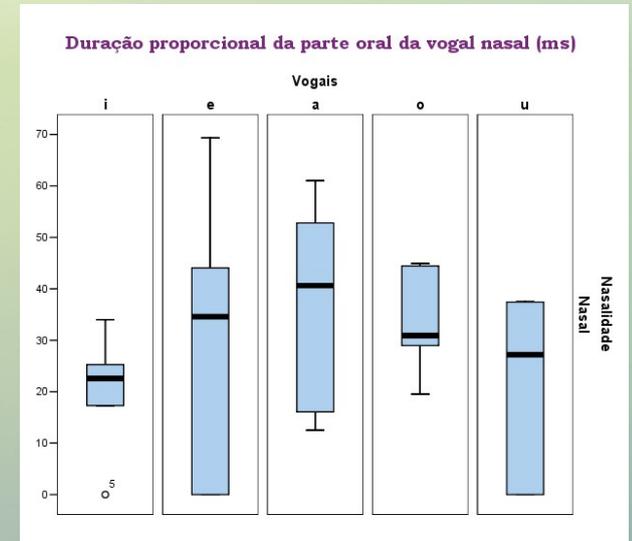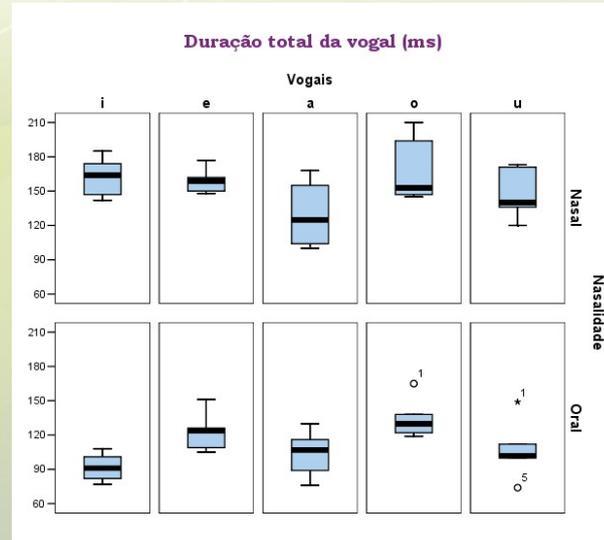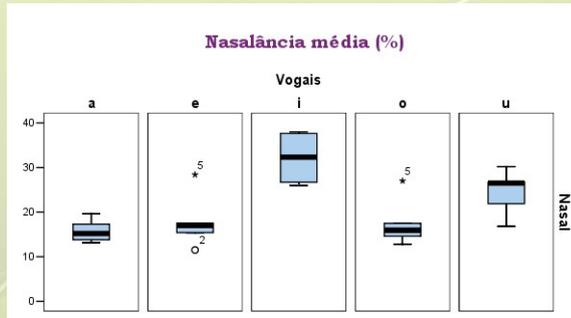
☑ Greater nasalization in tautosyllabic then in heterosyllabic sequences (Cohn, 1990; Solè, 1995)

☑ There is a relation between vowel duration and velum opening movement, as seen at VN oral portion (Beddor, ICPhS 2007)

☒ Lower vowels are more heavily nasalized (Bell-Berti, 1993)

Vowel duration is differently affected by N context, vowel quality, and subsequent C

But subsequent C and N context are mostly important through their interaction with vowel quality

- All models are wrong

- Some models are better than others

- The correct model can never be known with certainty

- The simpler the model, the better it is

  (M. J. Crawley, 2002)