

Restructuring Rhythm Patterns

Maartje Schreuder

Sound Intelligence

13 oktober 2004

M.J.Schreuder
(with Dicky Gilbers)
Department of Linguistics
P.O. Box 716
9700 AS Groningen
The Netherlands
<http://www.let.rug.nl/~schreudr>



Outline

- **Topic:** Rate adjustments: compression or restructuring?
- **Experiment:** Eliciting fast speech
Phonetic evidence?

2

Research Question

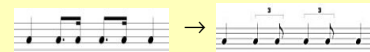
- Does a higher speaking rate lead to adjustment of the phonological structure or are we only dealing with phonetic compression?

- Phonetic compression is mainly shortening and merging of vowels and consonants with preservation of the phonological structure

normal stretched

Music: Re-/misinterpretation of rhythm in accelerated or sloppy playing

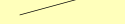
- Rhythmic restructuring:
dotted notes rhythm → triplet rhythm



120 bpm:



80 bpm:



4

Language: Re-/misinterpretation of rhythm in accelerated or sloppy speaking

Data

type 1: *stú die tòe la ge* → *stú die toe là ge*
'study grant'

Rightward Stress Shift

5

Language: Re-/misinterpretation of rhythm in accelerated or sloppy speaking

Data

type 1: *stú die tòe la ge* → *stú die toe là ge*
'study grant'

type 2: *per fèc tio níst* → *pèr fec tio níst*

Leftward Stress Shift

6

Language: Re-/misinterpretation of rhythm in accelerated or sloppy speaking

Data

- type 1: *stú die tòe la ge* → *stú die toe là ge*
'study grant'
- type 2: *per fèc tío níst* → *pèr fec tío níst*
- type 3: *zùid à fri káans* → *zùid a fri káans*
'south african'

Beat Reduction

Phonological Analysis in Optimality Theory

Analysis based on conflict between:

Output Output Correspondence:

- stúdiètòelage* ↔ *tòelage*
- perfèctionist* ↔ *perfèct*
- zùidàfrikáans* ↔ *àfrikáans*

(cf. Burzio 1998)

Clash Avoidance

rhythmic beats are not too close together

(cf. Kager 1994)

Language: Re-/misinterpretation of rhythm in accelerated or sloppy speaking

zùidàfrikáans (andante)
perfèctionist
stúdiètòelage

constraints →	O-O CORR	*ΣΣ
candidates ↓		
σ ^o (zùid) (a fri) (kaans)		*
s s w s		
(zùid a) fri (kaans)	*!	
s w w s		

zùidafrikáans (allegro)
perfèctionist
stúdiètòelage

constraints →	*ΣΣ	O-O CORR
candidates ↓		
σ ^o (zùid) (a fri) (kaans)	*!	
s s w s		
(zùid a) fri (kaans)		*
s w w s		

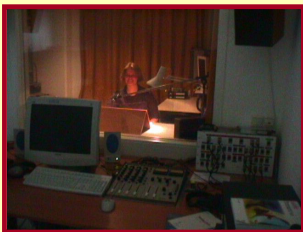
Hypothesis

There are different OT-grammars for different rates and styles of speaking

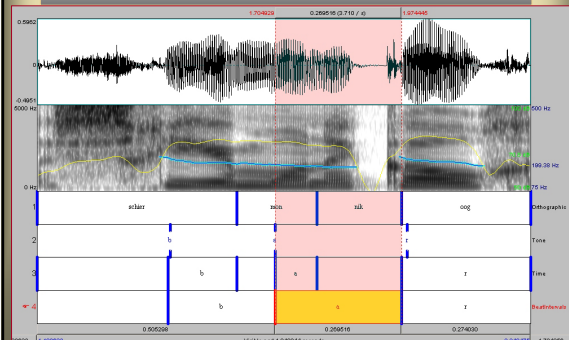
Phonetic Compression is not the sole explanation

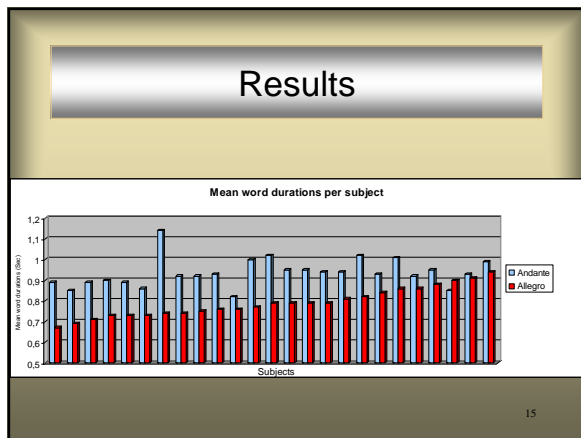
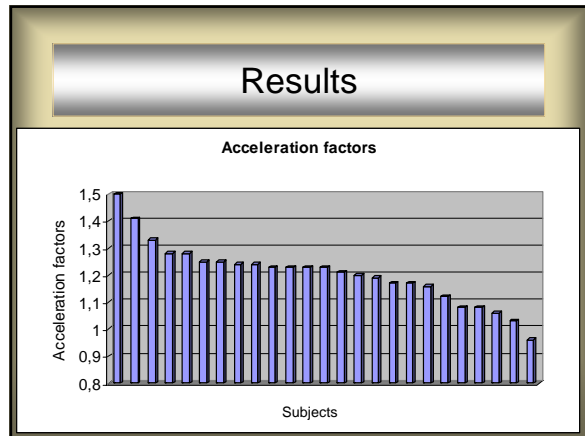
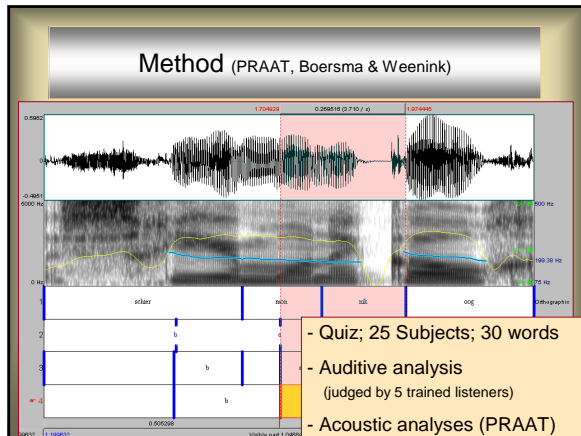
In fast speech it is more important to avoid clashes. The triplet patterns in fast Dutch speech resemble the patterns of e.g. Estonian rhythm.

Design Experiment



Method (PRAAT, Boersma & Weenink)





Results

MANOVA Tests of Between-Subjects Effects

Source	Dependent Variable	df	Mean Square	F	Sig.	Observed Power(a)
AUDITORY	total durations	1	5,908	191,454	,000	1,000
	Acceleration_Factors (round)	1	2,156	47,370	,000	1,000

Descriptive Statistics

	AUDITORY	Mean	Std. Deviation	N
total durations	0	,924	,1937	779
	1	,798	,1535	710
Total		,864	,1866	1489
Acceleration_factors (round)	0	1,07	,187	779
	1	1,14	,239	710
Total		1,10	,217	1489

Auditory Analysis

Examples: Andante Allegro

Left Shift *perfectionist*

'perfectionist'

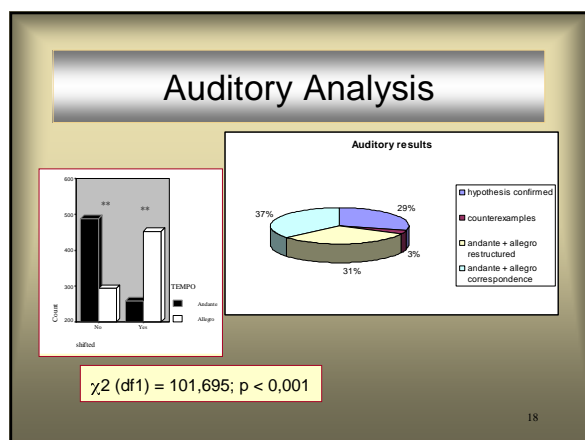
Right Shift *studietoelage*

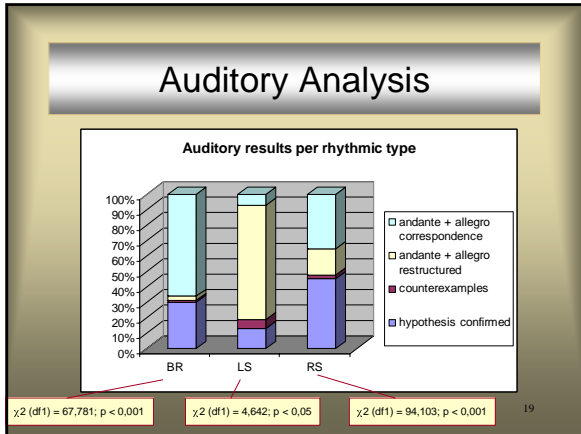
'study grant'

Beat Reduction *Zuidafrikaans*

'South African'

blue = syllable a
red = syllable b





Conclusion

Phonology:

In fast speech Mark >> Corr over Corr>>Mark is preferred, whereas it is the other way around in Andante speech

This result resembles the preferences in andante and allegro music

Phonetic Evidence?

Is there phonetic evidence for rhythmic restructuring in allegro speech?

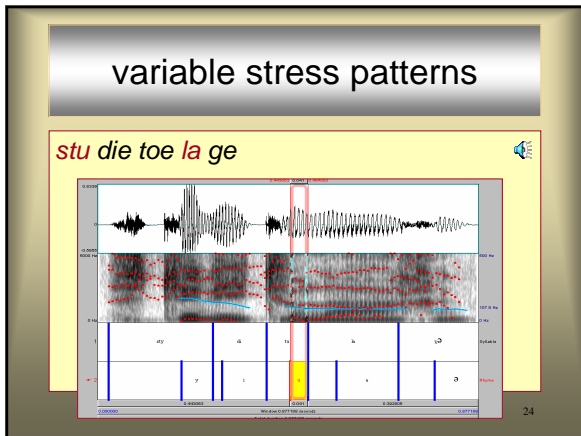
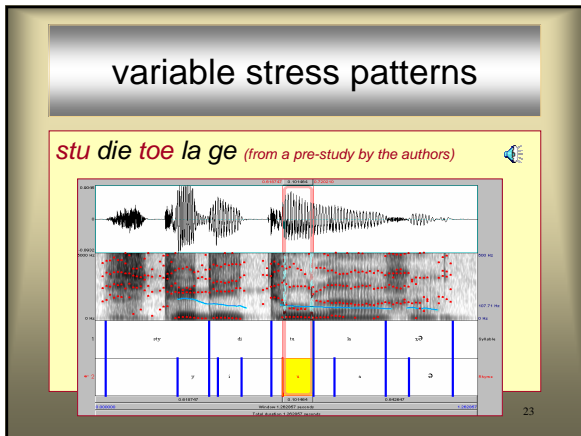
Stress Correlates:

1. Duration
2. Pitch
3. Intensity
4. Spectral Balance (Sluijter, 1995)
5. Timing (Quené & Port, 2002 a.o.)

Phonetic Evidence?

Just Noticeable Differences:

Duration	JND: 4.5%	(Eefting & Rietveld, 1989)
Pitch	JND: 2.5%	('t Hart et al, 1990)



variable stress patterns

stu die toe la ge
(1.164 ms)

	[u]	[a]
pitch	116.8 Hz	99.5 Hz
duration	0.101 ms	0.169 ms
intensity	85.7 dB	80.7 dB

stu die toe la ge
(0.85 ms)

multi-plying factor 1.37

	[u]	[a]
pitch	117.3 Hz	99.8 Hz
duration	0.056 ms	0.196 ms
intensity	80.7 dB	78.5 dB

25

Acoustic Analysis

Pitch, duration, intensity

0 = no shift
1 = shift

	AUDITORY	Mean	Std. Deviation	N
a_maxpitch	0	180,171	62,6368	765
	1	186,299	62,3552	698
	Total	183,094	62,5562	1463
a_meanpitch	0	169,2314	55,99621	765
	1	178,0874	58,02636	698
	Total	173,4566	57,12590	1463
a_duration(norm)	0	,1208	,04872	765
	1	,0937	,04470	698
	Total	,1079	,04875	1463
a_intensity	0	68,8575	6,14766	765
	1	69,8803	6,08864	698
	Total	69,3455	6,13879	1463

a = corr. syllable When a word is perceived as shifted (1), syllable a is expected to have **lower** values than where no shift is perceived (0)

Acoustic Analysis

Pitch, duration, intensity

	AUDITORY	Mean	Std. Deviation	N
b_maxpitch	0	177,3691	61,26285	760
	1	187,4453	58,10147	703
	Total	182,2109	59,95614	1463
b_meanpitch	0	167,0725	55,22418	760
	1	179,2741	54,93000	703
	Total	172,9356	55,40084	1463
b_duration(norm)	0	,1609	,07698	760
	1	,1212	,06039	703
	Total	,1419	,07226	1463
b_intensity	0	66,8939	6,36863	760
	1	71,1036	6,11909	703
	Total	68,9167	6,59258	1463

b = shift syllable When a word is perceived as shifted (1), syllable b is expected to have **higher** values than where no shift is perceived (0)

Acoustic Analysis

Duration

Syllables a (corr.)

$\chi^2 (4) = 26,348, p < 0.001$

Syllables b (shift)

$\chi^2 (4) = 25,203, p < 0.001$

28

Acoustic Analysis

Duration

Syllables a (corr.)

$\chi^2 (4) = 26,348, p < 0.001$

Syllables b (shift)

$\chi^2 (4) = 25,203, p < 0.001$

29

Acoustic Analysis

Spectral Balance

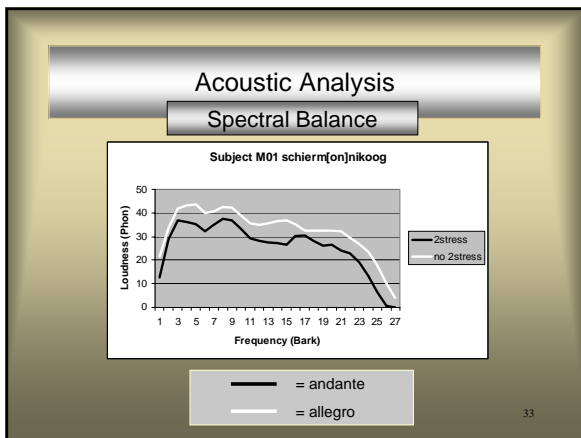
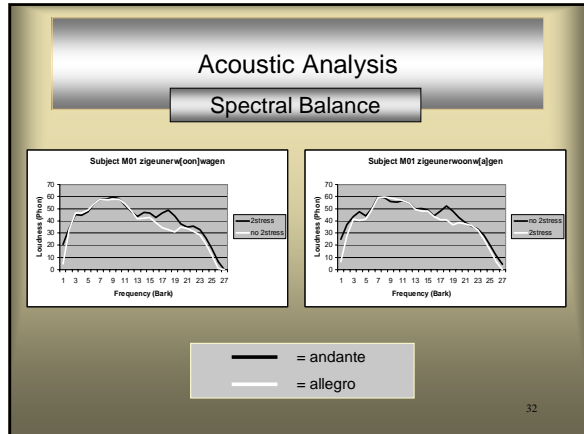
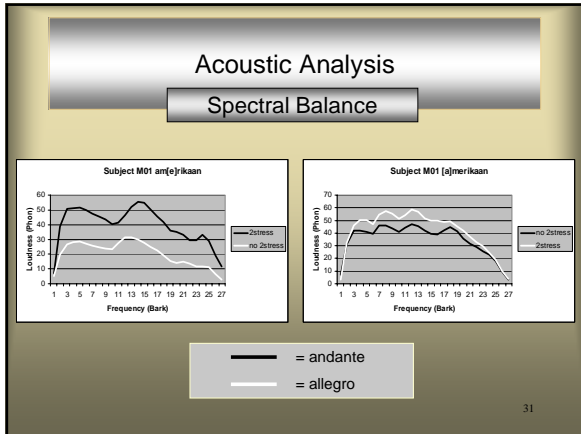
Andante: unstressed [a]

studietoe|[a]ge (Andante)
(from a pre-study by the authors)

Allegro: stressed [a]

studietoe|[a]ge (Allegro)
(both syllable b)

30



Acoustic Analysis

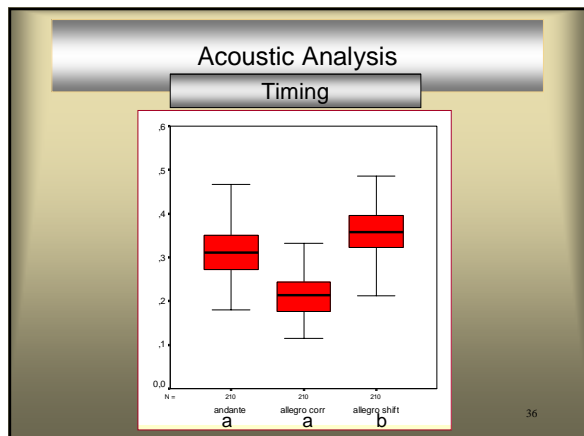
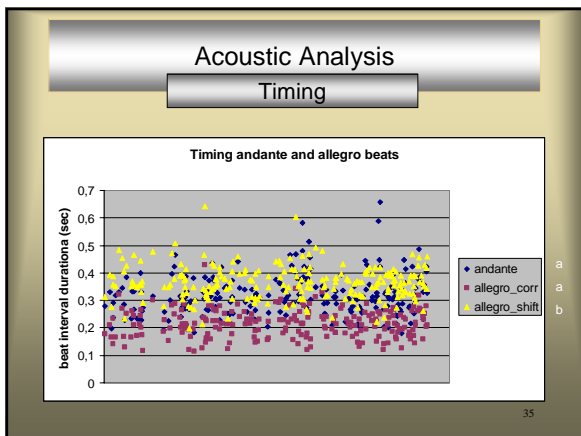
Timing

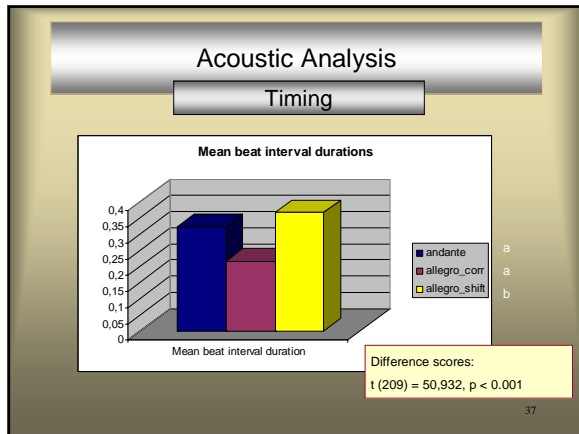
Equal Spacing Constraint:
 Prominent vowel onsets are attracted to periodically spaced temporal locations
 (Couper-Kuhlen 1993; Cummins & Port 1998; Quené & Port 2002)

studietoelage (Andante): 0.358 sec
 studietoelage (Allegro): 0.328 sec factor: 1.091

(from a pre-study by the authors)

34





Conclusion acoustics

- Listeners expect a prominent vowel at about 300 msec from the main stress syllable and therefore perceive a secondary stress at the (stressable) syllable which is nearest to that distance
- “Mental metronome”:
 - ♩ = 200 (secondary stress)
 - ♩ = 100 ((main stress) beat)

38

Conclusion

Phonology:

- Listeners prefer **Mark >>Corr** over **Corr>>Mark** in **Allegro** speech, whereas it is the other way around in **Andante** speech
 - This result resembles the preferences in andante and allegro music
- Mostly, this results in triplet patterns in allegro speech

Phonetics:

- Acoustic correlates of stress do not show a difference in rhythmic pattern; secondary stress is only perceptual
- The perception of a rhythmic difference between andante and allegro words is based on timing differences: the “mental metronome”.

39