

Phonetic correlates of stress patterns in Dutch (compound) adjectives

1. Introduction

1.1. Culminative versus equal stress

Stress is an abstract, lexical property that specifies which syllable is the strongest in a polysyllabic word. Generally, linguists take view that only one syllable can bear the (main) stress. This is called the culminative definition of stress (Trubetskoy, 1958; Hyman, 1977). Generative phonology explicitly captures this principle in its rule mechanisms, which clearly prevent the occurrence of two equally strong, primary stresses within one word or larger domain.

There has always been, however, an alternative view, which does permit two equal, strong stresses even within a single word or word group. Proponents of this view are typically found among the traditional British phoneticians (e.g. Jones, 1918; Kingdon, 1958), although it has not been without influence in the United States as well. For example, the American-English pronouncing dictionary (Kenyon & Knott, 1944) often transcribes two primary stresses in words for which the generative stress rules (e.g. Chomsky & Halle, 1968; Liberman & Prince, 1977) output only one.

For Dutch, too, words with two equal primary stresses have been claimed to exist (e.g. Krusinga, 1918). Adjectival compounds constitute a productive word type that would generally receive two primary stresses. Table I shows Dutch sample words and stress patterns as transcribed under the two competing proposals, which we shall conveniently refer to by the names of "culminative" and "equal" definitions of stress.

Table I: Sample/stimulus words

RISING		EQUAL	FALLING	
STRONGLY	LIGHTLY		LIGHTLY	STRONGLY
[0-1]	[2-1]	[1-1]	[1-2]	[1-0]
gemengd 'mixed'	bizar 'id.'	lichtgrijs 'light gray'	komisch 'comical'	pittig 'spicy'
gepast 'fit'	concreet 'concrete'	beeldschoon 'very pretty'	logisch 'logical'	mager 'meagre'
[0-1]	[2-1]		[1-2]	[1-0]

It will suffice, for our purposes, to adopt three levels of stress: main or primary stress (level 1), medium of secondary stress (syllables containing a full vowel, level 2), and unstressed (strongly reduced syllables, level 0).

This study will be restricted to di-syllabic words only, the stress patterns of which will be symbolised by hyphenated pairs of digits 0, 1, and 2. When the stronger stress is in final position, the pattern is called rising, when the final stress is weaker than the leading stress, the pattern is falling.

Under the culminative view then, four distinct patterns are recognised: strongly and slightly rising, and strongly and slightly falling. Five distinct patterns are postulated under the equal definition: here the slightly rising pattern splits up into a truly rising pattern [2-1], and a patterns that contains two main stresses of equal strength: [1-1].

The first set of questions that I wish to answer are:

- (1a) Does the equal stress pattern exist,
- (1b) Are [1-1] and [2-1] two distinct patterns,
- (1c) Can we find acoustic correlates of four patterns or five.

1.2. Rhythmic variation

In English as well as in Dutch words with a slightly rising pattern (under the culminative conception of stress) reverse their stress to slightly falling in certain contexts (a process now commonly known in metrical phonology as the rhythm rule):

	[2-1] rising	changes to	[1-2] falling
(a)	2 1 lichtgrijs 'light gray'		1 2 1 lichtgrijs pak 'light gray suit'
(b)	2 1 beeldschoon 'very beautiful'		1 2 1 beeldschoon meisje 'very beautiful girl'
(c)	2 1 bizar 'id.'		1 2 1 *bizar voorstel 'bizar proposal'
(d)	2 1 concreet 'concrete'		1 2 1 ?*concreet voorstel 'concrete example'

Observe that the rhythmic inversion of the stress pattern seems mandatory in the examples (a) and (b) (compound adjectives), but optional at best in the cases (c) and (d), where the adjectives are monomorphemic (note 1).

In the British tradition rhythmic variation was claimed to apply to cases (a) and (b) only, that is, cases with lexically equal stress. Here [1-1] changes to a slightly rising pattern [2-1] when preceded by a stress, and to a slightly falling pattern [1-2] when followed by a stress, the generalisation being that the middle one of three successive stresses should weaken so as to ensure an alternating rhythm.

[1-1] equal	changes to	[2-1] rising	or	[1-2] falling
(a') 1 1 lichtgrijs		1 2 1 heel lichtgrijs		1 2 1 lichtgrijs pak
(b') 1 1 beeldschon		1 2 1 heel beeldschon		1 2 1 beeldschon meisje

Words of the (c) and (d) type were never subject to rhythmic variation.

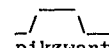
My second set of questions is:

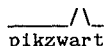
- (2a) Does rhythmic variation apply to [1-1] words only (e.g. adjectival compounds),
- (2b) Do adjectives (compound or simplex) have two (rising/falling) or three (equal/rising/falling) stress patterns depending on their rhythmic environment,
- (2c) Is there an acoustic difference between the [1-2] and [2-1] patterns derived from adjectival compounds on the one hand, and lexically - invariable - [1-2] and [2-1] words on the other.

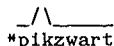
Clearly, even if no direct (acoustic) evidence should be found supporting the distinct status of equal stressed words, assuming a different lexical stress pattern for adjectival compounds (i.e. [1-1]) would be an elegant way of accounting for differences in rhythmic behaviour between these and non-compound adjectives.

1.3. Effects of accent

Though compound adjectives are often pronounced with an accent (salient pitch movement) on each of their stressed syllables, the leftmost accent may be dropped without affecting the interpretation of the utterance. However, if the rightmost accent is omitted, the remaining accent implies a semantic contrast at below-word level:


 pikzwart
 'pitch black'


 pikzwart


 *pikzwart

*: contrastive accent

It would follow from this that the cleanest cases of equal stress will be found in the absence of accents. Accents are dropped when a constituent is out of Focus, that is, when the speaker wishes to instruct his hearer that the constituent contains relatively unimportant information (cf. e.g. Gussenhoven, 1984; Ladd, 1980).

This prompts our third question:

- (3) Is equal stress only manifest outside Focus?

A further complication arises from the work by Bolinger (1965). He, and others (cf. Vanderslice, 1968), take the view that the rhythmic variation observed in

section 1.2 is really a matter of accents. In an array of closely spaced accents, there is a tendency to drop accents in medial positions, but to leave the marginal accents intact. This tendency has been experimentally verified for Dutch by Baart (1983) and Kruyt (1985). Rhythmic inversion is then viewed as a strategy to avoid accent clashes rather than stress clashes. As a consequence we should predict that no rhythmic variation is needed when a phrase contains no accents, i.e. is spoken outside Focus. Our final question is therefore:

(4) Does rhythmic variation occur within Focus only?

I shall now report on a small experiment that was designed to provide some preliminary answers to the various questions raised above.

2. Method

The 10 words given in table I (2 exemplars of 5 theoretically distinct stress patterns) served as our basic stimulus words. Each was embedded in 4 different rhythmic environments, with a strong stress that did or did not precede and/or follow the crucial word in all four logically possible combinations), as follows:

Table II: Rhythmic environments for stimulus material

- | | |
|--|--|
| 1. Stress left nor right
Wil je ... een keer zeggen
'Would you ... once more say' | 2. Stress left only
Wil je heel ... een keer zeggen
'Would you quite ... once more say' |
| 3. Stress right only
Wil je ... ding een keer zeggen
'Would you ... thing once more say' | 4. Stress both left and right
Wil je heel ... ding een keer zeggen
'Would you quite ... thing once more say' |

Each of these 10 * 4 phrases was then embedded in two sentences. In the first sentence the crucial phrase occurred in Focus position, but was immediately repeated in the second sentence with a single contrastive accent on a different word (viz. harder 'louder'), which moved it outside Focus, as illustrated below:

Table III: Focus conditions

1. [+ Focus]: Wil je (heel) ... (ding) een keer zeggen
'Would you (quite) ... (thing) once more say'
2. [- Focus]: Wil je (heel) ... (ding) een beetje HARder zeggen
'Would you (quite) ... (thing) a little LOUder say'

One male and one female speaker each read the entire material twice from cards, and were recorded on audio tape using (semi-) professional equipment. The pairs of sentences containing the [+/- Focus] versions of the same crucial phrase appeared on one card, and were read in quasi random order across words and rhythmic environments, such that immediate successions of the same lexical items or rhythmic patterns were excluded.

3. Analysis

Acoustic measurements were performed on each of the 320 recorded utterances (10 words * 4 rhythmic environments * 2 Focus conditions * 2 speakers * 2 repetitions). For each of the two syllables in the crucial adjectives the following properties were measured:

- (1) Duration of the vowel (in milliseconds, ms) from oscillograms (Honeywell 2206 Visicorder, 10cm/s),
- (2) Peak intensity (in decibels, dB; FJ-Electronics IM-360 intensity meter, 20 ms integration time, full bandwidth),
- (3) Pitch excursion (in semitones, ST), i.e. the difference between the highest and lowest pitch measured within the syllable (FJ-Electronics FFM-650 fundamental frequency meter, using FJ-Electronics EG-830 electroglottograph signals recorded simultaneously with the audio signals). An ST is a musical interval of one-twelfth of an octave, or a pitch difference of 6%. Notice that this measure abstracts from the direction and complexity (rise/fall etc.) of the pitch movements.

Next, these measurements were converted to relative difference measures as follows:

- (1') Duration difference, by dividing the duration of the longer vowel in the word by that of the shorter, and subtracting 1. The result (in %) was given a negative sign if the first vowel was shorter than the second.
- (2') Intensity difference, by subtracting the intensity of the weaker from that of the stronger vowel, with a negative sign if the first vowel was the weaker of the two.
- (3') Pitch excursion difference, by subtracting the smaller excursion from the larger one in the word, again with a negative sign if the first syllable contained the smaller value.

Thus, falling stress patterns are consistently characterised by positive differences, rising patterns by negative values. Notice further that all differences are expressed as ratios (or percentages) so as to account for certain properties of the human hearing system, which evaluates duration, intensity and frequency differences logarithmically rather than linearly.

4. Results

The results are presented in figure 1 for the crucial adjectives spoken in Focus, and in figure 2 for the material spoken outside Focus. Each figure contains a three-dimensional plot of the mean positions of the five stress patterns, separated out for the four rhythmic contexts, but accumulated over exemplars, speakers and repetitions (i.e. each point represents 8 word tokens). The three-dimensional representations are split up into two two-dimensional plots: one for intensity difference versus pitch excursion difference (panel A), and one for intensity versus duration difference (panel B). When the two vowels in a word have equal duration, intensity and pitch excursion, it assumes a position near the origin (centre) of the plots; strongly rising patterns appear near the bottom-left corner, while falling patterns will be found in the right-top corner. For the sake of clarity only the four different rhythmic realisations per stress pattern (indicated by different symbols) have been enclosed by ellipses, which were drawn by eye.

As predicted, we find the various stress patterns distributed along the bottom-left to right-top diagonal. There is a clear separation in each of the panels between rising, equal, and falling patterns. Within the class of rising patterns, slightly and strongly rising are distinct, but the two falling patterns coincide. The best separation is obtained in the intensity-by-duration plot, with duration as the stronger correlate of stress pattern. Pitch excursion allows a separation into rising and falling patterns only.

We also note that there is considerable variability in the data due to rhythmic environment. Though there are some interesting regularities underlying this variation (e.g. pitch excursions are larger when the crucial adjectives are embedded in a non-stressed context), the effect of rhythmic context is essentially random for all word types, except for the class of compound adjectives. Only in this latter case do we observe the regular alternation between (more) rising and (more) falling as was predicted by the British phonetians.

These results unequivocally indicate that either the first or the second vowel in a compound adjective is accented. In terms of intensity and duration differences, however, the adjectival compounds always take up a position closer to the equilibrium than the lexically rising or falling patterns do, even though the effects of rhythmic environment are clear-cut and regular.

When we now turn to the material spoken outside Focus (figure 2), we observe, first of all, that all differences in pitch excursion have disappeared. Clearly then, pitch movement is the principal acoustic correlate of accent, and no accents were realised in the material spoken outside Focus.

Concentrating on the two remaining parameters, we notice that the separation between the five stress patterns is even better here than above, as if the elimination of the pitch parameter has been compensated for along the remaining parameters. Again, the compound adjectives assume positions near the equilibrium, and display the regular effects of rhythmic variation. In the other word types the differences due to rhythmic variation are much smaller and essentially random.

5. Conclusions and discussion

We conclude, first of all, that it is eminently feasible to characterise the stress pattern of Dutch di-syllabic words acoustically. Generally five distinct stress patterns are revealed, and there is not a shadow of a doubt that the stress pattern of adjectival compounds is different than that of lexically rising or falling patterns: it has equal stress, or at least a more equal distribution of stress over the syllables than any other pattern.

Also, the predicted effects of rhythmic context were found to apply to the adjectival compounds only. Lexically slightly rising stress patterns [2-1] for concreet and bizar were never affected by their rhythmic context.

However, the effects of rhythm do not lead to three distinct stress patterns for the compound adjectives: they are very slightly rising (in fact, perceptually equal, note 2), but change to very slightly falling (but perceptually quite noticeably so, note 2) when followed by a strong stress. A following strong stress is a necessary and sufficient condition for the rhythmic variat-

ion to take place; the stressed or unstressed nature of the preceding word is irrelevant to this decision. Even though compound adjectives are subject to rhythmic changes, they never completely coincide with a lexically rising [2-1] or falling [1-2] pattern.

Next, we conclude that an equal distribution of stress is rather difficult to find in [+ Focus] material, since there is always a clear pitch movement on one syllable that by far outweighs the other. However, when adjectival compounds (and similar words such as compound numerals and certain adverbs) are spoken outside Focus, the true nature of their equal stress is quite manifest. Apparently these words have double stress, and therefore two potential positions for an accent, but - in our material - only one of these is realised at a time.

Finally, the rhythm rule applies both within and outside Focus: rhythmic inversion takes place on adjectival compounds, whether accented or not. This falsifies Bolinger's claim that the rhythm rule is a matter of accent clash: the process is more aptly characterised as stress clash.

Most importantly, our results argue against a strictly culminative view of stress. To me this presents a challenge to generative phonologists. Would they be prepared to revise their rule mechanisms so as to allow the generation of two primary stresses within a single domain; and if so, how can this be done?

Notes

- * The experiments reported here were run by Marjorie van der Kruis and Mienieke Muntendam in a seminar on Experimental Phonetics at the Depts. of English and Linguistics/Phonetics Lab, Leyden University. I thank Joan Baart, Simone Langeweg, and Jan Kooij for valuable comments on an earlier version of this manuscript.
- 1. J.G. Kooij points out (p.c.) that optional inversion of stress pattern extends to morphologically simplex words if these are longer than two syllables, e.g. kathol'iek ('catholic') but 'katholieke 'eredienst ('catholic service').
- 2. For reasons of space, no elaborate description of the perceptual experiment can be provided here. Briefly, listeners were asked to decide which of the two syllables in the compound adjectives was the stronger, when the words were electronically excised from their spoken context. When no following stress had occurred there, the distribution of stress judgments was evenly balanced.

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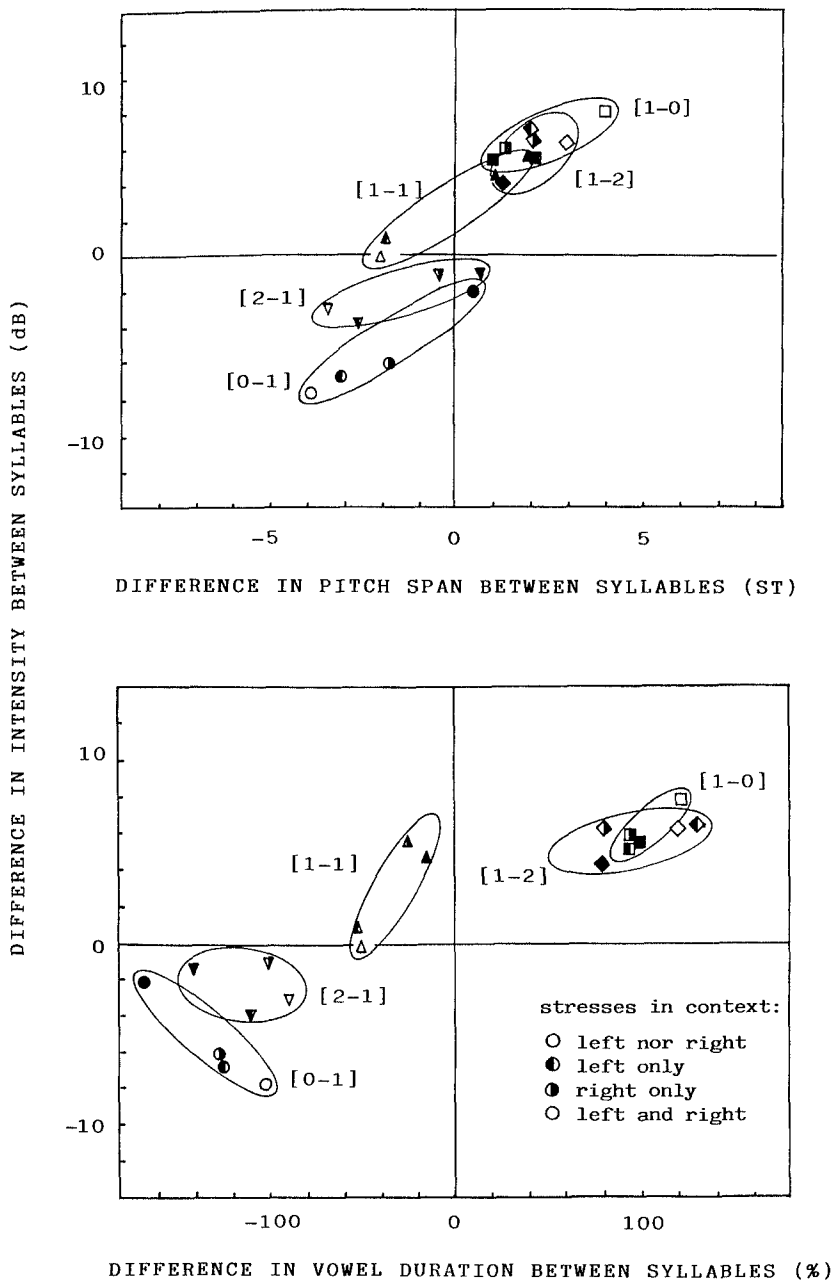


Figure 1: Intensity difference (dB) plotted against duration difference (in %), (panel A), and against pitch excursion difference (in ST) (panel B) for 10 Dutch adjectives as spoken in [+ Focus] material. The data are broken down by stress pattern and by rhythmic context, but accumulated over speakers, repetitions and exemplars (each symbol represents 8 data points).

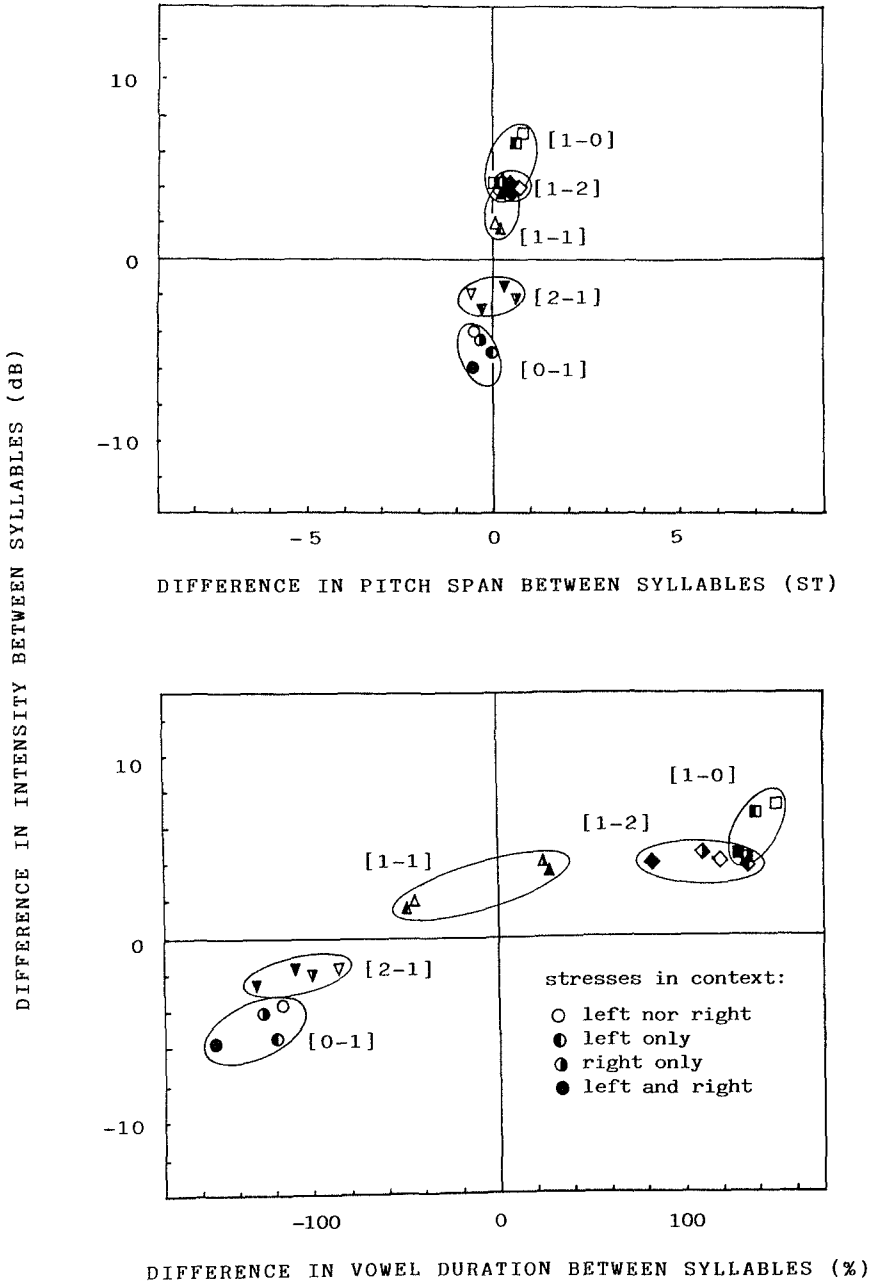


Figure 2: As figure 1 for adjectives spoken in [- Focus] material.