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Stress Patterns in Dutch (Compound) Adjectives: Acoustic Measurements and Perception Data[1]

Vincent J. van Heuven[2]

Department of Linguistics/Phonetics Laboratory, Leyden University, Leiden, The Netherlands

Abstract. Under the so-called culminative definition of stress, present-day linguists hold the view that within one word or larger domain only one syllable can bear the stress. This is in contrast with the classical (British-English) phonetic tradition which allows the occurrence of two strong stresses within certain words, which are then called 'double-stressed'. Moreover, precisely the class of double-stressed words was said to be subject to rhythmic variation (or 'stress clash'). The present paper purports to find acoustic and perceptual evidence that may allow us to choose between these competing proposals, comparing the behaviour of Dutch adjectives with canonically rising, falling, and double-stress patterns, in spoken contexts that should bear out the predicted rhythmic changes in double-stressed words. Our results argue against a strictly culminative definition of stress.

Introduction

Culminative versus Equal Stress

Stress is an abstract, lexical property that specifies which syllable is the strongest in a polysyllabic word. Generally, linguists take the 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 exclude the occurrence of two equally strong, primary stresses within one word or larger domain.

In the so-called linear phonological theory [e.g., Chomsky and Halle, 1968; Halle and Kayser, 1971, for English; van den Berg, 1972, for Dutch] it is impossible, in principle, to generate two or more equal primary stresses within a word or larger domain. As long as more than a single primary stress remains within a given domain, stress rules remain applicable that ultimately select one of the candidates as the strongest,

[1] The experiments reported here were run by Marjorie van der Kruis and Mieneke Muntendam in a seminar on Experimental Phonetics at the Departments of English and Linguistics/Phonetics Laboratory, Leyden University.

[2] I thank Joan Baart, Simone Langeweg, and Jan Kooij for valuable comments on an earlier version of this manuscript.

Table I. Sample/stimulus words

Rising		Equal	Falling		
strongly	lightly		lightly	strongly	
0–1	2–1	1–1	1–2	1–0	'equal stress'
gemengd (mixed)	*bizar* (id.)	*lichtgrijs* (light grey)	*komisch* (comical)	*pittig* (spicy)	
gepast (fit)	*concreet* (concrete)	*beeldschoon* (very pretty)	*logisch* (logical)	*mager* (meagre)	
0–1	2–1		1–2	1–0	'culminative stress'

after which all the competitors are weakened by one degree of stress.

In the 'hierarchical' approach [Liberman and Prince, 1977, and other metrical phonologists after them, e.g. Hayes, 1984], a completely different mechanism was developed that generates exactly the same stress patterns as the linear model. For each word (or larger domain) a binary tree is erected over the syllables each branch of which is explicitly labelled as weak or strong. Ultimately, there is one and only one syllable that is exclusively dominated by strong branches, which is the primary stress.

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 and Knott, 1944] often transcribes two primary stresses in words for which the generative stress rules [e.g. Chomsky and Halle, 1968; Liberman and Prince, 1977] indicate only one.

For Dutch, too, words with two equal primary stresses have been claimed to exist [e.g. Kruisinga, 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 label 'culminative' and 'equal' definitions of stress.

It will suffice, for our purposes, to adopt three levels of stress: main or primary stress (level 1), medium or secondary stress (syllables containing a full vowel, level 2), and unstressed (strongly reduced syllables, level 0). This numerical expression of stress levels has been taken over from established practice in generative phonology, where integers of ascending order reflect lower degrees of stress, but where zero stress – somewhat illogically – refers to unstressed syllables.

This study will be restricted to disyllabic words only, the stress patterns of which will be symbolised by hyphened 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 pattern 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, and perceptual evidence for, four patterns or five?

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 grey)		1 2 1 *lichtgrijs pak* (light grey 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.[3]

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 *beeldschoon*		1 2 1 *heel beeldschoon*		1 2 1 *beeldschoon meisje*

[3] J. G. Kooij points out [personal commun.] that optional inversion of stress pattern extends to morphologically simple words if these are longer that two syllables, e.g. *kathol'iek* (catholic) but *'katholieke 'eredienst* (catholic service).

Words of the (c) and (d) type were never subject to rhythmic variation. Our second set of questions derives from these conflicting views:

(2a) Does rhythmic variation apply to 1–1 words only (e.g. adjectival compounds)?

(2b) Do adjectives (compound or monomorphemic) 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-stress 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.

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:

*: 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 [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 [Vanderslice, 1968] take the view that the rhythmic variation observed above 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], Kruyt [1985], and Terken [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 two experiments that were designed to provide some preliminary answers to the various questions raised above.

Experiment I: Acoustic Measurements

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 (table II), with a strong stress that did or did not precede and/or follow the crucial word in all 4 logically possible combinations. 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

Table II. Rhythmic environments for stimulus material

(1) Stress neither 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'

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*)

single contrastive accent on a different word, i.e. *harder* (louder), which moved it ouside focus, as illustrated in table III. 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.

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 (ms) from oscillograms (Honeywell 2206 Visicorder, 10 cm/s);

(2) Peak intensity (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 measured pitch that could be associated with the excursion on a given syllable (FJ-Electronics FFM-650 fundamental frequency meter, using FJ-Electronics EG-830 electroglottograph signals recorded simultaneously with the audio signals). The pitch peak was always located within the crucial syllable; pitch movements could extend somewhat beyond the syllable boundaries, so that the lowest point associated with a movement was occasionally located in the preceding or following syllable. An ST is a musical interval of one-twelfth of an octave, or a pitch difference of 6%. Note that this measure abstracts from the direction and complexity (rise/fall) of the pitch movements.

The choice of this particular set of primary parameters is arbitrary to some extent. For each of the three acoustic domains (duration, pitch, intensity), additional or competing measures can be, and occasionally have been, suggested.

Next to vowel duration, for instance, prevocalic consonant duration has been mentioned as a reliable correlate of stress [Huggings, 1972; Nooteboom, 1972]. However, effects of stress on consonant duration appeared to be dependent on the presence or absence of a pitch movement, and we wished to isolate parameters that were maximally independent of one another. Similarly, there are good indications that measures of intensity integrated over time (intensity averaged or summed over the whole vowel duration) bring about a better separation between stressed and non-stressed syllables than peak intensity does [Lieberman, 1960;

Lea, 1977; Beckman, 1986]. Yet, again, integral intensity reflects the combined influence of duration and intensity, so that this correlate is no longer independent of the others. Also, none of the alternatives discussed here have been submitted to perceptual testing.

Because we wished to keep the number of acoustic parameters small, we decided to opt for basic parameters that have traditionally been regarded as most suitable, and that have been extensively tested in perceptual experiments [Fry, 1955, 1958; Morton and Jassem, 1965; van Katwijk, 1974].

Finally, our analysis might have been refined by correcting the raw measurements for inherent duration, pitch, and intensity. Again, we decided against this possibility, for various reasons. Firstly, the vowels in our stimulus words were randomly distributed over the various stress patterns, so that effects of inherent properties would average out. Secondly, there are no data available on inherent pitch and intensity for Dutch vowels, and borrowing correction factors from American-English [Lehiste and Peterson, 1959] seems hazardous. Finally, such corrections beg the question in the case of inherently reduced vowels (schwa): it is precisely because of their short duration and low intensity that they constitute reduced syllables.

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 (%) 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.

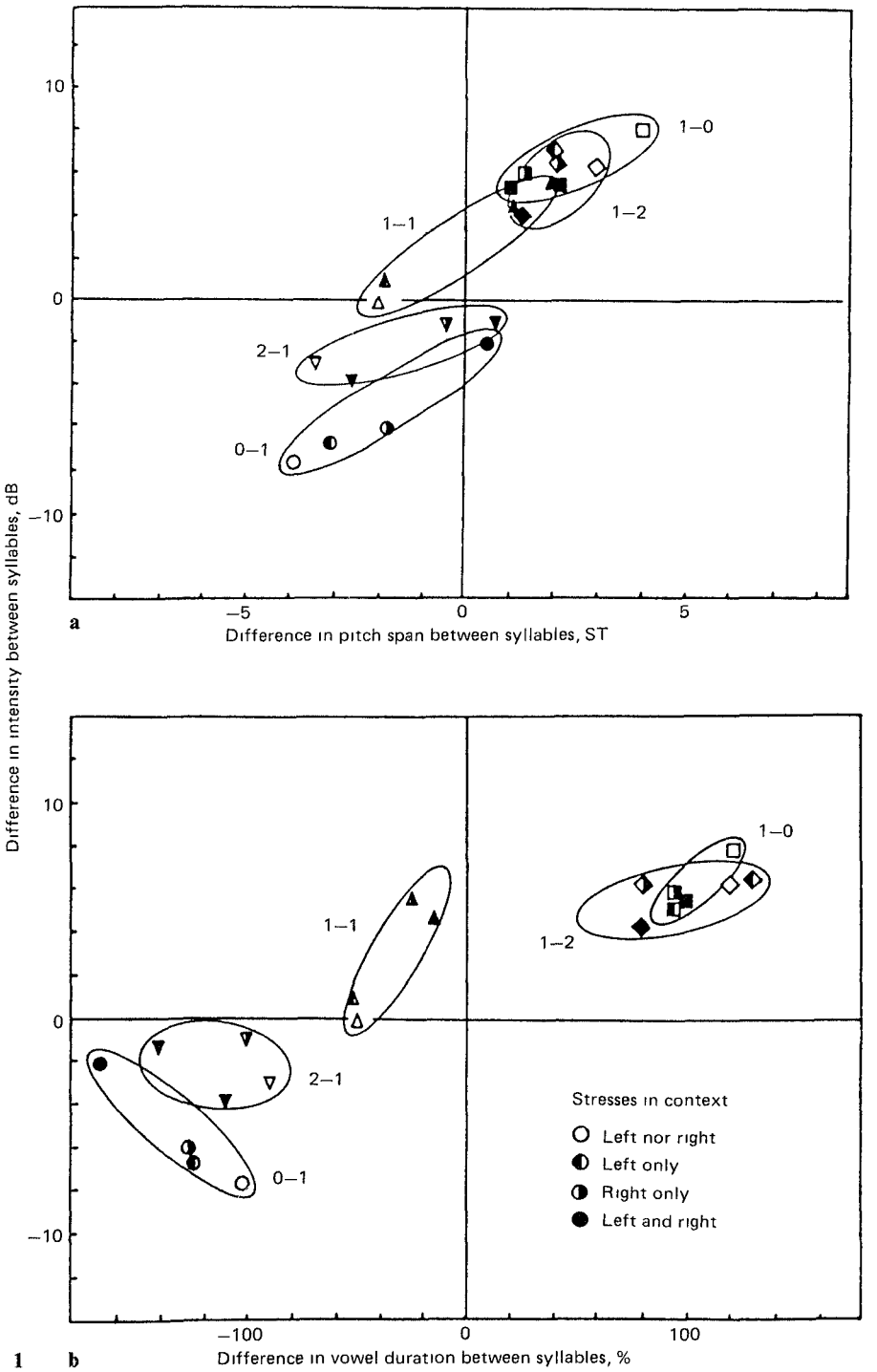
Thus, falling stress patterns are consistently characterised by positive differences, rising patterns by negative values. Note further that all differences are expressed as ratios (or percentages) so as to account for certain properties of the human hearing system, which evaluates duration, intensity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

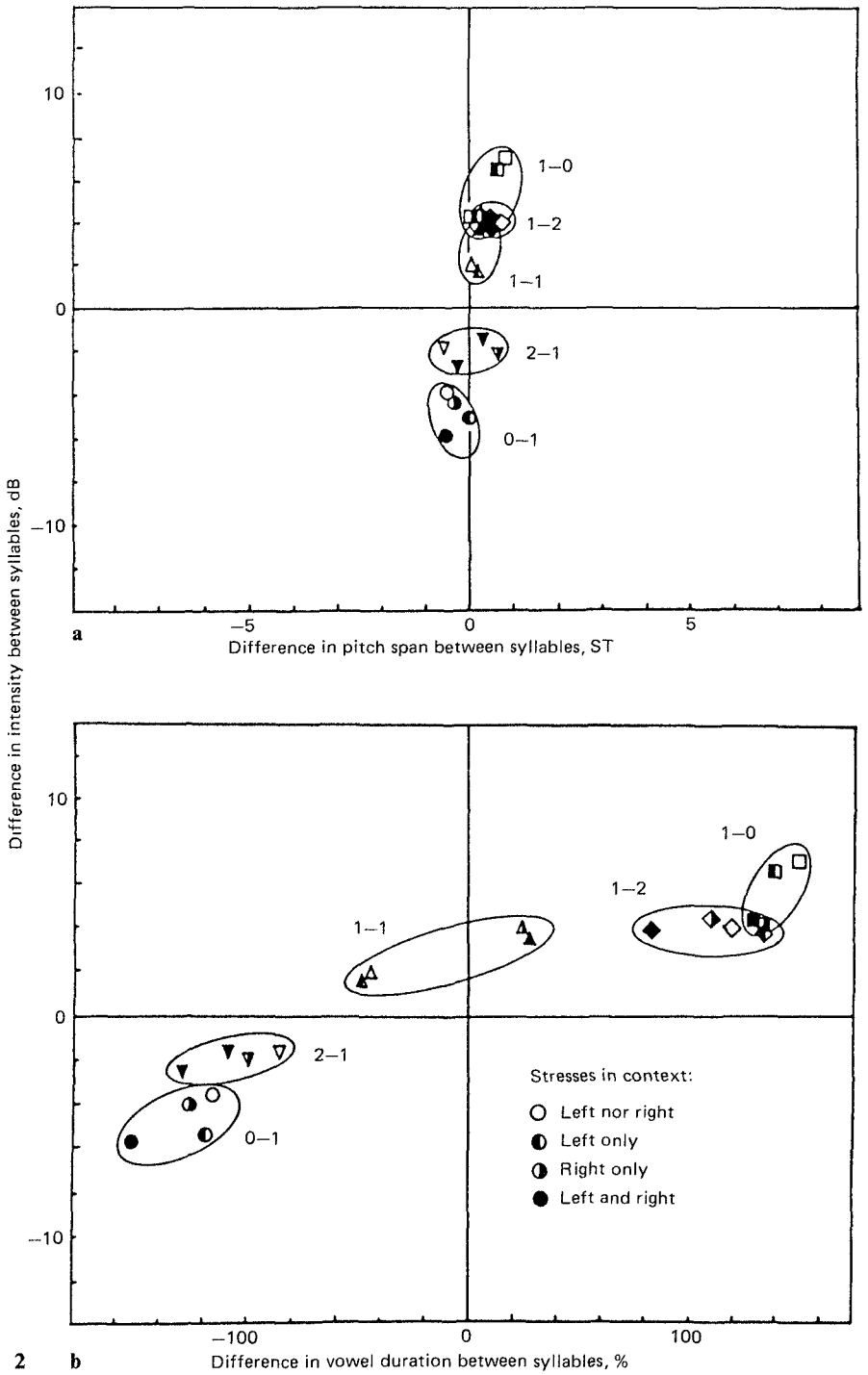
Results

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 plots 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). Each figure contains two subplots: one for intensity difference versus pitch excursion difference (fig. 1a, 2a), and one for intensity versus duration difference (fig. 1b, 2b). 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. Merely for the sake of clarity, 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 dura-

Fig. 1, 2. Intensity difference (dB) plotted against pitch excursion difference (in ST) **(a)** and against percent duration difference **(b)** for 10 Dutch adjectives as spoken in + focus **(1)** and – focus **(2)** 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).


10
0
−10
−5
0
5
1–0
1–2
1–1
2–1
0–1
a
Difference in pitch span between syllables, ST
Difference in intensity between syllables, dB
10
0
−10
−100
0
100
1–0
1–2
1–1
2–1
0–1
Stresses in context
Left nor right
Left only
Right only
Left and right
b
Difference in vowel duration between syllables, %


10
0
−10
1–0
1–2
1–1
2–1
0–1
−5
0
5
a
Difference in pitch span between syllables, ST
Difference in intensity between syllables, dB
10
0
−10
1–0
1–2
1–1
2–1
0–1
Stresses in context:
Left nor right
Left only
Right only
Left and right
−100
0
100
b
Difference in vowel duration between syllables, %

2

tion 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 phoneticians.

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 (fig. 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.

Experiment II: Perception

Before drawing any conclusions from the acoustic data, we must know how listeners perceive the measured differences, since it is not clear, a priori, whether, e.g., the (temporal) differences between phrase final and non-phrase final compound adjectives are large enough to cue a stress shift. Therefore, the perceptual relevance of the crucial differences was established in a second experiment. In doing so, one important practical problem had to be solved in order to prevent the listener's judgments from being unduly influenced by rhythmic information present in the context. It was therefore decided to suppress context information by gating out the crucial adjectives from their spoken environment.

Method

Each of the 64 adjectival compounds was electronically excised from its spoken context using a Grason-Stadler 1284B electronic switch (5 ms rise/fall time) which was controlled by a Devices D4030 Digitimer, and copied onto a new tape in random order across speakers, with 5 s interstimulus intervals (onset to onset).

Fifteen native Dutch subjects, male and female students at the Faculty of Letters of Leyden University, listened to the tape, which was played over headphones in an AAD-type language laboratory at a comfortable listening level. They were instructed to decide for each word on the tape whether the first or the second syllable bore the stronger stress, with forced binary choice and with no ties allowed.

Prior to the experiment subjects were given an explanation of the double-stress phenomenon, so as to make sure that they fully realised that the stimulus words could be pronounced with stress on either syllable. After seven practice stimuli the entire set of

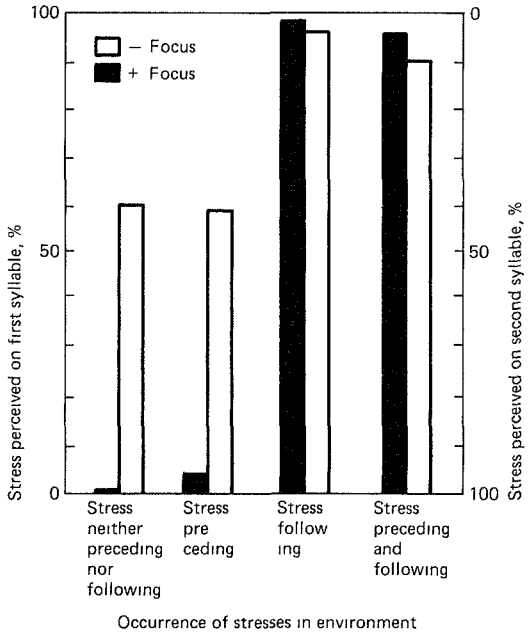


Fig. 3: Percent stress perceived on first/second syllable broken down by position of adjective in original context and by focus condition.

64 words was presented twice with a short break in between to collect answer sheets. Collecting repeated measures for the stimuli would allow us to establish the subject's response consistency.

Results

Listeners with too many inconsistencies in their responses were eliminated from the data set. Subjects were considered inconsistent, rather arbitrarily, whenever they gave conflicting responses to the same stimulus in more than 10% of the cases. The stress judgments of the remaining 12 listeners are presented in figure 3.

This figure presents the percentage of stresses perceived on the first syllable (and by implication that on the second, i.e. the complement score to 100%) broken down for material spoken in and out of focus, and for the four rhythmic environments in which the words had originally been spoken.

The material collected in focus clearly divides into two groups. When used in phrase-final position (no stress following), the second syllable is heard as stressed; with a stressed syllable following the crucial adjective (i.e. non-phrase final use) stress is heard on the first syllable. Obviously, the presence of a pitch movement completely determined the listener's decision.

The situation is different for the material spoken outside focus. Again, we find that stress is clearly perceived on the initial syllable when the adjective is used in non-phrase final position. However, when in phrase-final position, the distribution of the responses over the two syllables is random, indicating that both syllables have been pronounced with an equal amount of stress ($\chi^2 = 3.01$, d.f. = 1, NS).

Conclusions and Discussion

Culminative or Equal Stress?

We conclude, first of all, that it is eminently feasible to characterise the stress pattern of Dutch disyllabic words acoustically. Generally five distinct stress patterns are revealed, and there is not a shadow of a doubt that the stress pattern of an adjectival compound is different from 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.

Effects of the Rhythm Rule

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

Equal Stress and Focus

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 quite probably similar words such as compound numerals and certain adverbs that were not included in the present experiments) 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 accent is realised at a time.

Stress Clash or Accent Clash?

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 [1965] claim that the rhythm rule is a matter of accent clash: the process is more aptly characterised as stress clash.

In general, then, our results rehabilitate the traditional phoneticians' view that allows the occurrence of two equally strong stresses within one word or word group, under specific conditions. Therefore 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?

References

Baart, J. L. G.: Surface structure effects on the accentuation of verbs in read aloud text; in Bennis, van Lessen-Kloeke, Linguistics in the Netherlands 1983, pp. 1–7 (Foris Publications, Dordrecht 1983).

Beckman, M. E.: Stress and non-stress accent (Foris Publications, Dordrecht 1986).

Berg, B. van den: Foniek van het Nederlands (Van Goor, Den Haag 1972).

Bolinger, D.: Pitch accent and sentence rhythm; in Abe, Kanekiyo, Forms of English: accent, morpheme, order, pp. 139–180 (Harvard University Press, Cambridge 1965).

Chomsky, N.; Halle, M.: The sound pattern of English (Harper & Row, New York 1968).

Fry, D. B.: Duration and intensity as physical correlates of linguistic stress. J. acoust. Soc. Am. *27:* 765–768 (1955).

Fry, D. B.: Experiments in the perception of stress. Lang. Speech *1:* 126–152 (1958).

Gussenhoven, C.: On the grammar and semantics of sentence accent (Foris Publications, Dordrecht 1984).

Halle, M.; Kayser, S. J.: English stress, its form, its growth, and its role in verse (Harper & Row, New York 1971).

Hayes, B.: The phonology of rhythm in English, Ling. Inq. *15:* 33–74 (1984).

Huggins, A. W. F.: On the perception of temporal phenomena in speech. J. acoust. Soc. Am. *51:* 1279–1290 (1972).

Hyman, L. H.: On the nature of linguistic stress, Sth. Calif. occ. Pap. Ling. *4:* 37–82 (1977).

Jones, D.: An outline of English phonetics (Heffer, Cambridge 1918).

Katwijk, A. F. van: Accentuation in Dutch (van Gorcum, Assen 1974).

Kenyon, J.; Knott, T.: A pronouncing dictionary of American English (Merriam, Springfield 1944).

Kingdon, R.: The groundwork of English stress (Longmans, London 1958).

Kruisinga, E.: An introduction to the study of English sounds (Wolters-Noordhoff, Groningen 1918).

Kruyt, J. G.: Accents from speakers to listeners, an experimental study of the production and perception of accent patterns in Dutch: thesis Leyden (1985).

Ladd, R. D.: The structure of intonational meaning: evidence from English (Indiana University Press, Bloomington 1980).

Lea, W. A.: Acoustic correlates of stress and juncture, Sth. Calif. occ. Pap. Ling. *4:* 83–119 (1977).

Lehiste, I.; Peterson, G. E.: Vowel amplitude and phonemic stress in American English. J. acoust. Soc. Am. *31:* 428–435 (1959).

Liberman, M. Y.; Prince, A.: On stress and linguistic rhythm. Ling. Inq. *8:* 249–366 (1977).

Lieberman, P.: Some acoustic correlates of word stress in American English. J. acoust. Soc. Am. *33:* 597–603 (1960).

Morton, J.; Jassem, W.: Acoustic correlates of stress. Lang. Speech *8:* 159–181 (1965).

Nooteboom, S. G.: Production and perception of vowel duration, a study of durational properties of vowels in Dutch; thesis Utrecht (1972).

Terken, J. M. B.: Use and function of accentuation, some experiments; thesis Leyden (1985).

Trubetskoy, N. S.: Grundzüge der Phonologie (Vandenhoeck & Ruprecht, Göttingen 1958).

Vanderslice, R.: Synthetic elocution: considerations in automatic orthographic-to-phonetic conversion of English with special reference to prosodic features. UCLA Work. Pap. Phonet. *8:* (1968).

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Dr Vincent J. van Heuven,
Department of Linguistics,
Phonetics Laboratory,
Leyden University,
PO Box 9515,
NL–2300 RA Leiden (The Netherlands)