



THE INFLUENCE OF FOCUS DISTRIBUTION AND LEXICAL STRESS ON THE TEMPORAL ORGANISATION OF THE SYLLABLE

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ABSTRACT

According to Neijt [8] two independent representations for prosodic prominence are needed in languages such as Dutch and English. A non-culminative autosegmental structure with high and low tones accounts for pitch accents in focused constituents, and a culminative metrical structure accounts for the lexical stress position in a word, which is phonetically coded in relative duration. The most far reaching consequence following from this proposal is that relative temporal structure of a word does not change if a pitch accent is shifted to an unstressed syllable. Sluijter [12] showed on the basis of syllable duration measurements that this prediction was untenable. However, since the rhyme of the syllable is the most important part for stress assignment, we reanalysed our duration data for the onset and rhyme portions separately. Our results now support the hypothesis of a culminative metrical structure, which remains observable even when pitch accents do not cooccur.

I. THEORETICAL BACKGROUND

Tonal structure is the succession of H (high) and L (low) tones in a sentence [5]. If a particular tone is accent lending (indicated by an asterisk following the tone symbol) the syllable or larger unit carrying the accent is put in focus, i.e., made communicatively important. Phonetically, an accented syllable is characterized by a fast pitch movement (rise, fall or both), [6]. Generally, all the segments in the accented version of a word are pronounced longer than in the unaccented version in stressed and unstressed syllables alike [4].

Metrical structure (the prominence relations among syllables expressed as strong and weak nodes in a tree structure) is predominantly coded in the durational properties of syllable strings [11]. The lexically stressed syllable is the metrically most prominent syllable. This syllable has the longest duration (after normalisation for inherent segment duration and linear position within the word).

The conclusion seems warranted, and has in fact been advanced by Neijt [8], that metrical structure determines relative duration of syllables within words and that the only temporal contribution of an pitch accent is linear expansion of the entire word.

Neijt goes one step further by concluding that the contributions of metrical structure and accent to the temporal organisation are independent. However, this conclusion might be premature. The literature data that were used in support of this view, were exclusively based on experiments in which pitch accents occur on lexically stressed syllables. The conclusion that the relative duration of syllables is independent of accentuation can be based only on speech material with accents on unstressed syllables as well. Once we know what happens when stress and accent no longer coincide, it may be possible to decide on the validity of Neijt's conclusion.

On the basis of linguistic theories there are three possible rela-

tions between duration and tone, each predicting a different outcome of such an experiment:

- 1 No separate levels for metre and tone; metre determines tone:* Pitch accents are always placed on the metrically most prominent syllable. Tone structure is not represented on a separate level, but it is just another acoustic correlate of metrical structure. This option was put forward by Chomsky and Halle [3]. However, they based their mechanism only on neutral utterances whose accents always occur in stressed positions. We will not go into this option any further. The fact that there are constructions in which a contrastive accent is realized on an unstressed syllable [2] makes this option unviable.
- 2 Separate levels for metre and tone; the levels do not interact:* Duration and tone structures are represented on separate autonomous prosodic levels [8]. Metrical constituent structure [7] reflects the relative duration of the syllables. Tone structures are generated by rules and conventions of autosegmental phonology [5]. Tonal prominence is brought about by a pitch movement on a constituent that places that constituent, or a larger constituent of which it is the prosodic head, in focus [1]. The prediction of this view is that contrastive accents do not affect the relative duration of the syllables no matter where an accent is placed.
- 3 Separate levels for metre and tone; tone determines metre:* Pitch accents are able to change not only absolute duration, but also the relative duration structure of words. Tone and duration have separate prosodic levels but are not independent: lexically unstressed syllables carrying a pitch accent have to be made metrically prominent [10]. The prediction of this view is that the relative duration of syllables within a word is affected by an accent on an unstressed syllable. Selkirk [10] endorses the this view, although she explicitly excludes contrastive accent constructions from her theoretical domain. In her opinion the metrical level accounts for the rhythmical organisation of the various constituents. The assignment of a pitch accent changes the metrical structure on the level of the word and above, but not on levels below the word. Below the word level her view is compatible with that of Neijt [8].

In [12] we described a production experiment in which accent position was varied in disyllabic words by placing different parts of the same word in focus. We measured absolute and relative syllable durations. The measurements showed that if accent position was shifted to the unstressed syllable, relative duration behaves as if the stress position was shifted. We therefore concluded that Neijt's assumption of completely independent representations was untenable and adopted a revised version of Selkirk's theory. We extended the use of Selkirk's rules to below the word level. Thus our version of the theory differs from that of Selkirk in two respects: (i) it was extended to the levels below the

word and (ii) contrastive accents were now accounted for as normal accents. The viability of this latter assumption was also examined in [12] as a methodological question. Since we did not find any difference in the phonetic realization of contrastive accents and normal accents on exactly the same material, we accepted our extension of Selkirk's theory as valid.

The conclusions in [12] were based on syllable durations, whereas only the rhyme part of the syllable is generally accepted as the linguistically relevant part for stress assignment in quantity sensitive languages like Dutch and English [7]. It is therefore conceivable that the results will be more meaningful if we consider only rhyme durations thereby removing an irrelevant source of variation introduced by the onset durations. In the present contribution we shall reanalyse the materials collected in [12] and examine the effects of stress and accent position on the level of syllable constituents: rhyme vs. onset.

In summary, we focus on the following research question: (i) does the relative duration of a syllable rhyme in a word change when an accent is realized on an unstressed syllable of that word? Also, there is an extension to the methodological question that addressed the postulated exceptional status of contrastive accents as opposed to normal accents: (ii) is it true that speakers make no difference, in terms of rhyme and onset duration, between a contrastive accent on the lexically stressed syllable and a normal accent on that syllable placing the whole word in focus?

II. METHOD

2.1 Focus conditions

Accentuation is used to focus [1], i.e., to highlight a word or a group of words. This is done by placing an accent on one of the words in that constituent. If the accent is on the prosodic head of the word group, it can highlight the whole word group ("broad focus") or just the word ("narrow focus") containing the accent. In the former case we speak of an integrative accent. Narrow and broad focus were here defined on the word level [1].

In our experiment words and individual syllables were placed in focus. Therefore, we treated the notions "narrow" and "broad" focus as relative notions and defined them on the syllable level as well. When a whole word is placed into focus, we use the term broad focus. This broad focus is expressed by an integrative accent on the lexically stressed syllable of that word. If only one syllable is placed in focus, expressed by a pitch accent on that syllable, we use the term narrow focus.

We need four experimental conditions to answer the research questions. A condition in which no accent is realized on the target word was adopted as the baseline condition. Question (ii) compares normal and contrastive accents. Therefore, we needed a condition with a normal integrative accent on the word and a condition with a narrow-focus accent on the stressed syllable. To answer the main question of this paper we needed a condition in which an accent is realized on the unstressed syllable to compare it with the condition in which an accent is realized on the stressed syllable (integrative or contrastive). To realize the four focus conditions the following question-answer pairs were used (accented syllables are written in capitals, lexical material in focus is underlined, the target word in the examples is always versie 'version'):

1. *No focus (NF)*: focus on a word other than the target word, e.g.:

Q. Heb je versie geZEGD of opgeSCHREVEN?
'Have you version said or written down?'

A. Ik heb versie geZEGD.
'I have version said'

2. *Broad focus on the word (BF)*, expressed by an integrative accent on the lexically stressed syllable of the target word. The target word was contrasted with a word taken from the same semantical field, e.g.:

Q. Heb je VERSIE of DEEL gezegd?
'Have you version or part said?'

A. Ik heb VERSIE gezegd.
'I have version said'

3. *Narrow focus on the lexically stressed syllable (SF)*, expressed by a narrow-focus accent on that syllable. The target word was contrasted with a word with an identical unstressed and a different stressed syllable, e.g.:

Q. Heb je VERSIE of FUSIE gezegd?
'Have you version or fusion said?'

A. Ik heb VERSIE gezegd.
'I have version said'

4. *Narrow focus on the unstressed syllable (UF)*, expressed by a narrow-focus accent on that syllable. The target word was contrasted with a word with an identical stressed and a different unstressed syllable, e.g.:

Q. Heb je verSIE of verBUM gezegd?
'Have you version or verbum said?'

A. Ik heb verSIE gezegd.
'I have version said'

2.2 Stress position and rhyme structure

The position of the stressed syllable in Dutch di-syllabic simplex words depends on the weight of the **rhyme** of the final syllable. If the final syllable contains a long vowel and at least one final consonant it is regularly stressed. If the final syllable is open, stress regularly falls on the first syllable. As a consequence it is impossible to come up with segmentally identical structures differing in regular stress position. In such minimal stress pairs, one stress position will have to be marked as an exception. However, we also want to compare different stress positions across identical syllable structures. Therefore we need a 2*2 factorial design for our lexical material, as exemplified in the table below:

	initial stress	final stress
vc-vv	versie 'version' <i>regular</i>	pigmeë 'pigmy' <i>exception</i>
vc-vvc	potlood 'pencil' <i>exception</i>	portiek 'doorway' <i>regular</i>

Each cell in this stimulus matrix was filled with 2 or 3 lexical instantiations.

2.3 Subjects and acoustical analysis

The total set consisted of 44 question-answer stimuli (4 focus conditions x 11 words). The stimuli were randomized and read twice by two speakers. All accents were realized as so called pointed hats [6]. Rhyme durations were then measured by hand using a high resolution waveform editor.

Onset durations were computed by subtracting the rhyme durations from the syllable durations which had been measured in our earlier paper [12]. Relative rhyme duration was expressed, for each syllable, in per cent by dividing its absolute rhyme duration by the total rhyme duration (i.e., the absolute rhyme duration of the first syllable plus the absolute rhyme duration of the second syllable) and then multiplying the fraction by 100. Relative onset durations were calculated by applying the same procedure to the duration of the onset portions.

III. RESULTS

3.1 Preliminary data analysis

A three-way analysis of variance was performed on both absolute and relative rhyme duration with focus and word type as fixed factors and speaker as a random factor. Although speaker 1 in general has somewhat longer initial syllables [$F(1,174)=23.0$, $p<.001$] and speaker 2 longer final syllables [$F(1,174)=5.3$, $p=.023$], there are no significant interactions involving the factor

speaker. Therefore, we decided to collapse the results over both speakers in the breakdown of means. Table 1 presents mean absolute and relative rhyme durations broken down first by word type and broken down further by focus condition.

Table 1. Absolute rhyme durations (in ms) and relative duration of the rhyme of the stressed syllable (in % of the total rhyme duration) broken down by word type by focus condition (NF, BF, SF, UF, see above)

VC-vv (VERsie)			VC-vvc (POTlood)		
rhyme1	rhyme2	%rhyme1	rhyme1	rhyme2	%rhyme1
+stress	-stress	+stress	+stress	-stress	+stress
NF 147	80	65	151	128	54
BF 162	121	58	169	160	51
SF 165	115	59	168	160	51
UF 140	154	48	150	183	45

vc-VV (pigMEE)			vc-VVC (porTIEK)		
rhyme1	rhyme2	%rhyme2	rhyme1	rhyme2	%rhyme2
-stress	+stress	+stress	-stress	+stress	+stress
NF 119	136	54	79	130	62
BF 131	177	58	92	155	62
SF 122	193	61	91	165	63
UF 182	163	47	135	155	53

Overall effect of word type. Table 1 shows that there is a difference between the four word types. The differences in duration are statistically significant both for the duration of the initial rhyme [F(3,172)=39.2, p=.007], and the duration of the second rhyme [F(3,172)=41.6, p=.006] as well as for the relative duration of the initial rhyme [F(3,172)=56.0, p=.004].

Overall effect of focus. Focus condition also affects the absolute duration of the rhymes. Rhymes in condition NF are always shorter than the same rhymes in condition BF and SF. These latter two focus conditions have virtually the same rhyme durations. For each dependent variable, the difference in duration between the focus conditions is significant [initial rhyme: F(3,172)=21.5, p=.016; second rhyme: F(3,172)=92.8, p=.002; relative rhyme duration [F(3,172)=91.5, p=.002].

Interactions. All the interactions between focus and word type were highly significant [all cases p<.001]. The significance of these interactions is caused by a difference in stress position across the four word types. Given these interactions between focus and type we decided to examine the influence of focus on the duration structure of words for each word type separately, by one-way analyses of variance performed on both absolute and relative rhyme duration with focus condition as the fixed effect. Newman-Keuls range tests ($\alpha \leq 0.05$) were used to make pairwise post hoc comparisons between the means. The results will be discussed in separate sections.

3.2 Detailed analysis: effects of focus

The influence of normal accentuation. Both rhymes (i.e., of first and second syllable) are shorter by about 25% in an unaccented word (NF) than in a normally accented word (BF), while the relative duration of both rhymes is unaffected by the presence or absence of an accent. Thus the influence of accentuation on duration is restricted to the absolute duration.

Contrastive accents versus normal accents. In [12] we did not find any difference in temporal organisation of the syllables between the condition in which a narrow-focus accent was realized on the stressed syllable and the condition with an integrative accent on the same stressed syllable. Table 1 shows that rhyme durations, and therefore also onset durations, are identical for these conditions (BF versus SF)¹. Thus the narrow focus that a

listener wants to express on the stressed syllable in the narrow focus condition is not realized by lengthening that syllable or changing its build-up relative to the same syllable with an integrative broad-focus accent. Obviously, the temporal structure is identical in both conditions.

Narrow focus on the stressed syllable versus narrow focus on the unstressed syllable. Our crucial research question concerned the validity of the hypothesis that duration structure will not be influenced by any type of accentuation. Based on the results presented in table 1 (condition SF versus UF) we can conclude that this hypothesis is false. Shifting the accent from the lexically stressed syllable to the unstressed syllable changes the absolute and relative duration of the two rhymes involved. In all cases the relative rhyme duration of the stressed syllable decreases by about 10 percent relative to the rhyme of the stressed syllable in the other focus conditions. We therefore conclude that duration structure changes under the influence of an contrastive accent. However, it would be premature to conclude that the abstract metrical structure changes as well, as will be explained below.

Let us compare the relative duration structure of words with a narrow-focus accent on the stressed syllable and words with a narrow-focus accent on the unstressed syllable. We derive different predictions from the different theories described in the introduction. If it is true that the placement of an accent on the unstressed syllable leads to a shift of the metrical prominence onto that syllable, we expect that the relative duration structure of a 'vc-vv(c) word with a narrow-focus accent on the stressed syllable has the same relative duration structure as a vc-'vv(c) word with a narrow focus accent on the unstressed syllable. In both cases an accent is placed on the first syllable making that syllable metrically prominent. Alternatively, if metrical structure is preserved we should at least find a remnant of the original duration structure. We found the following pattern in our data (the stress position is indicated with ', the accent position is written in capitals, the focus position is underlined):

RELATIVE RHYME DURATIONS

rhyme structure	[+acc]		[+acc]	
	↓		↓	
vc-vv	'VER-	sie	<u>59%</u>	41%
	PIG-	'mee	<u>53%</u>	47%
vc-vvc	'POT-	lood	<u>52%</u>	48%
	POR-	'tick	<u>47%</u>	53%

'ver-	<u>SIE</u>	48%	<u>52%</u>	
pig-	<u>MEE</u>	39%	<u>61%</u>	
'pot-	<u>LOOD</u>	45%	<u>55%</u>	
por-	<u>TIEK</u>	38%	<u>62%</u>	

These results suggest that stressed syllables preserve some of their original duration. The unaccented rhyme of the stressed syllable *mee* becomes 47% instead of 41%; *ver* becomes 48% instead of 39%; *tiiek* becomes 53% instead of 48% and *pot* 45% instead of 38%. Thus there is a considerable effect of accent on duration, but there is also a residual effect of stress. The results that were found for the syllable durations in [12] only showed a residual effect of stress position in vc-vvc words. From the latter results we concluded that metrical structure was not preserved. However the rhyme part of the syllable, considered as the most important part with respect to stress assignment, shows a residual effect of stress position in both vc-vv words and vc-vvc words. The original stress position is still visible in the rhyme part if the accent shifts to the unstressed syllable. Because of the fact that the residual stress effect almost disappears in the syllable durations of vc-vv words [12], we have to assume that relative onset duration is negatively correlated with relative rhyme duration. Since we also calculated onset durations, we are now in a position to present relevant onset durations in the same format as above:

RELATIVE ONSET DURATIONS

rhyme	[+acc]				[+acc]		
structure	↓				↓		
vc-vv	'VER-	sie	66%	34%	'ver-	SIE	53%
	<u>PIG-</u>	'mee	<u>80%</u>	20%	pig-	<u>MEE</u>	71%
							29%

These data show that onsets of underlyingly stressed syllables in vc-vv words are indeed shorter than onsets of underlyingly unstressed syllables, e.g., the unaccented onset of mee becomes 20% instead of 34%. Thus there is a considerable effect of accent on the relative syllable, rhyme and onset duration, but the residual effect of stress is restricted to rhyme in vc-vv words and visible in onset and rhyme in vc-vvc words. Thus there is a considerable effect of accent on duration, but there is also a slight residual effect of stress.

3.3 Control for inherent segmental duration

There is no guarantee, a priori, that the residual effect of abstract stress on de-accented syllables, is not a by-product of differences in inherent duration of the accidental segment structure of the target syllables involved. To check for the possibility of artefact due to inherent duration we ran a control study. The two speakers that produced the speech material for the present experiment, also recorded the 22 target syllables as monosyllabic nonsense items embedded in the accented position in two fixed carrier phrases, one allowing accurate segmentation of final vowels and sonorants, the other allowing optimal segmentation of final obstruents. Onset and rhyme durations were measured for both speakers. Subsequent analyses of variance revealed that there are no systematic differences in either syllable or rhyme durations (absolute nor relative) between the four lexical word types, nor is there any interaction between speaker and word type. Therefore, differences in inherent segment duration between the four lexical types cannot explain the residual effect of abstract stress.

IV. GENERAL DISCUSSION

In this study we examined the contributions to the duration structure of words of lexical stress and contrastive focus as realized by a pitch accent. Neijt [8] described this relation by assuming two independent levels for durational and tonal prominence. She claimed that relative durational structure, reflecting metrical structure is fixed. The consequences of this account were investigated in the present experiment.

It was shown that the absolute duration is influenced by realization of an accent. The unaccented version of a rhyme is shorter than the accented version. However, relative duration structure of a word does not undergo a change due to word focus accent on that word. These results are in agreement with earlier results [4,9].

Moreover, we saw that there was no acoustic difference between a narrow-focus accent on the stressed syllable and an integrative word accent on the stressed syllable. A speaker does not place a syllable in narrow focus by changing either the absolute or the relative duration of its rhyme or onset. Accent placement does influence the absolute duration of the entire word but placing the stressed syllable in narrow focus does not have an extra effect on the duration change. Notice that the same effect has been reported for larger constituents. Placing a word in narrow focus has no consequences for the temporal organisation of the word group relative to the same word group in broad focus with an integrative accent on the same word [4]. Thus it seems that focus domains are generally not marked by temporal means. In answer to our methodological question (ii), we therefore again conclude that contrastive accents are not different from normal accents.

As for the main research question, we found the following result: the relative duration of the rhyme changes in words with a narrow-focus accent on the unstressed syllable. Moving the accent from the stressed to the unstressed syllable leads to a decrease in relative duration of the stressed rhyme of about ten percent which is added to the unstressed rhyme. However, there is a residual effect of stress position. This residual effect reflects the original underlying metrical structure.

Contrary to our earlier conclusion based on syllable durations, we conclude that Neijt's assumption of an immovable metrical structure seems to describe the facts better than Selkirk [10]. However, Neijt assumed that the relative duration was not influenced at all by an accent. The results of the present experiment force us to reject this part of her hypothesis, which is better described by Selkirk. Thus, the phonetic reality is more complex than the present theories can cope with.

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1. A detailed F0 analysis of the data revealed that the conditions also had exactly the same location, duration and excursion size of the pitch accent.