WORD STRESS IN PROSODIC CONTEXT

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SUMMARY

This contribution deals with the acoustic realisation of 'primary' versus 'secondary' stress in monomorphemic and compound words in Dutch, and with the effect of the prosodic sentence accent on the acoustic realisation of syllables carrying lexical stress in simplex words. Measurements show a linear phonetic factor interacting with phonological variables to determine the acoustic realisation of lexical stress. Also, the important acoustic correlates of stress turn out to react differently to phonological prominence on higher prosodic levels. The unit under investigation is the syllable with 'main' stress; we believe the syllable to be the domain in which stress is manifested.

INTRODUCTION

Most phonetic work on stress has involved the search for the acoustic manifestations of lexical stress, and the question of the perceptual 'cue value' of each of a number of acoustic parameters which have come to be associated with stress. Stressed syllables differ from unstressed ones in that they show longer duration, specific pitch movements and more intensity. The difference between stressed and unstressed syllables is, however, not limited to the first element. In the experiment reported on here, the prosodic structure known as the phonological phrase is the context in which compounds and simplex words appear and within which phonetic conditions were rigidly controlled.

The highest level where prosodic prominence relations occur is that of the sentence. Sentence accent distinguishes strong and weak (more prominent or less so) intonational phrases, on pragmatic and contextual bases. The effect of sentence accent on syllables of either status is the second issue that was studied. Traditionally, sentence accent is primarily associated with specific prominence lending pitch movements, while acoustic features like intensity and syllable duration are affected to a lesser degree. In the context of the present experiment, there were two questions to be answered:

1) What is the difference, in acoustic terms, between a syllable assigned phonological main stress and the same syllable bearing 'secondary' stress in the wester phonological environment formed by the second part of a compound?

2) How does the presence or absence of sentence accent affect these characteristics?

To answer these questions, acoustic measurements were performed on some 500 syllables, pronounced in controlled phonetic contexts. Along with providing insights into the acoustic effects of both status and sentence accent, this setting defined a new phonetic parameter, namely the position of the syllable within the word.

THE EXPERIMENT

Material

Speech material was devised to study the influence of stress, lexical accent and to introduce a third independent variable, the position of the lexical stress within the word. The material was based on fifteen trisyllabic words with lexical stress on the first, middle or last syllable, five times each. The phonetic variable of position of the target syllable in the word was cued by the numeral indicating first, second or third position. To minimize acoustic differences caused by syllable make-ups, equal word length was ensured across word position types. The words are listed at the end of this paper.

To form two kinds of word groups in which the target word would be either strong or weak, we embedded the target word in a phrase, where the target would be strong, and in a nominal compound, where it was the second element and, thus, weak. So, the syllable could end up in a monomorphemic word (main stress) or in the weaker part of a compound (secondary stress). For example, (the target syllable is the middle syllable of kimono): 'die rode kimono'(that red kimono) (secondary stress): 'die mode-kimono'(that fashion-kimono) (main stress).

As the examples show, the phonetic context within the phrase was kept as similar as possible. The number of syllables preceding the stressed one was kept constant, through the introduction of the adjective. The CV-structure of all syllables within the phrase was the same, with identical vocalic segments.

In order to study the effect of the presence or absence of sentence accent, we used two different sentences of which the phonological phrase could be a part. One sentence prompted a reading with sentence accent on the phrase in question. In the other sentence the phrase was relatively unimportant; it was easy to pronounce it without sentence accent. The sentences were:

(accent) Geen idee niet die . . . je toepassing te toepassen. (don't forget to mention that in your speech) (no accent) Ik geef NKS om die . . . die de daar aanrangen.' (I don't care AT ALL for that . . . they're selling there.) Both sentences were to be pronounced as one intonational block.

Speakers, instructions and the recording session

Speakers were 8 males, who pronounced the set of sentences presented to them in random order. Each speaker produced 60 utterances: the product of 15 target words x 2 status possibilities x 2 sentence accent conditions. After some training, all speakers produced the accent patterns desired. This does not mean they delivered exact replicas of an example: performance was checked on the basis of perceptual equivalence. Recordings were made in a soundproofed studio with semi-professional equipment, the sessions led by the experimenter.

Measurements and computed values

Acoustic measurements were performed on the syllables stressed and without accent, both in compounds and phrases. 1) For each syllable, a number of values to capture pitch, duration and intensity, were measured. From three, new variables were computed, taking into account intensity features were obtained, computing into account speakers' speech rate, and melodic and dynamic speech characteristics.

- The new duration variable expressed syllable duration as a proportion of the sum of the four unreduced syllables in the compound or comparable phrase.

-Syllable intensity was expressed in dB above the intensity baseline. This was defined as the lowest mean value observed on unstressed syllables, for each speaker and condition separately.

- To arrive at the new pitch variable, the aim was to express pitch changes rather than absolute values. These changes were then to be related to speakers' melodic ranges. Pitch range was defined as the difference between highest pitch observed on stressed syllables and lowest pitch as found on unstressed syllables in a condition without accent, both mean values for each speaker and condition separately. The pitch change was chosen as the largest pitch movement occurring on a given syllable, and expressed as a percentage of the pitch range. 2) While using the variable names of 'pitch', 'duration' and 'intensity', reference is made to the variables defined above. Mean values were computed for these new variables, to gain an overview of the acoustic differences in each linguistic condition. Analyses of variance served to determine which of the independent linguistic variables (status, accent and the linear phonetic factor described above) most influenced the dependent acoustic variables.

RESULTS

The results for the three variables are presented separately. An overview of the results of the analyses of variance is in the Summary Table of Effects, given in the final section.

Intensity

As Figure 1 shows, there is an effect of word type on the values of the intensity variable. They range from means of 7.7 to 7.5 to 4.7 dB above the baseline for types 1 to 3. F(2,384)=3.0; p<.001. It is clear that the final position in the word leads to low intensities. This tallies with suggestions in Pierrehumbert (1979), where the phenomenon of amplitude downdrift in sentences is described.
The status of the stressed syllable also produces a clear difference in intensity: means of 7.1 dB for syllables with primary stress, against 6.2 dB for syllables with 'secondary' stress in compounds. This difference was statistically significant: F(1,384)=17.77, p<.001.

The presence of sentence accent resulted in higher intensities. The mean value of 7.5 dB for accented and 5.8 dB for unaccented items. Again, this difference was significant: F(1,384)=72.50, p<.001. There were no interactions at the significance level employed in this study.

Proportional syllable duration

The results for the duration parameter are presented in Figure 2. The most striking effect on the duration parameter can be seen on the horizontal axis. As the stressed syllable is situated further back in the target word, its duration is longer than if it is in the weak part of a compound. Remarkably, the presence or absence of sentence accent had no influence on the proportional duration in the analysis of variance the effect of accent was not significant.

There were no significant interactions between the independent variables. This means that the actual increase of the proportional duration across word types is independent of the status of the word. The two factors of type and status operate separately.

Pitch movements

The mean values for the proportional pitch movements are presented below. Figure 3 shows that word type and accent have significant effects on pitch movements (as well as on sentence accent). Type and status interacted with sentence accent. The second order interaction of type and status and accent yielded significant results as well.

Table 1 below gives the results of the analyses of variance with a significance level of p<.001. For the interactions, the effect of accent was not the same for three variables: duration increased towards the end of the word, while pitch movements got smaller, while intensity was negatively affected by the final position in such words. The status of the syllable had an effect as well. If a syllable was embedded in a compound, as the least prominent element, its intensity was lower, while the duration was (generally) shorter and its pitch movements were smaller than in a simplex word. To sentence accent, notice how this increased syllable pitch and intensity, but not duration. Higher order interactions occurred with the pitch variable only.

Table 1: Summary of the analyses of variance performed on the Pitch (Duration) and Intensity data.

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<td>type x accent</td>
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<td>status x accent</td>
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<td>all variables</td>
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Figure 3: Mean pitch movement, expressed as a proportion of the speaker's pitch range, for stressed syllables in various positions, in compounds and without sentence accent.

The results of the present study show unequivocally that there were no significant differences in the results obtained for accent or sentence accent. The pitch movements constitute the most complex variable; not only are status, accent and sentence accent important, but also their interactions further determine the behavior of the pitch variable.

The strategy to tackle this wealth of variables produced in speech would be to find out which of the observed regularities are also perceptual, and to what extent. Currently, we are investigating the interaction of syllable position and size of prosodic elements in a pitch adjustment experiment with naive listeners. It is only on the basis of results in the perceptual realm that we can realistically assess what is essential in higher level prosodic analysis.

REFERENCES


Notes

1) The measurements were performed by means of a speech editing system and the ILS speech analysis system.

2) We have compared the behavior of the pitch movement variable to that of the absolute pitch reached in the syllable. Effects of type, status and accent were present, with this difference: from types 1 to 3, the pitch peak was somewhat lowered, while the pitch movement diminished considerably. Examination of the measurements revealed no inconsistencies: in final positions, the pitch peak was reached via earlier steps on preceding syllables, so that the final step was indeed the smallest.

3) In spite of our efforts to rule out speaker-related variation in the variables computed, the factor 'speaker' still caused significant effects on duration and intensity. Also, two-factor interactions of 'speaker' and other independent variables occurred in the values of both pitch variables.

NOTES

1) This research was supported by the Foundation for Linguistic Research, which is funded by the Netherlands Organisation for the Advancement of Pure Research, ZWO. The authors are due to Jip Wester, for criticism and patience, and to Bert Cranen, for help with the measuring procedure.

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LIST OF WORDS USED

Stress on first syllable: bariton, risico, dominie, genesis, Aardappel
Stress on second syllable: dynamo, familie, kimono, komedie, fluit
Stress on third syllable: chocola, melodie, mirabeau, defil, residu.