THE NUCLEAR STRESS RULE AND THE DESCRIPTION OF ENGLISH STRESS*

ROBERT McALLISTER

1. PROBLEM

This presentation is a discussion of the correlation between syntactic structure and stress contours in American English. The problem was made more tractable within this framework by using the recent and well-known work of Chomsky and Halle described in *The Sound Pattern of English* (1968) as a point of reference.

Correlation has been sought between the output of the Nuclear Stress Rule (NSR) when applied to a right-branching syntactic structure and the fundamental frequency and intensity parameters in the speech wave. In other words: what do THE STRESS CONTOURS THAT ARE THE OUTPUTS OF THIS RULE MEAN IN TERMS OF THE PHONETIC FACTS?

Central in this presentation is an attempt to discover regularities in the aforementioned parameters that might lead to the formulation of rules that more adequately express the relevant factors in the correlation between surface structure and the speech wave.

2. EXPERIMENTAL PROCEDURES AND SPEECH MATERIALS

Special attention was given to the construction of the test phrases. The syntactic structure has been strictly defined and methodically expanded. Starting with a simple two-constituent tree 'big pants', a right branching tree was built up by expanding the construction to the left.

Figure 1 is a summary of the material used in this study presented in terms of its derivation. Sentence A represents the syntax in its longest form and below sentence A is the derivation of its stress contour through the cyclical application of the NSR. The phrases 1-7 below the stress level numerals are the phrases used as test utterances in this study. They are positioned so that the numerals above these sentences represent both a step in the cyclical derivation of the stress contour of sentence A and the final stress contour of phrases 1-7 which were used as test utterances.

* Read by Björn Lindblom.
the final stress contours of the test utterances. Mingograms were made of recordings of five readings of this material and fundamental frequency and intensity was measured.

3. RESULTS

Figure 2 is a summary of the average $F_o$ contours for all the test phrases considering only the stressed words. There seems to be no linear correlation here between the output of the NSR and the $F_o$ parameter in the speech wave. Chomsky and Halle’s (1968) use of the numbers which represent stress level would indicate a greater degree of perceptual prominence in connection with higher level of stress. It is clear from Figure 2 that when we consider the NSR, prominence does not bear a 1-1 relation with $F_o$.

Figure 3 shows a summary of the intensity contours considering only the stressed words. It is obvious that these curves are similar in some important ways to the $F_o$ data. As was the case for the $F_o$ curves in Figure 2 it appears difficult to discover meaningful correlation between the intensity patterns and the stress level contours which are the outputs of the NSR.

4. DISCUSSION

These data would be adequate motivation for us to systematically evaluate the NSR as a means of predicting acoustic parameters in the speech wave. In this evaluation, an NSR-based model for the prediction of the $F_o$ and intensity parameters in this study will be compared to an alternative model based on the number of stresses in a phrase and position of words in the phrase. In an NSR-based model, we must make use primarily of numerical outputs of this rule as a basis for predictions. A reasonable demand that may be placed on this rule is that it, through its stress contour outputs, show a correlation between the syntax (information the rule makes use of in its operation) and phonetic reality by predicting the parameters we have discussed in this paper. The capacity of the NSR to do so for the $F_o$ parameter is illustrated in Figure 4. This is a summary of observed $F_o$ values for each stress level including data for all the stressed words isolated and in context. It is immediately apparent that at least two problems are associated with the NSR-based model. First, there is no linear correlation between descending $F_o$ or intensity values and descending stress levels. The second problem apparent here is the spread of the data. The NSR-based model not only does not account for the spread, but perhaps more important, does not account for the obvious regularities in this spread. These two problems are also apparent in Figure 5, which shows the same type of summary for intensity as the previous one for $F_o$. Use of an NSR-based model for the $F_o$ and intensity patterns in this study would require considerable adjustments of the NSR outputs. These adjustments would be based on some of the same factors which an alternative model would make use of for prediction of $F_o$ and intensity such as the number of stresses and their position in the utterance.

Examination of the figure material presented in this study leads to the conclusion that it is possible to formulate rules that have quite different characteristics than the NSR. Instead of the syntactic information used by the NSR, it is possible to derive the $F_o$ and intensity values for the words in the test phrases by considering (1) the length of the phrase and (2) the position of the individual word in the phrase.
In Figure 6, observed values for $F_o$ have been plotted as a function of values predicted with formulas which utilize the number of stresses in the phrase and position of stress as variables. Figure 7 shows the same plot for the intensity parameter. It appears that these formulas display a reasonable degree of adequacy in prediction these parameters for the phrases in this study. The fact that these predictions can be made with only two variables, position and number of stresses, which in any case would have to be incorporated into the adjustments of NSR outputs to obtain equally satisfactory predictory capacity leads us to the conclusion that the NSR is, in fact, of no use in these predictions.

5. CONCLUSION

The preceding evaluation of the NSR raises the question of Chomsky and Halle’s view of stress and the role of the phonetic representation expressed in The Sound Pattern of English. If the phonetic representation can be viewed as a set of commands
to the speech mechanisms about the speech signal that is to be produced, and if rules, in this case the Nuclear Stress Rule, have outputs which are part of a phonetic representation which shows little correlation to the speech wave produced, we must conclude that the demands of the phonetic representation must be better defined and that rules which give rise to this phonetic representation be accordingly formulated.

Department of Speech Communication  
Royal Institute of Technology  
Stockholm

REFERENCES

Chomsky, N. and M. Halle  

McAllister, R.  

DISCUSSION

WODE (Kiel)  
Does McAllister's approach allow the specification of $F_0$ etc. for any morpho-syntactic string whatever, or is it limited to the set of examples contained in the experiments? Furthermore, which information is used for assigning the $F_0$ peaks etc. correctly to the respective underlying morpho-syntactic material?

McAllister  
The answer to your first question is simply that we do not know yet. As regards the assignment of $F_0$ values, McAllister's rules presuppose information on the degree of stress, (stressed, unstressed) position of stress and the number of stresses per utterance.

COLLIER (Michelen, Belgium)  
I would like to know whether the $F_0$ values are relative or absolute ones. It seems as if they are absolute. If that is the case, I would think it is quite unusual for absolute $F_0$ to be a good measure for the degree of stress.

McAllister  
The $F_0$ values are absolute. The reason for this is that the paper is based on material from one speaker. I think it is reasonable to suspect, however, that the overall $F_0$ and intensity patterns discussed in the paper have some generality since the utterances used seem to be regarded by native speakers as fully acceptable and prosodically neutral. If this is so, the absolute values could easily be replaced by constants in the formulas so that the same general contours can be predicted.

As to the question concerning absolute $F_0$ as a measure of degrees of stress I am not sure I understand the question. It was not my purpose to show that, say, 140 Hz should be considered stress level 2 and 90 Hz level 8. To argue that such an assignment of $F_0$ value to stress level would show any relevant linguistic generality would be unusual indeed. As a general rule of English, the NSR should be applicable to one speaker. The discussion here concerns the investigation of what relation the numerical outputs of the NSR have to the $F_0$ contours (expressed in absolute values) of this speaker.