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THE PERCEPTION OF STRESS IN INITIAL SYLLABLES\*

Lori Taft

This paper addresses the general question of the role of suprasegmental information in word identification. Current models of auditory lexical access have assumed segmental analysis of the acoustic input and lexical representations which are linear concatenations of segments (Marslen-Wilson and Welsh, 1978; Cole and Jakimik, 1979). In this paper I examine the consequences of assuming that one type of suprasegmental information, stress, is also a potential source of information in word identification.

1. Background

Before presenting the theoretical assumptions I am making for this study, I will review some general facts about spoken word recognition. First, the input to the auditory processor is temporally ordered, from "left to right". A listener receives information about the beginning of a word before he receives information about the end of the word (under normal listening conditions). This means that efficient word identification follows from efficient and accurate interpretation of the initial portions of words.

Second, spoken word recognition is fast. Identification of a word may be made within 175-200 milliseconds after its acoustic onset (Marslen-Wilson, 1978). In many cases, this means that a word is identified before all of it has been heard.

Third, once a word is identified, the listener pays less attention to the remaining acoustic input corresponding to that word (Marslen-Wilson and Welsh, 1978; Cole and Jakimik, 1979).

The lexical access model which has most directly taken these facts into consideration is the "cohort" model of spoken word recognition (Marslen-Wilson and Welsh, 1978; Marslen-Wilson, 1978). This model attempts to account for the time-course of word recognition and the relative importance of various types of information at different points in the identification of a word.

For the remainder of this paper I will adopt the cohort theory as a framework for discussion of the role of suprasegmental information in lexical access. In the next section I present the relevant aspects of the cohort model.

2. The Cohort Model of Lexical Access

The cohort model is an example of a "direct access" model of word recognition. All word-candidates are accessed directly and are available for comparison with the incoming signal.<sup>1</sup>

The cohort is established on the basis of acoustic ("bottom-up") information in the initial portions of a word (roughly, the first 2-3 segments). Once the cohort is defined, its members (i.e., all words of the language beginning with that particular sound sequence) will be compared to the incoming signal. The matching process proceeds left to right, comparing successive points in the

input signal to successive points of each candidate in the cohort. When a mismatch is found between a word candidate and the input, that candidate is eliminated from the cohort. Eventually, all words but one are eliminated from the cohort. The candidate which remains is the correctly identified word.

One question raised by the cohort model concerns the defining properties of the cohort. According to the assumptions of the theory, acoustic information alone is used to establish the cohort. This means that all words which are acoustically similar to each other in their initial portions will be in the same cohort.

From the assumption that lexical representations are linear concatenations of segments, we are led to believe that all words which are segmentally identical in their initial portions are members of the same cohort. If so, then words which are segmentally identical but which differ in stress pattern (e.g., PER'mit, perMIT') should be in the same cohort. On the other hand, if stress pattern is also a parameter of cohort establishment, then words with different stress patterns should be in different cohorts.

In order for stress to be a defining property of a cohort, information about a word's stress pattern must be available to a listener within the first two or three segments of a word - or, approximately, within the first syllable.

In the experiment reported below I tested listeners' ability to identify a word's stress pattern on the basis of its initial syllable.

### 3. Experiment

In order for stress pattern to be one of the defining characteristics of a cohort, a listener must receive accurate information about a word's stress pattern within the first few segments of a word. The purpose of this experiment was to see whether listeners do indeed get stress information from initial syllables. If the answer to that question is "yes", it means that the information is potentially used to establish a cohort.

The specific hypothesis is that there is sufficient information in the first syllable of a word to accurately identify the stress pattern of the word.

This predicts that if a subject hears only the first syllable of a word, he can correctly identify the stress pattern of the whole word (though he might not correctly identify the word itself). For instance, if a subject hears the initial syllable of the word PER'mit, he will know that the syllable came from PER'mit (with a stressed initial syllable) and not from perMIT' (with a stressed final syllable). Likewise, if a subject hears the first syllable of perMIT' he will know that the syllable came from the word with a stressed final syllable.

Materials. A list was constructed of 16 pairs of English words. The members of each pair were segmentally similar (contained the same linear concatenation of phonemes) but differed in stress pattern. All words were bisyllabic and had either initial stress (henceforth "SW", indicating Strong-Weak) or final stress (WS); for example, PER'mit-perMIT', EX'port-exPORT'.

## Taft: The Perception of Stress in Initial Syllables

In some word pairs of this type, the vowel quality of the first syllable differs depending on whether the syllable is stressed or not. The vowel is full if it is stressed (e.g., [kan] in CONtest) and reduced if it is unstressed (e.g., [k n] in conTEST).

In others, there is little difference in vowel quality between the stressed and unstressed versions; the vowel is more or less full in either case. For example, in both EXport and exPORT the initial syllable is [ks].

Equal numbers of each type of word pair were included in the test materials. The words are given in (1).

(1) Reduced initial weak syllable:	Unreduced initial weak syllable:
CONduct-conDUCT	EXtract-exTRACT
CONtest-conTEST	INcline-inCLINE
DIgest-diGEST	PERmit-perMIT
OBject-obJECT	PERvert-perVERT
PROgress-proGRESS	SUBject-subJECT
PROject-proJECT	SUSpect-susPECT
PREsent-preSENT	TORment-torMENT
REbel-reBEL	TRANsport-transPORT

Each test word was placed in a neutral sentence context: "I am about to say the half-word ....."<sup>2</sup> Sentences were recorded in a sound-proof booth by a female speaker of American English.

Two versions of each test item were prepared. For one version, the initial syllable of the word was excised from the sentence context and recorded on a second tape. For the other version, the entire sentence, up to the end of the test word's first syllable, was recorded on the second tape.

Two lists were prepared for the isolation condition, and two for the in-context condition. Each list contained all of the test items and were balanced for word-type (reduced vs. unreduced weak initial syllables) and stress (half SW and half WS). All lists differed in order of presentation.

Subjects. A total of 48 subjects participated in the experiment. All were undergraduates at the University of Massachusetts and were given course credit for their participation. All were native speakers of English with no known hearing impairments.

Presentation. Subjects were tested individually, in a quiet room with the experimenter present. They were told that they would hear a tape of the first syllables of two-syllable words, either in a sentence or in isolation. (This did not vary within subjects.) They were told that their task was to say the first word that came to mind that could be a possible continuation for that initial syllable. The experimenter was present during each session and transcribed each response.

Results. In many cases, the response word was longer than two syllables, and primary stress in those cases often is located past the second syllable. However, for our purposes what is relevant is the stress relationship between the first two syllables of the word. For each test word, this relationship

(represented as SW or WS) was compared to the responses (6 total for each item) The number of cases in agreement was counted as the number of correct responses.

The results are given in Table I. (All item scores are given in the Appendix.)

Table I. Mean Number of Correct Responses

	Reduced	Non-reduced
Context	5.5	4.38
Isolation	4.13	3.13

For both isolated syllables and in-context syllables, correct-response rates were significantly better than chance ( $t=3.66$  for isolation,  $t=6.43$  for context,  $p<.01$  for both). For each word, a t-test for matched pairs, comparing context and isolation, was computed and was found to be significant ( $t=3.59$ ,  $p<.01$ ). A paired t-test was also done to compare strong vs. weak initial stress for each word. For neither isolated nor in-context syllables was the difference significant.

A t-test for differences of means between reduced and non-reduced initial-syllable types was computed for both context and isolation. In context, the difference was significant ( $t=2.519$ ,  $p<.05$ ) though in isolation, the difference was not significant ( $t=2.009$ ,  $p>.05$ ).

#### 4. Discussion

The results support the hypothesis that the stress pattern of a word is potentially predictable from its initial syllable. Overall, identification rates were significantly better than chance, indicating that both in isolation and in context, listeners are getting some information about stress in the initial syllable of a word.

The comparison of context vs. isolation shows that context helps the listener in making these stress judgments. This is not surprising, since even a neutral context sets up a prosodic framework which can be used to compare incoming material. A syllable may be judged as stressed or unstressed on the basis of the preceding context regardless of the nature of the remainder of the word. For a syllable in isolation, this particular relational information is not available.

There is a significant difference in correct response rate between words whose first syllables are reduced and words whose first syllables are not reduced. There appears to be more information in the first syllable about a word's stress pattern if, in the case of WS word types, the first vowel is reduced. If it is not reduced, it more closely resembles its stressed counterpart and a decision about its stress value cannot be made until more of the word is heard.

This suggests an interesting dual role of stress in lexical access. In one sense, stress information is "absolute". An unstressed syllable can be recognized as such in isolation if it is reduced. If a syllable is not reduced, however, the stress information is relational. The stress value of a syllable cannot be deduced until more of the word is heard and a relationship can be established between the two syllables.

These results are particularly interesting in light of the cohort theory. Both in sentential context and in isolation, a word's overall stress pattern is, under certain circumstances, predictable from its first syllable. How could we incorporate such a finding into the cohort theory?

Given the assumption that the word-initial cohort is established solely on the basis of bottom-up information, it may be that stress information is part of that bottom-up information, and hence contributes to the establishment of the cohort. For instance, suppose that the word to be recognized is PERmit. If upon hearing the initial syllable the hearer can determine that it bears primary stress, then a number of potential members of the cohort would be excluded (namely, those that begin with [por] but do not have initial stress).

The reduced-syllable data is also interesting from the perspective of the cohort model. This could mean, for instance, that word pairs such as REbel and reBEL should not be in the same cohort, since information about their stress pattern is available at the time the cohort is established. On the other hand, for a word pair such as PERmit-perMIT, such information is not available at the time the cohort is established. Both words would be included in the cohort.

In this case, we may advance another possible role of stress in the cohort model, as mismatch information. In the PERmit-perMIT case, in which both words are in the same cohort, it is not clear what the recognition point for each word would be, since they are segmentally identical. However, if we assume that stress is used as mismatch information, we can predict that the recognition point will be as soon as the segment carrying stress information (e.g., the vowel of the second syllable) is heard. We can thus see how the relational nature of stress might be incorporated into a left-to-right model of word recognition.

APPENDIX  
Individual Item Scores

Word:	S W pronunciation		W S pronunciation	
	No. correct in context	No. correct isolation	No. correct in context	No. correct isolation
<b><u>NONREDUCED</u></b>				
permit	5	5	3	2
subject	3	3	5	3
incline	4	5	5	3
pervert	5	3	4	3
extract	1	4	6	4
transport	3	1	4	3
suspect	5	5	5	5
torment	6	4	3	3
<b><u>REDUCED</u></b>				
present	6	6	5	2
conduct	3	4	6	5
contest	3	2	5	4
project	4	6	5	4
object	4	5	6	5
rebel	5	4	6	4
progress	6	5	5	4
digest	2	2	6	5

FOOTNOTES

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1. The alternative to a "direct access" system is a "search" system, in which the lexicon is searched, word by word, until the correct match between entry and input is found. See Forster (1976) for a discussion of this type of model.

2. Huss (1978) reported that in a sentential context, the perception of words in a position following nuclear sentence stress is dependent on the rhythm of the sentence. In particular, the difference in stress between, e.g., INsult and inSULT can be neutralized and the word that is perceived by the listener is the one which fits with the rhythm of the sentence. A possible future experiment would compare the following two contexts for possible similar effects for these words in nuclear stress position:

"I am about to say the word \_\_\_\_\_."

"I am about to say the half-word \_\_\_\_\_."

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