

EXPERIMENTAL EVIDENCE FOR PHONOLOGICAL UNITS

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ABSTRACT

Experimental evidence is discussed that bears on the psychological status of three kinds of hypothesized units in phonology: the **syllable**, the **phoneme** (or **segment**) and a variety of **intermediate units** that have been proposed (viz., the **onset**, **rhyme**, **nucleus**, **coda**, **head**, and **margin**). Some of these units are seen to be more viable than others, though in all cases more cross-linguistic evidence is required.

INTRODUCTION:

THE SYLLABLE AND THE PHONEME

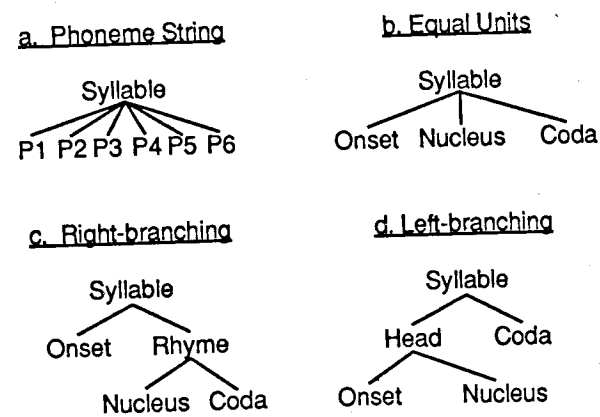
A variety of theoretical units have been proposed for the phonological description of languages and for the internal lexicon, but few experimental tests have as yet been carried out to determine which, if any, of these hypothesized units are psychologically real for speakers. Least controversial of the proposed units, perhaps, is the **syllable**, for, although much work certainly remains to be done on the question of actual syllable boundaries (not to mention cross-linguistic work on languages of different canonical types), it is nonetheless clear that something very close to the traditional notion of the syllable is a viable psychological unit for speakers of languages like English and Russian from the earliest linguistic stages of childhood (see especially [1,2,3] for evidence that even young children can do quite well at counting the number of syllables in words and can manipulate whole syllables in a variety of different experimental tasks).

Somewhat more controversial, however, is the notion of the **phoneme**, which corresponds in scope to the traditional idea of the individual consonant or vowel **segment**. Although most theorists in both phonetics and phonology have tacitly assumed that something akin to the phoneme is the basic unit of speech segmentation by speakers, experimental evidence in support of this position is neither abundant in quantity nor unequivocal in its interpretation. To begin with, for example, all three of the studies already cited above suggest that pre-literate children, at least, are much less successful at counting or otherwise manipulating individual phonemes than they are in dealing with whole syllables; and even after literacy is achieved, in fact, English-speaking children still exhibit some confusion in dealing with words for which the grapheme and hypothesized phoneme counts may differ (as in examples like *pitch* and *judge* [4]). Furthermore, though by now quite a variety of different controlled experimental techniques have been employed in the attempt to assess the psychological status of the phoneme (including concept-formation [5], string similarity judgments [6,7,8], and discrimination tasks [7,8], in addition to segment counting [8,9,10]), it is apparent that orthographic effects have contaminated the results of all of these studies at least to some extent, so that no clear answer has yet emerged on the phoneme issue (see especially [8] for a full discussion and review).

INTERMEDIATE UNITS

In addition to the syllable and the phoneme/segment, a number of units have also been proposed that are intermediate in scope between the two. Such **intermediate units** are highly controversial in two senses: (a) there is much theoretical disagreement on such fundamental matters as the actual number of such units and how they are organized in relation to one another, and (b) because, until the relatively recent advent of the so-called "metrical" approach to phonology (see [11] for an overview), few theorists subscribed to the idea that such units even existed. The classical view of the syllable, in other words, regarded it as a simple **linear** sequence of phonemes, with no internal structure beyond this (see Fig. 1a).

Figure 1. Alternative Models of Syllable Structure



Contemporary **hierarchical** models, however, assign to the syllable a kind of constituent structure not unlike that found in syntax. In one version of this model, for example, the syllable is broken down into the three intermediate units of **onset**, **nucleus** and **coda**, each of equal status (Fig. 1b). In another version of this model, the nucleus and coda are linked as part of an additional constituent called the **rhyme** (or **rime**), yielding the right-branching structure shown in Fig. 1c. In a third version of this model, a left-branching structure is proposed by grouping the nucleus with the

onset, rather than with the coda, thus supplanting the rhyme constituent in favor of what is called here the **head** (Fig. 1d). Finally, a third model, less prominent in the literature, provides for significant groupings of segments that are linked, not in a hierarchical way, but rather in terms of "affinity bonds" of varying strengths [12]. Such a **bonding** model allows for the introduction of significant units such as the **margin** (equivalent to Vennemann's "shell", i.e., onset + coda) that would involve cutting across constituent boundaries in the hierarchical framework.

Though research on this question has been quite limited to date, there is a modicum of evidence that attests to the viability of at least some intermediate units of the kinds described. Hierarchical models seem to account better for speech error data than does the simple linear model, for example [13], and some reading research has further suggested that even graphemes may be read preferentially in terms of onset and coda units, rather than as arbitrary letter pairs or triples [14]. More recently, in a series of experiments involving the use of novel word games, Treiman found that rules involving onsets, rhymes, and, to some extent, codas were easier to learn than rules that involved breaking up these units [15]. Such units are part of all three versions of the hierarchical model, however, not to mention the bonding model, so a new series of experiments was recently performed in our laboratory in the hope of further clarifying the situation (see [16] and especially [17] for further details).

Experiment 1 was a simple unit-counting task performed by young (K and G1) children and by high school students. As expected from prior studies, the former performed best on the syllable counts (61% correct) and worst on the phoneme counts (12%); a new finding was that performance on the intermediate units was significantly better than on the segments, particularly under the onset + rhyme analysis (36%). The HS students performed almost perfectly on the syllables (96%) and were

able to count both segments and intermediate units at about half of this level of accuracy.

Experiments 2 and 3 both involved variants of a highly flexible new experimental technique that we call the substitution-by-analogy task. This technique involves the aural presentation of two pairs of monosyllables (real or possible words), both of which illustrate a common modification pattern; the subject is then required to modify a test item "on analogy" with the examples. For instance, the pairs *beam-stream* and *cling-string* both illustrate a common change in the onset to /str-/ (from /b-/ and /kl-/), respectively), keeping the rest of the syllable (the rhyme) intact. In Experiment 2 a variant was used in which the manipulated unit was replaced by null (i.e., deleted), and the only three types of units involved were onsets, codas, and incomplete units (in which individual segments were deleted out of either an onset or a coda, as in *sprang-rang*). Subjects in this experiment were the same as in Experiment 1. The results were that the children performed significantly better in deleting onsets (42%) than either codas (12%) or incomplete units (7%), while the high schoolers deleted onsets and codas with about the same high rate of success (89% vs. 94%), significantly better than when either type of unit was broken up (63%). These findings attest to the integrity of both onsets and codas as phonological units for mature subjects, but with the former appearing earlier in development than the latter.

In Experiment 3 a variety of non-null patterns were employed for all six of the hypothesized intermediate units discussed above, with controls introduced for the number of segments affected, for spelling matches vs. mismatches, and for real vs. nonsense words. The results were scored in terms of both proportion correct and response latencies (for correct responses only), and both analyses revealed an almost identical response pattern, with rhymes and onsets the easiest/fastest to manipulate, nuclei and codas next, and heads and margins by far the most difficult/slowest.

An analysis of error types also showed a strong tendency for errors to move in the direction of changes in the onsets or rhymes, with very few errors of the other types.

CONCLUSIONS

Taken together, these results not only serve to confirm the earlier indications that a hierarchical model is preferable to the linear one (which implies that all single-segment changes ought to be of equal difficulty, demonstrably not the case), but, by revealing the prominence of the rhyme constituent, they also indicate that the version of the hierarchical model shown in Fig. 1c is preferable to either of those shown in Figs. 1b or 1d. A fourth experiment is now in progress, utilizing a phonetic similarity judgment technique, that we hope will help in the proper interpretation of the consistently poor performance on the heads and margins: are they not units at all, or are the "bonds" merely weak? It is also important to establish whether or not the superior performance on the onsets and rhymes will extend to languages of diverse canonical types and with orthographic and poetic traditions that are different from English.

REFERENCES

- [1] L. Zhurova. Razvitiye zvukovogo analiza slov u detey doskol'nogo vozrasta. *Voprosi Psikhologii* 9.20-32, 1963.
- [2] I. Liberman, D. Schankweiler, F. Fisher, B. Carter. Explicit syllable and phoneme segmentation in the young child. *Journal of Experimental Child Psychology* 18.201-212, 1974.
- [3] B. Fox, D. Routh. Analyzing spoken language into words, syllables, and phonemes: A developmental study. *Journal of Psycholinguistic Research* 4.331-342, 1975.
- [4] L. Ehri, L. Wilce. The influence of orthography on readers' conception of the phonemic structure of words. *Applied Psycholinguistics* 1.371-385, 1980.

- [5] J. Jaeger, Testing the psychological reality of phonemes. *Language and Speech* 23.233-253, 1980.
- [6] P. Vitz, B. Winkler. Predicting the judged 'similarity of sound' of English words. *Journal of Verbal Learning and Verbal Behavior* 12.373-388, 1973.
- [7] B. Derwing, T. Nearey. Experimental phonology at the University of Alberta. In J. Ohala & J. Jaeger (eds.), *Experimental phonology*. Academic Press, 1986.
- [8] B. Derwing, T. Nearey, M. Dow. On the phoneme as the unit of the 'second articulation'. *Phonology Yearbook* 3.45-69, 1986.
- [9] M. Dow. *On the role of orthography in experimental phonology*. M.Sc. thesis, University of Alberta, 1981.
- [10] B. Derwing, M. Dow. Orthographic effects on lexical representations. In S. Delancey & R. Tomlin (eds.), *Proceedings of the Second Annual Meeting of the Pacific Linguistics Conference*, University of Oregon, 1987.
- [11] H. Van der Hulst, N. Smith. An overview of autosegmental and metrical phonology. In H. Van der Hulst & N. Smith (eds.), *The structure of phonological representations (Part I)*, Foris, 1982.
- [12] T. Vennemann. The rule dependence of syllable structure. Unpublished ms.
- [13] S. Shattuck-Hufnagel. Sublexical units and suprasegmental structure in speech production planning. In P. MacNeillage (ed.), *The production of speech*. Springer, 1983.
- [14] J. Santa, C. Santa, E. Smith. Units of word recognition: Evidence for the use of multiple units. *Perception and Psychophysics* 22.585-591, 1977.
- [15] R. Treiman. The structure of spoken syllables: Evidence from novel word games. *Cognition* 15.49-74, 1983.
- [16] M. Dow, B. Derwing. Experimental evidence for syllable-internal structure. Paper presented at the UWM Linguistics Symposium on Linguistic Categorization, Milwaukee, WI, April, 1987.
- [17] M. Dow. *On the psychological reality of sub-syllabic units*. Ph.D. dissertation, University of Alberta, 1987.