[*Mechanical Translation and Computational Linguistics*, vol.11, nos.1 and 2, March and June 1968]

Computer Backup for Field Work in Phonology

by Joseph E. Grimes, John R. Alsop, and Alan Wares, Summer Institute of Linguistics

In the study of a previously unrecorded language, a taxonomy of the sound system is the most useful starting point for developing the phonological component of a grammar. If the linguist makes at least tentative assumptions about segmentation and fixes the limits of supposedly relevant contexts, a computer can approximate this taxonomy. A program by Alsop reduces a concordance of phonetic segments in their contexts to a series of taxonomic statements about phoneme distribution by applying Bloch's criteria for contrast within limited contexts. When applied to data on Paipai, a Yuman language of the Colorado delta, collected by Wares on a survey trip, the program found contrast between segments Wares had identified as allophones in two parallel consonantal series, indicating a distinction of presumably low functional load with morphophonemic implications.

There was a time when phonological analysis was thought of primarily as a data-processing operation to be performed on strings of symbols in a phonetic transcription. The symbols were classified with reference to their environments, and the resulting taxonomy was an end in itself.

One of the reasons this approach foundered was that no linguist is a sufficiently good phonetician to make it work consistently. The strings of phonetic symbols have to be completely correct. On the other hand, evidence from instrumental phonetics and theoretical backing from generative grammar suggest that even a good phonetic transcription will not necessarily guarantee a complete phonological analysis. There is also plenty of field experience that indicates that a self-correcting approach to field work can give the desired analysis readily, even though one starts with only reasonable phonetic ability. The first author explains such an approach in detail in a text on phonological analysis [1].

A second defect in phonology from phonetic transcription was its tendency to regard the sounds of speech as a unilinear sequence of segments. Junctures were put into the stream of speech by some linguists, and intonational change points were added; but the characteristic groupings of sounds in syllables, feet, and contours were regarded more as a nuisance than as part of a model of phonology.

There was also some fuzziness about the difference between investigating relationships among sounds for their own sake and relating sounds to the rest of language. There was something especially fitting about describing the phonology of a language with as little reference as possible to the way that phonology functioned in communication as a system for realizing the output of the grammar.

Although the phonology of the 1950s had its problems, it would be foolish to discount it as all bad. For field work, in which we include the process of validating the results of introspection about one's own language as well as that of validating observations about someone else's language, it provided the plan for an essential step that a modern linguist skips only at the risk of basing his generalizations on nothing but an ad hoc subset of a language that is convenient for him.

Even though a phonological taxonomy is no longer by itself a final goal in linguistic analysis, a linguist who tries to study the phonology of a language without first making a good taxonomy stands as much chance of success as a burglar who makes a robbery without first casing the joint to see what he is up against. There are times when this preliminary investigation can be aided materially by the use of a computer.

Normally we advocate working out a phonological taxonomy by hand. For the average language studied in the field, over 85 percent of the taxonomy can be pinned down in this way in a couple of weeks, while under the same circumstances it would take at least that long to get things ready for a computer. Furthermore, effective field procedures make maximal use of phonological grouping phenomena; and these are much more difficult to cope with in an algorithm than are unilinear symbol strings. The possibility of getting a really comprehensive analysis of the sounds people make when they talk is at present, then, greater if the computer is left out of the picture.

There are, however, three cases where a computer can contribute to making phonological taxonomies. The first is in simulating gibberish that is phonologically legal. One attempts to validate a taxonomy under what amounts to a random input from grammar. The second is in going over data that were collected under conditions that did not permit systematic, thoroughgoing examination of phonology, as, for example, in the linguistic survey of an unknown area. The third is in endeavoring to reinterpret linguistic material that was collected under the old assumption that a good phonetic transcription was the most scientific way to handle linguistic data.

The first case, random derivation of phonetic specifications, can readily be accomplished by the sort of programs that are already in use for simulating grammatical derivations [2]. The second kind of computation, which would also work for the third, or reanalysis of older phonetically oriented materials, was implemented by our group and tested on field survey materials with interesting results.

To begin with, some simplifying assumptions were made. Phonetic data were treated as a linear string by simply ignoring their very real grouping properties. Furthermore, the environment that was considered relevant for classifying sounds was arbitrarily limited to one segment before and one segment after the segment in focus. This bypassed the problem raised by Noam Chomsky about how much environment is needed to classify sounds [3] and permitted the use of Bloch's logical criteria for contrast [4]. By these criteria, pairs of sounds are said to *fluctuate freely* if any environment of one is also an environment of the other; they are in *complementary distribution* if no environment of one is also an environment of the other; and they are in *contrast* if some environments of one are also environments of the other but some are not. In computing terms, this involves testing the left and right neighbors of pairs of sounds. If the set on each side of one has identical membership with the corresponding set on the same side of the other, the sounds are reported to be in free fluctuation. If the set of neighbors of one sound on one side has no members in common with that of the other sound on the same side, the sounds are reported to be in complementary distribution. In any other case they are reported to be in contrast. Contrast implies a strong expectation that the difference between the sounds would somewhere in the language have to be taken into account in distinguishing underlying representations of formatives. Free fluctuation and complementation both imply a strong expectation that the phonetic difference is attributable to context. The program was implemented by Alsop in SPS II assembly language on the IBM 1620 at the University of Oklahoma and at the Instituto Politécnico Nacional de Mexico.

Wares had previously made a survey of indigenous groups that speak Yuman languages in Lower California and around the Colorado River delta. His list of around 600 words collected in Paipai was prepared for processing. Phonetic symbols were transliterated into strings in the computer character set and recognized by table lookup.

The most interesting result of the computer analysis of Wares's data was the phonological separation of velar and back velar stops and fricatives. Wares had noted phonetic *k* and *ķ*, *x* and *x̧* in his transcription. He had thought, however, on examining his data under the pressure of survey conditions, that the back velars occurred only adjacent to *o* and *a,* while the others never did. The program showed that both pairs were independently in contrast. In addition, it showed that the nonsyllabic voiceless vocoid *h* was in free fluctuation with the velar fricative, as in *xupá* 'four,' *hupá* 'four.'

The program also gave evidence for a suspected contrast between apical *s* and retroflex *s*, as in *saķ* 'leaf and *şák* 'to whip.' Between the voiced bilabial stop *b* and the corresponding fricative *β*, it corroborated the complementation that Wares had found.

Because the program did not react to hierarchical sound patterns like syllables and feet, patterns of stress and of vowel length did not show up in the results. The program treated long and short vowels as though they fluctuated freely, for example. It did not recognize minimal pairs like *ñá* 'path, road,' which is short, and *ñá·* 'sun,' which is long; and *yú* 'eye,' which is short, and *yú·* 'owl,' which is long.

A change in the pattern-recognizing approach is being considered to segregate phones at particular positions in syllables, syllables in feet, and feet in contours. The intermediate storage of what amounted to a phone concordance of the data was a major problem on the 1620; with larger machines a list structure for the right- and left-neighbor sets of each phone should prove easier to work with.

Received May 10, 1969

References

1. Grimes, Joseph E. *Phonological Analysis.* Mexico City: Summer Institute of Linguistics, 1969.
2. Bobrow, Daniel G., and Fraser, J. Bruce. "A Phonological Rule Tester." *Communications of the ACM,* vol. 11 (November 1968).
3. Chomsky, Noam. "The Logical Basis of Linguistic Theory." In *Proceedings of the Ninth International Congress of Linguists,* edited by Horace G. Lunt. The Hague: Mouton & Co., 1964.
4. Bloch, Bernard. "Contrast." *Language,* vol. 29 (January 1953).