Cognitive Phonetics — Some of the Evidence

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Reproduced from *'In Honor of Ilse Lehiste'*, eds. Robert Channon and Linda Shockey. Published in 1987 by Foris Publications, Dordrecht.

Cognitive Phonetics has been proposed (Tatham, 1983, 1986) to try to deal with the theoretical problem concerning the link between phonology and phonetics. The source of the problem is that two areas of linguistics have developed as different types of model. Phonology has been concerned with hypothesizing mental processes in dealing with establishing the sound pattern and phonetics with the neuromuscular events related to physical realization of the output of these phonological processes.

The difficulty lies in trying to account for the physical implementation of mentalistic units, or looked at the reverse way: how can a mentalistic unit be programmed into the neuromuscular system?

Cognitive Phonetics is about the mental processes involved in manipulating the vocal tract mechanism. It is concerned with the control of the speech mechanism after the phonology has established the sound pattern of the language. Cognitive Phonetics differs from phonology in that phonology selects from an inventory of sounds provided by phonetics; Cognitive Phonetics then makes decisions about how to realize the requirements of the phonology.

I should like to try to substantiate the view that Cognitive Phonetics is not the same as a low-level area of phonology by looking at particular types of data.

The speech mechanism is configured in various ways to produce sound. Within this range of sound produced, the hearer can identify different groups of sounds and differentiate between them. The human perceptual system has limits of discrimination which constrain the size of the inventory of sounds usable in the language. This set of sounds is further filtered by the need to be able to reproduce these sounds in the same manner in a relatively unvarying fashion. They must be repeatable. Thus the set of physical sounds which a phonology may employ as mental representations can only have members which are

- able to be perceived as distinct from each other, and
- able to be produced reliably such that they can be perceived unvaryingly by the hearer.

Sounds that are capable of being perceived a. and those that can be produced for perception b. are variables dependent on the overall inventory selected by the phonology. Two sounds, S1 and S2, might not satisfy conditions a. and b. in a particular language. They may not be opposed in any encoding or decoding operation, but S1 may be used in one language and S2 in another. So S1 and S2 are measurably different in the laboratory, are available for selection for a phonological inventory, but cannot both be selected for the same language. An example of this is [s] in English and French.

In general, [s] is articulated in French with a narrower constriction and greater intraoral air pressure than in English. This gives rise to greater aerodynamic post-constriction turbulence and a higher frequency and amplitude. The mental representation of both sounds at the phonological level is identical, in that [s] is different from [š] and [f], etc. The phonological decision for both languages is to have the single abstract object we symbolize as /s/; the phonetic decision for French is that this should be actualized with narrower constriction than for English. This cognitive process is phonetic, not phonological, since it has nothing to do with the sound pattern. It is also language dependent but not a property of the vocal tract mechanism itself, since a single individual can produce either sound at will, given a bit of practice. The constriction, which means width of gap between tongue front and palate, is a physical variable which is under cognitive control. It is limited by the mechanics of the vocal apparatus.

The apparatus is able to produce this kind of constriction; the phonology can abstractly employ it for sound pattern encoding; the phonetics can choose a degree of precision within the mechanical limits for production. What cannot happen is that the phonology selects an English type and a French type sound in the same language,

- because the degree of phonetic control available cannot guarantee a precise enough acoustic event to enable reliable perceptual discrimination, or
- because perceptual discrimination is not fine enough even if the phonetic control is there.

Another example: phonetic realization of the phonological feature [voice] in stop consonants produces the articulatory effect of delay of vocal cord vibration onset for vowels immediately following these consonants. Many researchers have shown that the actual average delay varies from language to language even in those languages where only two segments are being realized and differ between [+voice] and [–voice]. The delay, called VOT (voice onset time), which is phonologically dominated by the same [voice] feature in two different languages, may be systematically different. This difference, which is under voluntary control but which is systematic, is, controlled cognitively.

As another example, take the different tongue heights involved in actually pronouncing the vowel iii in French and English. French is consistently higher than English, but by the same reasoning as before, no single language may have both [i] of the French type and [i] of the English type. The phonological mental representation is identical; the phonetic representation is different. The precision with which these sounds are produced in each language is related to the contrasts required by the phonology of that language.

As a further example, consider /s/ as realized phonetically in standard European Spanish. Phonetically this approaches [s] in English, having a wider constriction, less turbulence and lower acoustic amplitude and frequency than English [s]. Probably also there is wider variation in its articulation. The reason for this is that Spanish has chosen not to have, phonologically, contrasting /s/ and /š/, leaving open, for phonetic realization of /s/; a greater acoustic range than could be allowed in English without causing perceptual confusion and possible problems of accuracy of motor control.

These examples involve decisions by the speaker about selection from a range of possibilities. When a particular realization of a phonological requirement is possible, then a process of selection occurs. It is clearly not left up to the vocal mechanism itself to freely realize abstract phonological requirements. It is suggested that a Cognitive Phonetic capacity controls this selection for the purposes of the phonology. There is another aspect to the role Cognitive Phonetics plays.

Realizations of intended phonological units which are repeated exhibit variations. The output of the vocal mechanism is not in a one-to-one relationship with the underlying representation of the utterance in the phonology. In the phonology segments are either the same or different, which means unambiguously able to function distinctly for encoding purposes. However, in deciding the inventory for this functioning, control of variability is a major consideration. Too much closeness or overlap in realization and the distinction between units cannot be made. Cognitive Phonetics controls the amount of separation necessary for the hearer to make a necessary phonological distinction and dictates the amount of variability acceptable.

In addition, we can observe that variation in articulation of segments or features of segments is often expressed differently from language to language or within one language between phonological context. Thus a segment might show on repeated articulation a wider variation, or less precision, than the same segment in another language. The existence of variation is inherent in the mechanical system, but since the variation is systematically different in different languages or in different contexts then the degree of the variation is under control. That control is cognitive since it involves a computation based on the sound pattern of the language. This also results in an increase in the size of the potential phonological inventory.

If one thinks of phonological segments as occupying a perceptual space, the range of variation determined by the mechanical system takes up a particular area. A phonology would be unable to use segments whose area overlapped. So intrinsic variability, that variability determined by the mechanical system, constrains phonological candidature for a segment.

However, if it were possible to reduce these areas by special control so that there would be no overlap and this control could be consistently precisely maintained, adjacent segments could be used in their abstract versions in the phonology.

It seems to be the case, for example, that where a language has vowels 'bunched' in a particular part of the vowel space, such narrowing of variation takes place. Or another example, the front/back range of variability in palatal consonants is narrower the more of these consonants a language has.

It's thought to be unlikely that a mature speaker sets up a phonological inventory each time he speaks. But there is one phenomenon that has been observed which suggests some sort of active ongoing cognitive process. Precision, or narrowness of area of variation, tends to vary itself during utterances for the articulation of the same segment in different contexts. This may mean that degree of precision of realization of the segment is not set once and for all by some phonological consideration but can vary as and when necessary. It is suggested that such precision is cognitively dominated. It involves a knowledge of the perceptual confusion effects of certain phonological contexts, and involves knowing if and to what extent certain phonetic contexts are going to suddenly change the variability of this segment's realization. It also involves a computation based on these factors which can assess their relative weighting of importance.

In considering a theory of Cognitive Phonetics, one needs to examine speech with a view to determining the nature of intervention in the actual speech production mechanisms. It seems clear that there can be such intervention. A theory which describes the output of a phonology and the intrinsic properties of the vocal mechanisms cannot on its own explain the data observed in the laboratory. Although there is of course a great deal that remains for phonology to describe and we don't know everything about motor control and aerodynamics, it is possible to see systematic phenomena which cannot be explained by either. These phenomena do not appear to be generated automatically, they seem to have mental representation, yet not be strictly phonological. These are the phenomena which constitute the evidence for a Cognitive Phonetics.

References

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