Processing Constraints of the Native Phonological Repertoire on the Native Language

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The Phonological Inventory as an Explanatory Factor in Psycholinguistic Experiments

As has been documented by contributors to this session, and by many other researchers, it is difficult to learn a non-native phonological inventory in those respects in which it dors not correspond to one's native language. The native phonological repertoire exercises severe constraints on second language learning.

It is beginning to become apparent, however, that the nature of the phonological repertoire may also exercise constraints upon processing in the native language. The presentation by Mehler (Mehler and Christophe, this volume) described unexpected disparities between the results obtained from ostensibly similar experimental procedures in French, English, Spanish and Catalan. The experiments measured listeners' response time (RT) to detect a match between a target CV or CVC sequence and the initial sounds of a word. In French, RT was crucially determined by whether or not the target corresponded exactly to a syllable of the word (Mehler, Dommergues, Frauenfelder and Segui, 1981). In English, in contrast, there was no effect of syllabicity, but a strong effect of whether the target-bearing word began CVCV or CVCC (Cutler, Mehler, Norris and Segui, 1986), reflecting the relative frequency of these patterns in the English vocabulary (Cutler, Norris and Williams, 1987). In Spanish, there was only an effect of target size, while in Catalan there was a syllabicity effect which appeared only in words with non-initial stress, and a target size effect which appeared only in words with initial stress (Sebastian-Galles, Dupoux, Segui and Mehler, 1992). Given that psycholinguists aim to study the human language processing system rather than processing in the individual case, it was disturbing to obtain such a variety of results from the same experimental paradigm in languages which are, historically, quite closely related.

As explanations of the different findings, the researchers invoked phonological differences between the four languages. Cutler *et al.* (1986) singled out the characteristic stress rhythm of English, especially the opposition of strong and weak syllables (i.e., syllables with full *vs* reduced vowels), in explaining the French-English differences; Sebastian-Galles *et al.* (1992) pointed to the difference in the size of the vowel inventory (large in French, small in Spanish) in accounting for the French-Spanish difference, and to the presence of reduced vowels in Catalan in explaining the Spanish-Catalan difference.

As the presentation by Kuhl (this volume) made strikingly clear, the native vowel inventory is of central importance in the development of speech capacities. Already within the first half year of life, as Kuhl's results show, infants form a representation of the vowel repertoire of the language to which they are exposed. It is perhaps not surprising that differences in vowel inventory may then be found to be crucially involved in how words are segmented by the adult language user. In our laboratory we have recently identified another effect which we believe may reflect the nature of a language's repertoire of vowels.

Vowels as Phoneme Detection Targets

The phoneme detection task, in which listeners' response time to detect a phoneme target is measured, has been widely used as a tool for studying components of human speech recognition: segmentation of continuous speech, word recognition, syntactic processing, and so on. Reasonably, the task has been of little interest in its own right, and the choice of which phonemes to use as detection targets has often been assumed to be arbitrary. In fact, for ease of measurement, most experiments have used stop consonant targets.

We have recently carried out a series of experiments in which subjects responded to vowels as phoneme detection targets. Two experiments are reported in Cutler, Norris and van Ooyen (1990): in the first experiment, targets occurred in real words, in the second in nonsense words. In each experiment we tested five vowels; four of these were full vowels, and the fifth was the central vowel schwa. Targets could occur in first or second syllables, stressed or unstressed; thus [al, for example, occurred in *CARton, carTOON, PLAcard,* and *disCARD* (plus 20 further words) in the real-word experiment. Response time was measured from the onset of the target vowel.

In both experiments, response times were long by comparison with consonant targets, and error rates were high. Full vowels were responded to faster and more accurately than reduced vowels in real words, but not in nonwords. We concluded that the process of phoneme detection in English is more difficult for vowels than for consonants.

In a follow-up experiment we measured detection times for consonants and for vowels in the same subject (van Ooyen, Cutler, and Norris, 1991). Subjects listened for two vowel targets which were highly distinct ([a] and [i]), and for two consonant targets which were highly confusable ([p] and [t]). Targets occurred in word- initial, word-medial and word-final positions. Again, response times to vowel targets were significantly longer than to consonant targets, in all positions (although the difference was smallest in word-initial position).

When listeners misperceive speech, they tend to make fewer errors on vowels than on consonants (Bond and Games, 1980). This should suggest that vowels are relatively perceptible, and hence should have proved relatively easy to respond to in a phoneme detection task. But the vowel space of English is quite densely populated; although vowels are intrinsically perceptible (they have relatively long durations, are periodic, etc.), they are *relatively similar to one another.* We speculate that it is this availability of similar competitors (which may result, for instance, in difficulty in forming a memory representation of the target sound) which is responsible for the difficulty of vowels as phoneme detection targets.

Note that the findings of our follow-up experiment, in which two distinct vowels were still harder to detect than two similar consonants, rule out a claim that the results of our first two experiments were simply due to confusability of the target sets *in these experiments.* Instead, we blame the confusability of the English vowel repertoire as a whole.

This hypothesis obviously implies that vowel detection should prove less difficult in languages with sparser vowel distributions than English. In both Spanish and Japanese, for instance, there are only five vowels, which occupy highly distinct positions in the vowel space. If our interpretation of the relative difficulty of vowel detection in comparison with consonant detection in English is correct, then vowel detection should prove to be *not* harder than consonant detection in these languages.

A further implication of such an explanation, however, is that phoneme detection would be recorded as another psycholinguistic paradigm in which language users' performance is unexpectedly constrained by the phonological inventory of their native language.

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