LANGUAGE AND COGNITIVE PROCESSES, 1997, *12* (5/6), 839–845

The Syllable's Role in the Segmentation of Stress Languages

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THE "SYLLABLE EFFECT"

If French listeners are asked to detect, as rapidly as possible, the phonological fragment *ba-* in a series of spoken words, they respond faster to the word *balance* than to *balcon*; conversely, the target *bal-* is detected more rapidly in *balcon* than in *balance*. Syllable boundaries in French are clear: The first syllable of *balance* is *ba-* and the first syllable of *balcon* is *bal-*. Thus listeners consistently respond faster to targets which correspond precisely to the initial syllable of a word. This "syllable effect" discovered by Mehler, Dommergues, Frauenfelder and Segui (1981) has prompted (so far!) a decade and a half of follow-up work (Frauenfelder & Kearns, 1996).

The finding is important because it suggests a mechanism by which listeners can attack the problem of continuity of spoken utterances: Clear cues to where words begin and end are rare, but listeners can only understand utterances by decomposing (i.e. segmenting) them into the individual words of which they are made up. Restricting the possible points at which words might conceivably begin to the set of detected syllable boundaries would simplify this segmentation problem.

Syllable effects are extremely robust in experiments with French listeners. They appear in the fragment detection task as described above not only with native materials, but also with materials in non-native languages, such as English (Cutler, Mehler, Norris, & Segui, 1986) and Japanese (Otake, Hatano, Cutler, & Mehler, 1993). However, they are also found in a wide range of other psycholinguistic tasks: phoneme detection (Dupoux & Mehler, 1990; Dupoux, 1994; Segui, Frauenfelder, & Mehler, 1981), migration (Kolinsky, Morais, & Cluytens, 1995) and word-stem completion

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Thanks to Wilma van Donselaar for comments on an earlier draft of the manuscript.

(Peretz, Lussier, & Béland, 1996). The attentional allocation task of Pitt and Samuel (1990) was shown by Pallier, Sebastian-Gallés, Felguera, Christophe and Mehler (1993) to be sensitive to syllabic boundaries in French: phoneme detection responses to targets in syllabic onset position are faster if the previous few targets also occurred in an onset as opposed to in a coda, and conversely for targets in coda position. Thus the argument for the importance of the syllable in speech segmentation by French listeners is not based on results from one task alone.

A syllable effect also appears under certain circumstances in Catalan and Spanish fragment detection (Bradley, Sánchez-Casas, & Garciá-Albea, 1993; Sebastian-Gallés, Dupoux, Segui, & Mehler, 1992); in Catalan, for instance, it appears in words with unstressed initial syllables but not in words with stressed initial syllables. However, although Catalan words vary in stress, Catalan is not termed a "stress language". Nor are French and Spanish. Stress languages are characterised by stress-based rhythm, and a wide variation in syllable weight between strong and weak syllables. Stress languages include English, German and Dutch.

ENGLISH

A direct analogue of Mehler and co-workers' (1981) study failed to find a syllable effect in English (Cutler et al., 1986), and this failure has been replicated many times (Bradley et al., 1993; Cutler, Norris, & Williams, 1987; Cutler, Mehler, Norris, & Segui, 1992; Kearns, 1994; Taft & Hambly, 1985). Even with input in a language in which the syllable effect is robust—that is, in which syllable boundaries are putatively clear—English listeners show such effects neither in the syllable detection task itself (Cutler et al., 1986) nor in word stem completion (Peretz et al., 1996). In the attentional allocation task, phoneme detection attention cannot be allocated to the internal syllable boundary in an initially stressed word (Pallier, 1994; Finney, Protopapas, & Eimas, 1996; Protopapas, Finney, & Eimas, 1995), but it can be allocated to either side of the boundary in a finally stressed word such as *submit* (Finney et al., 1996; Protopapas et al., 1995); as the boundary in such words is also the initial boundary of a stress unit (foot), this finding is consistent with stress-based rather than syllable-based segmentation in English. Also consistent with this is Gow and Gordon's (1993) finding that initial stressed syllables were detected more rapidly than initial unstressed syllables.

Recall that word stress location determines the presence of a syllable effect in Catalan (Sebastian-Gallés et al., 1992). Several researchers have independently investigated whether the effect might appear in English words with unstressed initial syllables, but have met with no success (T. Mintz, University of Rochester, 1990; F. Rhodes-Morrison, Hatfield

Polytechnic, 1992—both personal communication; Dupoux & Hammond, submitted). Since null results do not reach the archives of academic publication, further attempts of this kind, with similar results, may have been undertaken.

Cutler et al. (1986) argued that syllabic segmentation in a stress language is simply inefficient, and not worth undertaking given that effective stress-based procedures are available to achieve all the segmentation that is needed. For English, at least, the evidence to date does not seem to warrant a change in this verdict.

GERMAN AND DUTCH

German and Dutch, although both closely related to English, and both languages with stress-based rhythm, do not provide as clear a pattern of results. Neither the stubborn absence of an effect as in English, nor the robust perseverance of the effect as in French, is replicated in these languages.

In German, a study by Höhle and Schriefers (1995) compared bisyllabic words with initial and final stress, and found significant differences consistent with a syllable effect only in the case of final-stress words with open initial syllables (e.g. *ku-* was detected more rapidly than *kul-* in *Kulanz*).

In Dutch, the principal study in the literature is that of Zwitserlood, Schriefers, Lahiri and van Donselaar (1993). This study contains three experiments, and the authors argue for the presence of a syllable effect, although in no case are the results as clear as those found in French, Spanish or Catalan. Faster responses to CVC than to CV targets appeared with words with closed syllables and with ambisyllabic consonants in one experiment; a crossover interaction appeared in another experiment. Other directly comparable studies in Dutch have, however, failed to find a syllable effect (Vroomen & de Gelder, 1994). Moreover, studies in Dutch have shown clear acoustic bases for the presence of a syllable effect: target-carrier match effects appear only in words with clear allophonic syllable boundary cues (Frauenfelder, Rietveld, & van Til, submitted; van Donselaar & Stoutjesdijk, 1994), and cross-splicing initial portions of words can produce a reversed syllable effect (e.g. faster responses to CV targets in closed syllables if the CV portion of the closed syllable had originally been spoken as an open syllable, and vice versa; Zwitserlood, 1991).

If the results of Zwitserlood et al. (1993) imply, however, that Dutch listeners under certain circumstances can segment speech syllabically, then it makes sense to offer them the opportunity, as Cutler et al. (1986) did for their English listeners, to demonstrate this on easily segmented speech. Accordingly, Arie van der Lugt and I collected responses from 38 Dutch listeners to the original materials of Mehler et al. (1981), using exactly the

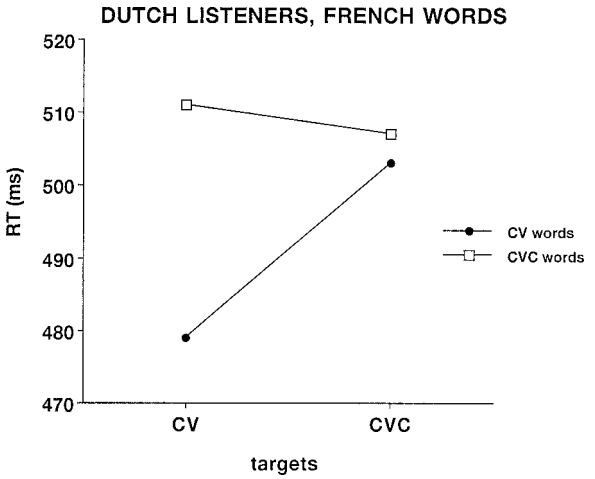

FIG. 1. Mean response times (msec) by Dutch listeners to CV and CVC targets given the CV-initial (*balance*) and CVC-initial (*balcon*) words from the study of Mehler et al. (1981).

procedure of the original study and of Cutler et al. (1986). These listeners did not show a crossover syllabic effect, nor an advantage for CVC targets, as Fig. 1 shows. In *balcon* words their mean response time to CV targets (511 msec) and CVC targets (507 msec) did not differ, but in *balance* words their responses to CV targets (479 msec) were considerably faster than their responses to CVC targets (503 msec). This latter difference was statistically significant, a finding in agreement with Höhle and Schriefer's (1995) German result with final-stress words; note that in the citation pronunciation of French words, accent falls on the final syllable.

In two experiments with Dutch and German listeners, the same word type (words with stress on the second syllable and an open first syllable) thus produced faster detection of syllable-matching than of syllable-mismatching targets. Note that even this effect does not appear in English; Dupoux and Hammond (submitted) found no difference in detection time for CV and CVC targets in words like *humanity*. In other word types (e.g. with initial stress, or closed first syllables), the evidence from Dutch and German conflicts, the modal finding being no effect. Furthermore, the apparent effects may all have an acoustic/phonetic basis, as argued by van Donselaar and Stoutjesdijk (1994). Certainly the evidence does not seem to warrant a general claim for syllabically based segmentation of speech.

CONCLUSION

In stress languages, experiments in which a true syllable effect could show itself mostly produce no such effect. A meta-analysis over all the attempts to

locate a syllable effect in stress languages would motivate the conclusion that much effort has been wasted on barking up the wrong tree. But why? Presumably the effort reflects a shared intuition that syllables *are* important in language processing, in a universal sense.

Indeed, in all the languages tested in the research described here, the syllable has a fundamental relationship with the very unit which listeners seek in speech, namely the word: any word must consist of at least one syllable. A syllable is, minimally, a vowel, plus optional surrounding material (which in many stress languages can be quite complex: *owe*, *toe*, *ode*, *stow*, *old*, *stroll*, *strolled*, *colds*, etc., are all monosyllables in English). Vowel-less words are impermissible.

A word-spotting study by Norris, McQueen, Cutler and Butterfield (in press) suggests that this relationship to lexical viability in fact provides the right framework within which to view the syllable's role in the segmentation of stress languages. In word-spotting (McQueen, 1996), listeners are presented with nonsense strings and respond whenever they spot a real word somewhere in the string; the task can be thought of as the minimal segmentation task. Norris et al. found that *egg* was spotted more rapidly and accurately in *mafegg* than in *fegg*, *sugar* in *sugarthig* than in *sugarth*. In other words, word-spotting is harder if what is left over cannot itself be a word; a syllable like *maf* or *thig* could conceivably be an English word, but an isolated phonetic segment such as [f] could not.

This, of course, is not itself a "syllable effect"; conceivably the finding could be sensitive to language-specific minimal word constraints (McCarthy & Prince, 1986), and Norris et al.'s result might be replicable only in English and similar languages. In languages in which the minimal word could be more or less than one syllable, the results of an analogous study might reflect this difference. (In fact, the minimal word in English must be a *bimoraic* syllable; Norris et al.'s materials conformed to this constraint, and further tests must determine whether this is a necessary part of the effect.)

Syllables are useful to the listener in so far as they provide exploitable information of one kind or another. In languages where syllable boundaries tend to be clearly signalled, the information thus provided can be used in segmentation, and a "syllable effect" can be expected to appear in speech segmentation tasks. In languages where the syllable corresponds to a minimal allowable word, it is in this constraint that the effect of syllables on the listener's performance may be sought. Stress languages on the whole do not provide clear signals of syllable boundaries; but in many stress languages, the minimal allowable word will indeed be syllable-sized.

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