Syllabifications of the /st/ cluster and vowel-to-vowel coarticulation in English

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Introduction

This paper investigates how different syllable boundaries involving the /st/ cluster in English affect vowel-to-vowel (v-to-v) coarticulation. Although several models of coarticulation offer accounts of vowels and consonants in different syllable positions (e.g. Articulatory Phonology (Browman & Goldstein, 1988; 2000) and 'carrier' models of coarticulation (e.g. Öhman, 1966)), the effects of syllable structure on v-to-v coarticulation remain poorly understood. Most studies on v-to-v coarticulation only deal with one syllable type, namely open syllables (though see Modarresi, Sussman, Lindblom & Burlingame, 2004). However, notwithstanding the lack of a clear definition of a phonetic syllable, many studies show that syllable onset and coda are different acoustically, articulatorily, typologically and perceptually.

Acoustic studies indicate that onset consonants are longer and exhibit stronger cohesion with tautosyllabic vowels than do coda consonants (e.g. Byrd, 1996; Sussman, Bessell, Dalston & Majors, 1997). Articulatory studies show that syllable onset and coda consonants coordinate differently with the vowels, and that gestures for onset consonants are stronger and more distinct than those for coda consonants (e.g. Browman & Goldstein, 1988; Krakow, 1999). Onset consonants are more frequent in the world's languages, and are more distinguishable than coda consonants in noise (Redford & Diehl, 1999). All this suggests that syllable onset and coda consonants have different coordination with the vowel, which might therefore be expected to affect v-to-v coarticulation.

The /st/ cluster in English can be syllabified in three ways: onset /#st/, heterosyllabic /s#t/ and coda /st#/ (where # denotes a syllable boundary). It was hypothesized that the onset /#st/ should allow the least v-to-v coarticulation because onsets are stronger and more stable, followed by the heterosyllabic /s#t/ and the coda /st#/ because coda consonants are the most variable. The /st/ cluster was chosen for investigation because it is homorganic, thus reducing conflicting influences of intervocalic consonants on formant transitions.

Method

Six native speakers of Southern British English (two male four female) were recorded reading sequences of two real monosyllabic words involving the /st/ cluster embedded in carrier phrases. Three sets of materials were collected: onset /CV_1#stV_2C/ (e.g. bar steed), heterosyllabic /CV_1s#tV_2C/ (e.g. pass teat) and coda /CV_1st#V_2C/ (e.g. past east). Three vowels, /ɑ/, /i/ and /u/ were used in all possible combinations. Focus stress was induced on the non-target syllables by the carrier phrases (Not a x x , but a x x again.). Altogether 324 sequences were used (3 syllable structures × 3 target vowels × 3 context vowels × 2 stress positions × 6 repetitions). F1, F2 and F3 frequencies were measured from LPC spectra (25 ms hanning window, supplemented by DFT spectra) at several temporal locations: 1) close to the offset of periodicity in V_1 or onset of periodicity in V_2 for anticipatory and carryover coarticulation respectively; 2) 26 ms after the /t/ burst (during the aspiration), in order to measure carryover coarticulation at a comparable place in the articulatory trajectory during heterosyllabic /CV_1s#tV_2C/ sequences. All formant frequencies were normalised before being submitted to statistical analysis. Intervocalic durations were also measured.

Results and discussion

Results show that heterosyllabic /s#t/ sequences had the longest intervocalic duration presumably because they contain a syllable/word boundary. The intervocalic durations for onset /#st/ and coda /st#/ are generally

not different from each other. However, four-way repeated measures ANOVAs (direction × syllable structure × target vowel × context vowel) of the normalised formant frequencies suggested that at the comparable place in the articulatory trajectory, different syllabifications of the /st/ cluster did not significantly affect the degree of v-to-v coarticulation, contrary to the hypothesis based on the various differences between onset and coda consonants.

Articulatory Phonology suggests that syllable structures result from different gestural overlap and timing patterns between vowels and consonants, with onset consonants showing the C-centre effect with the vowel while only the left-most consonant in the coda cluster is phased with respect to the vowel. This predicts that different syllabifications of the /st/ cluster should affect v-to-v coarticulation differently. However, the present results do not support this prediction. Rather, the results seem to be more compatible with 'carrier' models of coarticulation (e.g. Öhman 1966) in which vowels form a continuous diphthongal movement onto which consonantal gestures are superimposed, such that syllabification of the consonants does not affect coarticulation between successive vowels, although such models may not be applicable to all languages (see Smith, 1995).

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