

It has increasingly been observed that lexical frequency plays significant role on English phonology (vowel reduction: Fidelholtz 1975, Hooper 1976, lexical diffusion: Bybee 2002, cyclic stress: Hammond 2004). For example, vowel reduction occurs to a greater extent in relatively high-frequency words than in low-frequency words (e.g. *mem(o)ry* vs. **mamm(o)ry*) (Hooper 1976). Further, high-frequency words like *trànsformátion* exhibit different secondary stress patterns from low-frequency words such as *èxàltátion* (Pater 2000). However, there have been very few studies on how word frequency or degree of stress affects the inter-gestural timing relation such as vowel to vowel coarticulation. In this paper, we report the new findings from the acoustic experiments investigating how word frequency is related to the degree of V-to-V coarticulation and how degrees of stress affect the degree of V-to-V coarticulation in English.

Our results indicate that the degree of V-to-V coarticulation is highly conditioned both by word frequency and by the degree of lexical stress in English. This suggests that speakers' lexical information of word frequency and stress patterns interact with phonetic-fine details as explained by exemplar theories or by abstract structural theories.

First, we elicited 6 tokens of 21 different English words, each pair containing the same VCV sequence of a low or mid vowel followed by a coronal or velar, followed by a high front vowel with minimizing consonant effects according to the frequency as is illustrated in (1).

(1)	V-V	Lo-frq(1-50)	Hi-frq(50-400)	V-V	Lo-frq(1-50)	Hi-frq(50-400)
	a - i	<u>bar</u> ley	par <u>ty</u>	a - i	<u>co</u> ttage	col <u>le</u> ge
	æ - i	<u>sav</u> age	av <u>er</u> age	æ - i	<u>al</u> ley	car <u>ry</u>
	ʌ - i	<u>cun</u> ning	cut <u>ti</u> ng	ɔ - i	<u>lon</u> ging	mor <u>ni</u> ng

The materials were randomly selected from Brown corpus (with 1,026,604 words). Subjects read through the list of words in the verbal frame with a different randomized order. Data was collected from 4 subjects (2 male/2 female for native speakers of English). Acoustic measurements of the first and second formants (F1 and F2) were analyzed at 3 time points of the first low or mid vowels to see the anticipatory coarticulation effects.

Our results revealed interesting patterns. First of all, we obtained the new findings by showing that the same low or mid vowels are articulated higher and more forward in high-frequency words than in low-frequency words as a result of stronger anticipatory effect from /i,ɪ/. As expected, vowels like [a, æ, ʌ, ɔ] in high-frequency words had a significantly lower F1 ($F_{(1, 448)} = 161.97, p < 0.001$) and higher F2 ($F_{(1, 448)} = 147.72, p < 0.001$) than the same vowels in low-frequency words across speakers, indicating a vowel with a higher and more front tongue position. Significant carryover effects were not found, confirming the strongest articulation of /i/.

Second, we elicited 4 tokens of 12 words from the same subjects to test whether V-to-V coarticulation effects are stronger in secondary-stressed vowels than in primary-stressed vowels.

(2)	Primary stress vs. secondary stress			
	<u>op</u> érate	vs.	òp <u>er</u> ation	d <u>oc</u> ument vs. d <u>oc</u> umentation
	<u>co</u> mpe <u>ns</u> ate	vs.	co <u>mp</u> ens <u>at</u> ion	<u>an</u> ecdote vs. <u>an</u> ecdotal

We obtained new findings by showing that secondary stressed vowels are articulated higher than primary stressed vowels. As expected, low vowels /a, æ/ with secondary stress showed lower F1s than the same vowels with primary stress. This confirmed Magen's (1997) findings but makes significant contributions by analyzing real English words instead of hypothetical words with differently manipulated stress as in Magen's experiments and by dealing with the differences between primary and secondary stress, rather than between stressed and unstressed vowels as in Fowler (1981a,b). This result can be explained by different phonetic realizations of vowels with stronger degree of stress. That is, primary stressed vowels allow more resistance to coarticulation than secondary stressed ones because their acoustic properties involve longer duration, higher amplitude, or higher F0 (Edward *et al.* 1991).

These findings have two important implications. First, this is the first phonetic study revealing indirectly that even inter-gestural timing becomes more overlapped (in addition to segment internal vowel reduction) according to high-frequency. Such frequency-constrained V-to-V coarticulation will lead to the possibility of representing inter-gestural timing relations in the lexicon (Gafos 2002). Secondly, it implies that high-level phonological knowledge of stress influences low-level coarticulation along with various realizations of phonetic effects of stress.

Selected references

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