

The relationship between coarticulation, prosodic weakening, and sound change

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The paper is concerned with the influence of the stress hierarchy on the relationship between the production and perception of coarticulation. The longer-term aim is to consider whether a perceptual under-compensation for coarticulation contributes to the prevalence of historical sound change in prosodically weak constituents (Beckman et al, 1992, *Language & Speech*, 35, 45-58). Three types of studies form the background to those presented here: the demonstration that there is usually parity between the production and perception of coarticulation (Fowler, 2005, *J. Phonetics*, 33, 199-213); the evidence of greater coarticulation in the production of unstressed vs. stressed syllables (Mooshammer & Geng, 2008, *J. Int. Phonetic Assoc.*, 38, 117-136); and the association between sound change and perceptual under-compensation for coarticulation (Ohala & Feder, 1994, *Phonetica*, 51, 111-118).

The first experiment was concerned with the influence of sentence-level deaccentuation on coarticulation. Fifteen L1 speakers of German produced symmetrical non-word CVC syllables for $V = /y, \text{ʊ}/$ and $C = /p, t/$ in the carrier phrase 'Maria hat CVC gesagt' ('Maria said CVC') under two conditions: for the first, the nuclear accent fell on CVC; for the second, *Maria* was nuclear-accented and the following CVC was deaccented. The dependent variable was the second formant frequency (F2) at the acoustic vowel target which is higher for front $/y/$ than for back $/\text{ʊ}/$. The measurement of coarticulation was based on the F2-lowering influence of the labial locus on $/y/$ in $/pyp/$ and on the F2-raising influence of $/t/$ on $/\text{ʊ}/$ in $/t\text{ʊ}t/$. The same subjects took part in a forced-choice speech perception experiment in which they identified $/\text{ʊ}/$ or $/y/$ from $/pyp\text{-}p\text{ʊ}p/$ and $/t\text{ʊ}t\text{-}t\text{ʊ}t/$ continua synthesised by lowering F2 of the vowel in 11 equal steps. The tokens from the continua were embedded in a production of 'Maria hat CVC gesagt'; in addition, f_0 was synthetically manipulated such that the nuclear accent was perceived to fall either on CVC (the accented condition) or on 'Maria' (the deaccented condition). For speech production, the magnitude of coarticulation was found to be greater in the deaccented than in the accented condition primarily as a result of a greater degree of F2-raising of $/\text{ʊ}/$ in deaccented $/t\text{ʊ}t/$. Listeners compensated perceptually for this prosodic difference: thus, the perceptual boundary between $/y\text{-}\text{ʊ}/$ was shifted to a greater extent towards $/\text{ʊ}/$ in deaccented than accented $/t\text{ʊ}t/$ suggesting that listeners compensate more for the effects of coarticulation in deaccented than accented syllables. Thus this study shows that the influence of accented vs. deaccented on consonant-on-vowel coarticulation is matched in production and perception.

For the second experiment, 18 speakers produced $/pV_1pV_2l/$ target non-words for combinations of $V_1 = /y, \text{ʊ}/$ and $V_2 = /o, e/$. This target non-word was always nuclear-accented in the carrier-phrase 'Maria hat $/pV_1pV_2l/$ gesagt' but produced such that lexical stress fell either on the initial or on the final syllable. The dependent measure was a shift in F2 due to trans-consonantal V_2 -on- V_1 coarticulation in which F2 of $/y/$ was expected to lower and F2 of $/\text{ʊ}/$ to raise under the backing and fronting influences respectively of $V_2 = /o, e/$. The same subjects participated in an analogous perception experiment in which the target non-word with the same two lexical stress conditions was embedded in the same carrier phrase (and with f_0 synthesised such that the nuclear accent fell on the target non-word). As in the first experiment, a $V_1 = /y\text{-}\text{ʊ}/$ continuum was created by lowering F2 in 11 equal steps. In both production and perception, the lexical stress differences had no influence on the size of trans-consonantal V_2 -on- V_1 coarticulation. However, listeners were also found to compensate less for the F2-lowering influence of the consonantal $/p/$ context in unstressed compared with stressed syllables.

The overall conclusion from these findings is that the extent of listeners' compensation depends on the type of coarticulation and the level of the stress hierarchy: thus on the one hand, listeners are sensitive to the more extensive C-on-V coarticulation that is due to deaccentuation; but on the other, they do not compensate sufficiently for the same extensive C-on-V coarticulation at the level of rhythmically strong (primary lexical stress) vs. weak (secondary lexical stress) syllables.