

EFFECTS OF PROSODIC POSITION ON /t,d/ TONGUE/PALATE CONTACT

Patricia A. Keating
Phonetics Lab, Linguistics Department,
University of California, Los Angeles, USA

ABSTRACT

Two experiments tested the effects of lexical stress, phrasal stress, and position in utterance on the epg contact of onset and coda /t/ and /d/. Onsets have more contact than codas; utterance-initial onsets have by far the most contact. Effects of stress are variable and effects of accent are not significant.

INTRODUCTION

Several previous studies have shown that English non-continuant consonants in syllable- or word-initial position (onsets) generally have larger oral gestures and more oral contact than they do in syllable- or word-final position (codas) (e.g. [1], [2], [3], [4], [5]). Descriptively, this difference can be called *coda weakening*. Coda weakening is not due to some simple left-to-right weakening in an utterance: even codas which precede onsets have less contact [3]. It is not the same thing as American English flapping: coda weakening of alveolars is less extreme than flapping and occurs in non-flapping contexts [5]. It affects stops but not the fricative /s/ [3]. Aside from these observations, however, not much is known about the generality of coda weakening, in particular, whether coda weakening is limited to, or is enhanced by, particular prosodic positions. Prosodic here refers both to stress/prominence and to phrasal groupings of various sizes. The two experiments reported here consider the effects of lexical stress, phrasal stress (sentence stress with a pitch accent), and phrasal position on word-initial and word-final /t/ and /d/. Additional data will be reported at the Congress.

The reason to consider the effect of lexical and phrasal stress on coda weakening is that they all appear to involve effects on degree of stricture. DeJong [6] shows that English stress results in a hyperarticulation, or strengthening, of segmental contrasts in the stressed syllable. It seems to be assumed that this hyperarticulation

applies to all segments in the syllable, codas as well as onsets. It is possible, though, that because codas are generally weakened they would not be subject to the contradictory effect of prosodic strengthening. More subtle relations between the two are also possible. Expt. I was designed to test the effects of lexical and phrasal stress on onsets and codas.

The reason to consider the effect of phrasal position on coda weakening is that we know that glottal articulations are sensitive to phrasal position. Glottal opening associated with /h/ and with aspiration increases in magnitude word-initially and phrase-initially ([2],[7],[8]), just as it increases in magnitude with stress ([7]). We could expect initial oral articulations to pattern similarly. Since word-final aspiration is relatively rare [9], and glottal opening is reduced [2] word-finally, we could expect coda oral articulations to be reduced, rather than strengthened, word-finally. At the same time, we do not know much about how coda consonants are affected by prosodic groupings above the word. Expt. II was designed to test the effect of position in utterance on onsets vs. codas. Taken together, the two experiments explore how these three potentially different effects on degree of stricture (coda weakening, stress, phrasal position) interact.

METHOD

Equipment

The data in these experiments comes from electropalatography (EPG). EPG contact shows the net effect of jaw and tongue position on degree of stricture. The Kay Elemetrics Palatometer uses custom pseudopalates embedded with 96 contact electrodes to measure contact patterns over the hard palate and the inner surface of the molars. The EPG sampling interval is 10 ms, with the Palatometer taking 1.7 ms to complete a single sweep of the 96 electrodes.

Subjects

Subjects included in the present report were two middle-aged women, one a native speaker of Californian English and the other a native speaker of a mid-Atlantic dialect (the author). Because only two subjects have been tested, the results reported here may be viewed as preliminary.

Experimental materials

The test sentences were composed of real English words. In Expt. I, the variables under study were position of the consonant in the word (onset vs. coda), whether the consonant's syllable had lexical stress (stressed vs. unstressed), and whether the test word had sentence stress (nuclear pitch accent). The consonant /t/ occurred at the beginning or end of the test words, which were: *timid* (t is initial and stressed), *timidity* (t is initial and unstressed), *limit* (t is final and unstressed), *emit* (t is final and stressed). Each word appeared in the sentence "I wonder if (word) means anything". Phrasal stress was varied so that in half the sentences the test word had the nuclear accent of the sentence: "I wonder if EMIT means anything"; in the other half the nuclear accent was on "anything": "I wonder if emit means ANYTHING". No instructions were given about sentence accents other than the nuclear accent.

In Expt. II, /d/ occurred at the beginning or end of the test words, which were all content words of one or two syllables. Since the monosyllabic words had a lexical stress, the consonants in those words were in the lexically-stressed syllable. The disyllabic words had lexical stress on the syllable which did not contain the test consonant. Thus the test words were *deaf* (d is initial and stressed), *fed* (d is final and stressed), *demand* (d is initial and unstressed), *aphid* (d is final and unstressed). Thus the stressed /d/s come from monosyllables and the unstressed /d/s come from disyllables, but they will be referred to simply as stressed vs. unstressed.

These 4 words were put into sentences in three different positions: initial, medial, and final. I will refer to initial, medial, and final onsets and codas even

though when a word with a coda /d/ is utterance-initial, the /d/ itself is of course not initial in the utterance, and so on. The segmental contexts were kept very similar across utterance conditions. Absolute initial and absolute final positions might have special articulations due to a neutral or rest position. Therefore the test sentences were preceded or followed by extra words, though the subjects were instructed to produce the test sentences as separate utterances. The test sentences for *deaf* were: (*up.*) *DEAF bugs go out.*

Pick up DEAF bugs now.
Pick them up DEAF. (Bugs.)

In this experiment, the test word always had a pitch accent, which was the nuclear, and only, accent of the sentence.

Procedure

Subjects read the test sentences from a printed sheet, 8 times each for Expt. I and 9 times each for Expt. II, in a different order each time.

Analysis

The percent of all electrodes that were contacted was measured for each token at the point of greatest contact for the consonant. These measures were then analyzed by ANOVA. Because the results for the two subjects were somewhat different, only individual-subject analyses will be discussed here.

RESULTS

Experiment I

ANOVA showed that the two subjects shared only one significant effect, the main effect for onset vs. coda /t/. Both subjects showed some effects of both lexical stress and accent, but in different ways.

Both subjects had some kind of significant effect of lexical stress on EPG contact. For subject P there was a main effect of stress: stressed consonants had significantly *less* contact than stressless consonants (Fig. 1). For subject B there was an interaction of stress with syllable position: onsets had *more* contact when stressed; coda contact showed no effect of stress. Furthermore, for this subject, onsets differed from codas only in stressed syllables (Fig. 2).

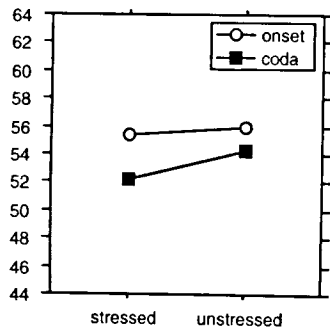


Figure 1. Percent contact for /d/, subject P: position in syllable x stress

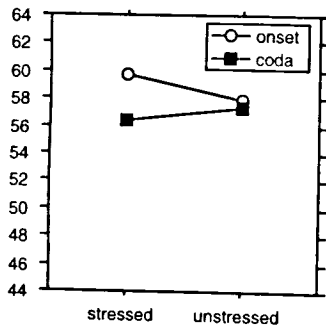


Figure 2. Percent contact for /d/, subject B: position in syllable x stress

Both subjects also had some non-significant effect of accent on EPG contact. For subject B, accent had a tendency ($p < .08$) to result in more contact for both onsets and codas. For subject P, there was a non-significant tendency ($p = .06$) for accent and syllable position to interact. The onset/coda difference was much stronger in accented than in unaccented syllables, and the effect of accent was seen only in codas, where accented codas had less contact than unaccented.

In sum, the only consistent effect for the two subjects was that onsets have more contact than codas in stressed syllables. Lexical stress clearly affects EPG contact too, but in different directions for the two subjects. Only for one subject did it affect onsets differently from codas. The effect of accent, in contrast, was only a trend for each subject.

Experiment II

For this experiment, statistically-reliable results will be presented only for subject P. However, the results appear similar for the other subject, with one exception to be noted. In Expt. II, accent was not varied, but lexical stress was again varied, in addition to the new variable of interest, position in utterance, all for the consonant /d/. All factors gave significant main effects for subject P. First, as before, onsets have more contact than codas. Second, with respect to stress, the result was different from before: stressed consonants, whether onset or coda, have more contact. Finally, with position in utterance, for subject P all three positions are significantly different from one another: initials have the most contact, finals the next, and medials the least.

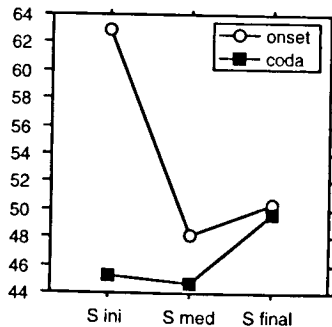


Figure 3. Percent contact for /d/, subject P: position in syllable x position in utterance

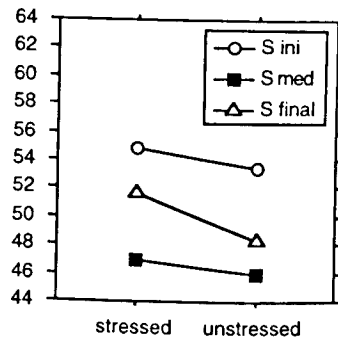


Figure 4. Percent contact for /d/, subject P: stress x position in sentence

This effect is fairly specific: there is a large increase in contact for utterance-initial onsets and a smaller boost of utterance-final codas. (Subject B appears to have no such coda boost.) As a result, the onset/coda asymmetry is much stronger utterance-initially than utterance-medially (Fig. 3). Furthermore, stress and position interact: the effect of lexical stress (which is to increase contact) is strongest in utterance-final position (Fig. 4).

CONCLUSIONS

These results suggest that "coda weakening" is a fairly robust phenomenon; indeed, it is the only consistent result of the two experiments. However, it does not occur all the time: for one subject it is not observed utterance-finally, and for the other it is not observed in unstressed syllables.

In these data, we see first that lexical stress and phrasal accent are not the same; lexical stress has significant effects on consonant contact while phrasal accent has only weak effects. Lexical stress for one subject operated in a way that is difficult to understand, because Expts. I and II showed opposite effects. Possibly the results of Expt. I were contaminated by an asymmetry in the carrier sentence, which had "if" (with [I]) before onsets but "means" (with [i]) after codas. Under an intricate scenario of how words overlap, it might be possible to explain the stress effect in codas as an artifact of the experiment. Expt. II used a more symmetrical carrier frame, and in this experiment the results were in accord with one of the predicted outcomes: stress resulted in more consonant contact in both onsets and codas, even against the fact that the stressed vowels in these test words were more open. Here, stress and coda weakening are independent effects, with the hyperarticulation of stress affecting both consonants about the same.

On the other hand, lexical stress for the other subject increased contact only in onsets, and only in stressed syllables was the onset/coda asymmetry observed. Possibly this result is also due to the asymmetry of the frame. However, for this subject, it is also entirely possible that the onset/coda difference is due to an asymmetry in the realization of stress:

that stress causes hyperarticulation in CV but not VC within the stressed syllable. Statistically-reliable data from Expt. II will be needed to distinguish these interpretations for this subject.

With respect to phrasal position, we see in Expt. II that lingual contact is greatest adjacent to an utterance boundary. Most notably, onsets are strongest utterance-initially, with more contact than any other consonants. For one subject, codas are strongest utterance-finally, though the strengthening of onsets utterance-initially is much greater in magnitude than the strengthening of codas utterance-finally. As a result of this strengthening, codas make up somewhat for their overall relative weakness, so that these strongest codas have about the same contact as a weak onset for this speaker. For the other subject, no final coda strengthening is seen. Clearly, to the extent coda strengthening occurs, it is a small effect.

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