Repetition Leads to Lenition in Consonant Sequences

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Abstract

This paper reports a study of phonetic properties of repeated-consonant segment sequences. Languages frequently disallow sequences of identical segments, a generalization usually described in linguistic theory as the Obligatory Contour Principle (henceforth OCP). This principle has generally been motivated by appeals to perceptual rather than production factors. The phonetic production of such sequences (in languages for which they are permissible) has not been studied, despite well-known correspondences between phonetic and grammatical patterns.

I investigate the phonetic properties of such sequences in American English, in which they are phonotactically acceptable, though statistically underrepresented [1]. The articulation of repeated consonants differs consistently from what is expected, in that high rates of consonantal lenition are observed for repeated versus non-repeated segments in similar contexts. This qualitative judgement is accompanied by quantitative measures demonstrating longer duration and lower intensity. I suggest that this variation is due to repetition presenting articulatory difficulty, contrary to previous claims [10], and that this difficulty results in the production of tokens that are both elongated and fail to reach prototypical articulatory targets. The relationship of these phonetic patterns to phonological repetition repairs is discussed.

1 Introduction

The field of "natural" (or "evolutionary") phonology argues for a close relationship between phonetic patterns and phonological processes [2, 6]. Thus coarticulation patterns often have counterparts in phonology as categorical assimilation processes [12, 13]. One possible approach, then, is to identify common phonological processes and look for phonetic counterparts.

One such class of phenomena is the wide range of repetition-avoidance phenomena classed as OCP effects. When sequences of identical consonants are expected, they are often subject to repairs such as dissimilation of one of them (Akkadian labial-to-coronal place dissimilation [15]) or deletion of one of them (English coronal deletion [7]). Dissimilation of one is also a possibility, for example with respect to continuancy (stop/fricative status; see [6] for a case in Ancient Greek). Phonetic counterparts to these processes have not been sought. On the contrary, such effects have been explicitly characterized as *not* possibly motivated by "natural" articulatory factors [2, 3, 10], without this claim having been tested.

The following experiments do so, by eliciting non-word productions with and without segment repetition. They show consistent effects on the consonants involved, such that one of them is subject to an array of modifications associated with lenition. Differences exist in duration, degree of closure, and persistence of voicing.

2 Method

Informed consent was obtained from 9 native speakers of American English (4 female, 5 male, vision normal or corrected to normal, none of whom reported hearing, language or neurological disorders). Subjects were presented with visual orthographic stimuli in random order using Psyscope software. They then read aloud each stimulus first in isolation and then in the following frame sentence: "Do you know what a ___ is?" Utterances were digitally recorded in a sound-proof booth. Microphone contact with the experimenter outside the booth was maintained throughout, so that subjects could request pauses or clarification if necessary. This routine was repeated twice per subject.

Stimuli consisted of trisyllabic stress-initial non-words with medial schwas, with surrounding vocalic and consonantal segments permuted according to place and quality among the segments shown below.

Tokens for which C1 and C2 share the same place of articulation (as well as voice and manner, which are always shared), are henceforth described as repetition (REP) environments.

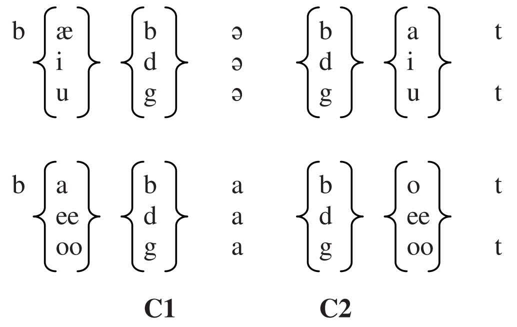

Figure 1: Stimuli in IPA and orthographic transcription.

Durations were measured for C1 and C2. This has been identified by Lavoie as the most reliable cue for lenition [9]. Second, the intensity nadir of each C1 and C2 token was measured. An intensity contour was generated and overlaid on a spectrogram using the PRAAT acoustic analysis software program. The lowest point in this contour was identified visually by the experimenter and recorded. Finally, each segment was also classified as either "lenited" or "non-lenited" by the experimenter, based on visual inspection of spectrographs. Segments were classified as lenited if they met both of two criteria. First, continuous voicing occurred throughout the stricture, indicating vocal fold leakage throughout the segment and incomplete constriction despite the segment being phonologically classifiable as a fully occlusive 'stop' consonant. Second, such voicing was robust enough for observable formant structure to persist throughout the stricture. (Coronal C1s were removed from the analysis, as they are already subject to grammaticalized lenition in the form of flapping in American English).

A second experiment attempts to replicate the first using a similar paradigm, but with speeded production. Informed consent was obtained from 9 native speakers of American English (4 female, 5 male, vision normal or corrected to normal, none of whom reported hearing, language or neurological disorders). Subjects were presented with visual orthographic stimuli in random order using Psyscope software. A metronome placed inside the sound-proof booth was started prior to initiation of the presentation script, set to beep at the rate of 120 beats per minute. Subjects were instructed t otime their productions to the metronome with one word per beat, to produce as many repetitions of each item as they could, and to pause and begin again if they made an error or became confused. An interval of 5 seconds was allowed between automatic stimulus presentations.

Stimuli consisted of four-syllable stress-initial non-words with the full vowels [ɪ] and [ɛ] in the third syllable, and the surrounding consonants permuting among the voiced stop series. This results in a total of sixteen stimuli: orthographically, tarra[b/d/g][i/e][bb/dd/gg]le (tarrabebble, tarrabiggle, and so on). Contexts with repeated consonants and no intervening [r] will be referred to as REP contexts, and others as non-REP contexts. Subjects were typically able to repeat roughly 7 tokens per stimulus item.

The qualitative lenition measure was eschewed for this experiment. Both the duration and intensity nadir of each voiced stop was measured.

3 Results

In Experiment 1, lenition occurs nearly half the time overall for C1 (which introduces an unstressed syllable), but relatively rarely for C2 (which introduces a syllable with secondary stress, and a prosodic foot). In a REP context, qualitative lenition classification is significantly more likely for both C1 and C2 (binary logistic regression analyses; respectively, Wald=4.191, p=.04; Wald=21.152, p<.001). The asymmetry is quite consistent for individual subjects (holds for all but two with respect to velar place, and all but three for labial).

Table 1. Experiment 1 consonants percentage qualitatively lenited.

	REP	non-REP
C1	46	36
C2	10	5

For the intensity measure, mean C2 intensity nadirs by REP/non-REP context differ by a single dB, which is statistically not significant. The C1 mean differs by the same amount, but does reach significance (RM ANOVA, F(1,8)=5.765, p=.043). C1 in a REP environment has a slightly but significantly *lower* intensity (62 vs 61 dB, with a standard deviation of 6 dB for both).

As with intensity, C2 is inert with respect to durational difference according to REP context, and no significant difference appears. However, a highly significant such difference does appear for C1. (RM ANOVA F(1,8)=13.953, p=.006). When followed by an identical consonant, C1 duration is significantly longer than otherwise (REP mean of 46 ms, vs 39 ms, with standard deviations of 25 and 16 ms respectively). The asymmetry holds for all but one subject.

Table 2 summarizes the intensity and duration findings of Experiment 1. Stimuli are divided not only by REP context, but by whether or not they were classified as qualitatively lenited.

Table 2: Experiment 1 C1 intensity and duration.

	REP non-len	non-REP non-len	REP len	non-REP len
dB	58	58	64	65
ms	59	51	51	41

Non-lenited consonants have lower intensity than lenited ones, and repeated consonants have lower intensity overall than non-repeated ones. Similarly, non-lenited consonants have longer durations overall than lenited ones. And repeated consonants have longer durations than non-repeated ones.

The results of Experiment 2 replicate these findings, only for a different consonant position. We saw in Experiment 1 that C1 varies and C2 is relatively stable with respect to intensity and duration, as well as qualitative lenition. For Experiment 2 the opposite holds. C1 does not differ significantly in either intensity or duration. C2 does for both (respectively, RM ANOVAs $F(1,8)=9$, $p=.017$ and $F(1,8)=12.41$, $p=.008$).

Table 3: Experiment 2 C2 intensity and duration.

	REP	non-REP
dB	45	46
ms	56	52

As before, intensity is lower in repetitive contexts, and duration is longer.

4 Discussion

Experiments 1 and 2 show consistent variation in consonant intensity and duration according to whether or not that consonant is repeated nearby in the (non)word. This variation is largely limited to the prosodically weaker consonant of the sequence. It manifests only on the one initiating a syllable without stress.

Qualitative lenition occurs primarily for repeated consonants, a pattern attributed here to greater articulatory difficulty of target attainment for such sequences. Because of the relative invariance of one of the consonants, the resulting sequence of lenited+non-lenited consonant embodies a type of dissimilation. Thus in addition to ameliorating articulation difficulty at the local level, the variation in lenition rates could represent the origin of a dissimilatory repair in phonology proper (with respect to stop versus fricative status).

However, the direction of the variation in quantitative lenition measures at first seems to fly in the face of the qualitative pattern. The expected acoustic correlates of lenition are higher intensity and shorter duration; not the lower intensity and longer duration actually observed.

I attribute this seeming inconsistency to the conflicting pressures of two competing pressures, both ultimately due to articulatory difficulty: constriction target undershoot, and longer duration. Undershoot is one way to conserve articulatory effort, and is evidenced by the qualitative lenition rates. In addition, I have shown in previous work that the presence of place of articulation repetition leads to a global slowdown in speech rate that may apply over a span of several segments, including both consonants and vowels [16]. However, longer duration is also known to facilitate target attainment, so that lenition rates are highly dependent on speech rate [9, 14].

These two factors interact so that for prosodically weak repeated segments, closure is less likely to be achieved overall than for non-repeated consonants in the same position. However, this incomplete closure is still a more constricted one than for the (qualitatively) lenited consonants in the same position, which still occur, though less prevalently.

5 Conclusions

Ohala's [13] claim that principles of speech production cannot explain or predict dissimilatory changes has been widely adopted, even by functionally-oriented researchers. Kiparsky [8] adds that because it is not articulatorily natural, dissimilation must be due to perceptual reanalysis, via the misapplication or 'undoing' of hypothesized coarticulation.

In producing evidence of a novel type of phonetic variation, I show that in at least some cases, dissimilation can be functionally motivated with reference to articulatory difficulty. (In this case, competing phonetic influences on the segments involved predict the rarity of the phonological repair, as well as its existence). Moreover, articulatory difficulty can explain grammatical processes previously attributed to perception.

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