Coda /t/ Glottalization in 20 & 50 Year Old American Women

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ABSTRACT

Realization of coda /t/ in American English is sensitive to segmental and prosodic context, as well as speaker age. One 20 year old and three 50 year old American women read an extensive word list designed to pinpoint some effects of context. For the older women, preceding low vowels conditioned more glottalization of /t/, presumably because of the greater effort involved in making an oral closure from a low tongue position. Even intervocalically, the four speakers produced some glottal /t/s, where flapping would be expected. The older speakers nearly always glottalized /t/ preceding /p, t, m, n, l, r, w, j/ and sometimes before /k, f, θ, s/. Segmental conditioning was practically irrelevant to the younger speaker who dependably released coda /t/ only utterance-finally. For her, the glottal variant is common enough that the flap is in danger of being replaced as the basic intervocalic allophone.

1. INTRODUCTION

This paper investigates a topic at the intersection of two facts: (1) creaky voice is on the rise in American women, and (2) the phoneme /t/ shows a great deal of allophonic variation in English. Several Europeans have remarked to me on separate occasions how creaky American women sound. One even offered to point out each time that I produced a particularly creaky stretch of speech. A range of work, e.g. [1], [2], [3], has examined variation in glottal source in English. The bulk of this work has concentrated on the glottalization of vowel-initial words, but glottalization also arises as a manifestation of /t/ in coda position.

In Selkirk's discussion of /t/ allophony [4], she reports obligatory release of /t/ when the next segment is a vowel. This may have been true in 1982, but this study shows that it is no longer true for all segments of the population. The glottal variant of /t/ is gaining ground at the expense of the flap allophone in younger women. In the MIT American English Map Task [5], there is almost no between-word flapping, because all of the word final /t/s are glottalized. This study explores the segmental and prosodic factors that influence realization of /t/.

2. HYPOTHESES

Glottalization of /t/ in American English shows considerable interspeaker and stylistic variation. These preliminary acoustic studies attempt to determine some of the principles behind the variation. The role of consonant quality, vowel quality, and prosodic position are examined. The following four specific hypotheses are tested:

(i) Likelihood of /t/ glottalization depends upon the manner of articulation of the following consonant. It is generally taken for granted that /t/ will glottalize before another stop. Pierrehumbert [6], [7] shows glottalization of /t/ is more frequent before sonorants and does not occur before fricatives.

(ii) Likelihood of /t/ glottalization depends on vowel height. If /t/ glottalization represents an attempt to reduce the effort of making an oral closure, /t/ in a low vowel context is more likely to lack oral closure than /t/ in a high vowel context. A high tongue position preceding the /t/ would require very little extra effort to make the /t/'s oral closure.

(iii) Likelihood of /t/ glottalization depends on whether the /t/ bears a mora phonologically. In English monosyllabic words ending in /t/, the quality of the nucleus determines if the /t/ bears a mora. Words with a tense vowel or diphthong already have two moras so the /t/ contributes none. In words with a lax vowel nucleus, the /t/ must bear a mora for the word to meet the bimoraic word minimum [8]. I expect a mora-bearing segment to be produced with greater faithfulness to its underlying representation than a non-mora-bearing segment. Marie Huffman (personal communication) reports hearing the opposite prediction, based on the functional load of the /t/. After tense vowels and diphthongs, there are possible English words either with or without the final /t/. After lax vowels, though, there is no possible English word without the /t/, as lax vowels are prohibited word-finally. Because of the possible lexical contrast in the case of the tense vowels and diphthongs, the final /t/ (which does not bear a mora) must be carefully produced.

(iv) Likelihood of /t/ glottalization depends on its position in the intonational structure. Two opposite predictions could be made: /t/ is either more likely or less likely to glottalize at the end of an intonational phrase. More glottal /t/s would be likely if speakers followed the common tendency to descend in pitch at the end of a phrase. Fewer glottalized /t/s would be likely if speakers hyperarticulated the final segment of the phrase, as American National Public Radio speakers often do [5]. I predict that /t/ is less likely to be glottalized at the end of an intonational phrase.

ISBN 1-876346-48-5

3. METHODS

The materials were developed to systematically manipulate the vowel preceding the /t/, the consonant following the /t/, and the prosodic position of the word ending in /t/. The words were presented either as part of an open-ended list of compounds or in a question, both of which assured a high tone context with no danger of glottalization resulting from a low tone in the phonology.

The lists of created compounds test concurrently the role of preceding vowel and the role of following consonant. In these examples, a variety of vowels are tested preceding /n/ in *nut* and /t/ in *tub*.

• *That gourmet shop has all kinds of exotic nuts. They've got fruit-nuts, bat-nuts, beet-nuts, vomit-nuts, slip-nuts…*

• *That shop on Commonwealth Avenue has all kinds of tubs. They've got kit-tubs, late-tubs, hot-tubs, root-tubs, night-tubs…*

Similar sets were created for words beginning with voiceless stops, glides, liquids, and voiceless fricatives (*pigs, tanks, tubs, cabs, fads, thin, sinks, hats, man, nuts, laws, roots, yams, wars*), and the same sets of preceding vowels [i,u,æ,a,ə] and tense/lax pairs and dipththongs [i,ɪ,e,ɛ,o,ɔ,u,ʊ,aw,ai]. Target words were also embedded in three types of questions.

• Direct object question: *Can you beat Theo?*

• Vocative question: *Can you beat, Theo?*

• Final question: *You can't spell the word* boot?

The first set of questions manipulates the vowel of the verb and the first segment of the direct object. The second set uses the same words, but inserts a comma after the verb so the name is parsed as a vocative. The intent was for speakers to place an intermediate intonational phrase boundary after the verb. The verbs *beat, boot, bat,* and *dot* were used to test the vowels [i,u,æ,a] preceding /t/ and the names *Edie, Oogie, Abbie, Augie, Tubby, Muddy, Theo*, and *Fuzzy* were used to test the initial segments [i,u,æ,a,t,m,θ,f] following /t/. The third set of questions tests release of /t/ in final position, with a variety of vowels in the nucleus.

Four female speakers, naïve to the object of the study, were recorded directly into Praat on a Macintosh Powerbook, using a head-mounted microphone. Acoustic analysis was carried out in Praat, using spectrograms and waveforms. Three professional women from the Boston area and approximately 50 years of age (subjects K50, L50 and M50) were recorded reading word lists containing the items of interest, as was one 20 year old college student from the Boston area (subject S20).

A /t/ was marked as glottalized if there was irregularity in the pitch periods, as visible on the waveform. A /t/ was marked as released if a release burst could be located visually in either the waveform or spectrogram, even if the release was not clearly audible.

4. RESULTS

Little of the predicted phonetic conditioning was found because the vast majority of the /t/s were glottalized. The following chart records the non-glottalized, or released, tokens, by speaker and by context in the compounds. A few isolated cases of release following other vowels were found, but are not included in the chart. A blank cell indicates that no tokens were released in those conditions.

	K50	L50	M50	S20
after i	5	4	4	2
after u	5	3	6	1
after ɪ	1	1	5	
after æ		2	2	
after ɔ	3	2	4	
before p, t	1	1	8	
before k	2	4		
before m, n	1	1		
before l, r	2		1	2
before w, j	1	1		
before f	2	4		1
before θ	1	4	3	
before s	3	2	4	4
before h	2		5	4

Table 1: Numbers of released /t/ in compounds

In the compounds, subject M50 produced more releases than the other speakers. The fewest releases and most glottalization occurred before the stops and sonorants. Some glottalization did occur before fricatives. In the cases where the /t/ is released instead of glottalized before a sonorant for example, it is almost always because the preceding vowel was high.

The results for the direct object and vocative questions are reported only for the three 50 year old women, as the younger woman glottalized almost all /t/s. With one token of each combination per speaker, the maximum is 3 for each of the cells in Tables 2 and 3. The /t/s in the vocative questions have the most releases and least glottalization. These /t/s are at the end of an intermediate intonational phrase whereas the /t/s in the direct object questions are medial in an intonational phrase.

As with the created lists, preceding high vowels conditioned more releases than low vowels in both the direct object and the vocative questions. The /t/s before fricatives in both sets of questions had the most releases.

ISBN 1-876346-48-5

	/i/ beat	/u/ boot	/æ/ bat	/a/ dot	totals
/i/ Edie	2	3		1	6
/u/ Oogie	2	2	1		5
/æ/ Abbie	1	3			4
/a/ Augie	3	3			6
/t/ Tubby		1			1
/m/ Muddy		2			2
/f/ Fuzzie	2	2	1		5
/θ/ Theo		2	1		3
totals	11	18	3	1	33

Table 2: Numbers of released /t/ in direct object questions

	/i/ beat	/u/ boot	/æ/ bat	/a/ dot	totals
/i/ Edie	3	2	1	1	7
/u/ Oogie	2	2	1	1	6
/æ/ Abbie	3	2	1	1	7
/a/ Augie	2	2	1	1	6
/t/ Tubby	2	1			4
/m/ Muddy	1	1		1	3
/f/ Fuzzie	2	2	1	2	7
/θ/ Theo	2	1		1	4
totals	17	13	5	9	44

Table 3: Numbers of released /t/ in vocative questions

The results for the third set of questions are quite straightforward. With rare exceptions, all speakers, including the 20 year old, released these intonation-phrase-final and utterance-final /t/s.

5. CONCLUSIONS

These studies reveal some segmental conditioning of glottalization, but not as much as expected. The results bearing on each of the hypotheses are summarized below:

(i) Likelihood of /t/ glottalization depends upon the manner of articulation of the following consonant. More glottalized /t/s occurred before stops and sonorants than before fricatives. Although Pierrehumbert [6], [7] found no glottalization before fricatives, this study found some before [f,θ,s,h], with interspeaker variation.

(ii) Likelihood of /t/ glottalization depends somewhat on the height of the preceding vowel. Preceding high vowels /i,u/ tend to inhibit glottalization whereas the low vowel /ɑ/ tends to encourage it. The high tongue position of /i,u/ facilitates the oral closure, to the point that the high vowel could encourage release of /t/ even before a sonorant, where glottalization was practically a given. When speakers did release a /t/ before a sonorant, the preceding vowel was almost always high. The following vowel has no discernible effect on release.

(iii) Likelihood of /t/ glottalization does not depend fully on whether the /t/ bears a mora phonologically. The lax vowels (after which /t/ bears a mora) and diphthongs (after which /t/ does *not* bear a mora) had fewer releases than the tense vowels (after which /t/ also does not bear a mora). If bearing a mora made the /t/ more likely to be released, the lax vowels alone should show more release. The factor of functional load bears further investigation.

(iv) Likelihood of /t/ glottalization depends on its position in the intonational structure. Final /t/ in an intermediate or full intonational phrase was more likely to be released and less likely to be glottalized in this data. For the twenty year old speaker, the final position in an intonational phrase was the only place she reliably released coda /t/.

It is important to emphasize that glottalization shows a great deal of interspeaker variation, so these studies are a preliminary investigation of what appears to be a change in progress. More speakers in very clearly delineated age/social groups should be studied. Though Pierrehumbert reports finding less glottalization than the literature led her to expect, I found more than I expected. Stefanie Shattuck-Hufnagel (personal communication) finds still other patterns of glottalization, depending upon the grammatical status of the words considered. In future studies, more intermediate categories of /t/ should be considered, to pinpoint the relationship between the presence of oral closure, stop release, and glottalization.

Although designed to facilitate detailed segmental comparisons, this study reveals a striking dichotomy between the two age groups. The older women show variation, but the younger woman quite consistently avoids releasing /t/. Speaker S20 glottalizes post-vocalic /t/ almost everywhere, including intervocalically, where the older speakers flap, glottalize or release. Speaker S20 dependably releases /t/ just utterance-finally, in questions like *You can't spell the word* bit*?* The only point of consistency between the groups is utterance-final position, as all speakers release there. These results show that glottalization of coda /t/ is most advanced in the younger speaker, but strongly evident in the older speakers.

The allophonic behavior of /t/ bears close continued observation because of the conflicting reports and the abundant interspeaker variation. The common phenomenon of intervocalic flapping is losing ground in some groups. Given the frequency of /t/ in the English lexicon, these possible changes in progress have the potential of changing the sound of American English.

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