# AMERICAN ENGLISH HAS GOʔ A LOʔ OF GLOTTAL STOPS: SOCIAL DIFFUSION AND LINGUISTIC MOTIVATION

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ABSTRACT: In word-final, prevocalic position (e.g., *it is*) there are various possible phonetic realizations of /t/ in American English (e.g., [t], [ɾ], [ʔ]). The present study examines the linguistic and social factors associated with the use of the glottal stop in American English in 1,101 instances of word-final, prevocalic /t/ from the Santa Barbara Corpus. The glottal stop occurred in 24% of the cases. Logistic regression analysis was used to identify factors that favor glottaling of /t/. Our findings concur with previous research in that age and region were significant: Westerners in their teens and 20s glottalized more than non-Westerners in the same age groups; speakers who are 30 and older, both Westerners and non-Westerners, glottalize to a much smaller degree. We also found that glottaling is favored by a following stressed syllable; however, gender and following vowel quality were not influencing variables, which contradicts previous experimental findings. If prevocalic glottaling is uncommon word-internally in American English, why is it apparently spreading word-finally? We provide evidence that word-final /t/s are more often followed by word-initial consonants than vowels, which places them in a glottalizing context. Instances with a glottal realization are stored in the mental lexicon and are available as possible pronunciation choices even in prevocalic position.

GLOTTAL STOPS ARE COMMON realizations of /t/ in most varieties of English. They were first documented in the late nineteenth century in Scotland and England (Andrésen 1968; Wells 1982; Collins and Mees 1996). In Contemporary English, the phonetic context in which glottal stops appear depends on the variety of English. For example, many British varieties demonstrate *t*-glottaling before vowels (e.g., *be*[ʔ]*er pu*[ʔ] *a lo*[ʔ] *of*) where American varieties tend to have a flap (e.g., *be*[ɾ]*er pu*[ɾ] *a lo*[ɾ] *of*). In contrast, glottal stops are extremely frequent before consonants in many varieties (e.g., *ou*[ʔ] *come, se*[ʔ]*back*). Regional variation has been observed in American English; Byrd (1994) recorded less overall glottaling in the North Midland region when compared to the South and North. In addition to phonetic context

*American Speech*, Vol. 85, No. 3, Fall 2010 DOI 10.1215/00031283-2010-019

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and geographic region, the use of the glottal pronunciation has also been linked to other factors: social class and prestige (Trudgill 1974; Macaulay 1977; Mees 1987; Milroy et al. 1994), age (Macaulay 1977; Holmes 1995; Tollfree 1999; Marshall 2003; Partin-Hernandez 2002; Eddington and Taylor 2009), and gender (Byrd 1994; Milroy et al. 1994; Holmes 1995; Levon 2006; Roberts 2006; Eddington and Taylor 2009).

In the present study, we focus on the realization of word-final /t/ as a glottal stop when it is followed by a vowel as in *at on, right around,* and *fit in.* Glottal stops have been documented in this position in both British varieties (Reid 1978; Wells 1982, 1997; Mees 1987; Coggle 1993; Docherty and Foulkes 1999; Fabricius 2000; Marshall 2003; Straw and Patrick 2007) and American varieties (Wells 1982; Byrd 1994; Partin-Hernandez 2002; Levon 2006; Roberts 2006; Eddington and Taylor 2009). In American English, there is a great deal of variation between [ʔ] and [ɾ] in this context. Roberts (2006) notes that in Vermont English this is the only phonetic environment in which glottal stops and flaps alternate. In like manner, Shaw and Patrick (2007, 390) cite prevocalic positions among those that "seem to allow the greatest play for social factors."

For this reason, Eddington and Taylor (2009) exploited the word-final prevocalic position in order to gain more insight into *t*-glottaling in the United States. They utilized a shadowing task (see van Heuven 1988; Rohena-Madrazo, Simonet, and Paz 2006; van der Veer 2006) to elicit tokens of /t/. In the study, participants heard a series of recorded utterances. Their task was to repeat each utterance three times upon hearing it. The /t/ and adjacent portions of the surrounding vowels in each utterance they heard had been deleted and replaced with a tone. This ensured that the participants did not merely mimic what they heard, but produced utterances uninfluenced by the pronunciation in the presented speech. In the repeated sentences, glottal stops were found to be favored before front vowels. In addition, younger speakers, women, and those from states in the Western United States were more likely to glottalize /t/ in this context. One interpretation of these results is that glottaling is on the increase in American English, especially in the West.

Eddington and Taylor's (2009) study has the advantage of being carried out under tightly controlled laboratory conditions. However, there are a number of drawbacks to its method. First, having participants merely repeat sentences means the results are based on somewhat artificial speech that may not accurately represent the spontaneous informal register. Second, only 19 sentences were used in the experiment, which opens up the possibility that one unusual word or word combination may have skewed the results. The

authors recognize that this may be the reason that vowel backness unexpectedly arose as a significant factor in glottaling.

The goal of the present study is threefold. First, we address the disadvantages of Eddington and Taylor's (2009) experimentally elicited data by examining glottaling in the same phonetic context, but with data from naturalistic sources. Second, we examine the linguistic and social factors associated with glottaling and compare the results with those of Eddington and Taylor (2009). Third, we explore why the /t/ tends to glottalize in word-final, prevocalic positions rather than word-internal positions in American English.

## PARTICIPANTS

All data were taken from parts 2–4 of the Santa Barbara Corpus of Spoken American English (Du Bois et al. 2003; Du Bois and Englebretson 2004; Du Bois 2005), which contain about 18 hours of recordings and transcripts of informal conversations between friends covering many different topics. We established controls for education and race among the 40 participants using the limited demographics in the corpus. The teenagers were all in high school, and all adults had attended some college. All participants were white. Recordings of 21 females and 19 males were used. Seven participants were between the ages of 11 and 17, ten between 20 and 29, eight were in their 30s, seven in their 40s, six in their 50s, and two were 60 or older.

Following the dialect boundaries of Labov, Ash, and Boberg (2006), we grouped all Westerners into one dialect area and contrasted them with non-Westerners. A number of participants reported having spent a significant amount of their lives in two different states, which is indicated on table 1. As the number of tokens indicates, our data from the West are highly skewed toward California, which must be taken into consideration when interpreting the results.

Eddington and Taylor (2009) reported differences in glottaling rates between Westerners and non-Westerners. Because the purpose of the present paper is to follow up their experiment with naturally obtained data, we chose participants who reflected this division. Further regional subdivision is not feasible given the holes it would create in the data. For example, only one participant was born and raised in the South, and the Inland North would not have a representative speaker from each age group.

TABLE 1
Number of Participants and Tokens by State

| *Region/State* | *No. of Participants* | *No. of Tokens* |
|---|---|---|
| Western | | |
| California | 10 | 400 |
| Idaho | 2 | 92 |
| New Mexico | 1 | 60 |
| Washington | 2 | 41 |
| Colorado/California | 1 | 22 |
| California/Idaho | 1 | 38 |
| Oregon/California | 1 | 4 |
| Montana/New Mexico | 1 | 36 |
| TOTAL | | 693 |
| Non-Western | | |
| Illinois | 1 | 36 |
| Louisiana | 2 | 27 |
| Louisiana/ New York | 1 | 57 |
| Massachusetts | 5 | 91 |
| Michigan | 3 | 64 |
| New Jersey | 1 | 3 |
| New York | 1 | 1 |
| Pennsylvania | 4 | 88 |
| Wisconsin | 3 | 41 |
| TOTAL | | 408 |

## METHOD

Using the written transcriptions of the chosen participants from the Santa Barbara Corpus, we identified all cases of word-final /t/ preceded by a vowel, nasal, or liquid and followed by a vowel. We then located them in the recording and classified each one impressionistically as a [t], [ʔ], [ɾ], or unpronounced/deleted. Some instances had to be eliminated due to cross talk by another speaker. We used spectrographic analysis to classify tokens whose realization was difficult to determine auditorily. Glottal stops appeared as unevenly spaced striations on the spectrograms. In this manner, we identified 1,101 instances of /t/ in the speech of the 40 speakers included in the study. This included instances of 140 different words. The classification yielded 73 instances of deletion, 110 of [t], 262 of [ʔ], and 656 of [ɾ].

In addition to the phonetic realization of /t/ we encoded the gender, age, and geographic region for each speaker. Information about the phonetic context in which /t/ appeared was also encoded: the backness of the vowel

after /t/ (following Eddington and Taylor 2009), the type of phone preceding /t/ (i.e., vowel, nasal, or liquid), and the stressed status of the syllables before and after /t/. Stress was marked on lexical words but not on function words unless they were given an emphatic rendering by the participant.

## RESULTS AND DISCUSSION

Logistic regression using Goldvarb (Robinson, Lawrence, and Tagliamonte 2001) was performed on the resulting data. The analysis calculated the factors that favor [ʔ] over the other possible pronunciations (i.e., [ɾ], [t], and deletion). Initial analysis revealed an interaction between age and region of origin, so these two factors were recoded into one. The only significant factors resulting from the subsequent analysis were age by region of origin and the stressed status of the following syllable. Gender, preceding syllable stress, backness of following vowel, and type of preceding consonant were not significant. In table 2, a factor weight above 0.5 indicates that the variable value favors glottal stops, while a variable value with a weight below 0.5 disfavors glottal stops.

TABLE 2
Significant Factors Resulting from a Logistic Regression Analysis of Factors Favoring the Glottaling of /t/

| | | | |
|---|---|---|---|
| Input | 0.23 | | |
| Log likelihood | –587.049 | | |
| Total N | 1101 | | |
| | *Factor Weight* | *Percentage* | *N* |
| Age by Region of Origin | | | |
| 11–19 Westerners | 0.64 | 35 | 23 |
| 20–29 Westerners | 0.62 | 33 | 314 |
| 11–19 non-Westerners | 0.48 | 22 | 124 |
| 40+ non-Westerners | 0.48 | 21 | 154 |
| 20–29 non-Westerners | 0.44 | 20 | 65 |
| 40+ Westerners | 0.43 | 19 | 145 |
| 30–39 Westerners | 0.42 | 18 | 210 |
| 30–39 non-Westerners | 0.42 | 18 | 66 |
| Range 22 | | | |
| Stress Following /t/ | | | |
| Stressed | 0.59 | 31 | 290 |
| Unstressed | 0.47 | 21 | 811 |
| Range 12 | | | |

The clearest connection appears in the age by region factor. The apparent trend is the divide in the younger age groups. Westerners ages 11 to 29 glottalize much more that their non-Western counterparts. On the other hand, speakers 30 and older, regardless of region, do not favor glottal pronunciations. This corroborates the findings of Eddington and Taylor (2009) that glottaling is more frequent among Westerners and among younger speakers. However, we did not find significant differences between the genders, whereas Eddington and Taylor (2009) observed more glottal realizations among women, especially younger women.

Word-internally, stress is cited as a major predictor of flapping; flaps are common when the following syllable is unstressed, as in *be*[ɾ]*er* and *ci*[ɾ]*y*, while [t] is more likely before stressed syllables as in *a*[t]*ack* and *a*[t]*end* (Zue and Laferriere 1979; Kahn 1980; Geigerich 1992). The finding that glottal stops are favored over flaps across a word boundary when they are followed by a stressed syllable somewhat parallels the fact that flaps are disfavored in this position word-internally. However, stress is not a conditioning factor for flaps across word boundaries (Oshika et al. 1975). Between words, flaps may appear followed by either stressed or unstressed syllables (e.g., *pu*[ɾ] *every*, *pu*[ɾ] *around*). Therefore, the finding that glottal stops are favored over flaps (and other realizations of /t/) when the following word begins with a stressed syllable is novel. Further research into the effect of stress is clearly called for.

In Eddington and Taylor's (2009) study, the quality of the following vowel was a significant factor (front vowels favored glottal stops), while stress did not influence the pronunciation of /t/. In contrast, we observed no influence of vowel quality. We suggest that this is due to differences in the data sets each study is based on. Eddington and Taylor's test words were extremely limited, involving only 19 words, repeated in a sentence three times by each participant. This opens up the possibility that their results were influenced by one of the particular words or collocations. In the present study, data were taken from informal conversations, which contained tokens of 140 different words. This makes the results less sensitive to the influence of one word.

Nevertheless, when taken in conjunction with Eddington and Taylor's (2009) study, the picture that emerges is one in which glottaling of /t/ is a more common trait in the Western United States, especially in California where the majority of the Western participants are from. The fact that younger speakers use more glottal stops in the context we studied corroborates Eddington and Taylor's (2009) finding and suggests that younger speakers are on the forefront of this phonetic evolution.

Glottal stops appear to be encroaching on the territory of the flap pronunciation rather on [t] or deletion of /t/. The 11–19 and 20–29-year-

old groups have the highest rates of glottalization (24% and 31%, resp.) in comparison to 30, 40, and 50+ year olds (18%, 19%, 21%). At the same time, the younger groups have the lowest usage of the flap variant (59% and 56%, resp.) compared to the older groups (30s: 63%, 40s: 62%, 50+: 60%). The rates of deletion for participants aged 11–29 fall in the middle of the other age groups (10s: 11%, 20s: 7%, 30s: 5%, 40s 5% 50+: 13%), as do the rates of [t] realizations (10s: 11%, 20s: 7%, 30s: 13%, 40s: 14%, 50+: 6%), which suggests that the younger speakers *t*-glottaling is not at the expense of deletion or [t], but at the expense of the flap variant.

## LINGUISTIC MOTIVATION FOR GLOTTALING

Glottal stops are common word-internally when followed by a vowel (e.g., *ci*[ʔ]*y*) in many British varieties. In American English, flaps are the more typical realization in this context. (e.g., *ci*[ɾ]*y*). The question that arises from this difference is why glottal stops are apparently becoming more common prevocalically across word boundaries, but not within words. Exemplar theory provides a plausible explanation for this.

Traditional models of phonology hold that each word has a unique underlying representation, which is modified by rules in order to derive the phonetic output. All predictable information is derived, not stored. These models entail a great deal of processing of underlying forms to produce the surface forms, while keeping storage at a minimum. A number of researchers have espoused exemplar models as an alternative (e.g., Medin and Schaffer 1978; Bybee 1985, 1988, 1995; Nosofsky 1988, 1990; Riesbeck and Schank 1989; Skousen 1989, 1992; Aha, Kibler, and Albert 1991; Lakoff 1993; Daelemans et al. 2001; Pierrehumbert 2001). Exemplar models assume the mental lexicon contains massive amounts of stored linguistic experience that includes even predictable, redundant, messy details. Rather than tacitly gleaning generalizations from the linguistic input and storing them as separate entities, speakers refer to the database of stored experience during linguistic processing to determine things such as the pronunciation of a word in a particular linguistic and social context. This sort of storage is responsible for the probabilistic knowledge that speakers have about their language. As far as acquisition is concerned, children appear to learn probabilities associated with linguistic forms and put this stochastic knowledge to use in language processing (Labov 1994). Exemplar models also explain the sort of variation governed by social factors (Foulkes and Docherty 2006; Scobbie 2006)

As a point of comparison, consider word-internal instances of /t/ such as in *city* and word-final cases as in *forget*. Word-internal instances of /t/ appear in the same phonetic context, which means that each time they are uttered they are subject to the same phonetic processes. As a result, the great majority of the stored exemplars of *city* have a flap for American English speakers. Of course, there will be other realizations, but these are generally due to different registers and experience with other varieties of English and not to changes in phonetic environment.

The situation is quite different for word-final /t/, because it can be followed by a variety of different phones. In other words, it appears in an alternating environment (Bybee 2000). Many have noted that in American English, when /t/ is followed by a vowel, it is often flapped (e.g., *forge*[ɾ] *any*), and when followed by a consonant or pause, it is often glottalized (e.g., *forge*[ɾ] *many*) (Kurath 1939; Zue and Laferriere 1979; Kahn 1980; Wells 1982; Nespor and Vogel 1986; Geigerich 1992; Byrd 1994; Partin-Hernandez 2002; Levon 2006; Roberts 2006; Edwards 2008; Gordon 2008; Kretzschmar 2008; Nagy and Roberts 2008; Thomas 2008). This leads to a situation in which words such as *forget* have many stored exemplars ending in a variety of phones (e.g., [t], [ɾ], [ʔ]). The high degree of variability among the stored instances of words with final /t/ is precisely what makes /t/ in this position a prime candidate for phonetic change and sociolinguistic variation in comparison to word-internal /t/. There are arguably many instances of *forge*[ʔ] in which glottal stop has been conditioned by a following consonant (*forge*[ʔ] *many*). Roberts (2006) gives data from Vermont English indicating the glottal stop realization of /t/ occurred in 17.6% of the cases when /t/ was followed by a consonant or pause and in only 11.6% of the cases when followed by a vowel. Although she does not give numeric data, she states that cases of /t/ followed by a vowel were almost exclusively realized as flaps. Exemplars in such proportions are stored in the mental lexicon and exert their influence on the pronunciation of *forget* even when it is followed by a vowel, which is a position that disfavors glottaling.

Bybee (2002) discusses a similar situation that lends itself to an exemplar explanation. She studied deletion of word-final /t/ and /d/ in English, which generally occurs when they are followed by a consonant. She observed that some words ending in /t/ and /d/ frequently appear before consonant-initial words, the phonetic environment that conditions deletion. This means that such words have more exemplars with deleted /t/ and /d/ stored in memory than words that do not appear in that environment as often. The crucial finding is that these words have higher rates of /t/ and /d/ deletion, even when they are followed by a vowel. The existence of instances of deleted /t/

and /d/ in the cloud of stored exemplars influences deletion even though the phonetic context does not condition it.

In like manner, Brown (2004) observed that in New Mexican Spanish word-initial /s/ is more often reduced to [h] when preceded by nonhigh vowels. The frequency with which an /s/-initial word follows a nonhigh vowel differs from word to word. Words that commonly appear in this reduction-favoring environment are more likely to be realized as [h] even when there is no preceding high vowel. Fox (2006) also studied /s/ lenition, but in syllable-final position (see also Bybee 2000). Word-final instances of /s/ are especially prone to lenition when they are followed by a consonant-initial word. However, /s/-final words that commonly appear before consonant-initial words are more likely to be lenited even when they appear before vowel-initial words. In other words, the frequency of occurrence in overall usage is a factor in lenition beyond the phonetic context in which a particular instance appears.

The role of exemplars in the origin of prevocalic, word-final glottaling of /t/ is of interest for the purposes of the present study. If English words ending in /t/ are more commonly followed by consonant-initial words rather than vowel-initial words, then /t/ occurs more frequently in a position that favors glottaling. This in turn would result in larger numbers of exemplars ending in [ʔ]. To test this idea, we consulted the Corpus of Contemporary American English (Davies 2008–, henceforth COCA).

We searched for all collocations containing words ending in *-Vt*, *-nt*, *-rt*, and *-lt* that are followed by a vowel (e.g., *part of, about even*) and those followed by a consonant (e.g., *pint barely, fault because*).[1] This yielded 12.5 million collocations of word-final /t/ followed by a word-initial consonant and only 6.3 million followed by a vowel. According to this rough estimate, *-t* is almost twice as likely to appear before a consonant, where glottaling is highly probable. The end result is a lexicon that contains many glottalized instances of *-t* in a word (e.g., *table*[ʔ] *can*). Even when *-t* is prevocalic (e.g., *tablet of*), a context in which [ʔ] is less expected, the large cloud of exemplars of *table*[ʔ] is also available to influence the glottal realization despite the lack of phonetic motivation.

While the frequency data from the corpus support the idea that stored exemplars may help explain glottaling, the data are somewhat coarse because they do not take individual words into account. A more fine-grained method is to compare the actual pronunciation of the 140 different words we examined in the spoken corpus with the frequency with which each individual word is followed by a consonant or vowel. Using COCA, we calculated the proportion of following consonants for each word. For example, *part* precedes consonant-initial words in only 11% of the cases, while *submit* is

followed by a consonant-initial word in 92% of the cases. We would therefore expect more glottaling in words such as *submit*, even when they precede a vowel initial word.

To test this, we performed an ANOVA with the proportion of following consonants for each word (taken from COCA) as the dependent variable. The independent variable was whether /t/ was realized as [ʔ] or was given another pronunciation; this was taken from the spoken corpus. Of the 1,101 total instances, 79 had to be excluded from the analysis because they do not appear in COCA; hence, the proportion of consonants could not be determined. In spite of the fact that all cases of *-t* that we considered were prevocalic, words pronounced with a glottal stop are more often followed by consonants in COCA. That is, words pronounced with [ʔ] prevocalically in the spoken corpus appear before consonants 64% of the time in COCA, in comparison to words given a different pronunciation of /t/ that are preconsonantal only 60% of the time. Although the differences are not large, they are statistically significant ($F(1) = 7.996$, $p = .005$).

## CONCLUSIONS

We found *t*-glottaling to be more prevalent among younger Western speakers (comprised mostly of Californians) than among non-Westerners, but more fine-grained geographical distinctions could not be made with the present data set. Byrd (1994), on the other hand, observed less glottaling in the North Midland region when compared to the South and North; however, Western speakers were not included in her data. Clearly, research that includes more specific geographical distribution of glottaling is warranted in future studies.

Although gender did not arise as a significant factor in the present study, others have observed gender differences in glottaling rates in the United States (Roberts 2006; Eddington and Taylor 2009). To our knowledge, the influence of factors such as social class, education, and race also have not been explored. Our anecdotal observations suggest that speakers of African American Vernacular English often glottalize word-final /d/, which may indicate the spread of this process to other stops. Once again, more research is called for to answer these questions.

Glottal stops are extremely rare word-internally before a vowel in American English, yet at word boundaries we found glottaling in about 24% of the cases. In contrast to word-internal instances, whose phonetic context does not vary, word-final positions have /t/ in an alternating context in which they can be followed by many different consonants and vowels. When followed by

a consonant, /t/ falls in a position that favors glottaling. The corpus evidence we presented above demonstrates that word final *-t* is more often followed by consonants than vowels. If detailed pronunciations are stored in long-term memory, as exemplar theory suggests, many exemplars of words that end in /t/ have a glottal realization. These stored glottalized representations then influence the pronunciation of the word even when it precedes a vowel-initial word—a context that does not normally condition glottal stops. The resulting variation between [ʔ] and [ɾ] is apparently being exploited as a linguistic marker of age and regional origin.

## NOTES

1. The search engine limits the search to those collocations that occur 10 or more times. We thank Mark Davies for his help with this search.

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