[V̰] is the new [ʔ]: A real-time diachronic study of lenition in Wisconsin English

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Abstract

This paper investigates glottalization rates of word-final /t/ in Wisconsin English over time, based on both historical (1950s) and newly collected (2018) recordings of Wisconsin speakers. Real-time diachronic data show that glottalization rates have been subject to rapid change since the 1950s, doubling by 2018. There is no consistent correlation between glottalization rates and speech style, with great interspeaker variability in how glottalization interacts with formality. A fine-grained acoustic analysis of realizations of word-final /t/ reveals a lenition hierarchy where /t/ is subject to increasing lenition over time and ultimately phonetically reduced to zero. This paper identifies a [ʔ] > [V̰] > ∅ lenition hierarchy, where laryngealization of the preceding vowel or nasal and deletion gradually gain ground over time, starting in the leading environment.

1 Introduction

This paper investigates patterns in the glottalization rates of word-final /t/ in Wisconsin English over time and across speech styles. Real-time diachronic data show that glottalization rates in this context have been subject to rapid change between the 1950s and today, and that there is a surprising correlation between glottalization and speech style, where more glottalized forms can be associated with greater formality in speech. This is a continuation of a pilot study conducted by Holmstrom et al. (2019), which showed doubling glottalization rates over the aforementioned time period. In related work, Holmstrom (2021) investigates

interactions between /t/-lenition rates and word frequency, finding no significant frequency effects on lenition rates. The present study provides a more in-depth analysis of change over time and phonetic conditioning and adds the speech style dimension.

For the purpose of this study, /t/-glottalization is considered to be a type of lenition, i.e. a 'weakening' of a sound to become more vowel-like. By glottalization, I mean a type of lenition where the oral gesture of a stop is replaced by a glottal gesture. See Hock (1991: 83) and others for proposed lenition hierarchies. This paper provides support for a (partial) lenition hierarchy where word-final /t/ over time is increasingly lenited and ultimately phonetically reduced to zero in the following phases:

0. [t] – an alveolar stop which may or may not be accompanied by a glottal stop.
1. [ʔ] – /t/ is represented only by the glottal closure, with the alveolar closure no longer present.
2. [V̰] – the sound is more vowel-like in the sense that there is no longer any discernible closure. There remains a 'glottal' element in the form of a laryngealized vowel or nasal (as illustrated below).
3. ∅ – deletion: there is no phonetic trace of /t/.

Other potential realizations of word-final /t/, particularly flaps [ɾ] were also recorded as a part of this study. Flaps appear in very specific environments that rarely overlap with glottalized and deleted /t/ and are therefore not a part of this proposed lenition hierarchy.

Beyond the real-time perspective, this study goes beyond previous work in that it provides a finer-grained phonetic picture of glottalized realizations of /t/. Through acoustic analysis using Praat, Holmstrom et al. (2019) observe that the category commonly thought of as glottal stop in reality is more phonetically diverse, containing both 'proper' glottal stops [ʔ] and laryngealized vowels or

nasals, transcribed here as [V̰], which Holmstrom et al. consider to be one step down on the lenition hierarchy towards full deletion. In earlier work on glottalization, Eddington & Taylor only passingly recognize the existence of glottalized tokens that do not contain a stop (2009: 306) but lump these in with glottal stops for their analysis. Holmstrom et al. (2019) and the present study treat glottal stop and laryngealization as two separate lenition categories. The distinction between [ʔ] and [V̰] is illustrated in more detail in the methods section of this paper.

/t/-glottalization has been a well-attested phenomenon at least since the 1940s (see Trager 1942; Roberts 2006; Eddington and Taylor 2009; Eddington and Channer 2010; Eddington and Brown 2020; Holmstrom 2021). In his 1942 study on the phoneme /t/, Trager discusses in great phonetic detail potential allophones and hints at stylistic associations specifically with glottalized forms: " … I have 'free' variation between [ʔ] and [t], the latter being more usual in informal and non-emphatic speech" (Trager 1942: 147). This idea that glottalized forms may be associated with a higher degree of formality seems counterintuitive if we do take glottalization to be a form of lenition. In their experimental approach to studying glottalization in American English, Eddington and Taylor (2009: 310) report surprisingly high glottalization rates, similarly suggesting some stylistic factors associated with glottal stop. These informal observations on the stigmatization of glottal stop aside, few studies have described its specific patterns of variation and change in American English. To date, there has not been any study dedicated to the systematic observation of /t/-glottalization across different speech styles in American English.

Eddington and Taylor (2009) observe in their experimental data that young female speakers glottalize more than any other gender/age group. This observation has the important implication of signalling a potential change in progress, as young women are more often and more likely early adopters of

innovative linguistic structures (2009: 306; Labov 2001: 280). The present study is the first to track real-time changes in /t/-glottalization and its stylistic implications, using historical data from Wisconsin English speakers. In what follows, section 2 describes the data used for this study and section 3 details the method of analysis. Section 4 summarizes the results, including patterns of change over time, phonetic conditioning and stylistic implications. Conclusions are drawn in section 5.

2 Data

The primary data for the study are two sets of recordings of Wisconsin English speakers. The first is a set of historical recordings that were collected in the first half of the 1950s as part of Frederic Cassidy's Wisconsin English Language Survey (WELS). This effort involved the recording of English speakers across the state of Wisconsin in two separate speech styles. Each speaker first read aloud a specific text, the story of "Arthur the Rat," and then engaged in free conversation with the interviewer. The Arthur story allows for straightforward comparison between speakers, as it yields an identical dataset for each speaker. For the purpose of the pilot study, which focused only on the reading task, six speakers of the WELS set were selected, three female and three male, all living in southeast Wisconsin, and all born around the turn of the twentieth century. The current study eliminated two of these speakers because their conversational part was missing or unusable, so their data were not included in this study.

The second set of data was collected at the University of Wisconsin-Madison in 2018[1] and designed to mimic the WELS set, in that it also included a reading of the Arthur story as well as free conversation. This group of speakers was selected

[1] This pilot study was conducted as part of a linguistics course on Sound change. I thank Sarah Holmstrom, Sam Tao, Caleb Thompson, Madeline Urbanz, Aileen Wagner, and Joe Salmons for their foundational work.

to live in roughly the same areas as the selected speakers from WELS. The six speakers, again three female and three male, were all born in the 1990s. Considering the speakers' years of birth, this allows for diachronic study across approximately one hundred years. This dataset facilitates comparison across two dimensions, examining both real-time historical change and stylistic variation.

Figure 1. Speaker Locations

Figure 1 shows the locations of each of the speakers within Wisconsin. The red pins represent speakers from the WELS dataset. The blue pins represent our 2018 speakers.

The results of this study are based on impressionistic and acoustic analysis of a total of 1652 tokens of word-final /t/. The 1950s WELS recordings yielded 529 tokens: 315 from the reading task and 214 from free conversation. The 2018 recordings yielded 1123 tokens: 484 from the reading task and 639 from free conversation. The tokens included for analysis were all word-final /t/-phonemes, regardless of the following sound.

3 Methods

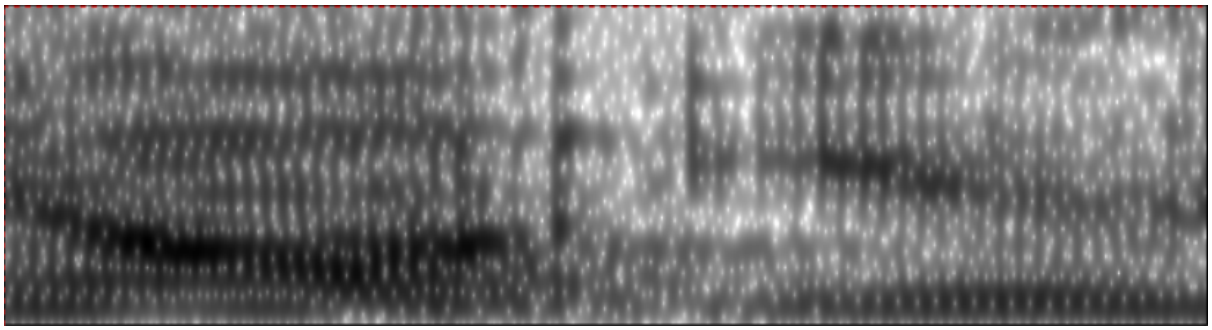
This study focuses exclusively on the various phonetic realizations of word-final /t/. These can include, following Holmstrom et al. (2019), alveolar [t], a flap [ɾ], often between vowels in connected speech, a glottal stop [ʔ], laryngealization of the preceding vowel or nasal [V̰], or complete deletion (∅). While there is further variation within the category of [t], such as in the presence or absence of glottal reinforcement or the intensity of the burst, the data presented below do not distinguish between these and consider all tokens of /t/ that feature an alveolar or dental closure to belong to the same category, that is, realizations of /t/ that retain the alveolar place of articulation and have not undergone the relevant type of lenition. The present analysis is finer grained in the category of glottalized variants, distinguishing between glottal stops, with or without glottalization of the preceding vowel (creak), and instances where there is no discernible closure but instead the glottalization period is increased. In what follows, *laryngealization* refers to these instances with no closure but increased glottalization of the preceding sonorant (Holmstrom et al. 2019). This study focuses primarily on the two glottal types [ʔ] and [V̰] and deletion ∅.

The analysis portion of this study consisted of creating an inventory of each instance of word-final /t/ in the dataset and encoding the phonetic environment, i.e. the segments immediately preceding and following /t/. For the analysis, a combination of impressionistic and acoustic analysis with Praat was used. Often, the distinction between a glottal stop and laryngealization, specifically, cannot be readily determined impressionistically. Signs of glottalization (irregularly spaced striations) and stops (silence followed by some kind of release) in the spectrogram help to identify the sound. Even so, establishing a clear boundary between glottal stop and laryngealization can be tricky, and deciding between the two sometimes remains a judgment call.

Figures 2 and 3 below illustrate the distinction between the two glottal subcategories. Figure 2 shows a glottal stop realized by a female speaker from the WELS database. The visible time in this spectrogram is approximately 304 milliseconds. Centrally in the spectrogram is a clearly discernible silent period indicating a stop of some kind. Around it we see irregularly spaced striations, the tell-tale sign of glottal activity. In Figure 2, the duration of the irregular striations preceding the closure is approximately 20 milliseconds. The closure has a duration of approximately 30 milliseconds.

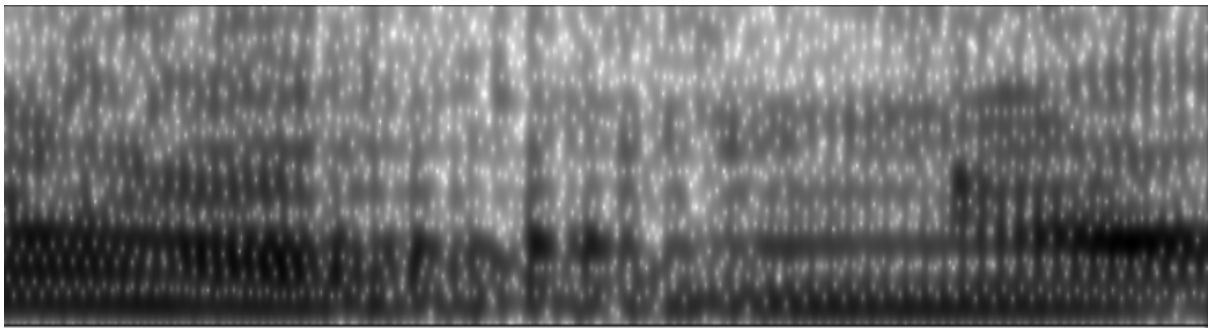
Figure 3 is a spectrogram taken from the same WELS recording, where the speaker realizes what we labelled as a laryngealized nasal [n̰]. The visible time below is approximately 309 msec; nearly the same as Figure 1 to allow for easy comparison. Note that there is no discernible stop, but the first nasal is characterized by irregularly spaced striations throughout. The duration of this creak is approximately 86 milliseconds, and it is followed by a plain nasal without creak. Figures 2 and 3 illustrate the two factors that are relevant in deciding between glottal stop [ʔ] and laryngealization [V̰]: (1) the presence or absence of a visible closure, and (2) the duration of creak.

Figure 2. *Don't you think so?* Glottal stop. (Baraboo 43.81-22.12)



t o n ʔ j u

Figure 3. *I don't know*. Laryngealized nasal. (Baraboo 133.575-133.785)



o n̰ n o

Based on these metrics, each token was coded as one of the five possible realizations of /t/ listed above. In addition, I recorded the immediate phonetic environment for each token (preceding and following sound), as one of five categories: Stop (S), Fricative (F), Nasal (N), Approximant (A) or Vowel (V). At the acoustic analysis stage, a small number of tokens could not be determined due to lower recording quality or noise. This amounted to fewer than 2% of the reading task tokens and approximately 3.5% of the conversational tokens. These tokens are not included in the numbers listed in this paper.

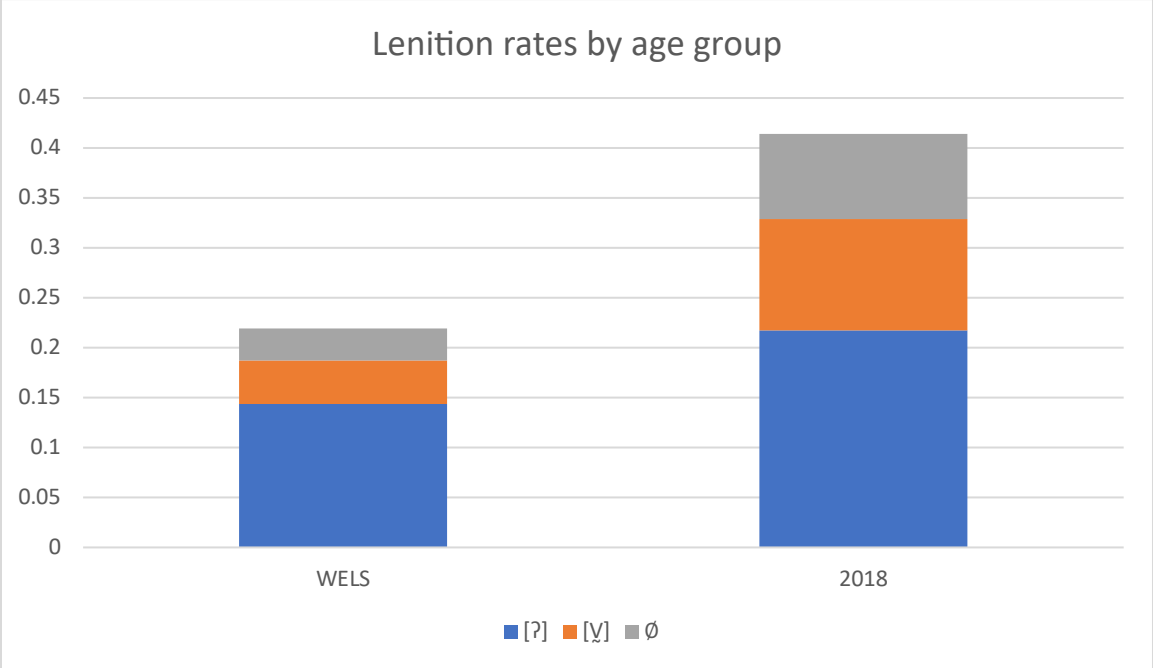
4 Results

4.1 Real-time change

Previous work on t-glottalization (Byrd 1994; Eddington and Taylor 2010; Eddington and Brown 2020) cites indirect and apparent-time indications that the phenomenon is increasing over time in American speakers. Until recently, there had been no real-time diachronic investigation into glottalization to put these findings to the test. Holmstrom et al. 2019, Holmstrom 2021 and the present study have been the first to compare glottalization rates at different points in time, using historical and new recordings created fifty years apart. The real-time data presented here show a clear trend of increasing glottalization rates between the 1950s (WELS data) and 2018 (new data).

Figure 4 summarizes the combined lenition rates for word-final /t/ in the WELS and the 2018 data set. The data set was expanded from the pilot study (Holmstrom et al. 2019) to include conversational speech, but the findings from

Figure 4. Average rates for glottal stop, laryngealization and deletion by age group

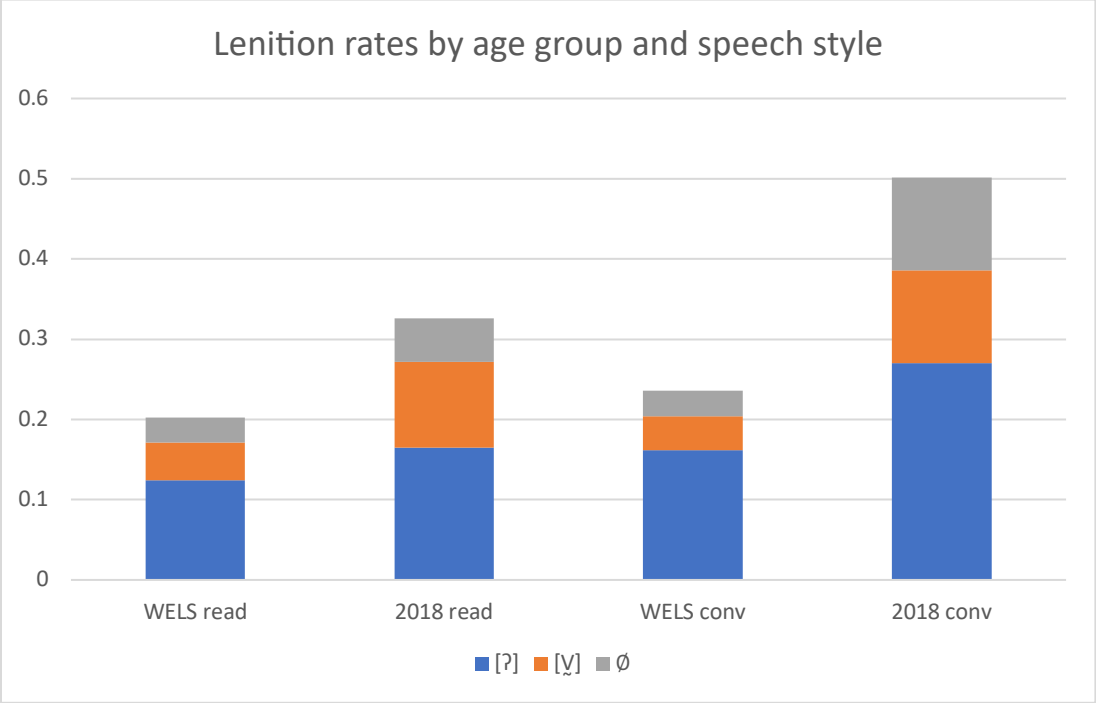


that study hold here: real-time data reveal a doubling of overall lenition rates over time, from approximately 21% in the 1950s to approximately 41% in 2018. While some growth is present across all lenition categories, the overall increase is driven primarily by laryngealization ([V̰]) and deletion (Ø), with glottal stop showing more conservative growth.

Figure 5 further breaks down the data by speech style. Considering glottal stop, laryngealization and total deletion together as steps in the lenition hierarchy for word-final /t/, the overall lenition rate was at around 20% for middle-aged speakers in the 1950s, whereas total lenition rates for younger speakers in 2018 are closer to 50% in conversational speech, and just over 30% in the reading task.

Apart from the clear increase in overall glottalization rates over time, figures 4 and 5 also show a shift in the distribution of glottal stop and

Figure 5. Average rates for glottal stop, laryngealization and deletion per age group and speech style



laryngealization within the overall glottalization category. When we separate glottal stops from laryngealized vowels or nasals, we see that the increase in lenition is driven primarily by a sharp increase in laryngealization as defined above, with no discernible stop (also Holmstrom et al. 2019), as well as deletion. This is especially clear in the reading task, where there is only a very small increase in the rate for glottal stop. Where laryngealization was still a marginal phenomenon in the 1950s, by 2018 it competes with glottal stop, with deletion not lagging far behind.

4.2 Phonetic conditioning

In their initial foray into this topic, Holmstrom et al. (2019) observed that glottal variants of word-final /t/, including glottal stop and laryngealization, generalized over time from postnasal to postvocalic environments. This section examines in more detail the phonetic conditioning for the various realizations of /t/ by breaking down the rates by preceding and following sound category. Figure 6

Figure 6. Phonetic conditioning of word-final /t/

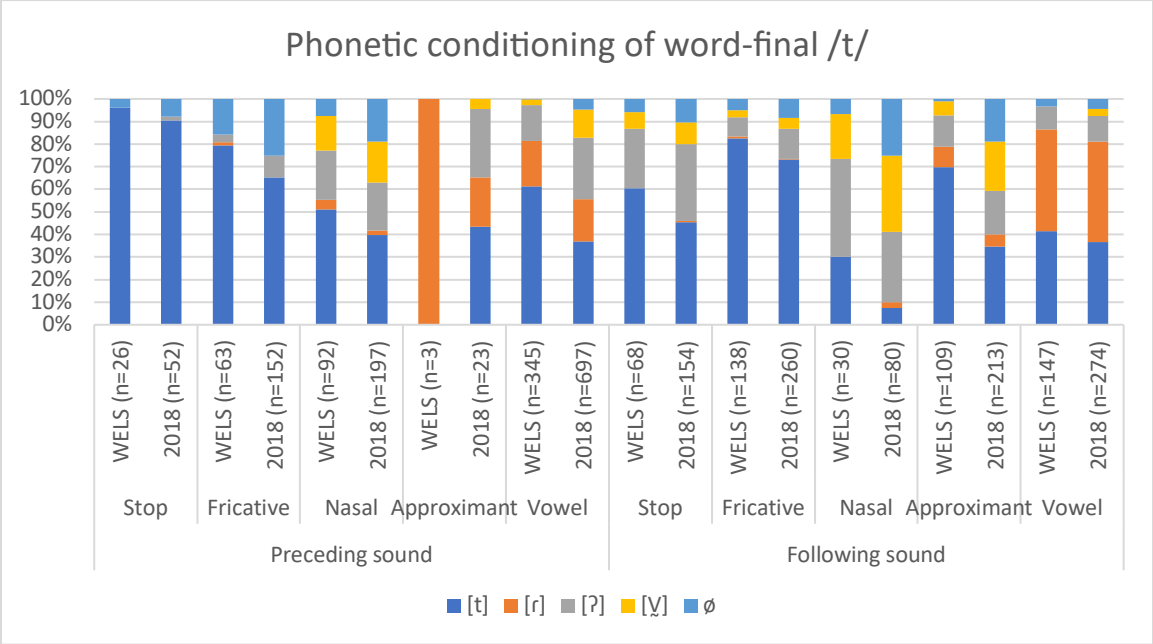


Table 1. Leading and trailing environments for /t/-lenition with rates expressed as %. Shading reflects density of occurrences

	WELS				***2018***			
	[t]	**[ʔ]**	**[V̰]**	**∅**	**[t]**	**[ʔ]**	**[V̰]**	**∅**
_N (Prenasal)	30	43.33	20	6.67	10	31.25	33.75	25
N_ (Postnasal)	55.7	21.47	15.22	7.61	41.63	21.32	18.27	18.78
V_ (Postvocalic)	81.46	15.94	2.31	0.29	55.52	27.26	12.63	4.59

represents the distribution of the five phonetic categories of word-final /t/, broken down by preceding segment on the left, and following segment on the right.

Figure 6 illustrates a few key points about phonetic conditioning of the various realizations of /t/. Obstruents on either side of the /t/-segment create an unfavorable environment for glottalization. Both the WELS and 2018 datasets show essentially zero glottalization immediately following stops, and only minimal after fricatives — 3.17% and 9.87% respectively. Glottal variants of /t/, including glottal stop and laryngealization, are favored by nasal or vocalic neighbors. The highest overall rates for both glottalized categories as well as deletion are found in prenasal positions, followed by postnasal and postvocalic. Table 1 provides an overview of the rates for the lenition categories [ʔ], [V̰] and ∅ in these environments. It illustrates two related processes taking place over time:

(1) the prenasal position as a leading environment for lenition, with glottal stop already being present at high rates in this environment in the WELS data, and generalizing by 2018 to postnasal and postvocalic trailing environments, and

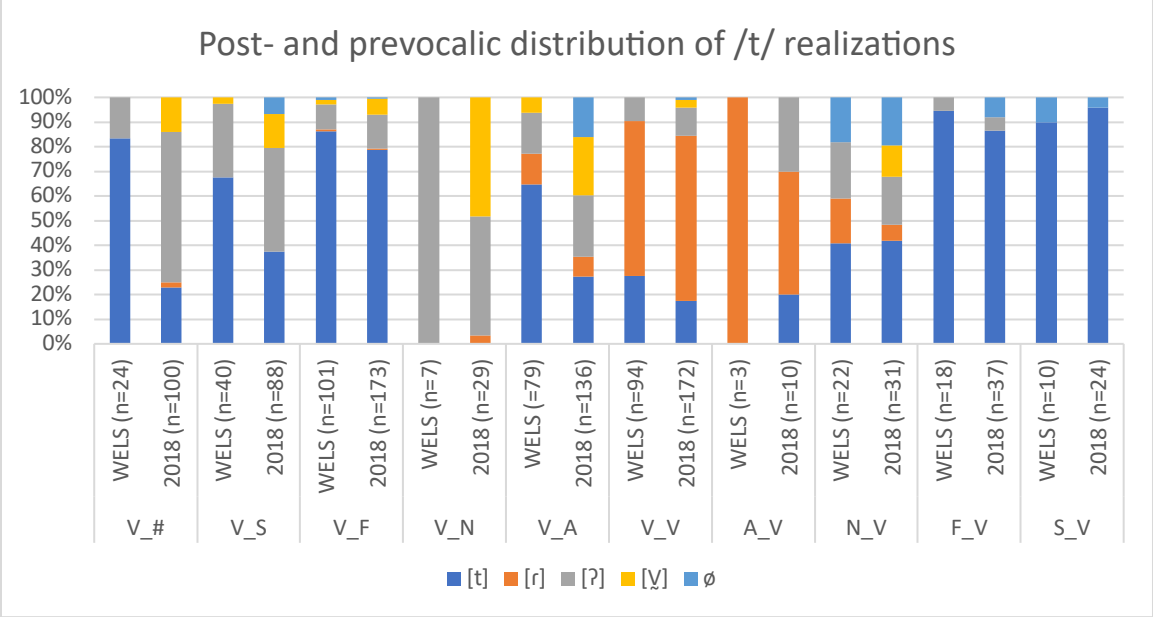
(2) the lenition hierarchy [ʔ] > [V̰] > ∅, where laryngealization and deletion gradually gain ground over time, starting in the leading environment.

Note that laryngealization is almost exclusively associated with nasal environments in the WELS data, and generalizes to vocalic environments by 2018, as previously observed by Holmstrom et al. (2019), with deletion following according to a similar pattern.

Vowel-adjacent environments merit some additional scrutiny. Glottal stop and laryngealization compete with flap in positions adjacent to vowels, but the overall picture in figure 5 obscures their specific distributional patterns. Figure 6 examines more closely the distribution of flap, glottal stop and laryngealization in post- and prevocalic environments specifically.

Figure 7 illustrates that as an allophone of word-final /t/, the flap is only an important player in very specific phonetic environments, namely intervocalically and to a lesser extent between approximants and vowels. In these

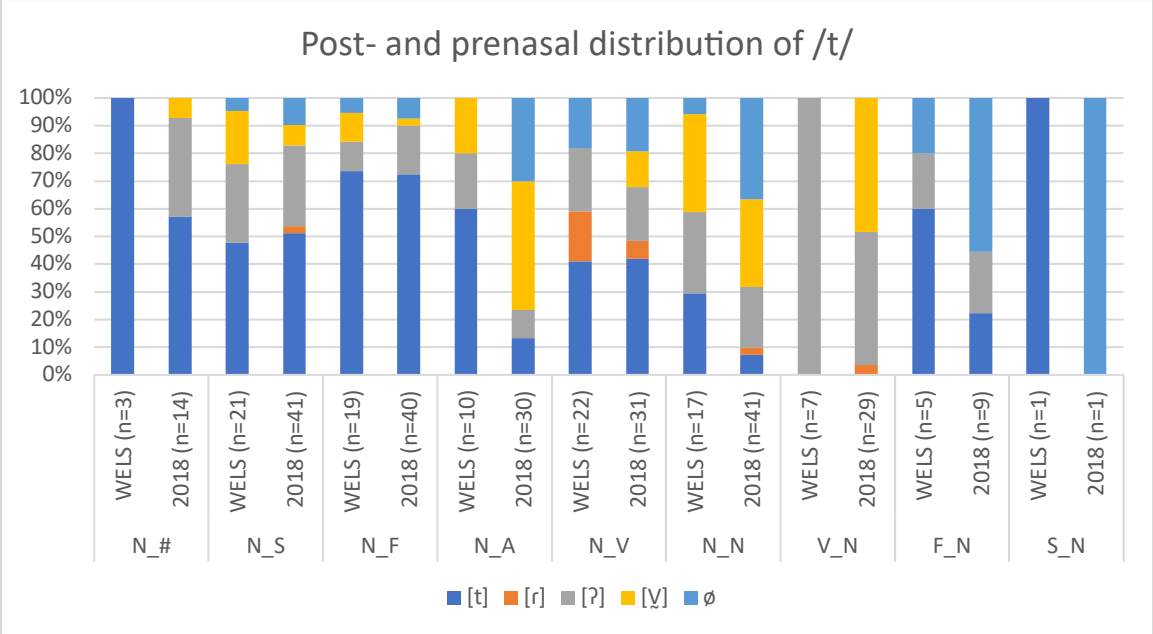
Figure 7. Breakdown of post-and prevocalic environments



contexts, [ɾ] substantially outcompetes glottal variants. Excluding these specific environments yields a better picture of the relationship between vowels and /t/-glottalization. Postvocalic environments have the highest glottalization rates overall, led by V_N (postvocalic prenasal) specifically. Note that in these postvocalic environments, the increase in overall glottalization over time is driven largely by an increase in laryngealization.

Figure 8 provides a breakdown of all post- and prenasal environments found in the data. A comparison of figures 7 and 8 shows again how laryngealization as an allophone of word-final /t/ was already established in nasal-adjacent contexts in the 1950s, and only by 2018 began to spread to other environments. N_N (internasal) environments report the highest laryngealization rates, followed by N_A and N_V. These environments also show an increase in lenition over time, driven largely by an increase in laryngealization and deletion. Looking specifically at the foremost leading environment for glottalization, N_N, we see that laryngealization was already firmly established there in the 1950s,

Figure 8. Breakdown of post-and prenasal environments



and in 2018 this environment shows a remarkable overall lenition rate with mostly an increase in deletion. This supports the previously mentioned idea that glottal stop, laryngealization and deletion are successive downward steps in a lenition hierarchy: [ʔ] > [V̰] > ∅. Trailing environments follow this pattern.

4.3 Stylistic variation

The interpretation of speech style variation is less straightforward. The results show small differences in glottalization rates between the reading task and conversational speech for all speakers, but with a high degree of interspeaker variability. The distribution of /t/-allophones broken down by speaker and speech style is shown in table 2.

Overall glottalization and lenition rates, as shown in figure 5, are higher in conversational speech than in the reading task for both age groups. It is useful to bear in mind that these averages obscure considerable interspeaker variation. The WELS speaker from East Troy, who has glottal stops but no instances of laryngealization or deletion, shows higher lenition rates in casual conversation than in the reading task, as does the speaker from Wausau. The other two WELS speakers have the opposite pattern, with considerably higher lenition rates for all phonetic categories in the reading task compared to conversational speech.

The 2018 speakers all have higher overall lenition rates in the conversational part of the data compared to the reading task. This is consistent with the implicit expectation that a reading task might produce more careful speech, avoiding 'stigmatized' features, and challenges Trager's (1942) and Eddington & Taylor's (2009) intuition that glottalized forms might be associated with more formality. Looking at the distribution of the individual lenition categories, there is some interspeaker variation. The speaker from Sheboygan has very similar overall lenition rates across both speech styles, but with a marked

Table 2. Categories per speaker and speech style in %

	1950s WELS								2018													
	East Troy (F)		Watertown (M)		Baraboo (F)		Wausau (F)		Portage (F)		Sheboygan (M)		Appleton (F)		Brookfield (M)		Menomonee Falls (F)		Wausau (M)	
Speech Style	Reading	Conv	Reading	Conv	Reading	Conv	Reading	Conv	Reading	Conv	Reading	Conv	Reading	Conv	Reading	Conv	Reading	Conv	Reading	Conv
Token count	*78*	*28*	*77*	*78*	*82*	*18*	*78*	*90*	*82*	*54*	*80*	*163*	*80*	*117*	*80*	*117*	*82*	*161*	*80*	*109*
[t]	87.2	75.0	67.5	65.4	43.9	38.9	73.1	45.6	47.6	48.1	48.8	33.7	61.3	22.4	68.8	29.9	62.2	47.9	68.8	33.0
[ɾ]	7.7	14.3	18.2	23.1	6.1	27.8	15.4	15.6	9.8	13.0	7.5	20.9	6.3	15.5	0.1	13.7	1.2	8.1	12.5	12.9
[ʔ]	5.1	7.1	9.1	7.7	30.5	22.2	5.1	27.8	4.9	22.2	12.5	28.8	23.8	19.8	18.8	31.6	29.3	29.2	0.1	30.3
[V̰]	0	0	26.0	0	13.4	0.11	2.6	5.6	3.3	14.8	22.5	2.5	5.0	22.4	1.3	11.1	1.2	5.0	1.3	13.8
∅	0	3.6	26.0	3.8	6.1	0	3.8	5.6	4.9	1.9	8.8	14.1	3.8	19.8	1.3	13.7	6.1	9.9	7.5	10.1

dominance of [ʔ] in conversation and [V̰] in the reading task. Other speakers have lower laryngealization rates in the reading task.

All things considered, these data do not provide compelling evidence for any correlation between glottalization and formality or speech style. It appears that /t/-glottalization, including the further lenited laryngealization category, are not stigmatized word-finally in American English and mostly not salient to speakers, as future work should explore.

5 Conclusion

This study moves beyond previous work on glottalization in American English in the following ways. First, the primary data discussed here are real- rather than apparent-time, including historical recordings from the Wisconsin English Language Survey (WELS) conducted in the 1950s as well as new material collected in 2018. Each dataset includes a reading task and a portion of conversational speech. Using historical data exposes real-time patterns of change, both in the rates of glottalization and in the social and stylistic implications, providing a more detailed and more reliable picture of change in progress.

Second, following Holmstrom et al. (2019), this study provides a finer-grained analysis of glottalized /t/ which distinguishes between glottal stop and a further stage of lenition where a longer period of laryngealization (creak) on the preceding vowel or nasal compensates for the absence of a discernible closure. Awareness of this additional stage in the lenition process helps to shed light on patterns of variation and change that might otherwise be obscured.

Third, this study identifies the specific phonetic environments that host glottalized forms of word-final /t/. As observed previously by Holmstrom et al. (2019), nasals form the most important historical trigger for glottalization, with N_N as the main leading environment, followed by other prenasal and

postvocalic environments. A breakdown of the data by phonetic environment also provides compelling support for a [ʔ] > [V̰] > ∅ lenition hierarchy, where glottal stop, laryngealization and deletion form successive steps in the lenition of word-final /t/.

These results corroborate earlier claims that glottalization is steadily spreading in American English, as the 2018 data consistently show higher glottalization rates than the 1950s WELS data across both speech styles. Over a period of approximately one hundred years, there has been a doubling in overall lenition rates.

Interpretation of speech style variation is less straightforward. Preliminary results show some stylistic differences in glottalization rates between the reading task and conversational speech for most speakers, but the precise patterning shows great individual variation.

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