Glottalisation of voiceless stops in Multicultural London English

Adam J. Chong[1], Marc Garellek[2]

[1] Queen Mary University of London; [2] University of California, San Diego
a.chong@qmul.ac.uk; mgarellek@ucsd.edu

ABSTRACT

Glottalisation of voiceless stops is attested in many English varieties. Most commonly, this occurs with /t/ especially in coda position. The occurrence of glottalisation has been shown to be influenced by a range of phonological, lexical and social factors. Some recent work has also sought to formulate an explanatory theory for why glottalisation occurs more often in certain phonetic and phonological contexts. Many studies, including those examining glottalisation in the UK English varieties, however, have focussed primarily on the glottalisation of /t/, even though glottalisation in coda position is also attested with voiceless stops at other places of articulation. This exploratory study examines glottalisation of voiceless stops in a small corpus of Multicultural London English. We examine the relative frequency of glottalisation of voiceless stops at different places of articulation in different positions. We further find that previous coarticulatory theories of glottalisation are not supported in this set of data.

Keywords: glottalisation, voiceless stops, Multicultural London English, phonetic theory.

1. INTRODUCTION

In many varieties of English, voiceless stops, in particular /t/, have glottal or (pre)glottalised variants (e.g. [ʔ], [ʔ͡t]) in various positions [5,12,13,18,28]. Glottalisation refers to a phonological phenomenon in which a particular segment is associated with vocal fold constriction [11]. This is often phonetically realised as creaky voice, either co-occurring with or without a full glottal stop. For the current study, we do not distinguish what is often referred to as glottal replacement (full replacement by glottal stop, e.g. /t/ -> [ʔ]) and glottal reinforcement (glottal closure along with oral stop). We refer to both phonetic realisations as 'glottalisation' [11]. Glottalised variants of /t/ can occur in several phonological contexts. In a number of British varieties of English, glottalised variants can occur in word-medial intervocalic position, when /t/ is either post-tonic (e.g. *pre**tt**y*) or in between unstressed vowels (e.g. *ident**i**ty*) [26]. More typically, glottalisation occurs with coda /t/, and also with /p/ and /k/, although the rates at which this occurs differs across varieties [13,20]. Listeners seem to use glottalisation to more quickly perceive an upcoming voiceless (vs. voiced) stop [4,21]. Additionally, glottalisation has been shown to occur with voiced stops in some varieties like African American English [11] and with [t͡ʃ] in some British varieties [22]. Previous work, especially examining British English varieties, has shown that glottalisation (typically full replacement of /t/) varies across varieties and is also subject to a range of social (e.g., gender, age, social class and style) and lexical variables, with glottal variants of /t/ often perceived as a stigmatised form [5,7,8,17,24,26]. Further, variable coda glottalisation is also subject to phonological constraints. Coda glottalisation has been shown, for example, to occur more often before sonorants in mainstream North American English [13,25].

Most work on coda glottalisation cited above describes the relation between the occurrence of glottalised variants and other phonological events (e.g. adjacent phonological context) and/or social factors (e.g. speaker age, gender). Explanatory theories, particularly phonetic ones, for *why* coda glottalisation occurs more frequently in these environments, are more limited [10]. Here we consider whether coda glottalisation in Multicultural London English (MLE, [2,3]) can be explained by the theory elaborated in [25]. The authors claim that, at least for mainstream American English of Ohio, the occurrence of coda glottalisation can be partly explained by distinct phonological and phonetic factors, including but not limited to near-categorical allophony (/t/ → [ʔ] before sonorants), the fact that [t] allophones already include glottalisation (to inhibit voicing) [29], and that the glottalisation already associated with [t] can be rendered more perceptible due to gradient reduction of the coronal gesture in certain environments (e.g. phrase-finally, and before non-coronal and aspirated sounds), leading to higher rates of *observed* glottalisation where [t]'s coronal gesture is reduced.

In this exploratory study, we seek to present an initial examination of the quantitative patterns of glottalisation of voiceless stops at all places of articulation in MLE. The questions we address are as follows: (1) Do all voiceless stops /p, t, k/ in coda position show perceptible glottalisation in MLE (c.f. [27]) compared to word-medial intervocalic position? (2) If so, does the rate of perceptible glottalisation

differ by place of articulation? (3) Which phonological factors affect the variation in occurrence of perceptible coda glottalisation? (4) Can [25]'s explanatory theory of glottalisation account for the patterning of glottalisation observed in MLE? Given the small sample examined in this study, we are unable to address the question of how glottalisation of voiceless stops in MLE varies as a function of social factors, such as gender or social class, and how these influence rates of glottalisation across different phonological environments. We leave these questions open for future examination.

2. METHODS

2.1. Corpus information

The data examined in this exploratory study comes from the *Multicultural London English* project corpus [15]. This corpus consists of recordings of 120 individuals in range of age groups: 4-5, 8-9, 12-13, 16-19, 20s-30s and roughly 40 years-old. Recordings were made in a multi-ethnic and multilingual north London borough in the late 2000s and involved sociolinguistic interviews recorded in small groups or pairs, and sometimes individually. No information is available regarding the recording apparatus.

For the current study, we examined four (M: 1; F: 3) of the eight speakers (M: 5; F: 3) in the 20s-30s year-old age group. These were chosen since the transcripts contained the fewest utterance alignment errors as well as fewest overlapping utterances in the recordings. Information about the sociolinguistic background of each speaker is presented in Table 1.

2.2. Annotation procedure

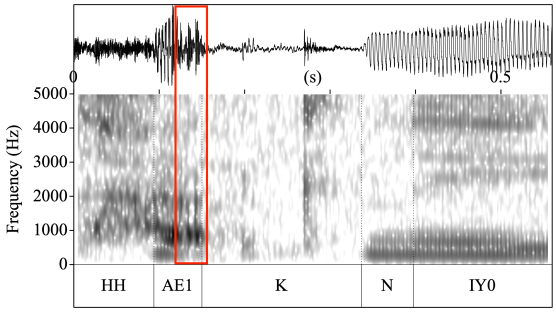

Figure 1: Spectrogram and waveform of the word *Hackney*. The irregular pulses in the final portion of the first vowel indicate glottalisation (red box).

To facilitate manual annotation and coding, the interview recordings from the four speakers were first segmented into utterances in Praat [1] textgrids based on time-points in the ELAN [8] transcripts. These were then forced-aligned using the Montreal Forced Aligner (MFA) [16].

The current study focuses on singleton voiceless stops in word-medial and word-final coda positions. For comparison, we also examined singleton voiceless stops in word-medial intervocalic position (e.g. in *better*) when the following syllable was not stressed. This is a context where glottalisation of /t/, but not /p/ and /k/, is common in many British varieties of English. Coding for perceptible glottalisation was initially done by two phonetically trained annotators, and all the tokens were then reviewed by a third. Annotators labelled a target stop as glottalised based on both auditory analysis, common in sociolinguistic studies [26], and visual inspection of the waveform and spectrograms. Following previous work on glottalisation [6,13,19], words were labelled as glottalised if there was visual evidence for irregularity in F0 and amplitude, based on irregularity pitch periods visible in the waveform and spectrogram, especially in the spacing of vertical striations in the spectrogram (Figure 1). Of course, irregular voicing can also arise due to phrase-final prosody (phrase-final creak) [11], however, in this study we follow [19] in not attempting to distinguish between glottalisation and creak. We leave open for future work the effects of phrase position on glottalisation [19,25].

The following factors were coded for each token (following [25]):

- **Position** in word: whether the target stop was word-medial or word-final.
- **Word**: word containing the target stop.
- **Preceding and following segment**: the (underlying) segment preceding and following the target according to the CMU pronouncing dictionary (dictionary used by the MFA). Pauses following the target stop were also annotated.
- **Stress and following stress:** stress on the syllable containing the target and the following syllable were marked as stressed if it had primary/secondary stressed marked by the MFA. Following [25], monosyllabic function words were always coded as unstressed and following pauses were marked as unstressed.

Tokens which involved speaker overlap, laughter or which were too quiet to recover the variant produced were discarded. The final data set contained 4503 tokens. A breakdown by speaker is shown in Table 1. The data included 3,658 word-final singleton voiceless coda stops (188 /p/, 2608 /t/ and 862 /k/). with 95 word-medial codas (7 /p/, 39 /t/ and 49 /k/). There were additionally 750 word-medial non-foot-initial intervocalic tokens (254 /p/, 269 /t/ and 227 /k/). Following [25], the following consonant was based on the dictionary pronunciation rather than

surface forms.

Speaker	Self-defined ethnicity	Age	N tokens
F1	White British	21	2005
F2	Jamaican	31	671
F3	White British	33	857
M1	Bangladeshi	23	970
		Total	4503

Table 1: Background information for speakers in the current sample and token counts by speaker.

3. RESULTS

This is an exploratory study, for which we have a small number of speakers and small number of tokens for some subset comparisons. Therefore, the analysis focuses on providing the descriptive statistics (means, standard deviations) and overall patterns in the data.

3.1. Glottalisation by place of articulation and position

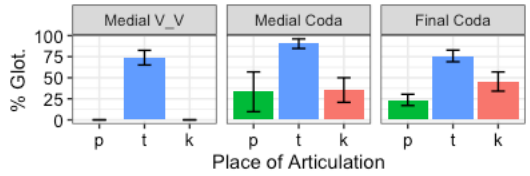

Figure 2: Rates of glottalisation by place of articulation and position (med. intervocalic, medial coda, final coda). Error bars indicate +/- 1 SE.

POA	Medial V_V	Med. Coda	Final Coda
/p/	0 (0)	33.3 (47.1)	23.7 (13.5)
/t/	**73.8 (17.4)**	**90.4 (11.3)**	**75.9 (13.8)**
/k/	0 (0)	35.4 (29.2)	45.5 (22.8)

Table 2: Mean and standard deviation (in parentheses) of glottalisation rate (%) by place of articulation and position.

Figure 2 shows the rate of glottalisation of voiceless stops in medial intervocalic position, word-medial coda position and word-final coda position. Means and standard deviations are shown in Table 2. First, we confirm that glottalisation (or glottaling) in word-medial intervocalic position (e.g. in *better*) only occurs with /t/. We did not observe glottalisation of /p/ or /k/ in this position, as expected. On the other hand, in coda position, /t/ is most frequently glottalised, but we also observed frequent glottalisation of /k/ and less frequent glottalisation of /p/, with slightly lower rates of glottalisation of /p/ in final vs. medial position.

3.2. Factors affecting coda glottalisation

Next, we examine what factors affect the rate of coda glottalisation. Due to the overall low number of tokens in word-medial position, and of /p/ in general, we focus here on examining word-final coda /t/ and /k/. We explore below the effect of the following phonological environment on glottalisation, focussing on the role of the following manner and place of articulation, as well as speaker and lexical effects. First, we find that the rate of glottalisation varies due to speaker and lexical effects (Table 3), with the female speakers glottalising /t/ more often than the one male speaker. Further, we observe that although the overall rates of glottalisation differ across speakers, the relative rate of glottalisation between the different voiceless stops is the same: /t/ > /k/ > /p/, suggesting that the overall trend in glottalisation rates by place of articulation is generalizable across speakers.

Speaker/ POA	/p/	/t/	/k/ (all)	/k/ (without *'like'*)	/k/ (only *'like'*)
F1	36.8	86.7	71.5	32.5	83.7
F2	20	77.1	28.3	16.9	42.6
F3	31.6	83.7	57.5	50	65.0
M1	6.5	56.0	24.5	9.0	40.3
Mean	**23.7**	**75.9**	**45.5**	**27.1**	**57.9**
St. Dev.	**13.5**	**13.8**	**22.8**	**18.1**	**20.5**

Table 3: Rate (%) of coda glottalisation by speaker and place of articulation.

Further, the overall higher rate of glottalisation of /k/ compared to /p/ seems to primarily be driven by a relatively high rate of glottalisation with the word *"like"*. The last two columns of Table 3 show the rates of /k/ glottalisation in a subset of data without tokens of *'like'* (n = 311) and of just *"like"* tokens (n = 551). More than half of the total /k/ tokens come from *"like"*, and glottalisation rate for /k/ is much lower (closer to /p/) when *"like"* is excluded. Given this, we excluded *"like"* in our examination below of phonological effects on glottalization.

Figure 3 and Table 4 shows rates of glottalisation for coda /t/ and /k/ based on following manner and place. Here we grouped individual segments into broad manner and place classes due to the low token count for some segments. Overall, /t/ is glottalised at a very high rate regardless for the following phonological environment. In almost all cases, /t/ was glottalised more than 70% of the time, suggesting that glottal stops are likely a near-categorical allophone of /t/ in coda position.

Next, we examine coda /k/ where glottalisation is more variable and less frequent compared to /t/. [25] proposed that the (voicing inhibiting) laryngeal gesture associated with voiceless stops is more likely to be perceptible when the oral gesture is more liable

to be obscured/weakened. For /k/, this would occur mainly before non-velars (which can obscure the velar gesture if contemporaneous) or aspirated sounds (whose glottal spreading could weaken the glottalisation). However, we observed the opposite: compared to before pauses, /k/ was glottalised as often before coronals, but less often before labials and palatals. Unfortunately, there were too few tokens before velars to make any observations. Further, we observed less frequent glottalisation when the following segment was a vowel or voiceless obstruent. We discuss these results in the context of [25]'s coarticulatory account below.

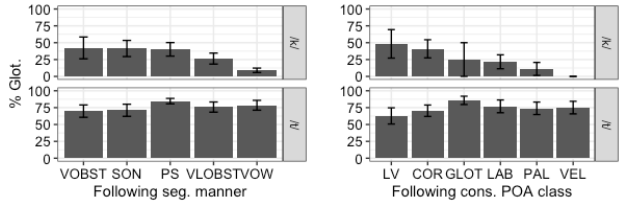

Figure 3: Rates of glottalisation by following (L) segment manner and (R) consonant POA. Top = /k/ without *"like"*, bottom = /t/. LV = Labial-velar (/w/), PS = Pause. Error bars indicate +/- 1 SE.

	/k/ (without *"like"*)		/t/	
	Mean (SD)	*n*	Mean (SD)	*n*
Manner				
SON	41.4 (23.9)	47	71.1 (17.9)	569
VOBST	42.3 (32.4)	40	69.9 (18.3)	417
VLOBST	26.4 (16.2)	83	75.9 (15.1)	431
VOW	9.1 (6.6)	105	78.5 (14.6)	827
PAUSE	40.1 (20)	36	84.7 (8)	364
POA				
LAB	21.7 (20.7)	34	76.9 (19)	283
LAB-VEL	48.3 (42.3)	15	62.7 (24.1)	212
COR	40.9 (26.9)	96	70.4 (16.9)	620
PAL	11.1 (19.2)	6	74 (18.5)	101
VEL	0 (0)	4	75.1 (18.7)	123
GLOT	25 (50)	15	85.8 (12.3)	78

Table 4: Means and standard deviations (with token counts) of glottalisation rate for /k/ and /t/ by following segment (top) manner and (bottom) POA.

4. DISCUSSION AND CONCLUSION

In this exploratory study, we examined the extent to which glottalisation occurred with MLE voiceless stops at in different prosodic positions. We found that all three voiceless stops are glottalised in coda position [27], where /t/ is glottalised at much higher rates than both /p/ and /k/. Unsurprisingly, only /t/ is glottalised in medial intervocalic position.

A second goal of this study was to examine what factors influence coda glottalisation, and to determine if a proposed explanatory theory of coda glottalisation [25] could apply to MLE. Here, we found that coda glottalisation patterns in MLE can be explained by a combination of phonetic and phonological factors. Firstly, the very high rate of /t/ glottalisation across all environments suggests that [ʔ] might be a (near)-categorical allophone of /t/ in this position. As for /k/, we did not find clear support for [25]'s coarticulatory account of glottalisation. We expected that glottalisation would be more observable before non-velars, where the velar gesture is more likely to be weakened. While we found relatively higher rates of glottalisation before coronals, glottalisation was less frequent before labials and palatals, contrary to [25]. The lower rate of glottalisation before palatals (/j/) might be explained by resyllabification across word boundaries of /k.j/ to [.kj]. The lower glottalisation rate before vowels could, similarly, be due to resyllabification processes across a word boundary [14]. The lower rate before labials, however, is problematic under [25]'s account. Glottalisation also occurred less often before voiceless obstruents, which here would have included initial aspirated stops and voiceless fricatives, which both involve glottal spreading. We further found that /k/ was glottalised more frequently before sonorants, a pattern similar to that found for /t/ in North American English [13,25]

Glottalisation of /k/ is also influenced partly by speaker and lexical effects. Particularly, /k/'s overall glottalisation pattern was heavily influenced by high rates of glottalisation with *"like"*, the discourse marker, which was the most frequent /k/ word. Other words showed far lower rates of /k/ glottalisation. Whether this is due to *"like"* occurring more often before phrase boundaries (where glottalisation is more likely to occur) or to word-specific effects is still unclear. Certainly, this allows for future work to examine the trajectory of change for /k/ glottalisation in present-day MLE.

More generally, future work would further test [25]'s proposal with a larger sample of MLE. Our data also raises the question of how listeners perceive glottalisation in MLE, and whether they associate it primarily with voicelessness or whether they show place asymmetries in favour of recovering /t/ given the much higher rates of glottalisation [cf. 4]. Finally, most previous work has typically focused on /t/ glottalisation. Since coda glottalisation also occurs with /p, k/, it would be interesting to examine if these are similarly conditioned by social variables shown to constrain /t/-glottalisation in many English varieties, and whether these differ by position [cf. 24], especially given that glottalisation of /p, k/ does not occur medially but does in codas, unlike /t/.

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