FRICATION, PRE-ASPIRATION AND TAPPING OF MEDIAL /t/ IN NEW ZEALAND ENGLISH[1]

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Abstract

Previous studies have shown that New Zealand English (NZE) medial /t/ can be realised as a canonical stop, with varying degrees of aspiration, a flap, a fully-voiced variant, a glottal stop and a fricative. The patterning of medial /t/ is highly socially conditioned: it has been shown that the use of medial /t/ variants in NZE varies according to speaker age, gender and occupation (Bell, 1977; Holmes, 1994, 1995; Bayard, 1999; Taylor, 1996). This study aims at replicating the results of those auditory-only analyses while combining acoustic and auditory analyses for the first time. The study also aims at uncovering new variants using the acoustic method. The key findings are the following: 1) The data confirm the claim by Taylor (1996) that the prestige medial /t/ variant is a fricative. The results further show that the fricative has entered NZE through the speech of females, and has strongly established itself in the dialect; 2) Conversely, analyses of T-voicing confirms the claim by Holmes (1994) that it has entered NZE through the vernacular style of working-class male speakers and has increasingly established itself in middle class speech; 3) A large amount of pre-aspiration for both stop and fricative realisations of /t/ in medial position. This is interesting because pre-aspiration is said to be rare diachronically and synchronically across languages, given its lack of phonetic salience (Silverman 2003).

1. Introduction

1.1 Background

Previous studies have shown that NZE medial /t/ can be realised as a canonical variant with varying degrees of aspiration, a flap, a fully-voiced variant, a glottal stop and a fricative (Bell 1977; Holmes 1994, 1995; Bayard 1999; Taylor, 1996). The reviewed literature showed that the patterning of medial /t/ is highly socially conditioned. Holmes (1994) found that medial T-voicing entered NZE through the vernacular style of working-class male speakers and increasingly established itself in middle class speech. Holmes (1994) analysed spoken NZE both in conversational settings in broadcast interviews. Furthermore Taylor (1996), who included wordlist data in his sample as well as conversational data, found that the voiced variant did not occur at all for females and gay males. He inferred that the prestige variant might be in fact the fricative as it was the most preferred form in his wordlist data. He suggests that the fricative is a prestige variant for the females and gay males specifically while straight men orient more towards aspirated, voiced and glottalised variants.

1.2 Limitations of previous studies

The number of participants in Taylor's study was low (4 gay males, 3 straight males and 2 straight females). It is unclear whether this pattern would hold true with a larger number of speakers due to individual phonetic variation. Also, he only analysed 15 tokens per speaker, so the total number of observations he made was 135. Given his small sample size he was not able to report statistical tests and suggested that the pattern he observed should be taken with caution. Also, while the auditory identification of T-voicing is relatively straightforward – there is no doubt that the T-voicing analyses done in NZE are very reliable – it is less so for the fricative variant. Auditorily, the fricative variant is not consistently saliently different from an aspirated stop. During the course of the present research, medial /t/ tokens were presented to 6 trained phoneticians who were asked for their judgements. They were presented auditorily and acoustically. It was not uncommon for listeners to respond that they heard aspirated stops, but that they could clearly see fricatives on spectrograms. In her analysis of medial /t/, Holmes (1994) categorised auditorily the realisations as being either voiceless aspirated stops, voiced variants (T-voicing) or glottal stops. Taylor (1996) was the first to discuss a

fricative as a possible variant of /t/ in medial position and his analysis was also auditory-based. It is possible that Holmes' identification of /t/ as an aspirated variant was in fact a fricative. So far I have uncovered no previous acoustic-based categorisation of medial /t/ in NZE.

1.3 Aim of this study

The study presented here is part of a larger set of speech production and perception experiments that focus exclusively on the variants of medial /t/. In this paper I present a sociophonetic analysis of the patterning of medial /t/ in NZE. I examined medial /t/ variants in free conversation as well as in wordlist data. Medial /t/ tokens were taken from archived speech of New Zealanders born as early as the late 19th century. Speakers were grouped according to year of birth, gender and professional status. Each medial /t/ token was analysed acoustically and auditorily. The first goal of this study was to verify claims on the sociolinguistic patterning of medial /t/ in New Zealand by utilizing auditory and acoustic analysis on a large data set, as opposed to auditory analysis only. In that sense, the aim was to replicate previous findings with a different method. The second goal was to extend previous documentation work on the dialect by providing a descriptive account of new variants, if any could be found.

2. Methods

2.1 Dataset

The University of Canterbury holds recordings that span the history of New Zealand English from the late 19th century until the present. These recordings are part of the ONZE archive (Origins of New Zealand English), which comprises three main corpora: the Mobile Unit, the Intermediate Archive and the Canterbury Corpus (Gordon et al. , 2007). Comparing those three corpora is a means of tracking the evolution of the variants under study over the entire history of NZE. The content of the corpora will be described in detail in section 2. 3. All of the /t/ tokens used came from these three databases. All searches were carried out using LaBB-CAT (Fromont and Hay, 2008). LaBB-CAT is a browser-based interactive client which enables researchers to search across and interact with sound files with time- aligned lexical and phonetic transcriptions, and export the search results into CSV files together with links to the audio files. Lexical items, consisting of two syllables with a strong/weak

stress pattern, were analysed: *city*, *letter*, *fatter*, *scatter*, *better*, *batter* and *Peter*. Those words were chosen because a large number of speakers produced them in isolation in the Canterbury Corpus as part of a wordlist reading. This enabled the comparison of the same words produced in free conversations in the other corpora.

2.2 Grouping of the speakers

The speakers presented in the corpora below were all grouped according to age and gender. Age is the most self-explanatory sociolinguistic variable used in the ONZE Corpus since it refers to the year of birth of the speakers. Gender refers to male or female speakers. Additionally, the Canterbury Corpus has a binary professional/non-professional status associated with each speaker, as defined by Gordon et al. (2007).

2.3 Content of the corpora

2.3.1 The Canterbury Corpus

The data was collected by members of the NZE class of the Linguistics Department at the University of Canterbury between 1994 and 2009 (see Gordon et al. 2007). The Canterbury Corpus (CC) includes recordings of New Zealanders born between 1930 and 1985. Speakers were grouped according to age, gender and professional background so that female young professional speakers are labelled as FYP, old male non-professional speakers are labelled as MON and so forth. The wordlist data was taken from this corpus. A search through LaBB-CAT provided a total 432 wordlist recordings. 147 recordings were discarded because of bad recording quality reasons. 285 wordlist recordings were retained, thus providing 2,023 medial /t/ tokens for analysis. Another search for the same words in spontaneous speech taken from informal interviews yielded 385 words for analysis.

2.3.2 The Intermediate Archive

The data was collected by Rosemary Goodyear, Lesley Evans and members of the ONZE team in the 1990s (see Gordon et al. , 2007). The Intermediate Archive (IA) includes recordings of New Zealanders born between 1890 and 1930. Background information on the speakers included age and gender. A search matching the lexical items present in the word lists returned 138 tokens for analysis.

2.3.3 The Mobile Unit corpus

The data was collected by the Mobile Disc recording Unit of the NZ Broadcasting Service (see Gordon et al. , 2007). The Mobile Unit corpus (MU) includes recordings of New Zealanders born between 1851 and 1910. Background information on the speakers included age and gender. A search matching the lexical items present in the word lists returned 51 tokens for analysis.

2.3.4 Comparisons across corpora

The aim of combining those three corpora is to provide a descriptive account of variation and change of medial /t/ in New Zealand English over a relatively broad span of time. However, the number of tokens considered for each corpora is unbalanced, since the analysis was restricted to specific words as explained in section 2. 2,023 tokens of read speech were extracted from the CC, 385 tokens from spontaneous speech were extracted in the CC, 138 from the IA and 51 from the MU. Fortunately, modern statistical methods – such as random mixed effects models used in this paper (Baayen, 2008) – are specifically designed to handle unbalanced datasets.

2.4 Categorisation of /t/ variants

The realisations of intervocalic /t/ were divided into four main groups: canonical articulations, fricated articulations, glottal articulations and taps. Analyses were conducted auditorily and acoustically by looking at spectrograms for each word. Typical spectrograms for each realisation are presented in figure 1. Canonical articulations were defined as having a closure gap (silence after the first vowel) which was followed by a release burst. The release burst could be followed by a certain amount of aperiodic noise preceding voicing in the next vowel. It is not clear whether the release was followed by aspiration or frication noise. Although most of the tokens could be heard as heavily fricated they were collapsed together with aspirated stops, as the main criterion for grouping articulations in this group was too see a closure followed by a clear burst on waveforms and spectrograms. Fricated articulations were defined as having aperiodic noise following the first vowel all the way through the second vowel. The primary distinguishing characteristic of the canonical versus fricated categories was the period of aperiodic noise. Glottal articulations were defined as having a closure gap without any visible burst release between the first and the second vowel. The second vowel could show a certain amount of creaky voice. Contrary to canonical, fricated and glottal articulations, the

analysis of which relied solely on waveforms and spectrograms, taps were mainly analysed auditorily.

For taps, auditory analysis was considered more reliable than acoustic analysis, as they can take a multitude of acoustic forms and yet they can sound quite similar (Derrick and Schultz, 2013). Canonical and fricated articulations were frequently pre-aspirated. They were thus classified as being pre-aspirated post-aspirated variants or as being pre-aspirated fricated variants respectively. Pre-aspiration is understood in this study as the brief apparition of aperiodic noise in the 3–10 kHz range in the first vowel offset, similarly reported by Jones and Llamas (2003, 2008). Pre-aspiration is one of the areas of focus of this paper as its rarity in the world's languages (Silverman, 2003) makes it an important feature to report and discuss. Since this paper focuses on intervocalic /t/ exclusively, the analysis is restricted to this particular phonetic environment.

Pre-aspiration may also occur in different environments, and further studies could address that question. It is hypothesised that pre-aspiration might be the result of a sudden increase in sub-glottal pressure causing the glottis to spread and maintaining high air velocity for a few milliseconds. These articulatory suppositions will be investigated in further studies. In the case of pre-aspirated and fricated /t/s there is a drop in spectral energy at the offset of pre-aspiration followed by a rise in energy corresponding to the approximation of closure (*ie.* the frication of /t/). A clear gap between these two energy phases was hardly ever observed. Rather there was a smooth transition from the drop to the rise. Those acoustic characteristics are compatible with previous acoustic analyses of pre-aspirated variants of /t/, e. g. Jones and Llamas (2003).

Tokens in the three corpora were classified either as canonical articulations, fricated articulations, glottal articulations or taps. The further categorisation of /t/ into pre-aspirated variants was done for the Canterbury Corpus only.

3. Results

First, the results for the wordlist data within the CC corpus are presented. This corpus is the only one which provides carefully read speech and is treated separately. Secondly, the results for spontaneous speech are presented, including data from the CC corpus, together with data from the MU and IA. Thirdly, a direct comparison between wordlist data and spontaneous speech is established. Finally, the results for pre-aspiration in the CC with regards to carefully read speech are presented.

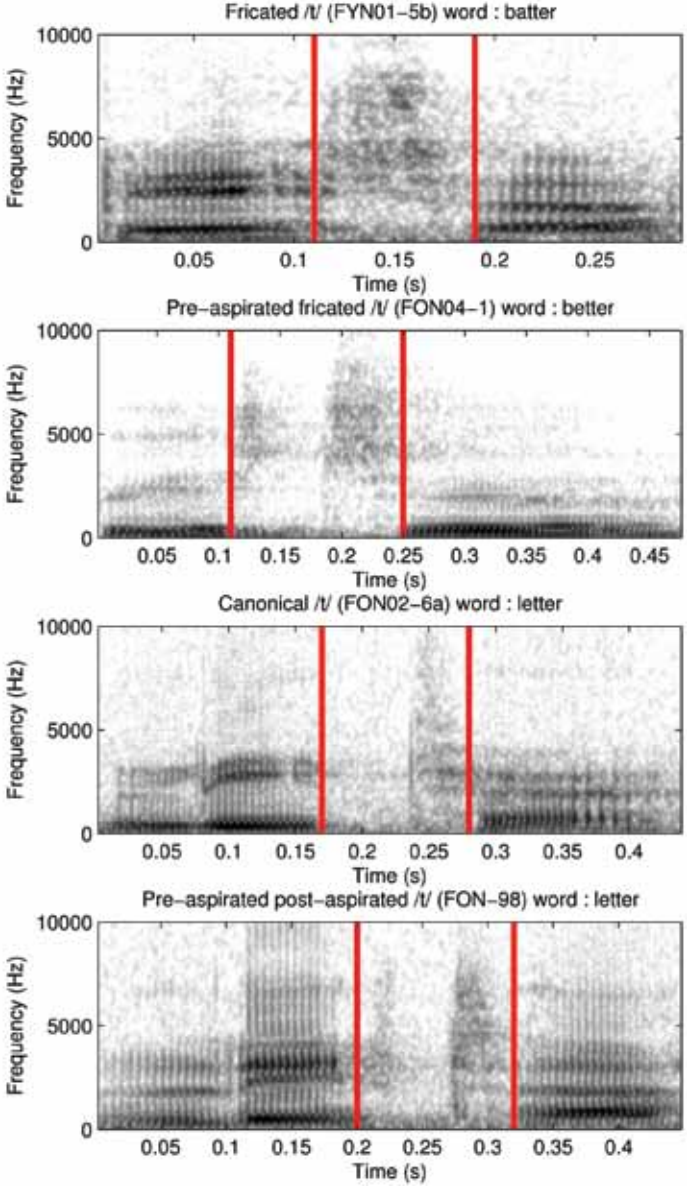

Figure 1: Spectrograms of words produced by four individual speakers in the Canterbury Corpus. Areas of interest are bounded.

3.1 Wordlist results within the CC (read speech)

Table 1 shows the distribution of the variants in the wordlist data. The most widespread variants are the fricated ones (including typical fricated variants and pre-aspirated fricated variants). They account for 67. 33% of the total number of observations. In second position come the alveolar stop variants (including canonical stops and pre-aspirated post-aspirated stops). They account for 28. 87% of the total number of observations. Glottal and tap articulations are very rare in comparison: they account for less than 4% of the total number of observations in this dataset. Interestingly, 43% of all voiceless stops were pre-aspirated and 16% of the fricatives were pre-aspirated as well. A logit mixed model (Bates, 2010) was fitted in order to analyse the probability of use of the fricated variant. The dependent variable was a binary variable coding for either the presence or the absence of the fricated variant. The fricated variant and the pre-aspirated fricated variant were collapsed together. The independent variables were (i) year of birth: a continuous variable centred on its mean (1960), (ii) gender: a two level factor coding for either male or female, with female selected as the reference level, and (iii) professional status: a two level factor coding for either professional or non-professional status, with professional status selected as the reference level. Two random intercepts were added to the model, one that accounts for the variability across the 285 speakers who produced the words in isolation and one that accounts for the variability across the 7 words that were present in the wordlists (*city*, *letter*, *fatter*, *scatter*, *better*, *batter* and *Peter*). A total of 2023 binary measures were submitted to the model. The coefficients for

Table 1: Raw counts and total percentage per variant present in the wordlist data. Data are separated by gender and professional status. N = non-professional; P = professional.

	MALE		FEMALE		**TOTAL**
	N	P	N	P	**%**
canonical stop	141	99	69	25	**16.51**
pre-aspiratedpost-aspirated stop	57	51	50	92	**12.36**
fricated /t/	167	247	382	354	**56.85**
pre-aspiratedfricated /t/	27	70	48	67	**10.48**
tap	49	16	11	0	**3.76**
glottal stop	0	0	0	1	**0.05**

the interaction between year of birth and professional status as well as year of birth and gender were non significant (p = 0. 63 and p = 0. 49 respectively) and were dropped from the final model.

Table 2 shows the output of the logit mixed model. The year of birth coefficient is significant and the slope is positive. This means that the probability of observing fricated variants increases over time in the corpus. The gender coefficient is negative and significant. As females were selected as the reference level, this means that males produce fewer fricated variants than females. There is a significant interaction between professional status and gender and the slope of the coefficient is negative. Since professional status was selected as the reference level, this means that professional males use significantly more fricatives than non-professional males. Figure 2 makes these effects more clearly visible. For both males and females there is an increase in the use of the fricative variant over time. For any given age, females use the variant more than males. While there is little difference between professional and non- professional females overall, professional males are more advanced in the use of the fricated variant than non-professional males. A logit mixed model similar to the one described above was used to analysed the probability of observing stops. This time the dependent variable was a binary variable coding for either the presence or the absence of the stops. The canonical variant and the pre-aspirated post-aspirated variant were collapsed together. Year of birth, gender and professional status were selected as fixed effects and words and speakers were selected as random effects. Interactions between fixed effects were non-significant and were dropped from the final model.

Table 2: Output of the model estimating the use of the fricated variant in the CC corpus, wordlist data.

	Estimate	Standard Error	*z* value	*Pr*(> *|z|*)
(Intercept)	2.84032	0.45956	6.180	p <. 0001
year of birth	0.08877	0.01398	6.352	p <. 0001
professional status (N)	-0.26280	0.56203	-0.468	0. 6401
gender (male)	-1.36131	0.57660	-2.361	0. 0182
professional status (N): gender (male)	-1.93659	0.81044	-2.390	0.0169

Table 3: Output of the model estimating the use of stops in the CC corpus, wordlist data.

	Estimate	Standard Error	*z* value	*Pr*(>|*z*|)
(Intercept)	-2.87140	0.33218	-8.644	*p*<.0001
year of birth	-0.09397	0.01411	-6.660	*p*<.0001
gender (male)	1.66470	0.40764	4.084	*p*<.0001

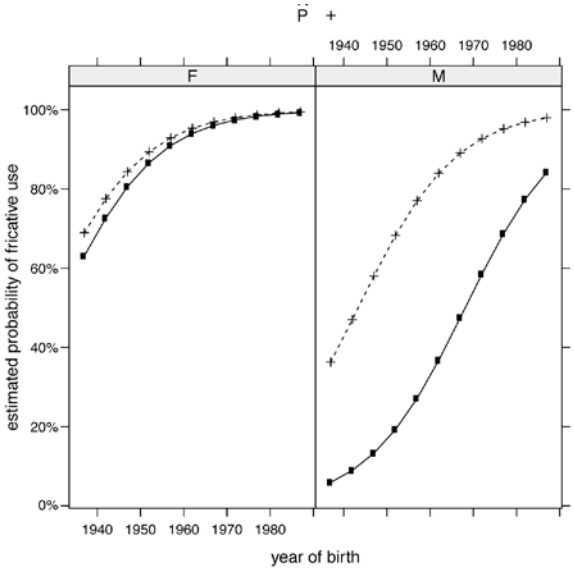

Figure 2: Estimated probability of fricative use obtained from the model coefficients (careful speech). Left panel: females (F). Right Panel: males (M). Dashed lines and plus signs: professional speakers (P). Continuous lines and circles: non-professional speakers (N).

Table 3 shows the output of the model of the logit mixed model. The year of birth coefficient is significant and the slope is negative. Thus the probability of observing stops decreases over time in the corpus. The gender coefficient is positive and significant. As females were selected as the reference level, this shows that males produced more stops than females. These results can be seen in figure 3.

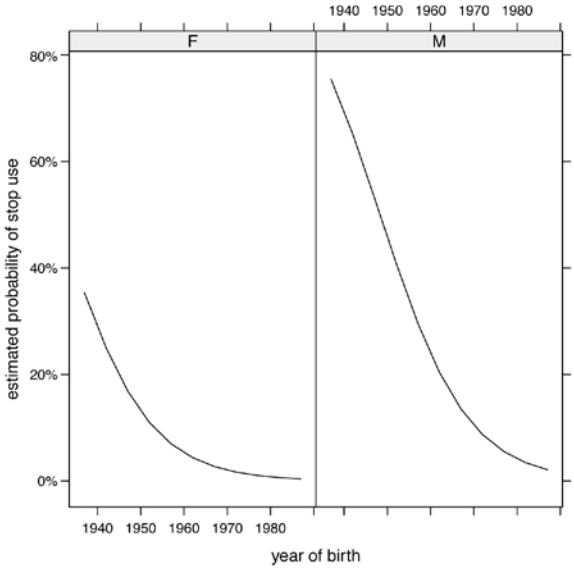

Figure 3: Estimated probability of stop use obtained from the model coefficients (careful speech). Left panel: females (F). Right Panel: males (M).

Seventy-six tokens out of 2023 were produced as taps, which accounts for less than 4% of the total number of observations in the dataset (see table 1). The individual patterns across words and speakers for those speakers who did produced taps (27 speakers in total) were examined. Amongst those speakers the majority of them used the variant only once across the list of words (11 males and 4 females). 5 speakers (4 males and one female) used the tap variant consistently. The words that were tapped the most were *city* and *Peter*. In summary, very few tokens in the corpus were tapped and the pattern observed a preference for males to tap over females, as well as preference for tapping *city* and *Peter* over the other words. Taken together the results support the conclusion of Taylor (1996) that the fricative is the prestige medial /t/ variant, since it is the preferred realisation found in careful speech. They also support his result that males used the variant less than females, at least at the time when his study was conducted. He recruited male speakers born between 1962 and 1976. It is clear from figure 2 that they male were not as advanced in the use of the fricated variant as the youngest speakers. Since the sexual orientation of

the speakers was not made available, it was not possible to examine his claim that gay men were more advanced in the use of the variant than straight men.

3.2 Results for the CC, IA and MU (spontaneous speech)

In order to allow a comparison with spontaneous speech, interviews from the MU, IA and CC interviews of New Zealanders were examined. There were very few instances of the same words that occurred in the wordlist. To balance the data set, the most common tokens (*city*, *letter* and, *better*) were used, providing 573 tokens for analysis. The distribution of variant 243 counts amongst the remaining data set is as shown in table 4.

Table 4: Number of observations per age group for the words *city*, *letter* and, *better*.

YEAR OF BIRTH	CANONICAL	PRE-ASPIRATED POST-ASPIRATED	FRICATED	PRE-ASPIRATED FRICATED	GLOTTAL	TAP	**TOTAL**
1850–1870	8	0	2	0	0	6	**16**
1870–1890	14	0	4	0	2	10	**30**
1890–1910	15	0	11	0	0	10	**36**
1910–1930	26	0	48	0	0	21	**95**
1930–1950	13	5	41	3	0	31	**93**
1950–1970	1	2	49	2	0	39	**93**
1970–1990	4	0	55	0	1	150	**210**

Raw counts from this table were then expressed as a percentage per age group. Thus, to observe the probability prob(c) for canonical stops produced by speakers born between 1850 and 1870, they were proceeded as follows: prob(c) = 8⁄total per age group = 8⁄5 = 0. 5. This yielded a bar chart tracing the evolution of each variant, as shown in figure 4. Given that there were relatively few glottal stops or pre-aspirated variants in this data set, the focus was placed on canonical, fricated and tap variants. This is the bottom plot in figure 4. Both the bar chart and the bottom plot display the same information but they do it in a different way. On the bottom plot, the size of the dots represents the total number of tokens analysed for each birth year range (*i.e.* their relative size is calculated using the last column from table 4). Given that there were very few tokens for analysis for the spontaneous data, this gives an indication as to the reliability of these measures. It is relatively poor for speakers born between 1850 and 1910 but much higher for speakers born after 1910.

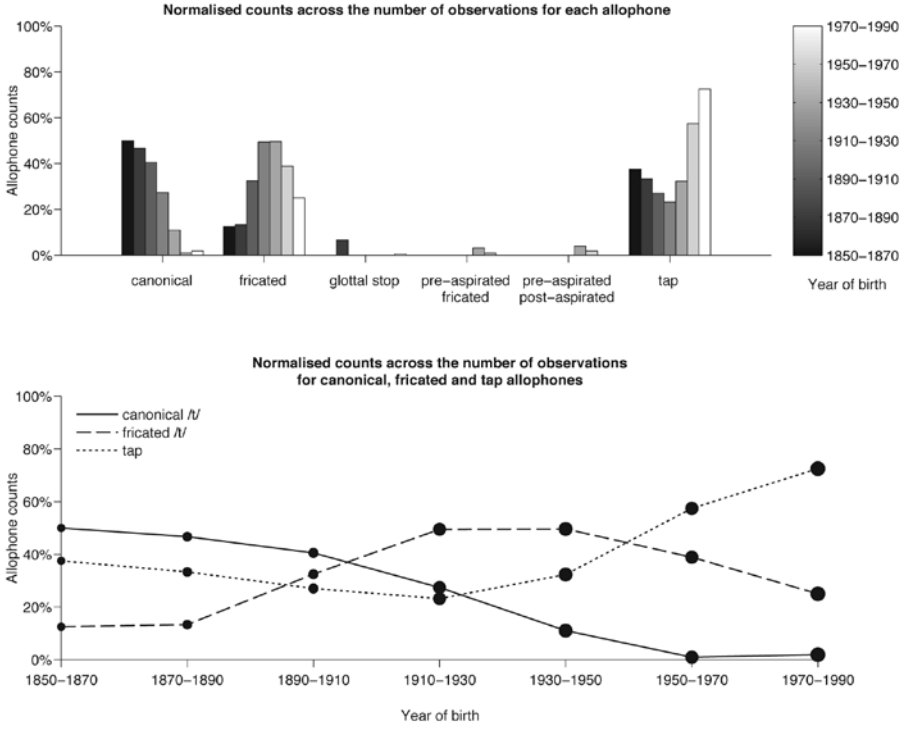

Figure 4: Normalised counts across the number of observations for the words city, letter and, better.

While canonical stops were the most used variants by the oldest speakers, they decrease steadily over time and are hardly to be found in the speech of young New Zealanders in the CC. Fricatives were already to be found in the speech of the oldest speakers. There is an increase in their use until they reach a plateau amongst speakers born between 1910 and 1950. For those speakers, the fricative is the most widely used variant. From 1950 onwards, there is a decline in its use in favour of the tap, which is the most widespread variant today.

Since the tap variant is the most widely used variant today, a logit mixed model was fitted on the CC spontaneous data. The analysis was not performed on earlier corpora given the lack of data points. The dependent variable was a binary variable coding for either the presence or the absence of taps. The

independent variables were (i) year of birth, a continuous variable centred on its mean (1960), (ii) gender : a two level factor coding for either male or female, with female selected as the reference level, and (iii) professional status :a two level factor coding for either professional or non-professional status, with professional status selected as the reference level. Two random intercepts were added to the model, one that accounts for the variability across the 164 speakers who produced the words and one that accounts for the variability across the 3 words that were used (*city*, *letter* and, *better*). A total of 383 binary measures were submitted to the model. Non-significant interactions ($p > 0.2$ using a Likelihood ratio test) were dropped from the final model using a backward stepwise procedure, see Baayen (2008).

Table 5: Output of the model estimating the use of taps in the CC corpus, spontaneous data.

	Estimate	Standard Error	*z* value	*Pr*(>|*z*|)
(Intercept)	-0.20957	0.46585	-0.450	0.653
year of birth	0.08817	0.01401	6. 295	*p*<.0001
professional status (N)	-1.69448	0. 39557	-4.284	*p*<.0001
gender (male)	2.41710	0. 40188	6.014	*p*<.0001

Table 5 shows the output of the logit mixed model. The year of birth coefficient is significant and the slope is positive. This means that the probability of observing taps increases over time in the corpus. The gender coefficient is positive and significant. As females were selected as the reference level, this means that males produce more taps than females. The professional status coefficient is significant and the slope is positive. Thus professional speakers use fewer taps than non-professional speakers. Figure 5 makes these effects more clearly visible. For both males and females there is an increase in the use of the tap variant over time. For any given age, males use this variant more than females and, overall, non-professional speakers are more advanced in the use of the tap variant than professional speakers. The results from spontaneous speech follow the pattern identified by Holmes (1994) whereby T-voicing has entered through the vernacular style of working-class male speakers and has increasingly established itself in middle class speech. The probability of observing fricatives was also analysed by submitting data to a logit mixed

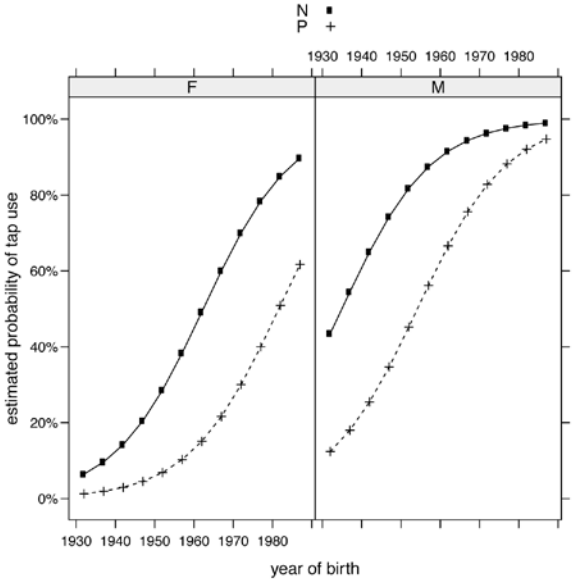

Figure 5: Estimated probability of tap use obtained from the model coefficients (spontaneous speech). Left panel: females (F). Right Panel: males (M). Dashed lines and plus signs: professional speakers (P). Continuous lines and circles: non-professional speakers (N).

model, following a similar method. This time the dependent variable was a binary variable coding for either the presence or the absence of fricatives. The fricated variant and the pre-aspirated fricated variant were collapsed together. year of birth, gender and professional status were selected as fixed effects and words and speakers were selected as random effects. Interactions between fixed effects were non-significant and were dropped from the final model. Table 6 shows the output of the model of the logit mixed model. The year of birth coefficient is significant and the slope is negative. Thus the probability of observing fricatives decreases over time in the corpus. The professional status coefficient is negative and significant. Professionals were selected as the reference level, thus non-professionals produced fewer fricatives than professionals. The gender coefficient is negative and significant. As females were selected as the reference level, this shows that males produced fewer fricated variants than females. These results can be seen in figure 6.

Table 6: Output of the model estimating the use of fricatives in the CC corpus, spontaneous data.

	Estimate	Standard Error	*z* value	*Pr*(>|*z*|)
(Intercept)	1.33717	0.43552	3.070	0.00214
year of birth	-0.05605	0.01260	-4.448	*p*<.0001
professional status (N)	-1.80663	0.37824	-4.776	*p*<.0001
gender (male)	-2.31774	0.38084	-6.086	*p*<.0001

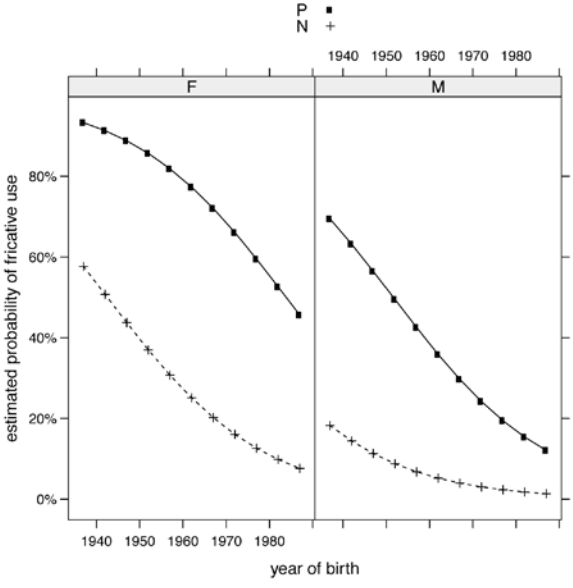

Figure 6: Estimated probability of fricative use obtained from the model coefficients (spontaneous speech). Left panel : females (F). Right Panel : males (M). Dashed lines and plus signs : professional speakers (P). Continuous lines and circles : non-professional speakers (N).

3.3 Direct comparisons between careful speech and spontaneous speech

The results have shown that speakers use variants differently in careful speech compared to spontaneous speech (*e.g.* the fricated variant is most widespread in wordlist data while the tap is most widespread in conversation). In order to further account for the effect of type of speech on variant selection models on a subset of data that allows for direct comparison were fitted. Next data from speakers who produced the three words (*city*, *letter* and, *better*) in both spontaneous and wordlist data were collated. Grouping fricated and pre-aspirated variants together, and excluding the one glottal stop token, the results are shown in Table 7, giving a total of 719 tokens spoken by 141 speakers.

Table 7: Raw counts of broad variants in the comparative dataset.

	SPEECH STYLE	
	CAREFUL SPEECH	SPONTANEOUS SPEECH
stops	130	16
fricatives	280	114
taps	15	164

This set of models was obtained by testing separately for the probability of use of broad variants as a function of type of speech using a logit mixed model. This yielded 3 models: one for stops, one for fricatives and one for taps. Each dependent variable was a two level factor coding for the presence or absence of one of the broad variants. The independent variable was type of speech, a two level factor coding for either careful speech or spontaneous speech.

Careful speech was selected as the reference level. Speakers and words were included as random effects. In all 3 models the effect of type of speech was significant (p <.0001). When predicting the probability of observing fricatives and stops the coefficients werenegative (*coef* = −1.6680 and *coef* = −3.5253 respectively). When predicting the probability of ob- serving taps, the coefficient was positive (*coef* = 5.3371). As careful speech was selected as the reference level, the probability of observing fricatives and stops decreases in spontaneous speech while the probability of observing taps increases in spontaneous speech.

3.4 Pre-aspiration results within the CC (carefully read speech)

Pre-aspiration could not be clearly identified within the MU and IA data given the quality of the audio recordings. However the CC corpus provided higher quality recordings and pre-aspiration could be clearly seen on spectrograms. Within the CC wordlist data 43% of all voiceless stops were pre-aspirated and 16% of the fricatives were pre-aspirated, as shown in table 1. On the other hand, the spontaneous data provided 12 cases of pre-aspiration in total, as seen in table 4, which accounts for 3% of the number of observations in spontaneous speech. Thus only the results within the CC wordlist data are presented in this section. A logit mixed model was fitted on the CC wordlist data. The dependent variable was a binary variable coding for either the presence or the absence of pre-aspiration. The independent variables were (i) year of birth: a two level factor coding for either older or younger speakers, as defined by Gordon et al. (2007), (ii) gender: a two level factor coding for either male or female, with male selected as the reference level, and (iii) professional status: a twolevel factor coding for either professional or non-professional status,with non-professional status selected as the reference level. Two random intercepts were added to the model, one that accounts for the variability across the 285 speakers who produced the words in isolation and one that accounts for the variability across the 7 words that were present in the wordlists (*city*, *letter*, *fatter*, *scatter*, *better*, *batter* and *Peter*). A total of 2023 binary measures were submitted to the model. Non-significant interactions were dropped from the final model.

Table 8: Output of the model estimating the use of pre-aspiration in the CC corpus, wordlist data.

	Estimate	Standard Error	*z* value	*Pr*(>|*z*|)
(Intercept)	1.33717	0.43552	3.070	0.00214
(Intercept)	-2.3958	0.3318	-7.221	*p*<.0001
age (young)	-0.5804	0.4623	-1.256	0.209278
professional status (P)	1.6425	0.4347	3.779	*p*<.0001
professional status (P): age (young)	-1.6223	0.6355	-2.553	*p*<.02

Table 8 shows the output of the logit mixed model. The professional status coefficient is positive and significant. As non-professional status was selected as the reference level, this means that professionals produce more pre-aspirated variants than non-professionals. There is a significant interaction between professional status and age and the slope of the coefficient is negative. Since non-professional status was selected as the reference level, this means that age has an effect, with older professionals using significantly more pre-aspiration than younger professionals. This interaction also means that the age effect only holds for professionals, which can be more clearly seen in figure 7.

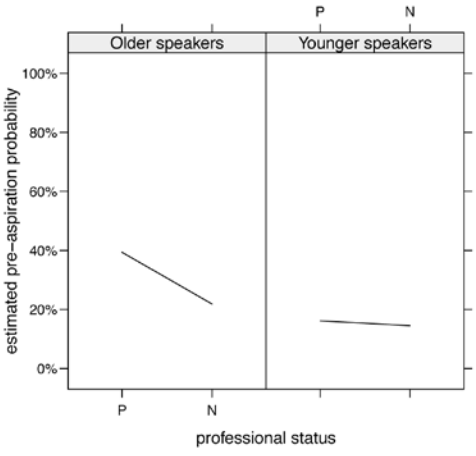

Figure 7: Estimated probability of pre-aspiration obtained from the model coefficients.

4. Discussion

Previous studies of medial /t/ have reported the existence of a canonical variant with varying degrees of aspiration, a flap, a fully-voiced variant, a glottal stop and a fricative (Bell, 1977; Holmes, 1994, 1995; Bayard, 1999; Taylor, 1996). This study presented here contributes to the literature on NZE by reporting frequent cases of pre-aspiration in wordlist data. Silverman (2003) argues that pre-aspiration is rare both diachronically and synchronically across human languages given its lack of phonetic salience. However recent acoustic evidence shows that pre-aspiration exists in several

varieties of English as a non-normative feature (*i.e.* a non-obligatory phonetic feature that can variably present or absent in different speakers of a single dialect). Jones and Llamas (2003) reported pre-aspiration of word-final plosives and fricated /t/'s in Middlesbrough English. Gordeeva and Scobbie (2007) identified pre- aspiration of fricatives in Standard Scottish English which may serve to enhance prosodic cues and phonemic voicing contrasts. They did not find a correlation between sociolinguistic variables and rates of pre-aspiration of fricatives. Non-normative pre-aspiration of /t/ has also been found in Northern Welsh dialects (Morris, 2010) and Australian English (Jones and McDougall, 2009). In the wordlist data pre-aspiration occurs in relatively high proportions : it accompanies 43% and 16% of all voiceless stops and fricatives respectively. On the other hand it appears in negligible proportions in spontaneous speech. It might be hypothesized that pre-aspiration is a feature of careful speech in NZE. Using a logit mixed effect similar to the ones reported in this paper, the dependent variable coded either for the presence orabsence of pre-aspiration. The model predicted that younger speakers use little pre-aspiration, regardless of their professional status. Older speakers use more pre-aspiration and even more so when they are professionals. There was no effect of gender,showing that males and females used pre-aspiration in equal proportions. Our research adds to the literature on pre-aspiration in other varieties of English by documentation another case of non-normative pre-aspiration, and by suggesting for the first time that pre-aspiration might be socially-conditioned. The results from the wordlist data also support the conclusion of Taylor (1996) that the fricative is the prestige medial /t/ variant, since it is the preferred realisation found in careful speech. The data shows that, overall, females use the variant more than males. The youngest females achieve a rate of a 100%, as predicted by our model. Moreover, the results show an interaction with gender and professional status so that the youngest male professionals also achieve similar rates. Professional males are more advanced in the use of the fricated variant than non-professional males. This prestige variant has therefore entered NZE through the speech of females and has strongly established itself in the dialect.

I reported very few instances of glottal articulations in this paper, which is in accordance with previous research on medial /t/ in NZE. Holmes notes that glottal replacement is very rare in intervocalic contexts and they are usually "all word-final not word-medial as in the stereotypical Cockney *bitter* and *butter* " (Holmes, 1994, p. 213). Word-final glottal stops before vowels are said to "function most frequently as an emphatic device in relation to

the following word" (Holmes, 1994, p. 220), therefore serving a pragmatic purpose in the speakers' discourse. In that case they were mainly reported in formal interviews and fewer occurrences were found in conversational speech with friends or family. The results on spontaneous speech also support the claim by Holmes (1994) that T-voicing has entered through the vernacular style of working-class male speakers and has increasingly established itself in middle class speech. The results showed that it was the most widespread variant in the conversational data. Evidence was also found within the Mobile Unit corpus that the fricative was already present in NZE and used by speakers born between 1850 and 1870. Clearly, the fricative variant is not a new feature of NZE but apart from the research conducted by Taylor (1996) no mention of the fricative as a possible variant for /t/ in medial position was made before. However the articulatory nature of the sound is not very well understood. This variant is very well-known to occur in Irish English. Hickey (1984, 234) describes it as "formed by bringing the apex of the tongue close to the alveolar ridge as if for the articulation of /t/ but stopping just before contact". He proposed the symbol [t̠]. Pandeli et al. (1997) provided EPG data on Irish English and demonstrated that this choice for a phonetic transcription was in fact problematic. They proposed to use the symbol [θ̠] instead. Also it is not guaranteed that the acoustic nature of the fricated variant is the same in Irish English and in NZE. So far I have not proposed a phonetic transcription but I believe it is safer to refer to the variant in plain text as a fricative or as fricated /t/. Finally, comparing careful speech data and spontaneous data directly, the probability of observing fricatives and stops decreases while the probability of observing taps increases in spontaneous speech. In summary, the present research replicated previous results on the distribution of medial /t/ variants in NZE. It also contributes to the description of the dialect by further identifying pre-aspirated variants and provides the first statistical results on the sociophonetic patterning of the fricated variant. Further work on medial /t/ in NZE will aim at better understanding the sociophonetic patterning of pre-aspiration observed. Further work is also needed to understand the acoustic, articulatory and perceptual nature of the fricated variant and will be presented in forthcoming papers.

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