A comparative acoustic study of Australian English fricated /t/: assessing the Irish (English) link

Mark J. Jones and Kirsty McDougall
Department Linguistics
University of Cambridge,
United Kingdom
mjj13@cam.ac.uk / kem37@cam.ac.uk

Abstract

This paper compares the acoustic characteristics of fricated realisations of /t/ in Australian English with /s/ and /ʃ/. Australian English fricated /t/, like Irish English slit-/t/, shows similarities with /ʃ/ rather than with /s/, whereas Middlesbrough English fricated /t/ is closer to /s/ (Jones and Llamas 2003). These findings raise the possibility that, rather than arising as an independent development from widely occurring casual speech processes, Australian English fricated /t/ could have its origins in the Irish English speech of many immigrants to Australia in the 1800s.

1. Introduction

Patterns of variation in which a plosive appears as a fricative in some phonological contexts occur in many languages, e.g. Finnish, Korean, Tuscan Italian, High German, Liverpool English. It is usual to view the fricative as derived and the plosive as original. The general term for this kind of phonological process is lenition, though differing interpretations and applications of the term abound (e.g. Bauer 1988, Honeybone 2001, Kirchner 2001, 2004). These cross-linguistic patterns appear to be phonologised instances of more widely occurring phonetic variation. In casual speech the realisation of a plosive consonant may fail to involve complete closure and when certain aerodynamic conditions are met the plosive is realised as a fricative: it is fricated (Shockey and Gibbon 1993, Simpson 2001).

Simultaneous electropalatographic (EPG) and acoustic data in Nicolaidis (2001) showed that fricated tokens constitute only a subset of all incompletely occluded tokens – only 12 of the 33 incompletely occluded realisations of /t/ of the two Greek subjects were fricated in the acoustic record. Aerodynamic factors are crucial.

Fricated realisations of plosives tend to occur in intervocalic position, possibly as the result of articulatory undershoot in forming a complete constriction between two vowels (Beckman, de Jong, Jun and Lee 1992: 49), or in word-final position, where a general articulatory tendency towards a reduction in stricture has been observed (see Krakow 1999 for a review).

Some varieties of English appear to have phonologised frication of plosives in that fricated realisations occur consistently as an identifying characteristic of that variety, e.g. Liverpool English (Honeybone 2001). Fricated /t/ occurs in Hiberno- or Irish English (Pandeli, Eska, Ball and Rahilly 1997, Hickey 1999), in varieties of British English in Newcastle and Middlesbrough in north-eastern England (Jones and Llamas 2003, Watt and Allen 2003), and in Newfoundland English (Clarke 1986). Australian English also has fricated realisations of plosives (Loakes and McDougall 2004): frication of /t/ in Australian English is the subject of this paper.

The frication of plosives in Australian English is relatively under-researched. The early work on Australian English, e.g. Baker (1945), Mitchell and Delbridge (1965), largely focussed on vowels and did not mention fricated plosives. Neither is frication of plosives reported in Ingram's (1989) outline of connected speech processes in Australian English, based on a corpus of Brisbane adolescent speech. Trudgill (1986: 141) mentions strong release of word-final plosives, especially in female speech, but rules out the possibility of actual frication. Frication of /k/ and /p/ in casual speech in Melbourne has been the subject of a recent study (Loakes 2006, Loakes and McDougall 2004). For /t/, an 'affricated' variant is noted by Horvath (1985: 97) in her auditory analysis of Sydney adolescent speech. The earliest report of a fully fricated variant of /t/ in Australian English is by Tollfree (1996) who observed it in data from Sydney, Adelaide, Canberra and Melbourne (see also Tollfree 2001).

As the frication of plosives is a common process which occurs independently in a number of languages, it is perhaps unnecessary to seek any particular source for its presence in Australian English. However, fricated /t/ is a well-known feature of varieties of Irish English,

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where it is often referred to as 'slit-/t/', and a number of English-speaking localities which exhibit fricated /t/ have Irish connections through migration, e.g. Liverpool (Wells 1982: 371), Middlesbrough (Chase 1995), and Newfoundland (Clarke 1986). The question thus arises whether fricated /t/ in Australian English results from an Irish connection, rather than as a completely independent development.

The suggestion of Irish influence in the formation of Australian English has a long pedigree. The early white settlement of Australia involved a considerable number of Irish migrants, e.g. Troy (1992: 462) reports that between 1788 and 1867, 23% of male convict arrivals in Australia were Irish and between 1829 and 1851, 48% of assisted migrants in Australia were Irish. Influences of Irish English are reflected in all aspects of Australian English – phonology, morphology, syntax and lexicon. Trudgill (1986: 138) discusses the role of Irish (English) and Scottish speakers in the relatively recent pronunciation of /h/ in Australian English, and provides other evidence supporting the view that Irish English has played a large part in the development of Australian English, e.g. the use of /ə/ not /ɪ/ in unstressed positions, and the near absence of pre-glottalised final /p t k/ (Bradley 2003, Horvath 1985, Trudgill 1986). There is also evidence of Irish being spoken among convicts in the early 1800's and having influenced the Australian English lexicon (Lonergan 2003). It is possible therefore that the presence of fricated /t/ in Australian English can be linked to Irish influences, as is explored in the present study.

Previous research on fricated /t/ in other varieties of Dublin English and Middlesbrough English, representing varieties of Irish English and north-eastern Anglo-English respectively, has found a marked difference between the phonetic realisations of fricated /t/ in these two varieties. In Dublin English, 'slit-/t/' is phonetically more similar to /ʃ/ than to /s/, while in Middlesbrough English the reverse holds: fricated /t/ is closer to /s/ than to /ʃ/ (Jones and Llamas 2003). Frication of /t/ is of particular phonological interest as English exhibits a contrast between the fricatives /s/ and /ʃ/. The emergence of fricated /t/ may place pressure on the maintenance of existing fricative contrasts.

The present investigation compares the acoustic characteristics of Australian English fricated /t/ with those of Australian English /s/ and /ʃ/. The results will provide a baseline for future work on the perception of these contrasts and on possible systemic consequences in terms of dispersion effects within a 'fricative space'. The more immediate aim is to address the question of whether Australian English fricated /t/ is more like /s/, as in Middlesbrough English, or more like /ʃ/, as in Dublin English. Similarity to /ʃ/ and the Dublin English pattern would support the view that Australian English fricated /t/ could have its origins in the Irish English or Irish speech of immigrants to Australia in the 1800's.

2. Method

2.1. Subjects

Subjects were six female speakers of Australian English with a 'General' accent from Melbourne (denoted AF1, AF2, …). The speakers were aged 28-31 and university-educated. They had mainly grown up in Melbourne, except AF3 who grew up in Geelong. All had attended private schools except AF4 who had attended a state school mainly and a private school for two years. Some subjects (AF4, AF5, AF6) were residing in Cambridge at the time of recording, after varying periods spent in a British English-speaking environment (9 months, 15 months and 5 ½ years respectively). AF6 is the second author on this paper.

2.2. Materials

Due to the phonetic (rather than sociolinguistic or phonological) focus of this research, controlled data is required for analysis. The experiment materials were a set of sentences of the form *Whisper* X *again* (X = test word), designed to elicit word-final and word-medial /t/, /s/ and /ʃ/ in intervocalic position with the preceding vowel quality /æ/. The test words were *mat*, *mass*, *mash* for the word-final intervocalic context, and *batting*, *gassing*, *dashing* for the word-medial context. Thus the vowel following the target consonant was schwa for the word-final intervocalic context, and /ɪ/ for the word-medial context. Six tokens of each word were elicited per speaker. The sentences were arranged in random order and interspersed with a number of filler items.

2.3. Recording

Subjects were recorded in the field or in the sound-treated room in the phonetics laboratory at the University of Cambridge onto a Sony TCD-D8 portable DAT recorder (sample rate: 48 kHz) with an omni-directional Sony ECM-16T electret condenser microphone (frequency response: 50-15000 Hz). The recordings were redigitised at a sampling rate of 22,050 Hz using a Toshiba Satellite laptop computer and band-pass filtered between 100 Hz and 9,000 Hz (30 Hz smoothing) for analysis using the Praat speech analysis program (www.praat.org).

2.4. Analysis

For each consonant, the relative duration of the frication was measured, then normalised as a percentage of utterance duration. Frication was identified by hand from the spectrogram and waveform windows. Various measurement techniques were applied to the central 50 ms of the frication itself. The frequency location and amplitude of the two major spectral peaks were identified by hand from FFT spectra of 50 ms of frication. The frequency range of

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energy falling within 12 dB of the major spectral peak was also measured (van Dommelen 2003). The amplitude of 50 ms of frication was measured and normalised against the amplitude of modal voicing in the preceding vowel. In addition, statistical measures of the frication spectrum were acquired (Jongman, Wayland and Wong 2000). These measures allow the fricatives /s/ and /ʃ/ and the fricated /t/ to be compared in a number of ways. The measures reported here are: relative duration, relative amplitude, major spectral peak frequency, range, and centre of gravity.

AF6 had the shortest average fricative duration of all subjects for each fricative type. As *all* her fricatives were shorter and it is unclear how this could be due to influence from British English, this appears to be a speaker-specific effect. In two cases in AF6's data, fricated /t/ in the word-medial intervocalic context (in *batting*) had a duration of less than 50 ms (41 ms and 49 ms). In these cases, the whole duration of frication was analysed for the relative amplitude and spectral properties.

Statistical analysis was undertaken using SPSS. The various measures were each subjected to a two-way repeated measures analysis of variance with the factors Consonant (fricated /t/, /s/, /ʃ/), and Position (word-final intervocalic, word-medial). Pairwise comparisons using the Sidak correction were also carried out.

3. Results

3.1. General Remarks

The data presented some variation in the realisation of word-final intervocalic and word-medial /t/. Some tokens showed an acoustic pattern consistent with a fully occluded realisation. Other tokens exhibited no evidence for closure but showed either transients within an extensive period of frication, or a change in the spectral qualities of frication over time. It is not clear what articulatory movements underlie these 'intermediate' tokens. Clearly occlusion is incomplete, and as such they are 'fricated', but transients and very obvious dynamic spectral patterns suggest articulatory movements, perhaps towards a greater degree of constriction, during the period of incomplete occlusion. Only results of the detailed acoustic analysis applied to fully fricated tokens of /t/ are reported here (see Table 1).

Figures 1-3 show wideband spectrographic images generated within Praat of individual tokens from a single speaker of *mat* (with fricated /t/), *mass*, and *mash*. The images start part way through the /m/ and continue to the onset of periodicity for the /ə/ of *again*. The fully fricated nature of the /t/ realisation is evident in the continuous and relatively uniform aperiodicity, also exhibited in the tokens of /s/ and /ʃ/. All tokens also show the acoustic effects of a high rate of airflow at the vowel-consonant transition, probably due to vocal fold abduction. This effect is known as 'pre-aspiration' for plosives, and may be universal for fricatives (Ní Chasaide and Gobl 1999).

Table 1: Incidence of fully fricated tokens of /t/ in the sample (total sample size per subject = 6)

subject	final	medial
AF1	6	6
AF2	4	4
AF3	4	4
AF4	5	5
AF5	1	5
AF6	6	5

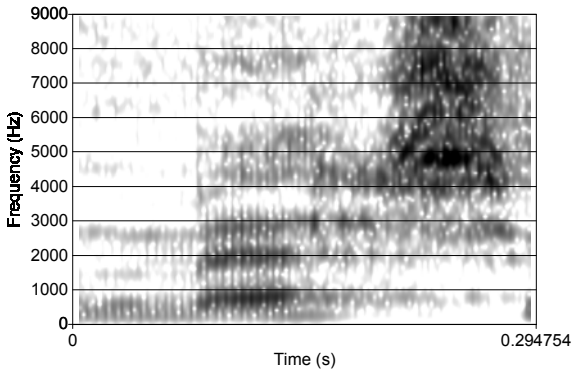

Figure 1: *Token of* 'mat' *with fricated /t/ (subject AF1).*

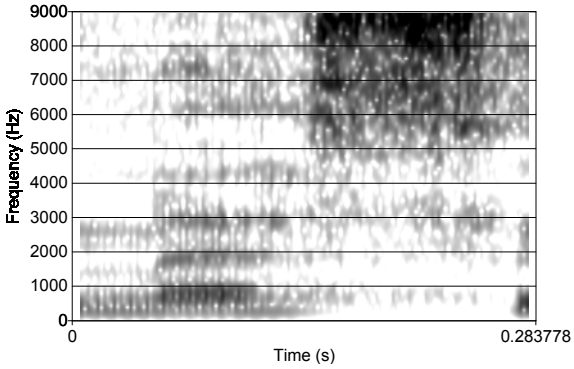

Figure 2*: Token of* 'mass' *(subject AF1).*

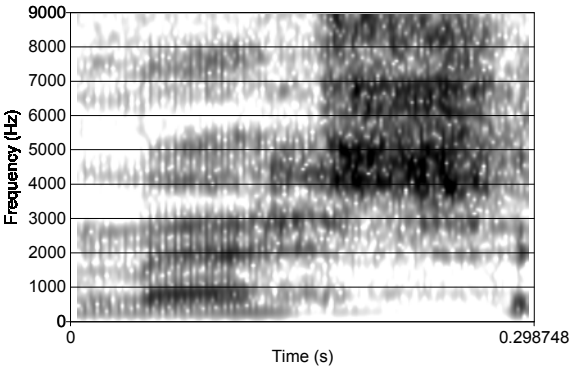

Figure 3*: Token of* 'mash' *(subject AF1).*

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3.2. Relative duration

Fricated /t/ has the shortest average relative duration of the three fricatives for all subjects in both word-final intervocalic and word-medial contexts, but word-medial durations are shorter than word-final intervocalic contexts for all fricatives for almost all subjects. Figure 4 shows the relative durations for the word-final context.

The effect of Consonant was significant ($F(2,10) = 78.237$, $p = 0.000$), as was Position ($F(1, 5) = 8.593$, $p = 0.033$), but there was no significant interaction. Pairwise comparisons showed a significant difference between fricated /t/ and each of the phonological fricatives /s/ and /ʃ/ ($p = 0.000$ in both cases), but there was no significant difference between /s/ and /ʃ/ ($p = 0.975$).

3.3. Relative amplitude

Fricated /t/ had the lowest average relative amplitude of all fricatives in both contexts. The relative amplitudes of /s/ and /ʃ/ were equal on average, but showed some individual variation in terms of which was highest.

Effects of Consonant and Position were both significant at the 5% level (Consonant: $F(2, 10) = 4.508$, $p = 0.040$, Position: $F(1, 5) = 11.395$, $p = 0.020$), but there was no significant interaction. Pairwise comparisons showed no significant differences, although the comparison of fricated /t/ and /ʃ/ approached significance ($p = 0.057$).

3.4. Centre of gravity

The average centre of gravity (COG) values differed across subjects as might be expected, but the same relationships held in every case. For all subjects in both contexts, average COG values were highest for /s/ and lowest for /ʃ/. The average COG values for fricated /t/ were in all cases much closer to the values for /ʃ/ than to the values for /s/, as can be seen for word-final intervocalic contexts in Figure 5.

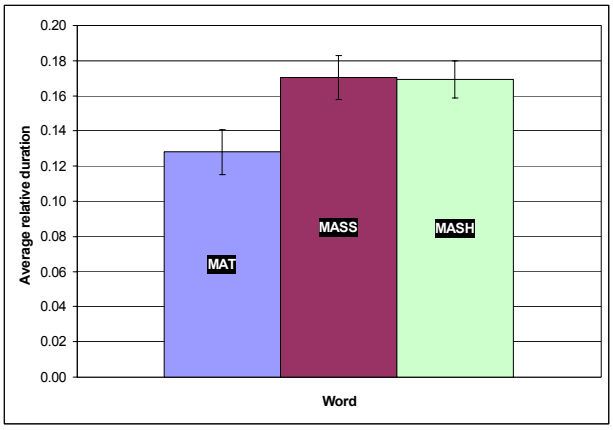

Figure 4: *Average relative duration plotted per word-final consonant. Error bars show one standard deviation.*

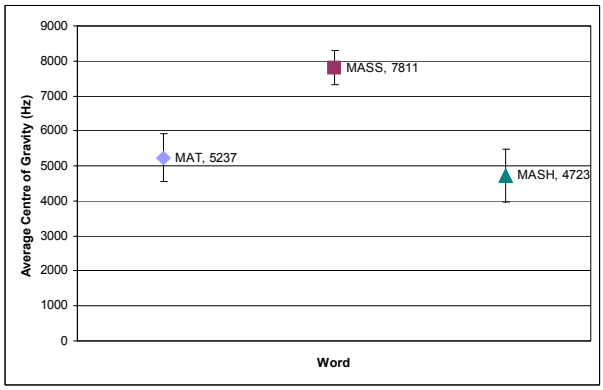

Figure 5: *Average centre of gravity (Hz) plotted per word-final intervocalic consonant. Average values are printed. Error bars show one standard deviation.*

Statistically, there was a significant effect of Consonant ($F(2, 10) = 131.281$, $p = 0.000$), but not of Position ($F(1, 5) = 0.794$ $p = 0.414$), and no interaction between them, $p = 0.442$. In pairwise comparisons, there was no significant difference between the COG of fricated /t/ and /ʃ/ ($p = 0.199$). Other comparisons were significant: fricated /t/ and /s/ $p = 0.000$; /s/ and /ʃ/ $p = 0.000$.

3.5. Range

The average range of frequencies within 12 dB of the major spectral peak (the 'range') for fricated /t/, /s/ and /ʃ/, together with the location of the average peak frequency within the range are shown for word-final intervocalic contexts in Figure 6. Comparison of this range and of the major spectral peak among the consonants also shows that in both word-final intervocalic and word medial contexts, fricated /t/ is more similar to /ʃ/ than to /s/. This is the case for all subjects except AF3 who showed a similar range for fricated /t/ and /s/ in the word-final intervocalic context.

Neither Consonant nor Position had a significant effect on the frequency bandwidth of the range (Consonant: $F(1.105, 5.23) = 3.518$, $p = 0.113$ with Greenhouse Geisser correction; Position: $F(1, 5) = 0.643$, $p = 0.459$).

3.6. Major spectral peak frequency

The average frequency of the major spectral peak for each fricative showed once again that there is greater similarity between the fricated /t/ and /ʃ/ then between fricated /t/ and /s/ for Australian English (Figure 6). For average peak frequencies, the effect of Consonant was statistically significant ($F(2, 10) = 161.212$, $p = 0.000$), but Position was not ($F(1, 5)$, $p = 0.547$) and there was no significant interaction between the two factors. In pairwise comparsions, the difference between fricated /t/ and /ʃ/ did not reach significance ($p = 0.118$). The

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remaining pairwise comparisons were significant (p = 0.000 in both cases).

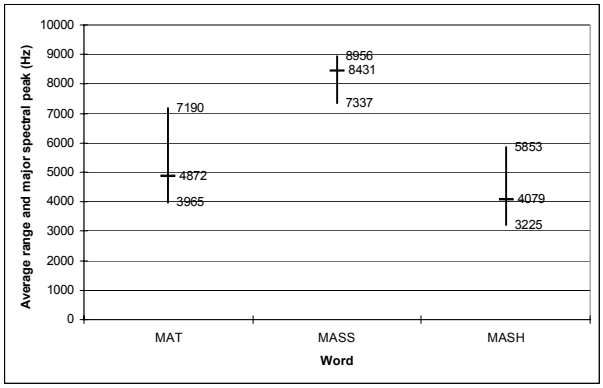

Figure 6: *Average range and major spectral peak (Hz) plotted per word-final intervocalic consonant. Average upper limit, major peak and lower limit values are printed for each consonant.*

4. Discussion

The available data show that Australian English fricated /t/ is more similar to Australian English /ʃ/ than to Australian English /s/ in terms of a number of spectral characteristics. Fricated /t/ and /ʃ/ show no significant statistical difference in average COG or average frequency of the major spectral peak. As in other accents of English with fricated /t/, the frication of /t/ in Australian English is shorter in relative duration and lower in relative amplitude than the frication of /ʃ/ or /s/. The role of these spectral, durational and amplitude differences in maintaining fricative constrasts in Australian English requires investigation in future perceptual work. Of particular interest here is the observation that in pairwise comparisons, the difference in relative amplitude between fricated /t/ and the spectrally similar /ʃ/ approaches significance (p = 0.057), although it is not statistically significant at the 5% level.

A further finding is that the spectral qualities of the fricatives are not affected by a change in position from word-final intervocalic to word-medial context, consistent with expectations for sounds which require precise articulatory control in their production. The data show duration and amplitude differences in different positions. Fricatives in word-final intervocalic position may be subject to a lengthening process relative to the word-medial context, or it may be that fricative duration is inversely proportional to the number of syllables in the elicitation phrases: five in word-final intervocalic context, six in word-medial context.

The pattern of similarity between Australian English fricated /t/ and /ʃ/ parallels the pattern of similarity seen for Dublin English slit-/t/ and /ʃ/, but contrasts with the similarity between fricated /t/ and /s/ seen in Middlesbrough English. Jones and Llamas (2003) have interpreted these patterns as evidence against an Irish or Irish English origin for Middlesbrough fricated /t/. The similarity of Middlesbrough fricated /t/ and /s/ accords with cross-linguistic patterns of merger between /t/ and /s/ lacking any Irish origin. Jones and Llamas suggest that Middlesbrough English fricated /t/ may be an instance of the cross-linguistically common pattern of /t/ frication rather than an Irish/Irish English contact effect.

Caution is required in the present study in interpreting the results as cross-linguistic data on the phonetics of /t/ frication are lacking. Furthermore, adaptations in the realisation of /s/ and /ʃ/ might result from the emergence of a fricated realisation of /t/. As these adaptations could affect the location of the yardstick against which realisations of fricated /t/ or slit-/t/ have been compared (i.e. the relative characteristics of /s/ and /ʃ/), an assessment of their existence is vital. Future work will address these issues.

Nevertheless, the results at this stage render the possibility of an Irish English connection difficult to ignore. Australian English fricated /t/ might be a transfer effect, possibly a very indirect one, from the Irish or Irish English speech of immigrants to Australia in the 1800's. Australian English fricated /t/ has remained largely unnoticed throughout most of the 20th century, suggesting a recent development involving some Irish-influenced subvariety of Australian English. However, preliminary auditory analysis of recordings in the Mitchell and Delbridge database (1998 reissue, The University of Sydney) indicates the presence of fricated /t/ in Australian English in the 1950's and 60's. More data is required, though demonstrating continuity may be extremely difficult. More problematic for the possibility of an Irish English link would be evidence from cross-linguistic studies of languages other than English that phonetically-driven fricated realisations of /t/ can be [ʃ]-like rather than [s]-like. The socio-linguistic significance of the variant (cf. Loakes 2006, Tollfree 2001) and the role of the ethnic Greek community in possibly spreading fricated /t/ (cf. Horvath 1985) also need to be assessed.

In the cases of /t/ frication investigated here, as in Jones and Llamas (2003), the word-final intervocalic plosives are pre-aspirated, i.e. they show the acoustic effects of a high rate of airflow at the transition between vowel and consonant presumably due to widely abducting vocal folds. In these cases, aerodynamic conditions for frication of the plosive would be met if occlusion were incomplete. Even with complete occlusion, a period of pre-affrication is often evident as the articulators approximate for closure. Beckman *et al.* (1992: 50) suggest that fricatives might result from word-initial post-aspirated stops if the turbulence in the release burst is misinterpreted as (af)frication. Something similar could happen with pre-aspirated stops if listeners come to regard the pre-affrication and turbulence at release as more canonical exponents of the final stop contrast than the closure itself.

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5. Conclusion

The present research indicates that Australian English fricated /t/ is spectrally similar to /ʃ/, a relationship reported for slit-/t/ in Irish English, and hence supports the view that fricated /t/ in Australian English could result from Irish English influence. Future work will address the role of various phonetic parameters in perceptually distinguishing fricated /t/ and /ʃ/ in Australian English and possible systemic adaptations to the emergence of fricated /t/, as well as historical data and sociolinguistic patterns.

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