THE DEVOICING OF FRICATIVES IN SOUTHERN BRITISH ENGLISH

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ABSTRACT

In connection with the phonological distinction between voiced and voiceless sounds in languages, it can be observed that voiced sounds are relatively frequently devoiced, i.e. they are realized phonetically with little or no vocal fold vibration. This study investigated the devoicing of /v/ and /z/ in Standard Southern British English (SSBE) by means of a production experiment in which vocal fold activity during fricative articulation was established by means of laryngography. From the results it appears that fricative devoicing in SSBE is much more frequent than previously assumed; 1 in 2 fricatives is devoiced. Fricative devoicing is found to be related to gender and particularly to its interaction with the age of the speakers. This suggests that besides physiological factors which determine fricative devoicing, a socio-linguistic component may have to be recognized: the difference in fricative devoicing between women and men is more marked in the older age group and this may be an indication of phonetic change in progress.

Keywords: fricatives, acoustic characteristics, laryngography, sociophonetic variation

1. INTRODUCTION

The phonological distinction between voiced and voiceless sounds in languages of the world is a rather fundamental one. In theory, voiced sounds are produced with vocal fold vibration, while voiceless sounds are characterized by the absence of vocal fold vibration. In practice, however, phonetic reality is far more complicated than that in that the phonological voicing distinction is often signalled by phonetic cues other than vocal fold vibration, such as amongst others segment duration (voiceless sounds are longer than voiced sounds) and length of a preceding/following vowel.

It has been observed that phonologically voiced fricatives are often devoiced [11], i.e. they are realized phonetically with little or no vocal fold vibration. The prime factor that seems to determine devoicing is the phonetic context in which the fricative occurs with significant effects of word position (word-final fricatives are devoiced most often), assimilation (devoicing occurs in the context of voiceless sounds) or whether the fricative occurs in an accented syllable or not (there is more devoicing in accented position). Besides these contextual factors, there are also a number of fricative-inherent and socio-linguistic factors that may play a role.

As far as the fricative inherent factors are concerned, evidence from research on other languages than English suggests that there is a devoicing hierarchy in that fricatives with a posterior place of articulation are devoiced more frequently than fricatives with an anterior place of articulation. In Dutch for instance the order of fricative devoicing is generally found to be /velar/ > /alveolar/ > /labio-dental/ [10]. This is accounted for in terms of cavity size between the location of the constriction and the glottis: for fricatives with a smaller vocal tract cavity the pressure differential between subglottal and supraglottal pressure equalizes faster so that the vocal folds naturally stop vibrating somewhat earlier than in fricatives with a bigger vocal tract cavity. This tendency has also been found in research on fricative devoicing on Southern British English. [4] found that 19.64% of labio-dental fricatives were devoiced while devoicing of the alveolar fricative was substantially more frequent (25.77%). This finding was not corroborated by [3] who explicitly states that 'the place of articulation of initial fricatives has no significant effect on the percentage of the fricative accompanied by devoicing' (p.163). These contrasting observations were taken as the starting point for a more comprehensive study of fricative devoicing in Southern British English in which the voicing characteristics of a lingual fricative /z/ were compared with a non-lingual fricative /v/. The articulation of alveolar /z/ is associated with a smaller overall cavity size than the articulation of /v/, i.e. 85 cm^3 for an alveolar

place of articulation vs. 140 cm^3 for a labio-dental place of articulation in adult male speakers [2].

Besides the place of articulation, it was also decided to carefully control for gender (male vs. female) and age of the participants (younger vs. older) since the influence of these socio-linguistic variables on fricative production has never been investigated with respect to Southern British English. In research on other languages, however, it has been found that female speakers devoice more frequently than male speakers [8]. As regards age, it has been suggested that younger speakers devoice more frequently than older speakers [8].

2. METHOD

In this study speech samples were collected from native speakers of Southern British English to investigate the voicing characteristics of the English voiced fricatives [v] and [z], thus comparing the devoicing in a non-lingual and a lingual fricative articulation.

2.1. Materials

The materials for this study consisted of meaningful English words which were selected on the basis of a small number of experimental variables, i.e. place of articulation of the fricatives and their position in the words. By this means the study investigates a labio-dental and alveolar place of articulation, i.e. /v/ vs. /f/ and /z/ vs. /s/ in word-initial, word-medial and word-final positions. The stimuli for the experiment thus comprised 120 words from a database of minimal pairs in English [5] selected in order to provide combinations of the 4 fricatives and 3 positions (10 words for each combination).

The target words were embedded in the carrier phrase 'In X you hear Y' in which the target word featured in position X and the vowel contained by the target word in position Y. As a result the target word was placed in [+focus] position so that it would naturally be realized with sentence accent. This yielded sentences such as 'In veal you hear EE'. This method was used to focus speakers' attention on the vowels and away from the fricatives in order to minimize any tendency towards un-natural production.

2.2. Experimental techniques

During the reading task both the audio signal and a registration of vocal fold vibration were recorded The audio signal was recorded by means of a head-set microphone which was positioned 1-2 inches away from the speaker's mouth at a 45 degree angle. Simultaneously, vocal fold vibration was registered by means of laryngography. In this technique two surface electrodes are placed externally on either side of the speaker's larynx and the electrical resistance is measured during vocal fold vibration: these variations in resistance are represented as a waveform which can be time-aligned with the audio signal.

2.3. Participants

A total of 20 participants were recruited for this study. All of them were native speakers of Standard Southern British English (SSBE). The primary selection criterion for subjects was a clear regional affiliation with Southern Britain, i.e. all participants had lived in Southern Britain for the last 10 years prior to the study. In addition, the presence and/or absence of specific pronunciation characteristics mentioned in [13] was assessed. Very specifically speakers were asked to pronounce the words 'bath', 'cup' and 'glass', and the broadness of these vowels was assessed. Furthermore, the words 'face' and 'goat' were used to assess the presence of a closing diphthong. Finally, the words 'water' and 'butter' were used to assess the non-rhoticity of the speakers' accents.

Other variables relating to the participants that were controlled for were age and gender. One group of participants qualified as young: their age range was between 20 and 40 years. The age of the participants in the other group ranged between 40 and 60 years. In each group there was an equal number of male and female speakers. None of the participants reported any history of speech or hearing difficulties and they all took part in the study on a voluntary basis.

2.4. Recording procedure

Before the start of the recording, subjects were fully informed about the test procedure including what they would be required to do and they were assured that the procedure was non-invasive. Participants were able to ask questions before consenting to the recordings.

The recordings were conducted in a quiet speech laboratory at City University London. Before the start of the reading task, subjects read a few practice sentences. Subsequently, they read three different presentation blocks of all the stimuli with a 5 minute break between each. Each block

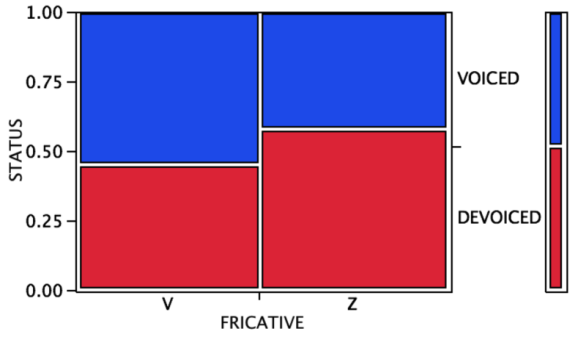
consisted of a different randomization of the same stimuli. All the stimuli were presented visually by means of a Powerpoint Presentation on a computer screen that was positioned at a comfortable reading level for each participant. Participants were asked to read the sentences in a tempo of their own choice with a natural intonation. Recordings were made directly onto a hard disk of a computer by means of Speech Studio (version 4.3.0.0, Laryngograph Ltd., UK) [6].

3. RESULTS

In this study a total of 7200 fricative realisations were collected, i.e. 4 fricatives X 3 word-positions X 10 words X 3 repititions X 20 participants. All the phonologically voiced fricatives were visualized using PRAAT [1]. On the basis of the duration measurements and the degree of vocal fold vibration during the realisation of the fricative, a proportion of devoicing was calculated. This measure of devoicing was used to label the fricatives as 'voiced' or 'devoiced' and fricatives were regarded as phonetically devoiced if vocal fold vibration was not sustained for less than two thirds of the duration of the fricative [7]. For longer relative durations of vocal fold vibration, fricatives were classified as 'voiced'.

The overall proportions of devoicing are illustrated in figure 1:

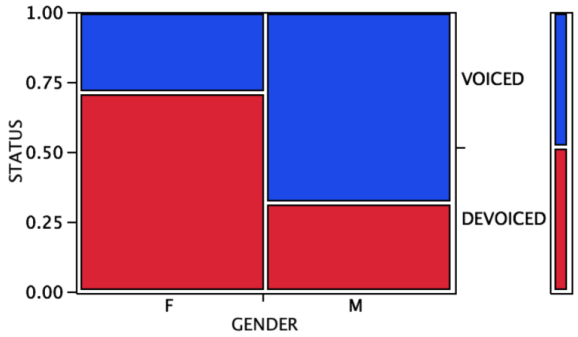
Figure 1: Proportion of fricative devoicing in the SBBE realisations of /v/ and /z/.



In Fig. 1 it can be seen that the proportion of devoicing in /z/ (58.01%) is higher than in /v/ (45.29%). In order to investigate the significance of this devoicing difference a nominal logistic regression analysis was carried out. In this analysis, the independent variables were fricative identity (2 levels /v/ vs. /z/), gender (male vs. female) and age (younger vs. older). The dependent variable was the proportion of devoicing. This analysis indicates that the difference in fricative devoicing observed above is significant ($\chi^2(1) = 70.61$, $p < 0.0001$).

The relationship between gender and fricative devoicing is summarized in Fig. 2:

Figure 2: Proportion of fricative devoicing in male and female speakers.



From Fig. 2 it is clear that devoicing is more marked in female speakers (71.58%) than in the male speakers (32.07%). The nominal logistic regression indicates that this difference is significant: $\chi^2(1) = 608.3131$, $p < 0.0001$.

Finally, the interaction between age and gender is summarized in Fig. 3 and 4. The nominal logistic regression analysis indicates that this interaction is significant: $\chi^2(1) = 31.0541$, $p < 0.0001$.

4. DISCUSSION

Fricative devoicing in this study was defined as the absence of vocal fold vibration during 2/3^{rds} of the duration of fricative articulation. Although this devoicing criterion is substantially stricter than in [3] and [4], the devoicing of fricatives was found to very much more frequent than previously assumed: overall, 1 in 2 voiced fricatives (51.65%) were found to be devoiced, while this ratio in [3] and [4] amounted to approximately 1 in 6 (17.52%). The frequency of devoicing in this study is almost as high as in Dutch where devoicing of /v/ and /z/ amounted to 58% [11].

The second finding of this study is that there is a significant effect of the place of articulation fricative on its devoicing: the alveolar fricative /z/ is devoiced more frequently (58.01%) than the labio-dental fricative /v/ (45.29%). This is consistent with a physiological account of fricative devoicing in which devoicing is assumed to be related to the size of the oral cavity: in alveolar /z/ the oral cavity size between the place of articulation and the glottis is smaller (85 cm^3) than in labio-dental /v/ (140 cm^3).

Figure 3: Proportion of fricative devoicing in the YOUNGER speakers.

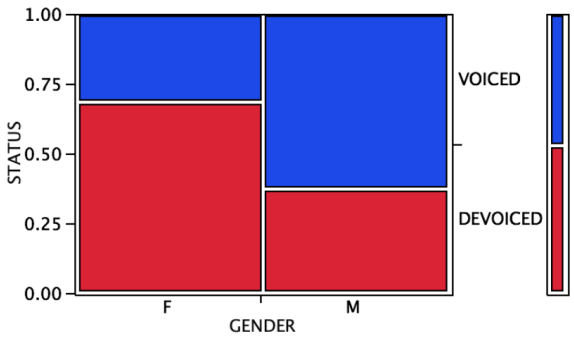
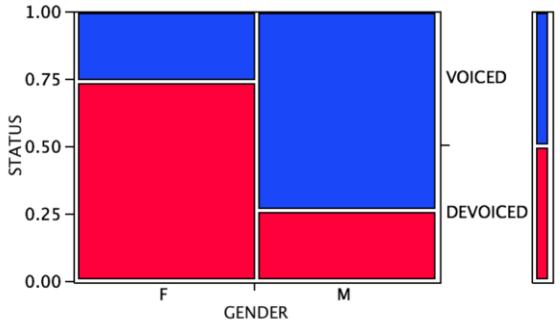


Figure 4: Proportion of fricative devoicing in the OLDER speakers.



As a result the pressure differential between subglottal and supraglottal pressure equalizes faster in /z/ so that the vocal folds stop vibrating somewhat earlier than in /v/.

The third observation from this study is that female speakers devoice very significantly more often than males: females devoice 3 in 4 fricatives (71.58%) and men 1 in 4 (32.07%). This may in part be accounted for by anatomical and physiological differences between men and women: the vocal tract volume in women is smaller than in men and thus leads more easily to a neutralization of the transglottal pressure differential than in men [9]. Furthermore, the vocal folds in women are stiffer than in men and it may be more difficult to set them into vibration [8]. Besides this physiological explanation, it cannot be excluded that this difference in devoicing (in part) represents a socio-linguistic difference. Women have an overall slower speaking rate than men [12] and it has been reported that females articulate speech segments more carefully. It is precisely these conditions that are conducive for fricative devoicing.

Finally, it was found that the difference in fricative devoicing between females and males is most marked in the older age group: while devoicing is similar in younger and older females, it was observed that younger males devoice more often than older males. On the basis of anatomical and physiological differences between young and old speakers the opposite is to be expected: the vocal folds in older males are stiffer and their speech rate is slower and these factors should in fact be conducive for devoicing. As a result, a socio-phonetic component may have to be considered in accounting for this difference.

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