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Articulatory Insights into Language Variation and Change: Preliminary Findings from an Ultrasound Study of Derhoticization in Scottish English

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Abstract

Scottish English is often cited as a rhotic dialect of English. However, in the 70s and 80s, researchers noticed that postvocalic /r/ was in attrition in Glasgow (Macafee, 1983) and Edinburgh (Romaine, 1978; Johnston and Speitel 1983). Recent research (Stuart-Smith, 2003) confirms that postvocalic /r/ as a canonical phonetically rhotic consonant is being lost in working-class Glaswegian speech. However, auditory and acoustic analysis revealed that the situation was more complicated than simple /r/ vs. zero variation. The derhoticized quality of /r/ seemed to vary socially; in particular male working class speakers often produced intermediate sounds that were difficult to identify. It is clear that although auditory and acoustic analysis are useful, they can only hint at what is going on in the vocal tract. A direct articulatory study is thus motivated.

Instrumental phonetic studies that examine the vocal tract during the production of sustained rhotic consonants and in laboratory-based studies of American English /r/ have identified a complex relationship between articulation and acoustics, including articulatory differences with minimal acoustic consequences (starting with Delattre and Freeman, 1968). In other words, different gestural configurations can be used to generate a canonically rhotic consonant. A pilot study (Scobbie and Stuart-Smith, 2006) using Ultrasound Tongue Imaging (UTI) with a Scottish vernacular speaker revealed something rather different: the occurrence of a strong articulatory retroflex tongue motion, which generated little or no rhotic acoustic consequences because it was timed to occur after phonation had ceased, before pause. This tongue motion was found in a speaker who was weakly rhotic. Thus we may have a situation in which acoustic differences with a sociolinguistic function have, in some prosodic contexts, imperceptible articulatory differences in tongue position, though timing will vary. The situation of language variation and change in Scotland means that an articulatory/acoustic study is likely to give very different results to similar studies of rhotic speakers in the USA (Mielke, Twist, and Archangeli, 2006), and be particularly relevant to understanding social variation.

Ultrasound is non-invasive and portable and therefore has great potential as an instrumental method for studying aspects of socially stratified variation: articulatory data can be physically collected in every-day social settings. However the technique requires refinement for effective use in recording

locations outside the laboratory (e.g. in school, at home), and the potential impact of using the equipment on speech is not known. Gick (2002) suggest methods for fieldwork, but we are not aware of any study which attempts to quantify the effects of the technique on vernacular speakers.

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1 Introduction

Scottish English is widely assumed to be almost uniformly rhotic, both in the popular imagination and in general linguistic descriptions. However, over the past few decades, researchers have observed a process of derhoticization in the speech of Central Belt Scots. In this paper, the preliminary results of a socially stratified articulatory and auditory study of the loss of coda /r/ in one variety of Scottish English will be presented.

1.1 The History of Coda /r/-loss in Scottish English

Any study of /r/-loss in Scottish English must take into account the possibility of non-rhoticity spreading north from Anglo-English speech. That Anglo non-rhoticity has had an impact on Scottish speech is without question; however, its influence has been socially restricted and levels of non-rhoticity have changed according to socio-political conditions since the 1800s. Researchers studying Edinburgh speech in the late 1970s and early '80s identified a movement among the Middle classes (MC), especially young females, away from semi-/non-rhoticity towards rhoticity[1] (Romaine 1979; Speitel and Johnston 1983; Johnston 1985). At the same time, researchers observed that many Working class (WC) speakers in Edinburgh and Glasgow, especially males, were using a form of coda /r/ that was weakened to a pharyngealized vowel (Romaine 1979; Macafee 1983).

Ridicule of MC Anglo-Scottish accents in popular culture and an increase in nationalism may have lead to the MC shift towards rhoticity (Romaine 1979; Johnston 1985); however, the WC loss of /r/ appeared to be a slow-moving, system-internal change, unconnected with Anglo non-rhoticity. Recently, Stuart-Smith has highlighted a large increase in levels of non-rhoticity among younger WC speakers in Glasgow (Stuart-Smith 2003, 2005; Stuart-Smith et al. 2007).

1.2 Using Ultrasound to Supplement Auditory and Acoustic Analysis

To date no effort has been made to explain the mechanism that might underlie the vernacular derhoticization process in Scottish English. Auditory and acoustic analyses of /r/ do not provide a clear picture of how /r/ is being lost with even trained phoneticians disagreeing about the nature of the reduced /r/s they hear (Stuart-Smith 2007). Our study follows those of Delattre and Freeman (1968) and Alwan and Narayanan (1996) in using imaging techniques to gain insight into how the /r/ articulation is formed. Ultrasound tongue imaging (UTI) is particularly useful in our study of Scottish coda /r/, because it is a safe and portable technology and, as Gick (2002:113) stated, it has proved to be an invaluable tool in studying dynamic tongue movement and enabling measurement of elusive tongue root movement, clearly important for this study where /r/ is being heard as a pharyngeal vowel. Its ability to dynamically image the tongue root to tip is also essential for the study of timing and synchronization of lingual gestures.

1.3 The Pilot Study: Identifying a Temporal Lag

A preliminary UTI study conducted by Scobbie and Stuart-Smith identified an articulatory feature that accounted for the difficulty researchers had when they attempted to identify coda /r/ variants from an auditory perspective. It was a covert tongue-raising gesture that occurred after voicing had ceased. Pilot subjects that formed part of the current study confirmed the presence of this covert gesture in other speakers (see Figure 1).

[1]MC Scottish coda /r/ today is typically an approximant with strong retroflection.

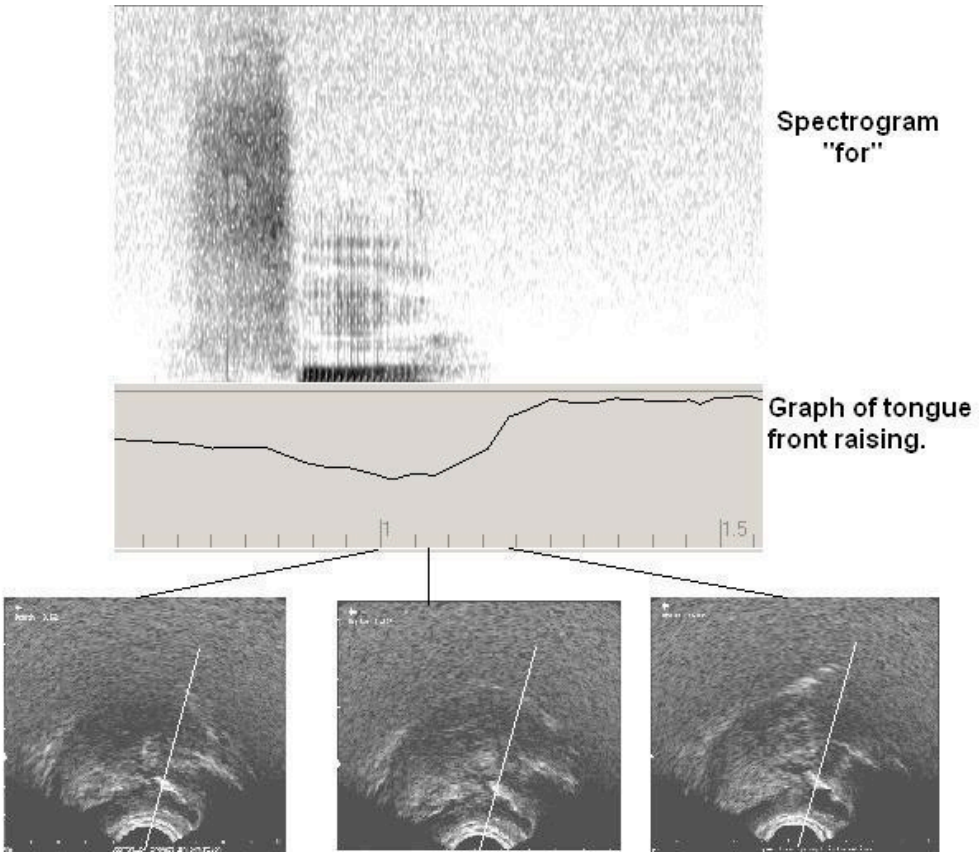

Figure 1: Key UTI frames of Pilot 2 (24 year old male from West Lothian) saying “for” (heard variably as [fɔ] and [fɔɻ])

In the spectrogram in Figure 1 above, the characteristic sharp rise in F2 and dip in F3, usually found in Scottish postvocalic /r/ (see Figure 2:1,3), are not evident, although subtle raising of F2 and falling of F3 are present towards the end of the voiced section. The graph of tongue front raising was generated by fitting a spline to the tongue surface using an edge-detection tool with manual correction. The graph shows at what distance the tongue-surface spline crosses a fixed line which is superimposed on the tongue image and radiates outwards from the ultrasound probe position (represented by a white line on each of the keyframes). The graph and the UTI keyframe images below it show that tongue front raising begins just as voicing is coming to an end, during a breathy period. The tongue front reaches its maximum height position after phonation and the breathy stage have finished. Tongue raising that occurs when formants fade may evidently be audible in the breathed period after voicing has ceased. Listeners sometimes have the impression that there is some sort of /r/ there, but not one that is easy to classify or even describe from an auditory basis alone (see Figure 2).

Images 1–2 in Figure 2 show retroflex rhotic [ɻ] spoken by female and male MC Scottish speakers respectively. They have characteristic rising F2 and lowering F3 and F4. Images 3–4 are from male WC speakers and show apparently non-rhotic pronunciations with little variation in formant values throughout the voiced section, yet some listeners still report hearing /r/. It is possible that the retracted vowel quality contributes to the perception of an /r/; however, UTI movies of these utterances show covert tongue-raising gestures in the silent period after voicing.

Derhoticization in Scottish English is clearly a change from below (in the social sense) and so the most informal types of speech must be investigated. Increasingly lightweight ultrasound machines and developments in probe stabilization in relation to the speaker’s head are making sociolinguistic UTI fieldwork a possibility. Nevertheless, the psychological impact of the ultrasound machine, probe, associated hardware and the essential stabilizing headset on

informants' speech style is unknown. This first attempt at using UTI as a sociolinguistic fieldwork tool must have a twofold function: to provide useful information about tongue movement in coda /r/ in younger speakers, and to assess the impact of the instrumentation on speech style. Thus, our research goals are: to gain insight into the articulatory processes involved in /r/-loss and to assess how useful UTI is as a sociolinguistic fieldwork tool.

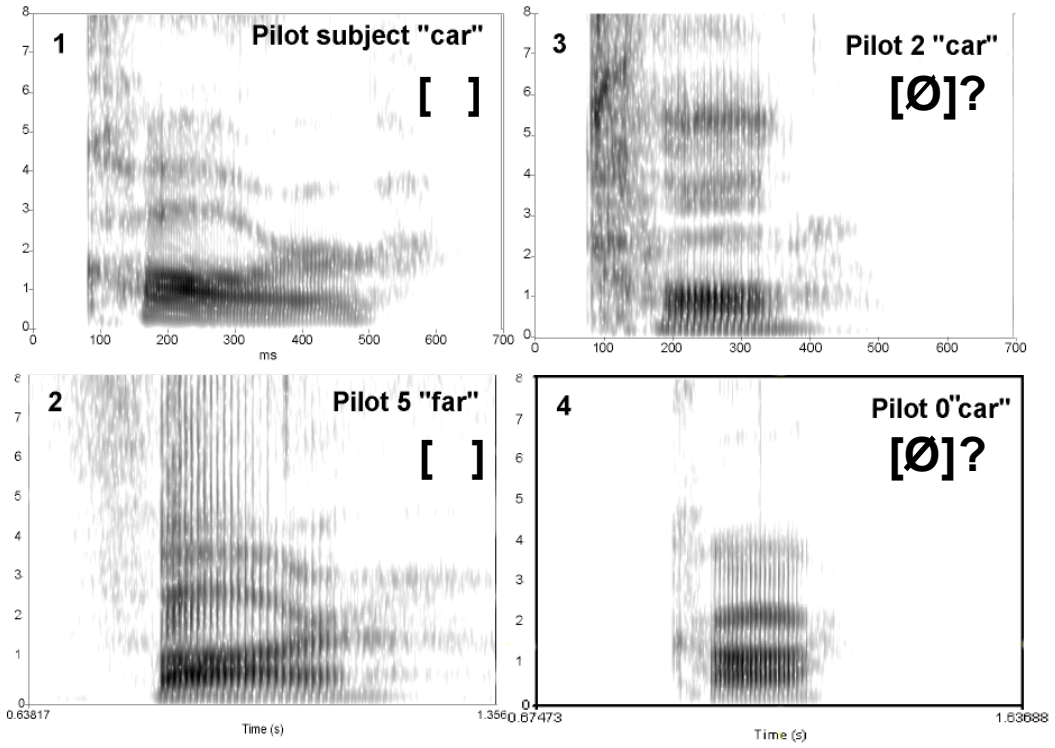

Figure 2: Spectrograms from the project pilot study showing four separate speakers producing words with coda /r/. Left hand images are of rhotic pronunciations; right-hand images show derhoticization and are heard variably as rhotic or non-rhotic depending on listener

2 Methodology

2.1 Location and Informants

Our study involved 14 male[2] High School pupils aged 12–13 from a New Town in West Lothian called Livingston. The town is situated in the populous "Central Belt" region of Scotland (see Figure 3). It is 13 miles west of Edinburgh and 25 miles east of Glasgow, sitting next to the M8 motorway that links these main Scottish cities. Previous sociolinguistic research has been carried out in this area by Pollner (1985) and Robinson (2005) (see also Macafee 1997). The school used in the study (cf. Robinson 2005) serves some of the most deprived areas in Livingston, which allowed us to gather informants from lower socioeconomic groups.

[2]Preliminary investigations by the researchers suggested that, in the Lothians region, males were more likely to exhibit derhoticization than females.

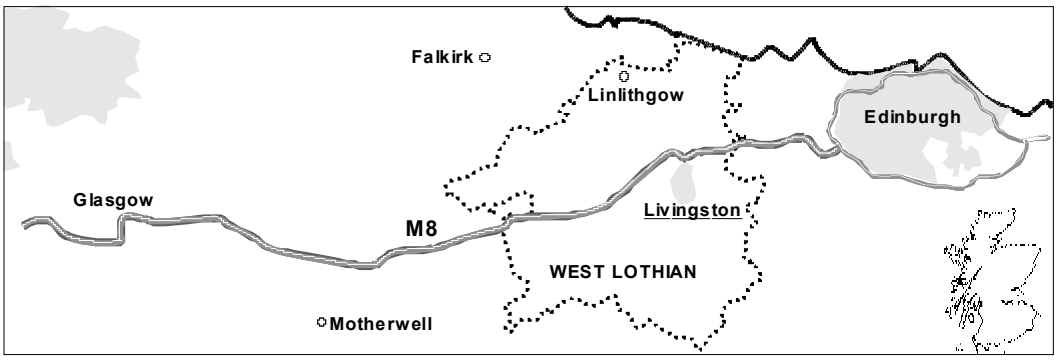

Figure 3: Map showing the location of Livingston and other major towns and cities in the central belt and the boundary of West Lothian

2.2 Procedure

Informants were recorded in friendship pairs. Each pair was recorded in school on two separate occasions (Phase 1 and Phase 2). On both occasions, informants were recorded having a conversation for 20 minutes and reading a word list aloud. Phase 1 recordings were audio only, but for Phase 2, four speakers ("control" subjects) were recorded for a second time with audio only and the ten remaining speakers were recorded with audio and UTI. It was possible to record UTI data from only one informant in each pair during the conversation; however, both informants were led to believe that they were being recorded.

The audio recording was continuous; however, due to the large file size of the UTI recordings, they were made using automatic sampling throughout the conversation. Around 15 seconds of speech were recorded followed by 10 seconds of saving. This process was repeated continuously throughout the 20 minute conversation.[3] Analyses of the UTI images obtained were carried out using the Articulate Assistant Advanced software package. For an alternative UTI methodology, see Miller-Ockhuizen (2000) and Gick (2002).

2.3 Audio and Ultrasound Equipment

Recordings were made in a quiet schoolroom using clip-on microphones and a digital sound recorder. Informants were asked to chat together for 20 minutes and later to read a word list aloud. This process was repeated the following day as described above.

Participants were encouraged to drink juice while they chatted; swallowing liquid is also a good means of obtaining a palate trace on the UTI image (Gick 2002:117).

The ultrasound machine used was a 9Kg portable Concept M6, fitted with two probes with 100° and 120° convex angles (imaging the root to the tip[4] of the tongue). The participants recorded under UTI conditions were asked to wear a headset made from lightweight aluminium in order to hold the probe in a fixed position under the chin. This ensured that there would be little lateral movement of the probe and no probe rotation. It also allowed the participants freedom of movement while they talked. Adjustable sections allow the headset to be fitted securely to an individual's head. Although the headset can cause discomfort after long periods of use, it might be considered preferable to holding the probe by hand, which can be tiring for the informant (see Gick 2002) and allows the probe to move, rotate and lose contact.

In this paper, we report preliminary findings on the potential psychosocial effects of the UTI recording context. Speech style might be affected by the recording scenario. We predicted that aspects of speaking might be affected by the UTI equipment, specifically the amount/nature of conversation between informants and variants used.

[3]During one recording session, this continuous saving option was not selected (human error) and so only audio data was collected.

[4]As the tongue tip raises, it becomes harder to image as the ultrasound waves do not easily pass through the pocket of air under the tongue tip.

3 Results

3.1 Quantitative Analysis of Auditory Data: Levels of Derhoticization in Livingston English

This section presents some preliminary findings for the degree of derhoticization among the Livingston informants, based on the first audio-only recordings. Post-vocalic /r/ was labeled in its phonological context for fifteen minutes of each 20 minute spontaneous speech recording (missing out the first five minutes). For the Phase 1 recordings, a total of 1,283 tokens of postvocalic /r/ were identified in spontaneous speech.

For the practical purpose of transcribing a large number of tokens from spontaneous speech, the auditory continuum of variation for all tokens of /r/ was categorized into "rhotic", i.e., those variants heard as articulated forms of /r/, including approximants, trills and taps (cf. Stuart-Smith 2007), and "non-rhotic", for which no articulated /r/-sound seemed audible: this included pharyngealized vowels. Figure 4 below shows the percentage of rhotic and non-rhotic tokens of /r/ for each informant for the initial audio-only recording.

The pattern of derhoticization in Livingston is somewhat different, and in particular less advanced, than that observed in Glasgow, where in 1997, 13-year-old adolescents showed around 63% non-rhotic tokens in spontaneous speech (Stuart-Smith 2003, Stuart-Smith et al 2007). Amongst the working-class Livingston informants, the average percentage of non-rhotic tokens is much lower at 20%. We also note a further difference. Some working-class speakers in Livingston use high levels of retroflex rhotic variants of coda /r/ alongside typical low overt-prestige features e.g. TH-/DH-fronting, historical L-vocalization [bɔ:] 'ball'; Scots vowels [hem] 'home', [hʉs] 'house' and Scots constructions such as *cannae* for 'can't' and *the morra* for "tomorrow". This is very different from working-class Glaswegian speech where retroflex variants occur far less frequently with the features mentioned above, and are rather associated with MC speech.

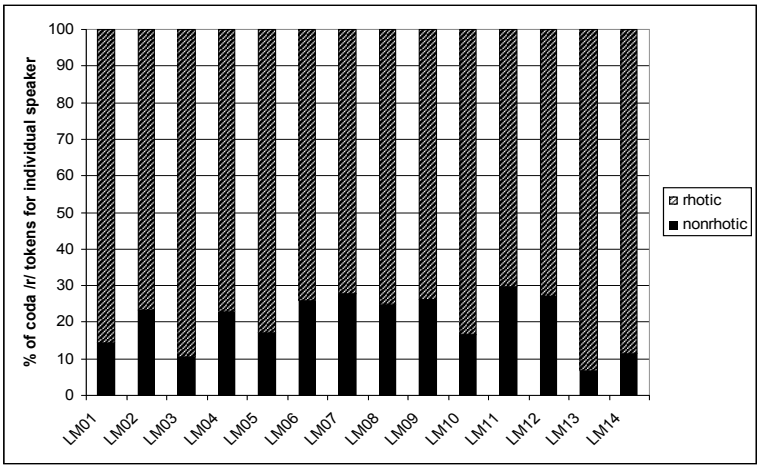

Figure 4: Percentage of vocalized and rhotic /r/ used by each speaker in spontaneous speech (Phase 1 spontaneous); n = 1,283

It was impressionistically observed that non-rhotic and derhoticized forms tended to occur in particular environments, so we recorded whether the syllable containing each coda /r/ token was stressed (primary and secondary) or unstressed and whether the token occurred utterance-finally or not. Figure 5 below shows the correlation between these conditions and the percentage of non-rhotic tokens obtained.

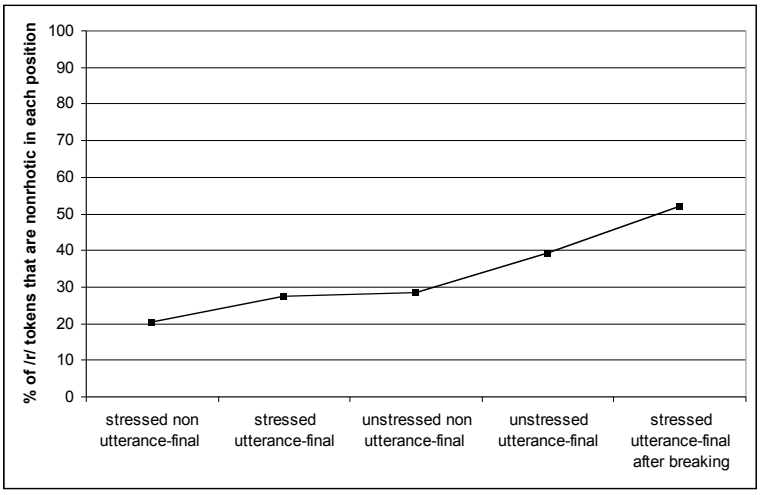

Figure 5: Percentage of (un)stressed tokens in utterance-final and non utterance-final position that were non-rhotic; n = 1,248

Stressed environments, with one key exception, occupy the lower end of the cline of non-rhoticity, while unstressed environments occupy the higher end.

While overall the tendency to use non-rhotic variants is less in Livingston than Glasgow, there seems to be a similar patterning according to phonetic environment, as in Glasgow too, derhoticization was more common in unstressed syllables (Stuart-Smith 2003). This association of unstressed syllables and non-rhoticity in turn corresponds with the earliest forms of Anglo non-rhoticity around 1700. Dobson observed from written evidence that /r/-less pronunciations were first evident in unstressed syllables (Dobson 1968:§427). It is possible that, as with many other coda consonants, deletion of /r/ is more likely in a reduced, unstressed syllable.

Nevertheless, in Figure 5 above, the environment yielding the greatest percentage of non-rhotic pronunciations is "utterance-final after vocalic breaking" e.g. "It's near here [ˈhiʌ(r)]".[5] This environment was impressionistically noted as being particularly associated with non-rhoticity and so was separately labeled in the spontaneous speech data. Romaine 1979:45, Speitel and Johnson 1983:28, and Stuart-Smith 2003 have also flagged up what is variously called utterance-final "level-stress" or "prepausal" environment as important in the /r/-loss process.

Breaking confirms that there is a secondary pharyngeal constriction in Scottish /r/. Even though Delattre and Freeman (1968) concluded that this secondary gesture was absent from British /r/, and this conclusion has been much repeated, analysis of ultrasound data gathered from the preliminary pilot study and the main data set shows tongue root retraction beginning before the tip-raising gesture when coda /r/ occurs in a stressed syllable.

The qualitative evidence (identification of delayed tongue tip raising) and quantitative evidence (identification of high levels of non-rhoticity in stressed utterance-final position) presented here suggest that the derhoticization process in Scottish English might in part be a case of gestural lag due to coda lengthening at an intonation boundary (see Sproat and Fujimura 1993). More analysis of the data must be undertaken in order to confirm or refute this hypothesis.

3.2 Effect of Ultrasound on Style: Word Lists

We now turn to a preliminary assessment of the effect of the ultrasound recording conditions on speaker style. The assessment is based on a comparison of percentages of a limited number of variables in the initial and repeat word list task.

A quantitative analysis of non-standard variants such as T-glottalling (e.g., [kæʔ] for 'cat', and [bɛʔʌɹ] for 'better'), non-standard variants of TH (e.g., [hɪŋk], [fɪŋk], and [ʔɪŋk] for 'think'),

[5]See Aitken (1979:103–4) on the history of vocalic breaking before /r/ in Scots speech.

and nonhistorical vocalization /l/ to a high back (un)rounded vowel (e.g., [wɪo] for 'will') was carried out for both word list recordings for each informant. Comparison of levels of these variants could indicate whether speakers are modifying style between the audio-only and ultrasound conditions. The control group (audio-only for both recordings) was compared with speakers who were recorded with UTI for the second set of recordings.

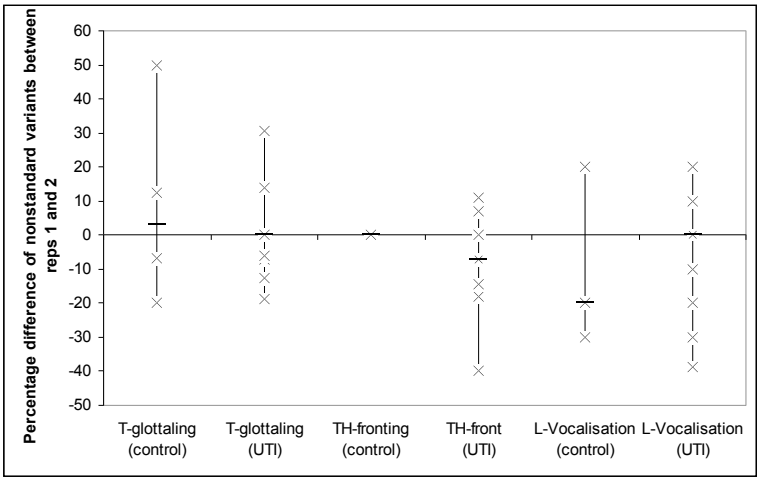

Figure 6: The variation (increase/decrease/lack of change) in the use of nonstandard variants of T, TH and L between the first and second repetition of the word list (i.e., %rep2 – %rep1)

Figure 6 above shows the increases/decreases in nonstandard variant use. For the purpose of comparison, separate plots are situated side by side for the two speaker groups: 'control' and UTI condition. Individual speaker values are marked by crosses (some crosses are situated on top of one another). The group median is indicated by a dark horizontal line.

There appears to be no clear pattern of variation between the UTI group and the controls. For T-glottalling and TH-fronting, the control group shows higher median scores than their UTI-condition counterparts. This shows that, although some speakers decreased their use of non-standard variants in both groups, on average, the control group increased their levels of non-standard variants during the second rep. or kept their levels the same, whereas the UTI group on average reduced their use of non-standard variants during the second rep. However, the reverse is true of L-vocalization, where the control group on average decreased their use of vocalized variants more than the UTI group did on average. Values of increase/decrease in the percentage of the non-standard variants used do not show consistency within speaker groups, with the exception of the TH-fronting control group, all four of whom neither increased nor decreased their use of non-standard TH variants between reps 1 and 2. The T-glottalling UTI group is also fairly consistent, with most speakers showing a small percentage decrease in T-glottalling between reps 1 and 2. It would seem that there is a good deal of individual stylistic variability between first and second repetitions of the word list in both the control and the UTI groups. On listening to rep. 1 and rep. 2 conversations, the use of non-standard features does not seem, impressionistically, at least, to have been affected by the ultrasound condition, which may be due to the normalizing influence of talking to a friend. An analysis of the use of non-standard variants in spontaneous speech must also be undertaken.

4 Conclusion

Vernacular /r/-loss in Scottish English does not seem to be a result of Anglo-English influence. The sound change has a recorded history of two to three decades in the Central Belt cities of Edinburgh and Glasgow. Among the Livingston speakers in the present study, /r/-loss seems to be in its early stages. Young working-class males from Livingston are using fewer non-rhotic

pronunciations than their Glaswegian counterparts. Nevertheless, on average, around a quarter of coda /r/ realizations in conversation were heard as non-rhotic.

This UTI study suggests some possible answers to the questions of why non-rhoticity is arising in Scottish English based on its quantitative and qualitative results. Non-rhoticity occurs most often in particular environments: in unstressed syllables and in utterance-final position—the latter especially in combination with vowel-breaking. Shortening of syllables which are unstressed may have led to the deletion of /r/ in coda position. On the other hand, lengthening of syllables that have utterance-final stress may cause separation of the tongue-root retraction gesture and the tip-raising gesture of approximant /r/ to the point that the anterior gesture occurs after voicing has ceased, making it less audible or inaudible. UTI confirms the presence of a delayed tongue raising gesture in many apparently non-rhotic pronunciations. Non-rhoticity may have spread from these restricted environments.

At this stage in our work, it appears that UTI conditions do not have any material impact on speaker style. This may be because the speakers were recorded in friendship pairs and/or because they were recorded in their normal school environment, so that the a priori intrusiveness of the technique was mitigated, and did not appear to be different in effect to the presence of audio recording equipment. The precise factors required to ensure comparable data from field acoustic recordings, field articulatory recordings, and laboratory-based recordings of both types remain to be determined. For UTI at least, it is clear that obtaining articulatory data for sociolinguistic research in the field is methodologically feasible.

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