DIVERSITY OF TONGUE SHAPES FOR THE AMERICAN ENGLISH RHOTIC LIQUID

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ABSTRACT

The American English rhotic liquid may be produced by a number of different tongue shapes. Using x-ray data of speakers from various regions of the United States, Delattre & Freeman [1] identified six basic tongue shapes used by speakers of "rhotic" dialects. It is unclear, however, whether different shapes are characteristic of particular dialect regions, or a matter of individual variation. In this study, we review findings from a number of published x-ray and MRI studies of tongue shapes for /ɹ/ using speakers from various dialect regions. In addition, we characterize the variability of tongue shapes used for /ɹ/ in a cineradiographic database of elderly men with normal speech from the area of Cincinnati, OH. Results show that variability in tongue shape prevalence is common across different regional populations. We conclude that tongue configuration is likely a matter of individual variation.

Keywords: Rhotic, Liquid, Tongue Shape, Dialect, American English.

1. INTRODUCTION

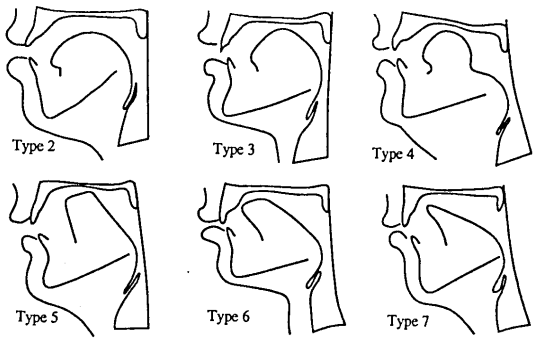
The North American English rhotic liquid /ɹ/ is produced in initial contexts in "r-less" dialects (e.g. Southeastern U.S. and Coastal New England) and in all word positions for rhotic dialects (e.g. Western New England, Standard Canadian, and California). It is commonly considered that speakers use at least two different types of tongue configuration to produce the rhotic liquid /ɹ/. These are typically referred to as "bunched" and "retroflex". However, more targeted articulatory studies have suggested a total of three, four or six alternative tongue shapes can be found among native speakers.

A question that frequently comes up is whether tongue shapes follow a dialectal pattern, or whether distribution is idiosyncratic to particular speakers. The underlying assumption of the dialect hypothesis is that the different shapes will appear consistently among speakers of a particular dialect. Alternatively, the population distribution may reflect some other structural idiosyncrasy of speakers such as anatomy or dentition history.

Delattre & Freeman [1] examined this question of population variability per dialect in a cineradiographic (x-ray) study that included 43 speakers of American English. The speakers produced various words containing initial, final, syllabic and medial /ɹ/. The speaker population included no more than three speakers from any one region of the United States except for California, which was represented by 10 speakers. The original intent of the Delattre & Freeman study was to determine whether the use of "bunched" and "retroflex" variants in "true", or unreduced, /ɹ/ was determined regionally—that is, they asked the question whether speakers of dialects from different parts of the U.S. tend to use particular tongue shapes preferentially.

After a careful analysis of tongue shape and acoustic data, Delattre & Freeman came to three conclusions. The first conclusion was that for "true" /ɹ/'s—that is, all /ɹ/'s in rhotic dialects and initial /ɹ/'s in non-rhotic dialects-- tongue shapes fell into a five-valued total of categories. A second conclusion was that each shape produced a phonemically equivalent and acoustically indistinguishable /ɹ/. These shapes are shown in as Types 3-7 of Figure 1. Those syllabic and post-vocalic productions by speakers of "r-less" dialects transcribed as schwa showed the shape of Type 2 of Figure 1.

Figure 1: Delattre & Freeman /ɹ/ Tongue Configuration Types for American English speakers. (Adapted by Robert Hagiwara and reprinted by permission of same.) Note that Type 2 occurred only in speakers of non-rhotic dialects.



Delattre & Freeman found no absolute consistency across speakers within dialect regions. The 10 speakers from California appeared to share a single type (Type 3), but for other regions, the two or three speakers showed widely different patterns.

Given the small number of speakers per dialect region, it is not possible to make absolute conclusions. However, these results are more consistent with a hypothesis of individual variation than dialect consistency.

Other studies of /ɹ/ have examined tongue configuration in large groups of speakers drawn primarily from single rhotic-dialect regions [2],[3]. Each of these studies used a different technique for visualizing tongue shape and each used a different analysis, but each found considerable variation in tongue shape. Westbury et al. [2] used speakers from the US Upper Midwest area. The data were x-ray microbeam images from a range of words containing /ɹ/. Tongue contours were determined by the location of x-ray-opaque pellets placed along the midline of the tongue. They determined that speakers showed at least four different tongue configurations for /ɹ/. The Mielke et al. study [3] used rhotic-dialect speakers who were students at the University of Arizona (USA). They used ultrasound images, again focused on tongue midline, to rate tongue shapes according to the Delattre & Freeman types. Of the 27 speakers, approximately half were judged to use a single type exclusively, with each type occurring in at least one speaker. Type 4 was the most common, occurring in 10 speakers. The remaining speakers used 2-5 types in different combinations according to phonetic context. Mielke et al. reported that some speakers used Type 8 (not shown in Figure 1), which Delattre & Freeman did not find in American English. Type 8 is a more curled-back version of Type 7. It should be noted that ultrasound typing of tongue configuration may be less accurate in the region of the tongue tip due to air cavities between the probe and tongue surface.

2. EXPERIMENT

In this paper, we consider the distribution of tongue shapes in an additional rhotic-dialect region. The major hypothesis of the study was that subjects would show a variety of tongue shapes within a constant phonetic context.

2.1. Methods

The major source of data was a set of videofluoroscopy exams conducted as part of an independent medical study [4], [5]. Participants were 47 elderly male native speakers of rhotic American English drawn from the areas of Southeastern Indiana, Northern Kentucky and Southwestern Ohio served by the Cincinnati V.A. Hospital. Speakers were not questioned about their dialect of origin, but three trained speech pathologists, of whom one was also a trained phonetician, evaluated their speech for dialect consistency and normal speech production characteristics. Each speaker repeated the sentence "We were away all year". This sequence was repeated three times. Thus, the speakers produced two instances of post-vocalic, word-final /ɹ/ per phrase on three occasions, for a total of six /ɹ/'s per speaker. Video images were obtained using the KayPentax Digital Swallowing Workstation. For each instance of /ɹ/ production, the video was halted at the point of most extreme constriction for /ɹ/. Tongue shape was categorized at that point. Figure 2 shows an example cinefluorographic image.

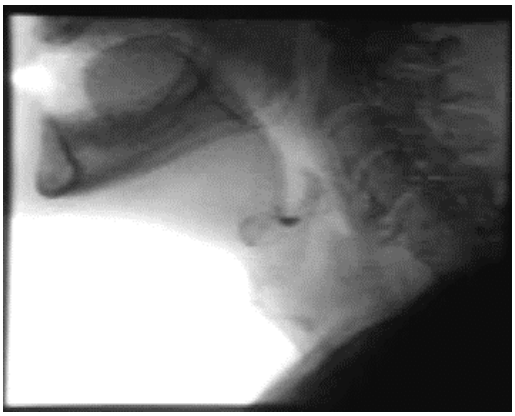
Additional data were drawn from a midsagittal magnetic resonance imaging (MRI) study of 8 speakers of American English native to the Cincinnati area [6],[7]. In this study, the speakers produced sustained /ɹ/ as in the word "pour". For the MRI data, the 3 mm sagittal slice closest to the midline tongue groove was used. Tongue shape categories were those shown in Figure 1.

For both datasets, tongue configuration type was assigned by agreement between a phonetician and a speech pathologist working together.

2.2. Results

An interesting categorization issue arose with the cinefluorographic data. As x-ray data, these images are most like those obtained by Delattre & Freeman in 1968, although advances in imaging techniques mean that our images are likely to be clearer. However, because our images were made during a medical investigation, contrast was additionally enhanced by ingestion of a barium sulfate "cocktail", which is opaque to x-rays and tends to collect in hollows and cavities in the vocal tract. It can be seen in Figure 2 as a darker line following the tongue groove, the pharyngeal walls, and the cavity between the epiglottis and the tongue root.

Figure 2: Example cinefluorographic image of Cincinnati male speaker producing sentence-final /ɹ/ in "year". The image was classified as Type 4.



For categorization purposes, this presents a dilemma; the outline of the tongue contour reflects the sides of the tongue, while the outline of the tongue groove reflects the tongue midline. In the case of the image in Figure 2, the shape of the tongue contour vs air fits Type 5, while the shape of the tongue groove fits Type 4. Without contrast medium in place, and given the limitations of x-ray studies in 1968, it is possible that the Delattre & Freeman categories were inconsistent in their identification of tongue contour; sometimes based on the tongue groove, sometimes on the tongue side outline. Inspection of sagittal MR images to the right and left of the midsagittal image for the MR data confirmed that for some speakers, tongue contours would be differently categorized depending on whether the image reflects the tongue sides or groove.

As noted above, while only one image was available per speaker in the MR dataset, there were 6 (2 words x 3 repetitions) images of /ɹ/ available for each speaker in the cinefluorographic database. However, for any one speaker, tongue shapes were notably consistent across repetitions. Thus, one tongue configuration type (Type 3, Type 4, etc.) was assigned to each speaker.

For greater consistency with the studies by Mielke et al. and Westbury et al., categorizations followed the tongue groove contour when it was clear in the image for the majority of images produced by that speaker. In some cases, the tongue groove contour seemed to follow a different contour than the tongue sides, but was not clear enough for the full contour to be identified. In these instances, the tongue shape was categorized based on the total edge vs air.

The images in the figures below are illustrative of both sets of data. Figure 3 is an MR analog of Figure 2, in that both images are categorized as Type 4. Figures 4 and 5 are analogous examples of Type 3.

Figures 6 and 7 illustrate additional types of tongue contour categories. Figure 6 shows an MR image that was determined to reflect Type 6. Figure 7 shows an MR image categorized as Type 7.

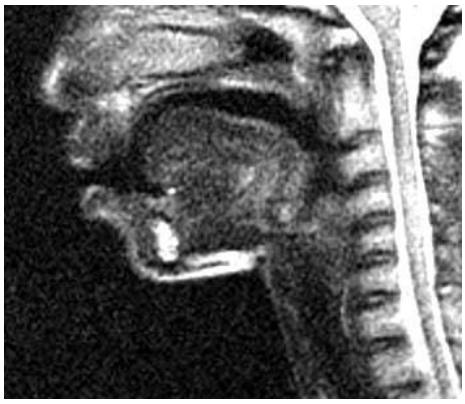
For the purposes of determining tongue contour prevalence in the Cincinnati population, the number of speakers with particular configuration types are shown in Figures 8 and 9 below as histograms. The y axis shows the number of speakers with that configuration type.

It is immediately clear that speakers of rhotic American English dialects from the Cincinnati, OH region show a wide variety of tongue shapes. These results are similar to those found by Westbury et al. [2] and Mielke et al. [3] using speakers largely from the Arizona area.

Figure 3. Example MR image of male speaker producing sustained /ɹ/ in “pour”. The image was classified as Type 4.

Figure 4. Example cinefluorographic image of Cincinnati male speaker producing sentence-final /ɹ/ in “year”. The image was classified as Type 3.

Figure 5. Example MR image of Cincinnati male speaker producing sustained /ɹ/ in “pour”. The image was classified as Type 3.



Taken together, the results of the present study confirm the results of the previous studies; at least for rhotic dialects of American English, speakers from a single dialect region use a variety of tongue shapes.

Figure 6: Example cinefluorographic image of Cincinnati male speaker producing sentence-final /ɹ/ in "year". The image was categorized as Type 6.

Figure 7. Example MR image of male speaker producing sustained /ɹ/ in "pour". The image was classified as Type 7.

It should be noted that Mielke et al. found a higher proportion of retroflex tongue contour types (Type 7 and Type 8) in phonetic contexts where /ɹ/ followed the vowel /i/. (As with the Delattre & Freeman study, we did not find any instances of Type 8 among our speakers.) Since one of the two /ɹ/ words in the cinefluorographic study was "year", it is possible that our data show a higher proportion of Type 7 contours than would be true in a dataset with a greater range of phonetic contexts. However, this caveat does not affect the larger message of the data, which is that speakers vary within a dialect region.

Overall, the simplest explanation of the data reviewed here is that the choice of tongue shape for /ɹ/ is a matter of individual variation rather than regional dialect. At this point, it is not clear whether tongue shape is conditioned by individual anatomy, or a matter of idiosyncratic preference. It remains possible that the distribution of tongue shapes across speakers is different from region to region, but this can only be determined by an appropriately large study using a wide distribution of many speakers from each region.

Figure 8. Tongue Configuration Types Per Speaker for 8-Speaker Cincinnati MRI Dataset.

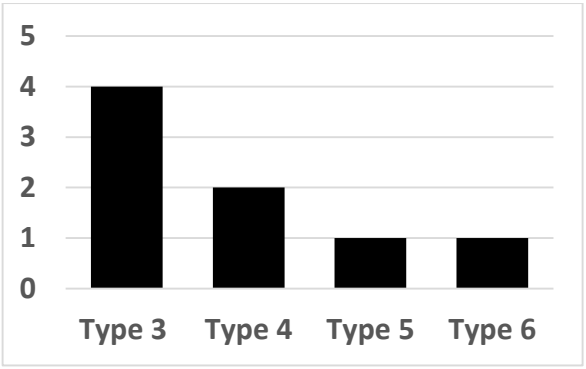
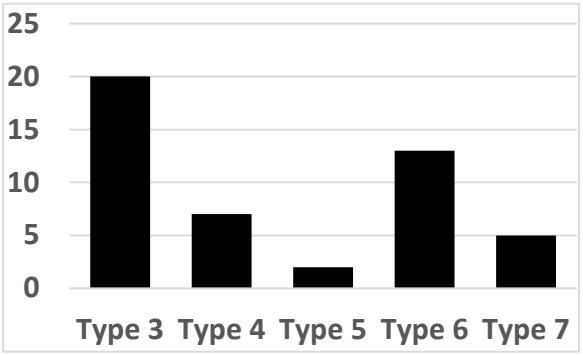


Figure 8. Tongue Configuration Types Per Speaker for Cincinnati Cinefluorographic Dataset of 47 Speakers.



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