Cue switching in the perception of approximants: evidence from two English dialects

Christina Villafaña Dalcher, Rachael-Anne Knight, and Mark J. Jones

1 Introduction

A surprising dissimilarity is found in the perception of approximant sounds by speakers of American English (AE) and Standard Southern British English (SSBE) dialects. Thirty-three subjects (eight AE and 25 SSBE speakers) performed a forced-choice identification task in which they judged whether stimuli were more like /r/ or /w/. The stimuli comprised five sounds copy-synthesised from a source /r/, where formant values (F2 and F3) were manually adjusted.

The only significant difference between the two dialect groups' performance occurred with a stimulus in which F3 was typical for /r/ and F2 was typical for /w/. AE speakers identified this stimulus as /r/ 93% of the time and SSBE speakers only 69% of the time. Such a disparity is unexpected given that alveolar approximant /r/ in both dialects is generally characterised acoustically by a low F3 in production (Delattre & Freeman 1968; Nolan 1983; Alwan et al. 1997; Stevens 1998; Espy-Wilson et al. 2000). The experiment reported here demonstrates that low F3 is indeed relevant to the perceptual contrast between /r/ and /w/, but not equally so in all stimuli for both sets of dialect speakers. Why then do we find the significantly different results between the two groups when Stimulus D involves the canonical /r/ cue of a lowered F3?

A possible solution to this problem lies in the well-documented existence of a non-standard realisation of /r/ in some parts of England which is increasingly common in adult speech as a sociolinguistic variable – 'labiodental' /r/ (Foulkes and Docherty 2001, Trudgill 1988). This variant functions as a rhotic for those speakers who use it, but does not have a low F3 (Nolan and Oh 1996, Lindsey and Hirson 1999, Docherty and Foulkes 2001).

2 Background

Because this study examines the acoustic cues of two different approximants, /r/ and /w/, a brief description of these sounds in terms of their acoustic characteristics, acquisition, and variation patterns is appropriate.

2.1 Phonetic qualities of /r/ and /w/

The standard description of /r/ in British and American English is a voiced postalveolar approximant, where the tongue tip is in wide approximation to the region of the palate behind the alveolar ridge. Although studies of American English /r/ show that speakers employ many different articulatory strategies (Westbury et al. 1998), there are two stable acoustic traits of /r/ in both dialects. One such trait is the low third formant (F3) (Delattre and Freeman 1968, Nolan 1983, Alwan et al. 1997, Stevens 1998, Espy-Wilson et al. 2000). Another is the proximity of the second and third formants (F2 and F3) (e.g., Guenther et al. 1999).

The labial-velar approximant /w/, in contrast, is generally characterised by a high F3 and low F2, resulting in a wide gap between these two formants (Espy-Wilson 1992, Stevens 1998).

2.2 The acquisition of approximants

Examining /r/ from an acquisitional point of view, research suggests that adult-like /r/ does not emerge until around the age of 4;5 (after most other sounds) and remains highly variable before being mastered (e.g., Vihman 1996:219-239). Many studies that have addressed children's acquisition of /r/ commonly class mispronunciations as [w]-like, and while some children may in fact substitute [w] for /r/, it is also likely that such a classification is a result of adult misperceptions of the developing sound.

Rather than a straight substitution, it appears to be the case that children at the developmental stage might be making a covert contrast (cf. Hewlett 1988) in their articulations of the two approximants. Instrumental studies (Klein 1971, Dalston 1975, Hoffman et al. 1983) indicate that some children produce an /r/ with an atypically high third formant and a relatively high, non-/w/-like F2 (that is, a second formant and general F2-F3 relationship more typical for /r/).

2.3 Sociophonetic variation of /r/

It has recently become apparent that many younger speakers in England now use a variant of /r/ that differs from the canonical form described in Section 2.2. This variant, typically symbolised as [ʋ], is characterised by the same acoustic qualities as developmental high-F3 /r/, and has been described in the literature as a labial or, more commonly, labiodental approximant (Kerswill 1996). Wells (1982: 303) and Cruttenden (2001: 83) comment that this variant may involve some velarisation (Jones 2005). As Foulkes and Docherty

(2001) state, many earlier descriptions class this variant as a speech defect (e.g. Gimson 1980), or as a feature of either immature speech (e.g. Gimson 1980) or upper-class speech (Wells 1982). More recently, however, the labiodental realisation is becoming increasingly common in varieties across England. For example, Trudgill's (1974) work in Norwich shows that in 1974 there were very few instances of the labiodental variant, but in Trudgill (1988) it is reported that by 1983, 33% of speakers born between 1959 and 1973 used [ʋ] in their speech.

In the United States, however, [ʋ] is not attested with regularity outside of Brooklyn, New York (Wells 1982:508). While acoustic studies of American English [ʋ] are absent from the literature and it may be heavily labialised rather than labiodental, the assumption that speakers outside of metropolitan New York are not exposed to a labiodental variant is central to the current study and its results.

2.4 A comparison of approximants

The formant values of the three approximants in question, postalveolar [ɹ], labiodental [ʋ], and labial-velar [w] can be compared in the schematic spectrogram in Figure 1, below. The samples, all taken from adult male speech, illustrate the common acoustic qualities that the labiodental variant shares with both postalveolar [ɹ] and [w]: the labiodental's second formant is similar to the mid-range formant frequency of [ɹ], while its third formant is similar to the high F3 of [w].

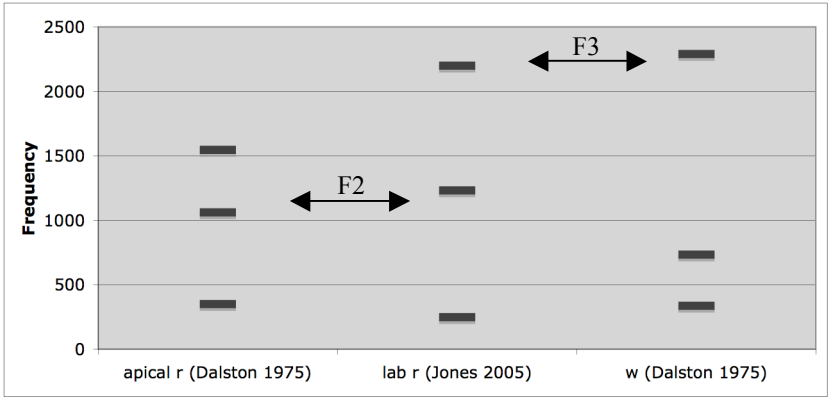

Figure 1: Formant frequencies of three approximants

Assuming there is a new /r/ variant in SSBE, we may ask whether there are implications of the existence of 'labiodental' /r/ for the way in which speakers handle the /r/-/w/ contrast, specifically with respect to the manner in which acoustic cues such as F2 and F3 frequency are utilised.

3 A perceptual study of /r/ variants

3.1 Overview

This study collected perception data from two groups of speakers who are assumed to differ in their exposure to adult 'labiodental' /r/ and tested for significant differences in perceptual cues between the speaker groups.

The subject pool comprised eight adult native speakers of American English from the Washington, DC area and 25 adult native speakers of British English from the southeast of England. As the AE data was collected remotely, these subjects were not recorded, but all were judged to use a postalveolar /r/ based on auditory analysis. The BE speakers were recorded and found to use either postalveolar /r/ or 'labiodental' /r/, although some of these speakers varied their articulations by context. Based on sociolinguistic studies of /r/ variants in AE and BE, it was assumed that none of the AE speakers (having never lived in the New York City metropolitan area) are exposed to 'labiodental' /r/, while the BE speakers, regardless of individual productions, are regularly exposed to the adult variant.

3.2 Methodology

The perception experiment, built in PsyScope (Cohen et al. 1993), consisted of two blocks – a forced choice identification task and a discrimination task. In the former, subjects were asked to judge whether stimuli in "a _ing" context were more like /r/ or more like /w/. In the latter, subjects decided whether pairs of stimuli in the same "a _ing" context were identical. The stimuli for both tasks comprised five copy-synthesised sounds from a source /r/ uttered by an adult male native speaker of SSBE, where the frequencies of F2 and F3 were manually adjusted. Table 1 shows the frequencies of the stimuli formants and Figure 2 presents a schematic illustration of the five tokens.

Stimulus	F1	F2	F3	Description
A	355	1201	1682	/r/-like formants
B	355	963	1682	F2 at midpoint of /r/ and /w/, F3 /r/-like
C	355	1201	2541	F2 /r/-like, F3 /w/-like
D	355	725	1682	F2 /w/-like, F3 /r/-like
E	355	725	2541	/w/-like formants

Table 1: Formant frequencies of copy-synthesised stimuli

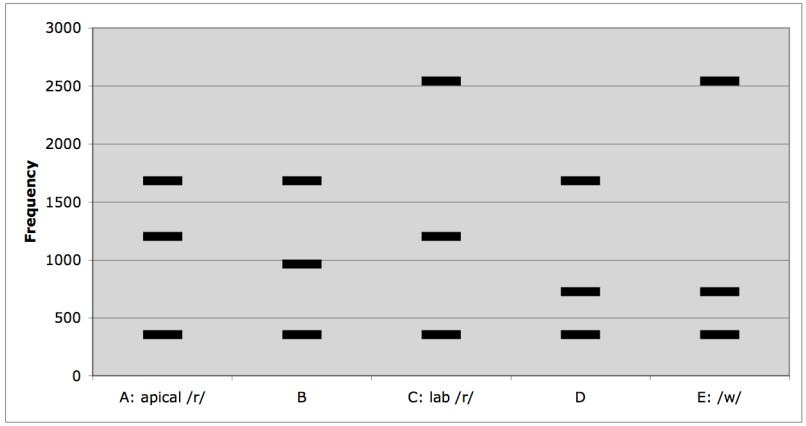

Figure 2: Formant frequencies of copy-synthesised stimuli

For the identification task, the total number of tokens equalled 50, with ten randomised repetitions of each stimulus. The discrimination task, used to assess subjects' perceptual sensitivity, comprised 105 tokens: five repetitions of each ordered pair of stimuli, with five instances of identical pairs used as controls.

Assuming low F3 as the primary acoustic cue for /r/ identification, subjects' behaviour was predicted as follows: stimuli with a low, /r/-like third formant (Stimuli A, B, and D) would be heard as /r/, while Stimulus E, with /w/-like formants, would be heard as /w/. Stimulus C, however, modelled on 'labiodental' /r/, would be categorised differently depending on dialect: its relatively high third formant would prompt AE subjects to hear it as /w/, while its resemblance to the existing /r/ variant in SSBE would encourage BE subjects as /r/, despite the non-/r/-like third formant frequency.

3.3 Results

The outcome of the identification task was that most subjects in each of the dialect groups identified Stimuli A, B, C, and D (that is, all stimuli except for the token with /w/-like formants) as /r/ a majority of the time. Table 2 summarises the responses in terms of the percentage of /r/ responses to each of the stimuli, by dialect group.

	Stim A	Stim B	Stim C	Stim D	Stim E
AE	100	100	93	93	5
BE	99	97	88	70	2

Table 2: Percentage of /r/ responses to identification stimuli

The shaded cells in Table 2 highlight the response patterns that do not fit with the predictions. Stimulus C, with a high, /w/-like F3, was identified as /r/ most of the time by both the AE and BE subjects, with no significant behavioural difference between the groups. Stimulus D, with a low F3, was judged as /r/ in a majority of instances, but heard as /w/ 30% of the time by the BE dialect group. Before addressing the dialectal differences in subjects' perception of Stimuli C and D, it seems appropriate to discuss the general level of subjects' perceptual sensitivity.

Another potential factor contributing to unexpected results is the general level of accuracy in subjects' judgments. To investigate whether subjects' sensitivity to differences among the stimuli was low (and therefore any perception testing results might be questionable), d-prime (d') analysis was run on the discrimination responses[1]. Following Macmillan and Creelman (1991), standardised scores of "false alarm" rates (the proportion of times a subject responded "different" to identical pairs of stimuli) were subtracted from the standardised scores of "hit" rates (the proportion of times a subject responded "different" to non-identical pairs of stimuli). Maximum sensitivity, or the highest possible d-prime is 6.93, and the larger the number of d-prime, the more accurate the subjects' judgments. For the AX discrimination test in this study, the mean d-prime for all subjects was 2.66, indicating that subjects were generally sensitive to differences among the stimuli. Of the 33 subjects, only nine had d-prime scores below 2.0, the typical value. Based on these results, we assume that subjects were sufficiently sensitive to the stimuli and not performing in a random manner.

1 d-prime analysis was not run on the identification data as the stimuli did not conform to a continuum.

3.3.1 Identification of high F3 token as /r/

With respect to Stimulus C, the problem lies in the response of the AE group. We might expect speakers not regularly exposed to a 'labiodental' /r/ in their linguistic community to perceive such a sound as non-/r/-like. In fact, many treatments of the variant in academic literature, popular culture, and literary sources claim or imply that the 'labiodental' /r/ is identical to [w]. Non-standard realisations of /r/ have been described as /w/ substitutions, or at least [w]-like substitutions by Jesperson (1909, per Foulkes & Docherty 2000 and 2001) and by Wright (1981) in his comments on East London speech where "some East Enders…pronounce instead a *w*." In popular films such as *Monty Python's Life of Brian*, Michael Palin exploits the /r/-/w/ substitution for comic effect, as does Peter Cooke in his role of the archbishop in *The Princess Bride*. In literary sources, Dickens uses an orthographic *w* to reflect Lord Mutanhed's unconventional /r/ in *The Pickwick Papers* (1836-37); Orwell's *Keep the Aspidistra Flying* (1936) marks a character as effeminate by substituting *w* for *r* in words like *weally* <*really*>, *bwowse* <*browse*>, and *tewwible* <*terrible*>. Despite the implications of this regular substitution, however, the AE group identified the 'labiodental' /r/ stimulus as /w/ only seven percent of the time.

Several possible explanations for this outcome exist. First, the high number of /r/ responses to Stimulus C might be a result of the proximity of F2 and F3 in this token. In other words, notwithstanding a low, non-/r/-like F3 in absolute terms, the closeness of the two formants may itself be a sufficient cue for /r/. It is also reasonable that the high, /r/-like F2 in this stimulus could have outweighed low F3 as an acoustic cue – in other words, if F2 isn't sufficiently high, then a sound will be perceived as /w/ regardless of the absolute frequency of F3. A third reason for Stimulus C being judged as /r/ lies in the nature of the stimulus itself, not the subjects' response. Although the copy-synthesised sound was intended to have the acoustic qualities of a 'labiodental' /r/, in fact it sounds much more like a lateral approximant than a labiodental approximant[2]. In other words, Stimulus C may simply have had acoustic characteristics which interacted with the expected perceptual cues for /l/ in AE. And recalling that the identification task was forced-choice, subjects did not have a "none of the above" option.

With the unexpected results for Stimulus C explained, the focus now turns to the judgments returned for Stimulus D.

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2 In a post-hoc survey of 13 native speakers of AE where the choice was expanded to /r/, /w/, and /l/, ten speakers identified Stimulus C as /l/, two speakers as /r/, and one speaker as either /r/ or /l/.

3.3.2 Identification of low F3 token as /w/

The surprising outcome of this study was the judgment of Stimulus D (a token with a typically low, /r/-like third formant) as /w/ significantly more often than predicted, at least by some subjects. This stimulus was identified as /r/ three times as often as it was identified as /w/, averaging over all subjects. However, when we split the subjects by dialect type, we find a robust difference in behaviour: the AE subjects judged the stimulus as /r/ 93% of the time; the BE subjects judged it as /r/ only 70% of the time. In fact, the only significant difference between the two dialect groups' identification of the five stimuli was found in the reaction to Stimulus D, based on independent sample T-tests (t=3.146, p<.005). No other statistically significant patterns between the AE and BE speakers were found with respect to identification of stimuli.

4 Discussion

4.1 Cue-switching in the perception of approximants

If postalveolar approximant /r/ in both American and British English is generally characterised acoustically by a low third formant, the results of this study pose the question of why such a robust difference was found between speakers of the two dialects in identification of a low-F3 stimulus. We suggest that a possible solution lies in a switching of acoustic cues on the part of the BE speakers, arising from the presence of an alternate form of /r/ in England and a continued pressure to differentiate /r/ and /w/.

As shown in Figure 1 above, the 'labiodental' variant on the rise in SSBE[3] is acoustically characterised by a third formant quite similar to that of /w/ making it difficult for speakers to use this cue to distinguish /r/ and /w. When the acoustic cue formerly necessary for contrasting the two sounds becomes an unreliable indicator of that contrast, a new differentiation strategy must be adopted. Looking only at formant frequencies, it becomes clear that the distinguishing characteristic remaining between 'labiodental' /r/ and /w/ is the positioning of the second formant. Figure 3 illustrates this alteration schematically.

The AE subjects, assumed to lack exposure to an adult high-F3 /r/ variant, experience no pressure to alter their acoustic cues in perception of the /r/-/w/ contrast.

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[3] Currently no articulatory data on 'labiodental' /r/ exist for either British or American English.

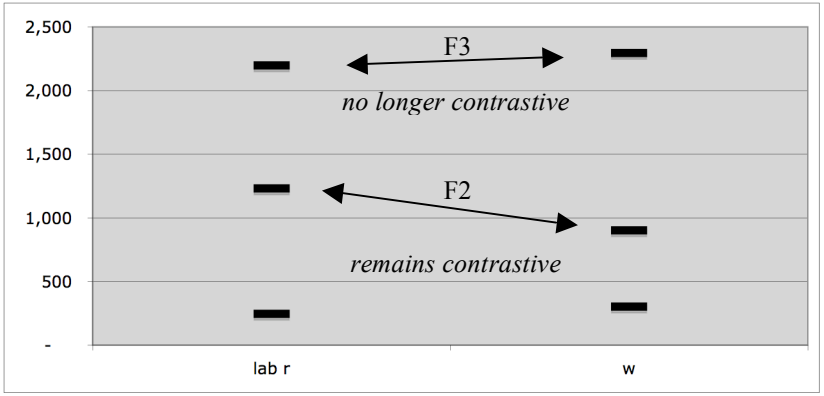

Figure 3: Formant contrasts: 'labiodental' /r/ and /w/ (Jones 2005)

We can now look at the stimuli used in the identification task in a more quantitative way, bearing in mind that the dialect groups in this study may reasonably adopt different strategies when presented with certain stimuli. Instead of examining the absolute formant frequencies of the 'labiodental' /r/ variant and /w/, we measured the slopes of the differences between these sounds' second and third formants. With the schematic spectrograms from Figure 3 serving as a plot, slope measurements may be calculated by subtracting the horizontal distance between the formants' centre points from the vertical distance. Note that the resulting slopes and their ratios are simply a way of quantifying formant differences in these schematic spectrograms, but are not indications of temporal relationships or correlation coefficients in the actual acoustic signal.

As Figure 4 illustrates, the absolute value of the F2 slope between 'labiodental' /r/ and /w/ is over four times the value of the F3 slope (absolute values are used due to the irrelevance of directionality for this data). These measurements serve to confirm intuitions about the relative salience of contrasts: 'labiodental' /r/ and /w/ will likely be distinguished by the height of F2, not of F3.

Given the role of F2 frequency as a likely contrastive cue for 'labiodental' /r/ and /w/, judgments of a stimulus where F3 is /r/-like and F2 is /w/-like as /r/ are predictable from the assumed exposure to 'labiodental' /r/ in a subject's linguistic environment. For speakers with this exposure, and therefore relying on F2 as the salient contrast between /r/ and /w/, Stimulus D will be perceived as a /w/, as Figure 5 indicates. Note that the slope of F2 when comparing /r/ and Stimulus D is over 25 times F2's slope comparing Stimulus D to /w/.

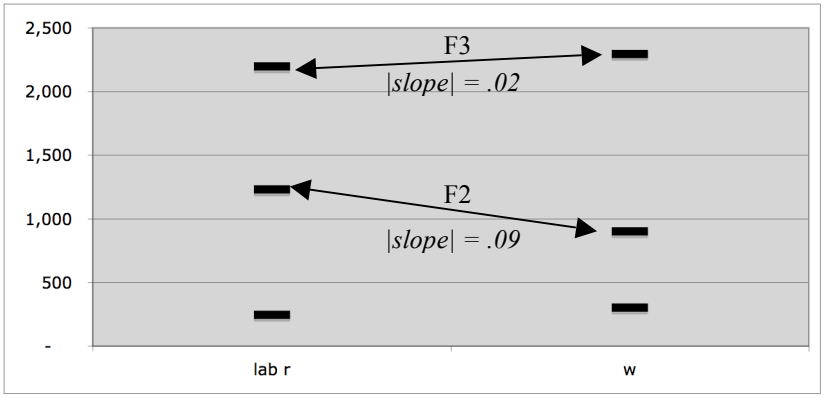

Figure 4: F2 and F3 slopes
'labiodental' /r/ and /w/ (Jones 2005)

Subjects without any exposure to high-F3 'labiodental' /r/, on the other hand, are assumed to rely on F3 as a contrastive cue and will therefore perceive Stimulus D as /r/, despite the fact that its F2 is identical to that of /w/:

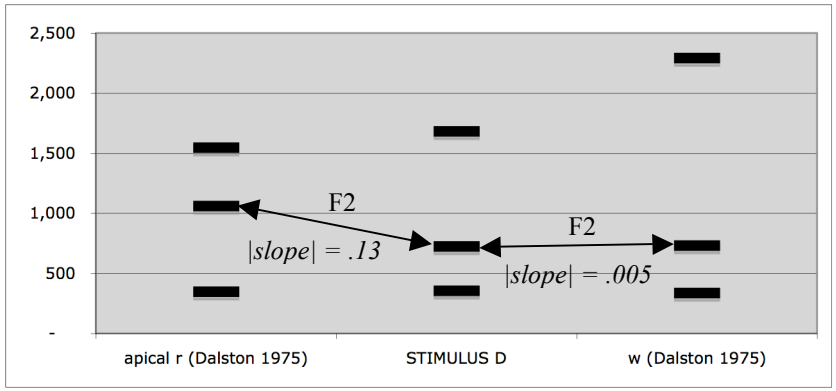

Figure 5: Comparison of F2 slopes
Stimulus D (present study), /r/, and /w/ (Dalston 1975)

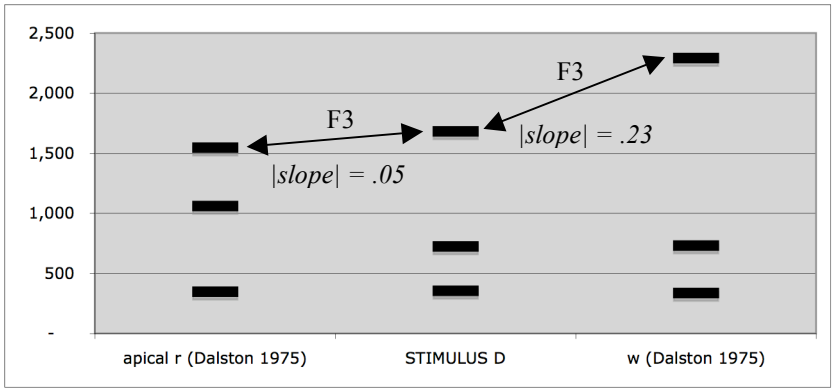

Figure 6: Comparison of F3 slopes
Stimulus D (present study), /r/, and /w/ (Dalston 1975)

The striking difference, then, in the AE and BE subjects' choices with respect to Stimulus D seems entirely predictable from the assumed characteristics of the two groups' linguistic environments: SSBE speakers must tolerate a wider diversity of /r/-types, including /r/s without a canonically low F3[4]. As a consequence, the approximant /r/ category in SSBE may be becoming increasingly defined by F2, rather than by F3. If this is the case, SSBE speakers will weight F2 more than F3 in their perceptual categorisation, and the F2 boundary between /w/ and /r/ will become sharper in SSBE relative to AE. AE speakers, who likely encounter 'labiodental' /r/ less frequently, continue to attend more to F3 than F2. For them, the /r/-like low F3 in Stimulus D leads them to a definite /r/ categorisation. For the SSBE speakers, however, the /w/-like F2 cue interferes with the low F3 cue to cause greater perceptual uncertainty – precisely the pattern we see in the data, where SSBE speakers categorise Stimulus D as /r/ in 70% of the cases, but as /w/ 30% of the time. This trend in identification is evident throughout the BE subject pool: only three BE speakers showed a strong preference for /w/ when presented with Stimulus D. Of the remaining subjects, 13 preferred /r/ and eight exhibited little or no preference between /r/ and /w/.

[4] In addition to 'labiodental' /r/ in SSBE, non-approximant realizations of /r/ are found in Scottish, Welsh, and northern English. BE speakers, therefore, may be exposed to much greater variation in /r/ than AE speakers.

4.2 Cue-switching as an effect and cause of sound change

Up to this point, we have shown that a shifting in acoustic cues may be a direct result of the presence of a sociolinguistic variant in a listener's environment. The increase in /r/ variability, specifically with respect to its third formant, serves to catalyse a cue-shift from F3 to F2 in the perception of the /r/-/w/ contrast. However, this shift can subsequently have an effect on articulation: listeners for whom the frequency of F3 is perceptually less prominent may at some point fail to reconstruct the low-F3 /r/, or be less concerned with attaining as low an F3 frequency, resulting in a subsequent increase in /r/ variability. As we have proposed that such an increase in the frequency with which a variant occurs serves as a trigger to acoustic cue-shifting, the relationship among presence of a variant, shifting in perceptual cues, and alterations in production is necessarily cyclic. Thus a gradual erosion of low F3 instances of /r/, and a concomitant increase in 'labiodental' /r/ may be predicted across SSBE.

5 Conclusions and future research

This study has presented /r/-variant perception data from two distinct dialect groups differing in the types of rhotics existent in their linguistic environments. Examining formant frequencies of /r/, /w/, and three variants, we have attempted to explain why speakers of Standard Southern British English exhibit a different pattern in their categorisation of certain acoustic signals than speakers of American English. This dialect-dependent variation in perception has been shown to be a logical consequence of the presence or absence of variant forms in a speaker's linguistic environment, where such forms are sufficiently similar in acoustic characteristics to necessitate a shift in perceptual strategy. Furthermore, the shift in reliance on one acoustic cue to another has potential ramifications for speech production.

Rather than a purely descriptive account of /r/ variants in a linguistic community, the present study supplies us with a way to address sound change propagation from a phonetic point of view. While the inception of the 'labiodental' /r/ variant in SSBE remains in question, Janda and Joseph (2003) argue that it is possible to examine the reasons for its spread independently of the reasons for its innovation.

This study can be expanded in a number of directions. A modified perception experiment that incorporates weighting of different acoustic cues (absolute formant heights and F3-F2 ratios) may bring out further disparities between and within dialect groups. Perceptual testing of a pool of subjects

exposed to a 'labiodental' (or at least labialised) /r/ variant commonly found in certain non-rhotic AE dialects may support the claim of cue-shifting in identification of the /r/-/w/ contrast. Articulatory data on 'labiodental' /r/ and BE /r/ in general will allow comparisons of speech production across dialects – it may be the case that postalveolar [r] in American and British English are not, in fact, as articulatorily similar as they are assumed to be.

References

Alwan, Abeer, Shrikanth Narayanan, and Katherine Haker. 1997. Towards articulatory-acoustic models for liquid approximants based on MRI and EPG data. Part II. The rhotics. *Journal of the Acoustical Society of America* 101: 1078–1089.

Cohen, Jonathan D., Brian MacWhinney, Matthew Flatt, and Jefferson Provost. 1993. PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavioral Research Methods, Instruments, and Computers* 25(2): 257–271.

Cruttenden, Alan. 2001. *Gimson's Pronunciation of English* (6th edition). London: Edward Arnold.

Dalston, Rodger M. 1975. Acoustic characteristics of English /w, r, l/ spoken correctly by children and adults. *Journal of the Acoustical Society of America* 57: 462–469.

Delattre, Pierre C., and Donald Freeman. 1968. A dialect study of American r's by X-ray motion picture." *Linguistics* 44: 29–68.

Dickens, Charles. 1836-37 [1986]. *The Pickwick Papers*. Oxford: Clarendon Press.

Docherty, Gerald J., and Paul Foulkes. 2001. Variation in (r) production: instrumental perspectives. In *r-atics: Sociolinguistic, Phonetic, and Phonological Characteristics of /r/ (Etudes et Travaux 4)*, ed. H. Van de Velde and R. van Hout, 173–184. Brussels: ILVP.

Espy-Wilson, Carol Y. 1992. Acoustic measures for linguistic features distinguishing the semi-vowels /w j r l/ in American English. *Journal of the Acoustical Society of America* 92(2): 736–757.

Espy-Wilson, Carol. Y., Suzanne. E. Boyce, Michel. Jackson, Shrikanth. Narayanan, and Abeer Alwan. 2000. Acoustic modeling of American English /r/. *Journal of the Acoustical Society of America* 108: 343–356.

Foulkes, Paul, and Gerald J. Docherty. 2000. Another chapter in the story of /r/: 'labiodental' variants in British English. *Journal of Sociolinguistics* 4: 30–59.

Foulkes, Paul, and Gerald J. Docherty. 2001. Variation and change in British English (r). In *r-atics: Sociolinguistic, Phonetic, and Phonological Characteristics of /r/ (Etudes et Travaux 4)*, ed. H. Van de Velde and R. van Hout, 27–43. Brussels: ILVP.

Gimson, A C. 1980. An Introduction to the Pronunciation of English (3rd edition). London: Edward Arnold.

Guenther, Frank H., Carol Y. Espy-Wilson, Suzanne E. Boyce, Melanie L. Matthies, Majid Zandipour, and Joseph S. Perkell. Articulatory tradeoffs reduce acoustic variability during American English /r/ production. *Journal of the Acoustic Society of America* 105: 2854–2865.

Hoffman, Paul R., Sheila Stager, and Raymond G. Daniloff. 1983. Perception and production of misarticulated /r/. *Journal of Speech and Hearing Disorders* 48: 210–215.

Janda, Richard.D., and Brian.D. Joseph. 2003. Reconsidering the canons of sound change: towards a "Big Bang" theory. In *Historical Linguistics 2001, Selected Papers from the 15th International Conference on Historical Linguistics*, ed. B.J. Blake and K. Burridge, 205–219. John Benjamins.

Jesperson, Otto. 1909. *A Modern English Grammar on Historical Principles* (7 vols). Heidelberg: Carl Winters Universitätsbuchhandlung.

Jones, Mark. J. 2005. An acoustic study of labiodental /r/ in British English. Ms., University of Cambridge.

Kerswill, Paul. 1996. Children, adolescents and language change. *Language Variation and Change* 8: 177–202.

Klein, Robert. P. 1971. Acoustic analysis of the acquisition of acceptable r in American English. *Child Development* 42: 543–550.

Lindsey, Geoffrey, and Hirson, Allen. 1999. Variable robustness of non-standard /r/ in English: evidence from accent disguise. *International Journal of Speech, Language and the Law* 6 (2): 278–288.

MacMillan, Neil A., and C. Douglas Creelman. 1991. *Detection theory: A User's Guide*. New York: Cambridge University Press.

Nolan, Francis. 1983. *The Phonetic Bases of Speaker Recognition*. Cambridge: Cambridge University Press.

Nolan, Francis, and Tomasina Oh. 1996. Identical twins, different voices. *Forensic Linguistics* 3: 39–49.

Orwell, George. 1936. *Keep the Aspidistra Flying*. London: Victor Gollancz.

Stevens, Kenneth. 1998. *Acoustic Phonetics*. MIT Press.

Trudgill, Peter. 1974. *The Social Differentiation of English in Norwich*. Cambridge: Cambridge University Press.

Trudgill, Peter. 1988. Norwich revisited. Recent linguistic changes in an English urban dialect. *English World-Wide* 9: 33–49.

Vihman, Marilyn M. 1996. *Phonological Development: The Origins of Language in the Child*. Oxford: Blackwell.

Wells, John. 1982. *Accents of English*. Cambridge: Cambridge University Press.

Westbury, John R., Michiko Hashi, and Mary J. Lindstrom. 1998. Differences among speakers in lingual articulation for American English. *Speech Communication* 21: 203–226.

Wright, Peter. 1981. *Cockney Dialect and Slang*. London: B.T. Batsford.

Christina Villafaña Dalcher
Department of Language and Communication Science
City University London
Northampton Square
London ECV 0HB United Kingdom
cvd1@ciy.ac.uk

Rachael-Anne Knight
Department of Language and Communication Science
City University London
Northampton Square
London ECV 0HB United Kingdom
r.knight.1@city.ac.uk

Mark J. Jones
Faculty of Modern and Medieval Languages
University of Cambridge
Sidgwick Avenue
Cambridge CB3 9DA United Kingdom
mjj13@cam.ac.uk