Chapter 7: Liquids

Eleanor Lawson, Jane Stuart-Smith, Jim Scobbie, Malcah Yaeger-Dror, Margaret Maclagan

/l/ AND /r/ INTRODUCTION

/l/ and /r/ are synchronically and diachronically complex speech-sound categories that can function phonologically as syllable margins, or as nuclei without being considered true vowels. They are articulatorily complex sounds that show a great deal of variation within and between languages, and comparable analytic techniques can be used to help understand them. However, when we take into account their heterogeneity, treating /l/ and /r/ as one category can be seen as an idealisation, implying greater similarity than is theoretically justified. Their variants, particularly the rhotics, are diverse to the extent that identifying unifying features (articulatory and acoustic) within each category is difficult, much less finding features that unify /l/ and /r/. The heterogeneity of /l/ and /r/ is extensively described in Ladefoged and Maddieson (1996, Chapters 6&7), Lindau (1985) and Scobbie (2006b) and is not addressed further here. However, it should be noted that, in addition to highly salient aspects of phonetic variation, acoustic and articulatory instrumental analyses reveal subtle, *covert* variation, including for example incomplete central occlusion, or even

absence of a central occlusion in [l] Ladefoged and Maddieson (1996:183-5), or marked variation in place of articulation and tongue configuration for [ɹ], Delattre and Freeman (1968). As we shall see, even such subtle articulatory variation can index social categories.

Although /l/ and /r/ variants may consist of a single articulation, the gesture composition of /l/ and /r/ often involves combinations of articulatory strictures of different degrees: e.g. in the pharynx, at the velar, palatal and alveolar regions and at the lips. Perceptible gradient variations in the quality of liquids can be the result of temporal gestural asymmetry, perhaps motivated by perceptual recoverability or biomechanical factors (Gick and Campbell 2003). Although evidence to date suggests that there is no language-universal pattern of gesture timing in onset and coda liquids (Gick et al. 2006), articulatory instrumental analysis of English liquids have revealed variability in gesture sequencing in syllable onsets and codas (Sproat and Fujimura 1993, Gick et al. 2006, Lawson et al. 2008, Scobbie and Pouplier 2010). In these studies, syllable-onsets condition greater simultaneity of gestures, while posterior gestures tend to occur first in syllable codas (Browman and Goldstein 1986, 1990, 1992). However, in their multilingual Ultrasound Tongue Imaging (UTI) study of gesture sequencing in liquids Gick et al (2006) found that although posterior articulations were always present in liquid coda variants, onset variants did not always involve "secondary" posterior articulations.

In English and many other languages positionally-conditioned variability results in variants which are respectively more consonantal (strong) or more vocalised (weak). Consequently, in postvocalic position, liquids have often weakened to the point of complete phonological deletion - e.g. postvocalic /l/ in Middle Scots (Aitken/Macafee 2002); postvocalic /r/ in early modern English (Dobson 1968: §427).

These posterior lingual gestures may also cause postvocalic liquids to exert breaking (epenthesis) or retraction of preceding front vowels (Gick and Wilson 2006). The phenomenon is evident historically (e.g. Old English, Campbell 1959:§139-§149, Marshall Denton 2001) and in present-day rless (nonrhotic) Englishes (Wells 1982b&c) and Dutch (Plug and Ogden 2003).

These multiple co-ordinated gestures help explain the phonetic diversity of /l/ and /r/; variation which co-varies with a number of extralinguistic variables such as national, regional or ethnic identity, social class and gender.

/r/ Sociolinguistic Variation

Rfulness/rlessness in English

The divide between postvocalic rful vs. rless ("rhotic/nonrhotic") accents (Wells 1982a,b,c) has proved fruitful ground for the sociophonetic study of /r/. One associated phenomenon is /r/ sandhi found in many rless varieties of English, which co-varies with local social categories (see below).

Rfulness has been found to index local identity on either side of the Scottish--English border (Llamas 2009 forthcoming), and in East New England (Irwin & Nagy 2007), ethnoracial identity (Cutler 2010 forthcoming), age and level of education in Southern American English (e.g., Feagin 1990; Strand et al 2010 forthcoming); the integration/segregation of white and African American speakers in North America (Pollock and Berni 1997, Hinton and Pollock 2000), and socioeconomic status, and speaker gender, in North America and Britain (Labov 1966, 1972; Stuart-Smith 2003). However, the rful/rless divide is not always categorical; weakened variants such as "derhoticised /r/" have been found in Glasgow and Edinburgh (Romaine 1979; Speitel and Johnston 1983; Stuart-

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Smith 2003, 2007; Lawson et al. 2008). The weakened variant is associated with lower socioeconomic class male speech.

In varieties where postvocalic /r/ has been eliminated word-finally (e.g., in most Anglo-English, Antipodean and some US varieties), hiatus-avoiding /r/ may occur where a vowel follows. Known collectively as "r-sandhi," it occurs as linking /r/ in etymologically rful words, e.g. in "fearing" and "fear and loathing" and as "intrusive" /r/ in etymologically rless words after nonhigh vowels and schwa e.g. "Shah[ ] of India," "I saw[ ] it.", see Hay and Maclagan (in press) Intrusive /r/ is often stigmatised and suppressed, e.g. in R.P. (Broadbent 1991: 282) and middle-class New Zealand speech (Hay and Warren 2002), while Foulkes (1998), found it to be prestigious in Newcastle English.

Not all socially-meaningful /r/ variation in English centres on the presence or evanescence of postvocalic /r/: Labial /r/, formerly stigmatised, has become increasingly common in the speech of British youth (Foulkes and Docherty 2000, Llamas 2001).

/r/ sociophonetic variation in other languages

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In other languages, /r/ variation is also correlated with national/local identity and social variation: The replacement of the apical trill with the uvular trill/fricative occurs in much of Western Europe (Chambers and Trudgill 1980: 185-8), in Quebec (Sankoff and Blondeau 2007), and the Middle East (Yaeger-Dror 1988, 1993). In frontier communities, particular /r/ variants are markers of maintenance or blurring of local identities (Gal 1979, Van De Velde and Van Hout 2001, Matus-Mendoza 2004, Spreafico and Vietti 2009, Lindh 2006). A doubly articulated interdialectal form - [ρ]-has been identified both in Israeli Hebrew (Yaeger-Dror 1993) and Quebec French (Poplack pc).

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/l/ Sociolinguistic variation

L-vocalisation in English

The vocalisation of postvocalic /l/ to a high back (un)rounded vowel is well attested in Romance languages and is increasingly common in young British speech, as part of a set of consonantal changes associated with "Estuary English" (Przedlacka 2002, Altendorf 2003). Vocalised /l/ is correlated with socioeconomic status and gender in many urban varieties of Anglo English (Foulkes and Docherty 1999), Scottish English (e.g. Stuart-Smith et al.

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2006), as well as New Zealand (Horvath and Horvath 2002) and American dialects (Dodsworth et al. 2006, Fix 2009).

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Other /l/ sociophonetic variation in English

The English onset-coda distinction (cf Carter and Local 2007) can be phonetically subtle, or more extreme. "Bright"/"Clear" (anterior) and "dark" (velarised) /l/ are in complementary distribution in Anglo English with the more anterior articulation generally prevocalic. Subtle allophony is found in English varieties that are traditionally considered to have only clear or only dark /l/: varieties spoken in formerly Celtic regions - Wales, Northwestern Scotland, Southern Ireland and parts of Northern Ireland (Wells 1982b) are traditionally considered to have a palatalised form of /l/ in all positions, while North America (Ladefoged and Maddieson 1996), New Zealand (Bauer and Warren 2004), and most of Scotland (Wells 1982b) have "darker" variants in both onset and coda.

In some varieties of English, darker /l/ quality correlates with lower status, and masculinity (e.g., Mathisen 1999). Stuart-Smith (1999) also found a greater prevalence of retracted tongue body settings for /l/ among working-class Glaswegian children, while some middle-class speakers adopt Anglo-English conditioned variation.

Summary

Phonetic variation, loss and sandhi for liquids reveal a variety of social meanings. Variation is sometimes extremely subtle at the articulatory/acoustic level. Here we will discuss laboratory techniques; measurement and analysis protocols for liquids which can be usefully applied in sociophonetic studies, looking in turn at auditory, acoustic, and articulatory methods.

AUDITORY ANALYSIS

Variability in auditory coding

For decades, starting with the analysis of /r/ in New York City (Labov 1966), auditory analysis of /r/ has been standard, but recent studies show that there is a great deal of variability in the perception of r-variation among trained phoneticians. This perceptual variability is in itself interesting, though methodologically challenging.

Recent studies involving the transcriptions of multiple listeners suggest that combining such judgements should be considered with caution. Plug and Ogden's (2003) study of

postvocalic /r/ in Dutch, Stuart-Smith's (2007) study of postvocalic /r/ in Scottish English, Carter and Local's (2008) analysis of labial /r/, Heselwood et al's (2008) analysis of degrees of rfulness, and Yaeger-Dror et al's (2009) study of /r/ perception of variable rhoticity, all found that trained phoneticians' judgements were inconsistent.

In the first study, only one of the four listeners was a native speaker of Dutch, the language under analysis; in the third study, the listeners were also well-trained, but not accustomed to the labial /r/ which was studied. In the second study, there were marked differences between the judgments of two native lowland Scottish English speakers (CT and RL), in a study of Glaswegian /r/, (see Figure 7-1).

FIG 7-1 NEAR HERE

All these studies concluded that even trained listeners' perceptions can be influenced by their global expectations that other variables in the sample are consistent with a given realization, or by having developed different transcription strategies for the representation of the same phonetic features.

There are a few strategies to help evaluate inter-listener variation: Both Heselwood et al (2008), and Yaeger-Dror et al (2009) suggest researchers compare participating listeners' perceptions with the acoustic evidence where possible, since both studies found judgements were correlated with specific psychoacoustic measures discussed below. Responses matched the acoustic criteria more consistently when listeners were well-acquainted with the dialect being analyzed. Auditory analysis of liquids improves when at least one intermediate, indeterminate, category is permitted.

Studies should determine the degree of acquaintance that listeners have with the dialect being analysed: inter-listener inconsistency may also provide useful information regarding the interaction of production and perception of liquids if the background and spoken variety of the listener are known. Plug and Ogden raise the interesting proposition that, due to /r/'s articulatory complexity and its, often long-range, resonance effects on surrounding segments (West 2000), a specifically segmental analysis of /r/ may not be the most effective form of analysis, and we can extend this to /l/. Rather, they suggest that a syntagmatic/parametric approach is more useful, particularly where /r/ is weakened or vocalised. In such cases, a segmental analysis would record that no liquid is present, whereas a parametric analysis of the entire rime component of a syllable captures subtle features such as the retraction, centralisation, pharyngealisation, epenthesis or rounding of a preceding vowel, all of which

are phonetic associates of a following /r/ or /l/ and may signal their presence, even when these sounds are apparently deleted. In many cases the vowel preceding a liquid is conditioned in a dialect-specific way, so that listeners perceiving a given vowel quality may "hear" the coda liquid [or its lack] based on such criteria.

Another segmental issue that may be solved by a parametric analysis is the rhoticisation of pre-/r/ vowels, e.g. schwar [ɚ], found in American English and some varieties of Irish and Scottish English. Whereas weakly rhotic tokens of /r/ may arise from a delay in the anterior lingual /r/ gesture (Lawson et al. 2008), an early onset of retroflexion or bunching can result in the merging of vowel and /r/ into an “r-colored” vowel. In such cases, the percept of rfulness remains strong, but a phonological analysis of such a sound is difficult; it could be variously considered to be a new vowel, a syllabic consonant, a vocalised consonant, or a case of /r/ deletion.

In short, listener perceptions may be used as an analytic tool for liquids; however understanding the underlying influences on listener perceptions requires more research in the form of carefully-targeted perception studies, combined with acoustic analysis, and if possible, articulatory investigation.

ACOUSTIC ANALYSIS

Acoustically, liquids show some similarities (Stevens 1998: 532f, Carter and Local 2007). Many variants are likely to show a characteristic pattern of formants, or formant-like resonances, and if before or after vowels, formant transitions in and/or out of the vowel. Stevens justifies the grouping for some variants in terms of similarities in the modeling of their production and some shared consequences in airflow and acoustic characteristics. There are also key differences, which are most easily identified if we consider /r/ and /l/ separately

Acoustics of /r/

The acoustic characteristics of /r/ depend on the particular variant under consideration. Ladefoged and Maddieson (1996) separate their discussion by manner, place, and voicing, showing the importance of the underlying articulation:

Taps and flaps involve a single momentary gesture (apical alveolar [ɾ], retroflex[ɽ], or uvular [ʀ]). Trills can be apical [r] (tongue tip at dental and/or alveolar place) or uvular [ʀ] (vibration of uvula against back of tongue).

Approximants/fricatives arise from approximation between articulators with or without frication (e.g. labiodentals [ʋ], alveolar [ɹ], retroflex [ɻ], and velar/uvular [ʁ(ˠ)]). All these are usually voiced, but may also be devoiced. All are articulatorily complex and likely to involve secondary and even tertiary constrictions, even trills (Scobbie and Sebregts, 2010).

American and British English /r/ show differing degrees of "darkness" (a product of tongue-root retraction; (Gick and Campbell 2003)) and can have labialization as a tertiary articulation (Foulkes & Docherty 2000). Temporal offsetting of secondary/tertiary articulations is common (Gick and Campbell 2003).

Approximant /r/ variants show formant transitions in and/or out of a "steady state" period which will vary in duration depending on factors such as position of /r/ in the word, speech rate and style of elicitation (Ladefoged 2003: 149f.; Labov 1972). Figure 7-2 arrows point to lowered F3.

FIG 7-2 NEAR HERE

Trills show a series of brief intervals of formant structures alternating with short periods of low energy; taps or flaps, a single brief interval of weakened formants (Ladefoged and Maddieson 1996: 217f.; Ladefoged 2003: 150f). (see Figure 7-2d,trill, and Figure 7-3a, tap).

FIG 7-3 NEAR HERE

Attempts to find a single, common, acoustic correlate across /r/ have observed a lowered third formant for postalveolar, bunched and retroflex approximants in e.g. American, English and New Zealand Englishes, see (Delattre and Freeman 1968) and (Hay and Maclagan in press) respectively. Hay and Maclagan found that the lower the F3 frequency, the greater the likelihood the /r/ was heard as strong. Third formant lowering is also evident in the short periods of contact during apical trills, and in surrounding vowels (Lindau 1985; Ladefoged and Maddieson 1996: 244-5.)

Stevens (1998: 535f.) notes that both articulatory configurations used to produce the American English approximant /r/, tongue tip up or with the tip low and the body bunched, have the effect of introducing an extra resonance in the second formant range. This means that approximants produced with these configurations not only show a much lower "third"

formant, but also a close approximation of the second and third formants during the constriction.

Researchers of American postvocalic /r/ have shown that bunched and retroflex /r/ are auditorily indistinguishable (Twist et al. 2007). A relatively stable acoustic signal (involving the stereotypical dip in F3) seems to be achieved by using articulatory tradeoffs, e.g. lengthening a cavity or constriction (Boyce and Espy-Wilson 1997, Guenther et al 1999). However, it is also possible that while similar, stable patterns occur for lower formants (F1--F3), there may be subtle acoustic variations in the higher formants (F4 and F5), resulting from the different articulatory strategies of bunched and retroflex /r/ (Zhou et al 2008).

Lowered F3 may not always be a consistent cue of rfulness: Heselwood (2009) hypothesises that F3 may have a suppressing effect on /r/ perception. The majority of participants in his study believed that lowpass-filtered tokens (where F3 was removed) sounded more strongly rful than their unfiltered counterparts, whether or not the tokens were initially rful. He suggested that the main cue in the perception of rhoticity could be a distinct F2, which is sufficiently separate from F1 on the Bark scale (a separation of greater than 3.5 Bark) to avoid integration with this formant, but also sufficiently low to avoid sounding like a front vowel or glide (therefore generally between 9-11 Bark).

Heselwood's hypothesis may go some way towards explaining why not all words that are perceived as rful involve a lowered F3. We also need to remember that the dependence of the lowered "third" formant on a specific array of articulatory configurations means that there are a number of differently articulated variants of /r/ for which the third formant is not low, but high, including uvular-/r/ (German, French, Hebrew and Swedish), dental-/r/ (e.g., Spanish), labiodental approximant [ʋ], (Knight et al. 2008,see also Figure 7-3b), and even some retroflex-/r/ (e.g. Hausa et al. 1994, 244-5). Likewise, *car, heart*, and other /ar/ words in vernacular urban varieties of Scottish English, typically show a high flat or rising third formant with or without glottal or pharyngeal friction (Stuart-Smith 2007, Figures 7-3c &d).

Measuring /r/

Acoustic analysis of liquids is more difficult than analysis of other consonants which differ more clearly from the adjacent vowel, see, for example, Chapter STOP.

Acoustically, it is possible to segment and label waveforms of onset, intervocalic and coda liquids; for approximant /r/, see Ladefoged (2003: 149f). With laboratory-quality sound, measures of the first four formants can be taken from a single point, at the midpoint of the

steady state (if this is easily identified). But, as [S/T etc.] are more "vowel-like," and even double as vowels in some cases the point of measurement can be difficult to determine. Moreover, an adjacent vowel can be coarticulated with the [S], making the dividing line between them even harder to determine. The most reliable means of determining the point of measurement is to consider where the amplitude of the acoustic signal drops radically due to the added approximant articulation. The vowel measurements are taken before the amplitude drop-off, while the [S] is measured where the amplitude is clearly reduced (as analysis of the audio examples will show). Until further articulatory-based work with ultrasound has been carried out, the safest choice is still to measure the liquid formants where the amplitude is lowest.

Single measures are useful when formants are clearly visible and the quality of the recording allows reliable segmentation. However, the disadvantage of single measures is that the articulation of liquids is dynamic: deciding where to take single measures of /r/ may be difficult, if not impossible.

A useful solution is the parametric approach advocated by Plug and Ogden (2003), who, in order to characterize the acoustic properties of rful and derhoticised variants of Dutch /r/, treated coda /r/ as a property of the syllable rime. This involved segmenting from the onset

of the vowel until the identifiable end of the syllable, and then taking: duration of the entire portion; vowel quality at the midpoint of the portion; and formant tracks for the last 6 glottal pulses of the syllable (see Stuart-Smith 2007). Heselwood et al's (2008) gating experments provide further support for such a position.

Acoustics of /l/

As an oral lateral approximant, /l/ also shows formant transitions, but there is often a more abrupt shift to or from the vowel to the constriction. The spectral "signature" of laterality is a zero, or "antiformant" between the second and third formants - the product of a side branch, or additional cavity created during the lateral articulation, Johnson (2003: 163). Other acoustic characteristics of laterals are a lowered first formant, a high third formant, and a range in potential F2 values, relating both to the location of the primary constriction, and to the overall configuration of the tongue (Ladefoged and Maddieson 1996: 193). Depending on the way that the constriction is achieved at the start of the hold phase, and then released at its end, laterals may also show transients, or burst-like spikes, in the waveform.

Intersecting with place of articulation are the accompanying tongue body gestures which tend to be divided into "clear/bright/light," i.e. the front of the tongue raised, and "dark," velarization and/or pharyngealization, with the dorsum raised and/or retracted. Clear /l/s show higher F2 values and dark /l/, lower values, with some variation depending on position in the word, adjacent vowel quality, and dialect (Recasens and Espinosa 2005, Hawkins and Nguyen 2004, Carter and Local 2007).

Clear and dark /l/s are also different dynamically, in that dark /l/s tend to show slower, smoother transitions with a shorter hold phase, and clear /l/s show shorter transitions and a longer hold phase; overall dark /l/ is acoustically more vocalic (Carter 2003:86), (see Figure 7-4).

It is difficult to distinguish dark /l/ in a vocalizing environment from a high back vowel that occurs in its place based on formant-frequency measurements alone, since both have low F1/F2, and low amplitude (Carter 2003: 86), see Figure 7-4d. Nor does qualitative analysis of time-normalized third formant tracks across the vowel + lateral portion demonstrate obvious links between the frequency of F3 and perceived vocalization (Timmins and Stuart-Smith 2004). The only (weak) correspondence found was between auditory identification of

vocalized or partly vocalized /l/ and reduction in amplitude of the third formant, or even no discernible F3 at all (See Figure 7-5b, c and d.)

Measuring /l/

Acoustic analysis of /l/ is helped by recognizing the different acoustic phases of a lateral: transition from the vowel, the steady state or hold phase, and the transition out (Carter and Local 2007). As for approximant /r/, when seeking the start of the steady state, look at the amplitude display: vowels have higher amplitude than liquids. Tracks of F1--F3 can be taken continuously across the vowel/lateral portion (as suggested for the INTERVAL ANALYSIS approach for measuring vowels in chapter 8) or within each phase, or at successive points at the boundaries of each phase. Even for syllable-initial /l/, difficulties may be encountered in taking F3 frequency values, and they may vary considerably. Distinguishing postvocalic and/or syllable-/word-final (dark) /l/ based on either amplitude or formants is very difficult. Stevens (1998: 553) notes that postvocalic laterals show less evidence of spectral discontinuities, and more variability than found in prestressed position. Timmins and Stuart-Smith (2004) took formant tracks across the vocalic portion of vowel + /l/ sequences - from the onset of the vowel until the offset of periodicity, in word-final, preconsonantal and postconsonantal/syllabic position, e.g. *fell* and *people* respectively, (see

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Figures 7-5b and c). Substantial difficulties were encountered in obtaining a formant track for F3. There have also been attempts to capture vocalised /l/ using formant amplitude, but this work is still under development. (Dodsworth et al. 2006, Fix 2009). As noted above, analysis may be most useful if a parametric approach is taken, with postvocalic /l/ a property of the syllable, and the interval approach providing both the formant measurements and duration of the V + liquid coda.

FIG 7-4 NEAR HERE

Finally, throughout this section we have left to one side the thorny issue of how the acoustics of liquids relate to their articulation. For example, articulatory investigations of English /l/ using EPG have shown a lack of primary constriction despite the persistence of a lateral auditory quality, e.g. Hardcastle and Barry (1989), Scobbie and Pouplier (2010). We consider articulatory data in the next section.

ARTICULATORY ANALYSIS

Direct study of articulation has largely remained a closed book for sociolinguistics, with our methodological bias towards the study of the vernacular (Labov 1972). By promoting

spontaneity, naturalness and the production of non-standard forms, sociolinguistic methodology focuses on the observation of phenomena in which the Observer's Paradox (Labov 1972) can be minimised. One downside of this approach is that the articulatory mechanisms which people employ to vary their output have to be inferred from auditory/acoustic data, and sociolinguistics tends to offer listener-oriented theories of variation. However, careful selection and adaptation of articulatory techniques, can permit collection of naturalistic, socially-stratified samples. As we will see, socio-articulatory analysis of /l/ and /r/ reveals that even fine articulatory variation correlates with social category.

Articulatory techniques

A range of articulatory instrumental techniques are employed by phoneticians, but experiments tend to be limited to more formal speech styles and standard varieties. The focus is on individual articulators, which are necessarily examined in isolation, rather than the familiar "whole picture" approach that fits more easily with acoustic recordings. Study of articulation promotes a parametric, paradigmatic perspective, where changes in voicing, or lip movement, or lingual constriction are examined, rather than the syntagmatic

perspective based around segments. Such a paradigmatic approach may be most effective for the analysis of articulatorily-complex liquid segments (cf Plug and Ogden 2003).

Data from magnetic resonance imaging (MRI) scanning (Zhou et al. 2008) or X-ray (cineradiography, x-ray microbeam, Delattre and Freeman 1968, Lindau 1985, Sproat and Fujimura 1993) can show detailed articulatory movement and configuration, but X-ray is relatively dangerous and MRI is expensive, noisy, intrusive and is not suitable for "casual vernacular" interactions. It is difficult to imagine these techniques implemented for sociolinguistic uses, though cross-dialectal research should still be encouraged.

Nevertheless, there are two instrumental techniques suitable for exploitation: Electropalatography (EPG) and ultrasound tongue imaging (UTI).

EPG (Hardcastle et al. 1989, Scobbie et al. 2004) requires a speaker-specific artificial palate that records the contact of the tongue against the hard palate at 200Hz using 62 contact points. The output is either a set of points of contact on a grid (see Figure 7-5 for the anterior part of two palates).

FIG 7-5 NEAR HERE

Kerswill, Nolan and Wright convincingly showed the value of articulatory data for sociophonetics (Kerswill 1985, Wright and Kerswill 1989, Kerswill and Wright 1990). EPG is particularly useful for the investigation of constriction in the anterior part of the palate, including transverse contact in the articulation of /l/, is only marginally intrusive, but due both to the cost per speaker and traditional concerns over the Observer's Paradox, the technique has not become popular. Unfortunately, EPG also provides no information regarding articulations taking place behind the velar region of the palate, (though see Scobbie and Pouplier 2010), and gives no indication of overall tongue body posture (dips and bunching in the tongue-body that shape resonating cavities, giving a sound a characteristic auditory quality).

The second technology to highlight is UTI (ultrasound tongue imaging) (Stone 1991, Gick 2002, Gick et al. 2006), which has the advantages of being safe, easy to use, and with very low per-speaker costs. For the study of comparatively slow-moving articulations, as is the case for most forms of /l/ and /r/ (with the exception of fast-moving taps or flaps), UTI has some powerful advantages. Ultrasound can be used in a hand-held (Figure 7-6L), or more effort can be taken to stabilise the probe to the head (Figure 7-6R), either by minimising the movement of the speaker, or by the speaker wearing a stabilisation headset, McLeod and

Wrench (2008) (see image 1). Although use of a headset may seem more constrictive than other methods of collecting UTI recordings; once the headset is in place, the participant can move their head an upper body in a more or less natural manner when speaking or conversing and do not have to remember to keep still or hold the ultrasound probe in a particular position. Good examples of spontaneous speech can be obtained once the stabilising headset is in place if the recording scenario involves speakers who know one another well, especially with an introductory icebreaker task (e.g. map task), see Lawson et al (2008).

FIG 7-6 NEAR HERE

UTI provides an image of the tongue surface's shape and location, almost from root to tip (Figure 7-7). The ultrasound transducer is placed below the chin and is orientated to image a midsagittal section of the tongue. In Figure 7-7 below, the root of the tongue is at the left of each image and the tip is at the right-hand side. The extent of the image is limited by the shadow of the hyoid bone, which obscures part of the tongue root, and by any sublaminal air-space created when the front of the tongue raises, resulting in the loss of the image of the surface of the tip and blade.

Although active articulators other than the tongue are not made visible by ultrasound, the surface of the palate is obtainable as a reference point after a sip of water or juice. Its location can then be overlaid on subsequent tongue images. However, obtaining a good palate trace is difficult and the soft palate is mobile and usually in a retracted position during swallowing. Other potential drawbacks of using UTI relate to the technical specifications of the ultrasound machine used: the output of most cheaper machines is an interlaced TV signal in which images are presented at only 30Hz, introducing spatio-temporal inaccuracies for fast-moving articulations and difficulties regarding synchronisation of the video with the audio data (Wrench and Scobbie 2006).

For the study of /l/ and /r/ in which tongue location and configuration are important and where synchronisation of lingual gestures is key, UTI can provide new insights into articulatory variation. (See figure 7-7, and URL = xyz)

FIG 7-7 NEAR HERE

Gick et al's (2006) multi-language UTI study of liquid consonants notes the correlation between the perception of "dark" allophones of onset /l/ in Squamish Salish, Western Canadian English and Serbo-Croatian and the visible presence of a secondary posterior

lingual gesture in UTI recordings. Other languages investigated by Gick et al with "clear" onset allophones showed no secondary posterior articulation. Gick et al also note that temporal separation of gestures in coda /l/ seems to contribute to the perception of darker-sounding variants.

Ultrasound can also help make sense of socially-conditioned variation. UTI work on Scottish English postvocalic /r/ demonstrates socially-varying rful articulations along socioeconomic class lines (Lawson et al 2008; Scobbie et al 2008; Lawson et al in preparation). Two important characteristics of these articulatory results show that articulatory data is not a mere addition to acoustic data, but reveals important descriptive details which are themselves theoretically interesting.

First, some of the clearly rful lingual articulations (i.e. those with tongue-tip raising associated with /r/) appear to have little or no rful auditory/acoustic consequences. Second, some of the differences between production strategies for approximant /r/ are socially distributed, Lawson et al (in preparation), which can only mean they are audible and learnable by speakers in some way, despite evidence from studies of North American /r/ articulations, Twist et al (2007) and Mielke et al (forthcoming).

SUMMARY

/l/ and /r/ can be similar in terms of their phonetic quality as well as their synchronic and diachronic phonological behaviour, but they are also characterised by their high variability, perhaps due to their articulatory complexity, and thus they are notable for their propensity to give rise to social variation, new variants, and to phonological change. Since these speech sound categories are often exploited as a means of signalling social category, sociophonetic studies of /l/ and /r/ have been particularly fruitful over the years. However, a good understanding of the relationship between articulation, acoustics and perception of /l/ and /r/ variants is still to be achieved. In particular, socio-articulatory methods of analysis are only just beginning to be exploited. This lack of articulatory research in sociophonetics has even led to the view (Thomas 2002: 168) that only acoustic data is ever relevant to sociolinguistics. The consequence is that sociolinguistics has focused on listener-oriented theories of variation; however, while the role of the listener is a necessary factor in the study of language variation and change (Ohala 1981) it is highly unlikely to be sufficient. Theoretically, a continuing debate in phonetics is whether speakers have articulatory or acoustic targets, or both. So we also need to strive towards finding a socially-situated conception of "target," *especially* for sociolinguistically varying phenomena like /l/ and /r/,

where the relationships between articulation and acoustics are particularly complex and variable.

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Comment [e35]: An annotated powerpoint/pdf of this paper exists, and could be made accessible so that it can be referenced here.

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