# Phonological variation – a global perspective

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## 1. Introduction

Interest in linguistic variation is probably as old as interest in language itself. Comments on variation trace back as far as the Sanskrit grammarian Panini (c. 600 BC) (Chambers 2002: 6). One of the earliest pronouncements on phonological variation in English comes from John of Trevisa (c. 1385), who describes an antipathy to northern British accents which is nobly preserved in some quarters even today:

> All the language of the Northumbrians, and especially at York, is so sharp, piercing and grinding, and unformed, that we Southern men can that language hardly understand. (Freeborn, French and Langford 1993: 23)

My aim in this chapter is to outline the various causes and effects of phonological variability. In doing this I draw on the methods and findings of phonetics, phonology, dialectology, sociolinguistics, psycholinguistics, pragmatics, language acquisition, and a range of applied disciplines. The integration of work from a variety of academic traditions is intended to highlight some of the areas of overlap and tension between disciplines, as well as to identify areas in which our understanding of variation is limited.

A few caveats are in order before we begin. First, while my focus is on variation in English, the discussion is presented in a more general framework. English examples are used to illustrate general principles and problems in the study of phonological variation. Modern linguistics is so dominated by work on English that much of what we know about variation *per se* is derived from analysis of English data, and especially data from North American and British varieties. A great deal remains to be learned about varieties of English elsewhere, and about variation in other languages. Secondly, it will become apparent that we know rather more about how variation is manifested in speech production than about how variation impacts on speech perception. Moreover, within the study of speech production more is known about segmental features than suprasegmental ones. Therefore my review of research is inevitably biased towards work on segmental production. Thirdly, I have interpreted *phonological* in the broad sense of 'pertaining to speech sounds', so as to include work that deals both with the physical medium of speech and also the cognitive representation of speech 'sounds'. The issue of whether particular variable features are the result of physical (phonetic) or cognitive (phonological) factors is one of the most interesting and important questions to emerge from the study of variation. Fourthly, I only discuss language using the vocal medium, although systematic variation is also found in the phonological elements of sign languages (Sutton-Spence, Woll and Allsop 1990, Bayley, Lucas and Rose 2002). Finally, given the range of different approaches to variation, the discussion is structured around sources of variation rather than academic tradition. Five broad categories are covered: physical and biological factors, contextual factors, grammatical factors, geographical and social factors, and individual factors. It will, however, become apparent that the factors interact with each

other, and that phonological variability must be understood with reference to them all simultaneously.

The sources of variation are discussed in sections 2 to 6. Section 7 then outlines the general contributions made by work on phonological variation to current theoretical debate in linguistics. Section 8 similarly summarises the relevance of phonological variation for applied fields beyond mainstream linguistics. The final section offers concluding comments and a speculative outlook for future work on phonological variation.

## 2. Physical and biological constraints on phonological variation

The first set of factors to consider in understanding phonological variation are not particular to any one language. Rather, they are the direct consequence of differences in the structures of the vocal tract and auditory system. The phonetic form of any utterance is governed to a large extent by the biological and physical components of the speech chain (Denes and Pinson 1993). The speech chain encapsulates the discrete stages in production and perception of speech. Any spoken event begins with cognitive processes: the speaker intends to convey a message, and plans the utterance in terms of the linguistic units and structures of the relevant language(s). This plan is then translated into neural motor commands which in turn drive muscular action. The vocal organs are moved into positions to generate the appropriate sounds by channelling airflow through the vocal tract. The acoustic signal thereby created travels to the listener's auditory system, from where it is transmitted by neural response to the cognitive perceptual system. The perceptual system then converts the neural information into linguistic terms to complete the transmission of the message.

This model is clearly universal, applying to all utterances in all languages. Moreover, the model largely defines the study of phonetics, which has developed through investigation of the various 'links' in the chain. Theoretical models have been developed to account for events that occur in particular stages of the chain, or in the transition from one stage to the next. Hayward (2000) provides a general introduction to phonetic theory, while thorough reviews of particular links are provided by Kent, Adams and Turner (1996) for speech production, Shadle (1997) for aerodynamics, Fujimura and Erickson (1997) for acoustics, and Moore (1997) for auditory processing. Thorough surveys of the speech perception literature are given by Goldinger, Pisoni and Luce (1996), Kreiman (1997) and Jusczyk and Luce (2002).

As far as speech production is concerned, there has been abundant work on the effects of context (section 3). Generally speaking, however, the study of variation has played a relatively peripheral role in phonetic theory. In fact, variation has usually been treated by phoneticians as an unwelcome obstacle. Research on speech perception and production has been plagued by the 'lack of invariance problem', and much effort has been directed at constructing theoretical models to explain it. The 'problem' is the fact that all acts of speaking, and thus all acoustic signals, are unique; yet listeners can understand the same linguistic message even when it is represented in varying acoustic forms. Theoretical

models have therefore sought to explain the mapping between production strategies and acoustic forms that are variable, and linguistic units that are assumed to be invariant. No universally accepted solution has been reached, but influential models include the motor theory of speech perception (Liberman and Mattingly 1985) and the direct realism model (Fowler 1986). For a brief introduction see Goldinger, Pisoni and Luce (1996) and Hayward (2000), and for critical discussion of the models see Mattingly and Studdert-Kennedy (1991) and volume 14(1) of the *Journal of Phonetics* (1986) respectively. More recent perceptual models, however, have approached the issue of variation from a fresh perspective, taking account of the structured variability in the acoustic signal which results from phonotactic and sociolinguistic factors (see further section 7 below).

In spite of the obvious variation to be found across the speech patterns of individuals, rather little phonetic research has been devoted to understanding the variation inherent to speech production (Mackenzie Beck 1997). The speech chain model does, however, predict variability and provides a partial explanation for why no two utterances are identical. Speech is largely dependent on the physical properties of the vocal-auditory channel, and, of course, no two human beings share exactly the same physical characteristics. Differences in spoken forms may therefore emanate from physical differences in each link in the chain. Furthermore, these physical differences are not only to be found across speakers: individuals are also subject to long- or short-term physical changes in the vocal tract and auditory system, which in turn may yield long- or short-term effects on their speech or hearing.

Mackenzie Beck (1997) surveys the available research on variation in anatomy and physiology of the vocal tract. She notes that differences between individuals may be relatively minor, for example slight variation in dentition which may lead to subtle effects on the acoustic properties of fricatives such as [s]. There may also be much greater physical (and thus phonetic) differences, for example caused by disease or malformation. A detailed consideration of the phonetic effects of speech and language pathologies is beyond the scope of this chapter, but see Weismer (1997) and Howard and Heselwood (forthcoming). The vocal tract of an individual also undergoes substantial physical changes during the life course, with marked developments occurring through childhood and adolescence into adulthood, and further changes emerging as a result of old age. For example, fundamental frequency (F0, which is perceived as the pitch of the voice) lowers from childhood to adulthood, and may undergo particularly dramatic short-term change in the case of adolescent males (the 'breaking' of the voice). In old age the atrophy of muscles and calcification of bones and cartilages may introduce marked phonetic changes (Mackenzie Beck 1997: 258ff.), including whispery phonation and further changes in average F0. Smoking may also affect parameters such as F0, and in turn may affect listeners' ability to estimate a speaker's age (e.g. Braun 1996).

All human beings are affected by short-term physical changes, occurring, for example, as a result of the common cold, mouth ulcers or tooth loss. The phonetic effects of such physical changes range from the subtle to the obvious, but all remain under-researched. Mackenzie Beck (1997: 278) points out that this is in part because of methodological difficulties: it is hard to distinguish the effects of physical variability from those which

stem from social and cultural influences such as regional accent (see further section 5 below). It is also often impractical to track individuals longitudinally.

Although the study of variation has been peripheral to phonetic theory, models of production, acoustics and perception do enable us to understand the parameters of variability in speech. For example, it has been shown that (all things being equal) vowels differ in intrinsic F0, with close vowels having higher F0 than open vowels. Lehiste and Peterson (1961) demonstrate this in a study of one American informant, while cross-linguistic evidence confirms the effect is genuinely universal (Whalen and Levitt 1995). One suggestion to explain the finding is based on the muscular linkage between the tongue and larynx: close vowels require the tongue to be raised, and the action of doing this may produce a side effect of increasing vertical tension in the larynx. In turn this tension in the vocal folds yields a higher F0 (Ohala 1978). Similarly, voice onset time (VOT) in stop consonants varies in relation to several factors including the place of articulation of the consonant. This has been explained with reference to the variable aerodynamic demands of different vocal tract configurations (Westbury 1983).

The quantal theory (Stevens 1998) explains the complex relationship between articulatory configuration and acoustic output. The theory predicts that articulatory variability is constrained by the potentially abrupt (quantal) effects on the acoustic signal. In some cases large articulatory variation results in only small degrees of variation in the acoustic domain. In other cases, however, small articulatory differences can result in quantal changes in acoustic quality. Perkell and Cohen (1989), for instance, studied the production of [i ɑ u] by one American speaker using X-ray imaging. They found that variability in articulation was greatest in the plane parallel to the midline of the vocal tract. Variability in the open back [ɑ] was greater in the vertical dimension, while that for the close vowels [i] and [u] was greater horizontally. Perkell and Cohen suggest that this variability is tolerated because the acoustic effects of variation in constriction location are much smaller than those which would result in variation in constriction degree. Vertical variation for /i/, for example, would potentially produce formant values similar to lower vowels in the American vowel system such as /ɪ/ or /e/. This would present a potentially confusing acoustic signal to the listener. Variability in articulatory configuration can therefore be said to be constrained by acoustic consequences.

## 3. Contextual constraints on phonological variation

In addition to the gross effects of the physical vocal system, phonological variation also results from the linguistic context in which a sound appears. Contextual constraints include the effect of sequential articulations upon one another, and also the effect of position within words or syllables.

### 3.1 Coarticulation

The effect of one sound on another is termed coarticulation or assimilation (for detailed discussion see Farnetani 1997, Hardcastle and Hewlett 1999). Well-known examples in

English are the addition of lip-rounding to consonants in anticipation of a following rounded vowel (thus the second /s/ of *see-saw* is likely to be rounded), and the abrupt consonantal changes that may occur across word-boundaries (e.g. *dress shop* [dɹɛʃ ʃɒp]). A subtler effect is described by Moreton (2004), who demonstrates that vowel formants vary in relation to whether a following consonant is voiced or voiceless. Cruttenden (2001b: 278ff.) discusses many more types of variation caused by syntagmatic context. Anticipatory effects are stronger than perseverative effects, thus sounds are more likely to be influenced by their following neighbours than their preceding ones (Gay 1978).

The variation in the acoustic signal which results from articulatory movement between neighbours is important for speech perception. In consonant+vowel sequences, the formants of the vowel take systematically different routes towards the final target position, depending on the place of articulation of the consonant as well as the quality of the vowel itself (see e.g. Ladefoged 2001: 180). These formant transitions are an important cue to the identity of the consonant (Harris 1958, Mann and Repp 1980), and may help to identify the vowel: Verbrugge and Rakerd (1986) found listeners could easily identify vowels in /bVb/ sequences even when the middle 60% of the vowel was replaced by a period of silence. Most perceptual work, however, has concentrated on syntagmatic variation between sounds in stressed syllables, while relatively little work has been devoted to perception of unstressed syllables or domains longer than individual segments (but see e.g. Fowler 1981).

How far assimilatory effects can stretch has been tested in perceptual experiments by West (1999). She found that listeners could distinguish minimal pairs containing /l/ and /r/ (e.g. *mirror/miller*) when the target sound was replaced by noise, presumably by responding to the different coarticulatory effects of /l/ and /r/ on other sounds. The listeners were able to distinguish pairs even when several syllables preceding the target sound were replaced by noise, showing that coarticulation may stretch much further than immediately adjacent sounds. Other studies have also shown non-adjacent effects. Fowler (1981), for instance, showed that unstressed English vowels may take on articulatory and acoustic properties of neighbouring vowels despite the presence of intervening consonants. Fitzgerald (2002) similarly finds evidence for vowel harmony in Buchan Scots.

Assimilatory effects have often been described as resulting from economy of articulatory effort (e.g. Abercrombie 1967: 87). In the course of fluent speech speakers may take 'short cuts' as they move from the production of one sound to another. Support for this explanation comes from studies which have examined the effect on articulation of speaking rate (e.g. Gay 1968, Crystal and House 1988a,b, Perkell, Zandipour, Matthies and Lane 2002; but see Harris 1978 for contrary evidence). In general, faster speaking rate is characterised by articulations of shorter duration, increased overlap, and greater articulatory undershoot (that is, the articulators do not fully reach their targets). Not all sounds are equally affected by changes in speaking rate, because the various articulators differ in degrees of inertia, and in the basic speed with which they can be moved (Ohala 1983: 207).

However, economy of effort does not tell the full story behind coarticulation. Ohala (1983) argues that some examples are better explained by aerodynamic principles. For example, stops develop into affricates most commonly in the context of close vowels or /j/ (for instance the pronunciation of *tune* as [tʃʉn] in some varieties of British English). The generation of fricative energy results not from articulatory change, but via the aerodynamic consequences of the vocal tract configuration. In [ti] or [tj] a narrow constriction is created behind the alveolar closure for [t], which in turn causes high velocity airflow to last longer when the stop is released. The long period of high velocity airflow may be perceptible as a fricative (Ohala 1983: 204).

Moreover, it is clear that some coarticulatory effects are not universal. They differ across languages, dialects and individuals (Lindblom 1963, Byrd 1994, Laver 1994). By way of illustration, Received Pronunciation (RP) is said not to show anticipatory voicing assimilation, unlike some Scottish accents where the medial consonant cluster in *birthday* may be [-ðd-] (Laver 1994: 384). Similarly, a contextually-determined difference in vowel duration is reported by Peterson and Lehiste (1960). Vowels before voiceless consonants are on average one third shorter than the same vowel before voiced consonants. Thus *brute* has a shorter vowel than *brood* and *bruise*. However, the effect of the following consonant is not universal (Laver 1994: 446). In Scottish English, for example, some vowels display a pattern known as the Scottish Vowel Length Rule (SVLR; see e.g. Scobbie, Hewlett and Turk 1999). (SVLR is not in fact restricted to Scotland, being also found in some north-eastern accents in England; Milroy 1995.) In SVLR accents vowels preceding voiced stops are short, and thus pattern with vowels preceding voiceless consonants. Thus, *brood* and *brute* are short, while *bruise* is long. Further contextual differences across English dialects are discussed by Fourakis and Port (1986) and Kerswill (1987), while Nolan and Kerswill (1990) demonstrate similar differences across socio-economic groups.

These differences across dialects and individuals show that coarticulation is not simply the automatic consequence of 'mechanical necessity' (Laver 1994: 379), but is to some extent planned by speakers. Knowledge of coarticulation can therefore be argued to form part of phonological competence (Whalen 1990, Kingston and Diehl 1994).

### 3.2 Prosody

The examples discussed in section 3.1 concern the simple sequential effects of sounds upon each other. Sounds also vary in response to their prosodic context, that is, their context with respect to higher level units of linguistic organisation such as sentences, intonational phrases, words or syllables. Generally speaking, articulations are longer and 'stronger' in initial contexts, and when in stressed rather than unstressed positions. Final contexts and unstressed positions present greater freedom for sounds to reduce or lenite (e.g. Harris 1978, Bauer 1988), although it is also common to find increased duration of segments before major prosodic boundaries (e.g. Wightman, Shattuck-Hufnagel, Ostendorf and Price 1992).

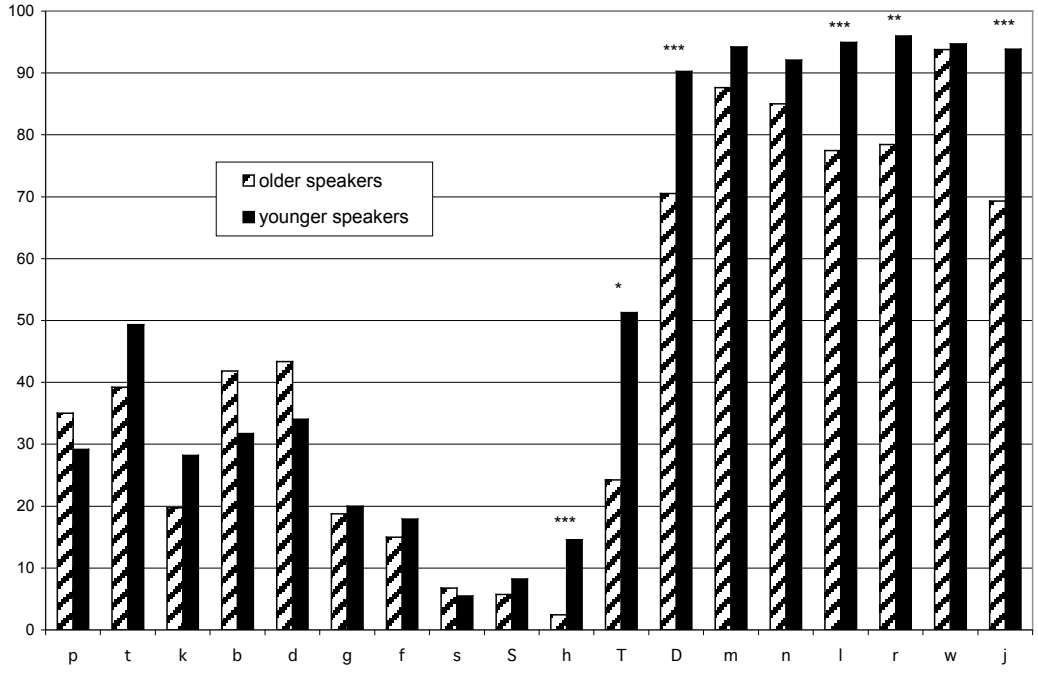
Evidence for these points is abundant in experimental phonetics (see the review by Shattuck-Hufnagel and Turk 1996). Lavoie (2001), for instance, analysed acoustic and electropalatographic (EPG) data from American English. She found consonantal features such as VOT to be longer when preceding stressed vowels and when syllable-initial. Similar findings are reported by Pierrehumbert and Talkin (1992) for /h/ and /ʔ/, and by Redi and Shattuck-Hufnagel (2001) for glottalisation. Byrd (1996) used EPG to show that there is less overlap between articulatory gestures in syllable onsets than codas, and that onsets are in general less variable than codas. Coda /l/ also has been shown to contain a 'weaker' consonantal gesture than onset /l/ (Sproat and Fujimura 1993). A contrasting example is provided by Vaissière (1988), who showed that the extent of velum lowering in the production of nasal consonants is systematically greater in coda positions than initial positions.

Not all sounds are affected equally by prosodic context, however. In Byrd's (1996) analysis of articulatory timing in consonants, she found that in coda positions plosives reduced in duration more than fricatives, and coronals were overlapped more by following velar gestures than vice versa. Pierrehumbert (1995) discusses variable effects of context on syllable-final glottalisation of /t/. She hypothesises that glottalisation is less likely in the context of a following voiceless fricative (e.g. *hat shop*) than other following sounds. This is because the aerodynamic consequences of glottalisation are in conflict with the aerodynamic needs of fricatives. Glottalisation involves a constriction or closure of the glottis, which therefore restricts airflow passing into the oral tract. Fricatives, however, demand high airflow in order to create turbulence. The data shown in Figure 1 lend support to Pierrehumbert's hypothesis. This figure displays glottalisation patterns produced by 32 speakers from Newcastle, England (the speakers are the same group reported in Docherty and Foulkes 1999 and Watt and Milroy 1999). The y axis shows the proportion of glottalised tokens produced for word-final /t/ in pre-consonantal contexts. The data combine glottal stop realisations with those displaying laryngealisation (see Docherty and Foulkes 1999, in press). Data from older (45-67) and younger (15-27) speakers are shown separately. The x axis refers to the consonantal context. We can see that glottalisation is lowest in the voiceless fricative contexts, particularly /f, s, ʃ, h/. Stops trigger higher rates of glottalisation, but substantially less than approximants and nasals. This pattern is also predicted by Pierrehumbert: stops require sufficient airflow to create plosion, while approximants and nasals can be produced with relatively low airflow rates. Note, however, that Figure 1 also reveals other factors to be at work in accounting for the variation in the data. In the case of /h, θ, ð, l, r, j/ the younger speakers have significantly higher glottalisation rates than the older generation, suggesting that the accent is undergoing change. Indeed, that is precisely what has been found with glottalisation in other contexts (Docherty, Foulkes, Milroy, Milroy and Walshaw 1997).

As with coarticulation, there is some debate on the extent to which prosodic effects are universal. While many effects seem to be found to similar degrees across languages, there are also clear differences between dialects in contextual realisation of sounds; hence these differences must form part of speakers' phonological knowledge. For example, in American English it has been suggested that nasal consonants in coda positions are in fact typically realised via nasality on the preceding vowel. This is especially true where the

nasal occurs in a cluster with a final voiceless obstruent. As a result, the duration of a nasal consonant in a word such as *tent* may be shorter than that in *ten* or *tend* (Fujimura and Erickson 1997: 105).

Figure 1. Glottalisation rates for pre-consonantal /t/ in Newcastle English. (* indicates p < .05, ** p < .01, *** p < .001; N tokens = 4,883; data for /v, tʃ, dʒ/ are not shown due to small number of tokens.)




The significant age effects in glottalisation shown in Figure 1 also testify that universal explanations for variable patterns (in this case based on aerodynamic principles) cannot be wholly satisfactory. Instead, aspects of prosodically-conditioned variability may differ across individuals or may correlate with social factors. Further evidence is provided by Docherty and Foulkes (1999, 2004). In an acoustic study of Newcastle English, systematic variation was found in the realisation of pre-pausal /t/. In addition to the expected voiceless oral stop variants, we also found variants which contained a continuation of voicing from the previous vowel and pre-aspirated variants which contained a period of high frequency fricative energy before the stop closure. The voiced variants were significantly more common in the speech of older males than any other group, while the pre-aspirated type was strongly associated with young women.

## 4. Grammatical constraints on phonological variation

It was noted in section 3 that aspects of contextual variation vary across languages and dialects, and are thus arguably represented cognitively in the phonological component of the grammatical system. This section addresses further sources of variation which are unequivocally the result of grammatical factors. Some of these involve the interaction of

the phonology with other levels of the grammar (4.1), while others occur as a result of speakers having access to grammars of more than one language or dialect (4.2).

4.1 Interactions between phonology and other levels of the grammar

Several phonetic and phonological studies have discussed the deletion of /t/ and /d/ in English coda consonant clusters. For example, in the phrase *perfect memory* it is common for the /t/ of *perfect* to be deleted, particularly in casual speech (e.g. Cruttenden 2001b: 287; see also Browman and Goldstein 1990, who show via X-ray evidence that the apparent deletion may be a perceptual effect, with the alveolar closing gesture for the /t/ still present but masked by labial closure for the /m/). The deletion of final /t/ and /d/ has also been a common topic in sociolinguistic work (e.g. Guy 1980, Guy and Boyd 1990). It has been shown that the rate of deletion is influenced by several contextual factors, including the phonetic quality of adjacent sounds. However it has also been shown that deletion rate is affected by the morphological status of the target word. Deletion is most likely in monomorphemes (*mist*) than in irregular past tense forms (*kept*), and less likely still in regular past tense forms (*missed*). This pattern is largely consistent across dialects, although differences have been found in a study in York (Tagliamonte and Temple in press). Similarly, Labov (1989) shows that the use of alveolar [n] for /ŋ/ (e.g. in *jumping*) is influenced by grammatical category. It is least frequent for nouns, but increasingly more frequent for gerunds, adjectives and progressives/participles. Labov claims there is a historical explanation for the patterning, as the modern *–ing* forms derive from two different historical roots, *-inge* and *–inde*.

The differential rate of cluster reduction in pairs like *mist* and *missed* shows that morphological structure may make itself apparent in phonetic form even where the phonological structure of words appears to be identical. Hawkins and Smith (2001) and Hawkins (2003) cite examples where similar differences are found even in canonical speech and without the influence of connected speech processes. In some dialects the pair *mistake* and *mistime* share a similar phonological structure, with a syllable break after /mɪs/. However, for some speakers syllabification of the /t/ differs: it is affiliated with the second syllable in *mistime* but ambisyllabic in *mistake*. As a result of the different syllabic structure the relative durations of acoustic segments may differ. *Mistime* has a more aspirated /t/, for example, because it is in syllable-initial position. The explanation for the difference is that *mistime* contains a morpheme boundary wheras *mistake* does not. Similar differences are found in SVLR accents (see 3.1): while *brood* has a short vowel in these accents, *brewed* has a long vowel because of its morphological complexity. Hawkins and Smith (2001) predict that listeners should be able to perceive such subtle distinctions and exploit them in speech perception tasks to facilitate lexical access (cf. findings on coarticulatory variation referred to in section 3.2).

A word's grammatical category can also constrain the degree of variability that speakers exercise in producing it. Function words and auxiliaries undergo quite different reduction processes from content words (Ogden 1999, Turk and Shattuck-Hufnagel 2000, Bell, Jurafsky, Fosler-Lussier, Girand and Gregory 2003). Usually this means a greater range of reduced forms are found for function words. In English, for example, forms of the

auxiliary *have* include [hav, həv, əv, v], but a similar range of reductions is not possible for minimally-different phonological forms such as *ham, heave, Gav*. Ogden (1999) cites this kind of evidence in support of a polysystemic approach to phonological structure (see further section 7 below).

4.2 Interactions between grammatical systems

The anglocentric world of linguistics has tended to treat monolingualism as the norm. It is often neglected that the majority of the world's population is bilingual or multilingual. Research on the phonology of bilinguals, however, shows that the grammatical systems of languages may interact and influence a person's speech production and perception (see e.g. Flege 1995, Flege, Schirru and MacKay 2003).

In the case of adult learners of a new language, it is of course usual for the new language to conform largely to the phonological patterns of the base language. This is why we tend to display a non-native accent when speaking a language learned in adulthood. Where a large population learns the same language, as is often the case with English around the world, there may be a long-term effect which comes to define the regional accent. For instance, features of South African English such as unaspirated stops and tapped /r/ have been attributed to the interference of Afrikaans phonology (Melchers and Shaw 2003: 117). Jibril (1986) notes regional differences within Nigerian English which appear to be the result of the differing influences of Hausa and Yoruba. Several varieties of North American English are characterised by influence from other languages, including Cajun (French, see e.g. Dubois and Horvath 1998) and Chicano (Spanish, e.g. Fought 2003).

Phonological studies of bilingual children – i.e. who are learning two languages simultaneously – also show that interference may take place between phonological systems (e.g. Leopold 1947). However, Khattab (2002a) shows that such interference may take place only in particular communicative settings (see section 5.6). She also argues that some differences between bilinguals and monolinguals are not the result of interference between the two grammatical systems, even if that may seem to be the case at first glance. In her study of Arabic-English bilinguals, the children did not show much success in producing Arabic pre-voiced stops /b, d, g/. Instead they produced short lag VOT, as is appropriate for /b, d, g/ in English. However, statistical analysis revealed that the children still made significant differences in VOT duration for the two languages, and were therefore not simply transposing the English pattern onto their Arabic productions (Khattab 2002b).

Interaction between two languages has also been shown in perceptual experiments. Elman, Diehl and Buchwald (1977) found that bilinguals categorised synthetic stimuli differently depending on which of their languages they believed they were listening to. Niedzielski (1999) showed similar effects at a cross-dialect level in experiments with listeners from Detroit. Some subjects were played voice samples and told that they were hearing Michigan English, while others were told they were hearing a Canadian variety. The subjects were then asked to listen to a set of synthesised vowels, and from them choose the best match to the vowels they had heard in the original samples. Listeners

made different choices depending on which variety they believed they had heard. Niedzielski's study therefore suggests that knowledge of dialect-specific variation is drawn upon in perceptual tasks.

## 5. Geographical and social constraints on phonological variation

One of the most obvious sources of phonological variability is the geographical and social background of the speaker. Speakers learn the dialect of the community in which they are raised. In the case of a global language like English this may result in phonological differences between speakers that are so large as to make communication difficult or even impossible. Furthermore, work carried out in the Labovian sociolinguistic paradigm since the 1960s has revealed differences between speakers of any given dialect as a function of social factors such as gender, social class, ethnicity, age and speaking style (see Chambers 2003 for a review).

The following sections (5.1 to 5.6) outline geographical and social factors in turn, explaining the influence of each factor on phonological variation with reference to key findings from dialectological, sociolinguistic and phonetic research. However, many published sources contribute to our understanding of several of these factors simultaneously. Sociolinguistic studies, for example, usually investigate the effects of various social factors within a geographical location. In addition to the works referred to in the specific sections below, other sources which provide valuable information about geographical and/or social differences across varieties include:

*General overviews of regional varieties*

Bailey and Görlach (1982), Wells (1982), Cheshire (1991), Burchfield (1994), MacMahon (1998), Melchers and Shaw (2003), Kortmann and Upton (2004). See also studies reported in the journals *American Speech, English World-Wide, Journal of English Linguistics, Language Variation and Change, World Englishes*.

*British Isles*

Trudgill (1974, 1988), Macaulay (1977), Bauer (1985), Petyt (1985), Milroy (1987b), Ramisch (1988), Deterding (1997), Pandeli, Eska, Ball and Rahilly (1997), Kerswill and Williams (2000), McClure (2002), Marshall (2003, 2004), Corbett, McClure and Stuart-Smith (2003). Several other studies are collected in Trudgill (1978) and Foulkes and Docherty (1999). Foulkes and Docherty (in press) summarise recent work on phonological variation in England.

*United States*

Fischer (1958), Labov, Yaeger and Steiner (1968), Pederson (1977), Feagin (1979), di Paolo and Faber (1990), Schneider (1996), Fridland (1999), Thomas (2001), Clopper and Pisoni (2004). A survey of work is provided by Wolfram and Schilling-Estes (1998).

*Canada*

Chambers (1991), Clarke (1991, 1993), Esling (1991), Woods (1991).

*Australia*

Mitchell and Delbridge (1965), Horvath (1985), Collins and Blair (1989), Burridge and Mulder (1998), Blair and Collins (2001).

*New Zealand*

Bauer (1986), Holmes (1997), Burridge and Mulder (1998), Bell and Kuiper (2000), Trudgill, Gordon, Lewis and Maclagan (2000), Watson, Maclagan and Harrington (2000).

*Elsewhere*

Holm (1983, Central American creoles), Bansal (1990, India), Khan (1991, India), Patrick (1996, Jamaican Creole), Tent (2001, Fiji), Sudbury (2001, Falkland Islands), Aceto and Williams (2003, Caribbean), Simo Bobda (2003, African varieties).

Information on the pronunciation of consonants and vowels is considerably richer than that on suprasegmental features, particularly in sociolinguistic studies. However, works referring to intonational patterns in specific dialects include Bilton (1982), Guy, Horvath, Vonwiller, Disley and Rogers (1986), Britain (1992), Douglas-Cowie, Cowie and Rahilly (1995), Rahilly (1997), Warren and Britain (2000), Daly and Warren (2001), Cruttenden (2001a), Fletcher, Stirling, Mushin and Wales (2002), Sutcliffe (2003) and Walters (2003). Grabe (2002) and Fletcher, Grabe and Warren (2004) compare patterns across dialects, while Cruttenden (1997: 128ff.) summarises dialect-specific intonation work.

Esling (1978, 1991), Henton and Bladon (1988) and Stuart-Smith (1999) show that social factors correlate with variation in vocal setting. Vocal setting is defined by Laver (1994: 396) as the 'tendency underlying the production of the chain of segments in speech towards maintaining a particular configuration or state of the vocal apparatus'. Examples of vocal settings include the use of breathy or creaky voice quality. Further comments on regional or social variation in vocal setting and voice quality can be found in Honikman (1964), Trudgill (1974), Catford (1977: 103), Knowles (1978) and Laver (1980: 4). Other suprasegmental aspects to have been analysed across dialects include pitch accent realisation (Grabe, Post, Nolan and Farrar 2000) and rhythm (Low, Grabe and Nolan 2000, Deterding 2001). The works cited on rhythm, for example, show Singapore English to be more syllable-timed than British English.

## 5.1 geographical variation

There is a long tradition of interest in geographical differences across English dialects, with systematic studies of regional varieties beginning at least as early as the eighteenth century. For example, Pegge's survey of the dialect of Whittington, Derbyshire, began in 1751 (published posthumously as Pegge 1896). Specific phonological interest is exemplified by Ellis (1889) and the editorial additions made by Hallam to Pegge (1896).

The study of geographical variation was formalised in national dialect surveys in the mid twentieth century (Chambers and Trudgill 1998). Major national projects include surveys of the USA and Canada (Kurath and McDavid 1961, Kretzschmar, McDavid, Lerud and Johnson 1994), England (Orton et al. 1963-1970), Scotland (McIntosh 1952), and Ireland (Barry 1981). These surveys yielded detailed descriptive data in the form of local lexical items and pronunciations, often presented as linguistic atlases (e.g. for the USA, Kurath, Hanley, Bloch and Lowman 1939-1943, Allen 1973-1976, Pederson, McDaniel et al. 1986-1992; for Scotland, Mather and Speitel 1975; for England, Orton, Sanderson and Widdowson 1978, Upton and Widdowson 1996). Such surveys have been criticised for the lack of representativeness in their fieldwork, with the focus usually on accessing the speech of NORMs (non-mobile older rural males). The data thus tell us relatively little about language in urban centres, or variation within communities or within the repertoire of individuals (see e.g. Pickford 1956, Milroy and Gordon 2003: 11ff.). Nonetheless, the wealth of descriptive data produced during national surveys remains an extremely valuable resource for research in historical phonology (e.g. Jones 2002).

Logistical and financial constraints, however, mean that national surveys are rare. One of the few ongoing projects is Telsur, which focuses on vowel pronunciations in the USA and Canada, and the results of which are being used to produce an Atlas of North American English (www.ling.upenn.edu/phono_atlas/home.html). Telsur has collected data from a socially heterogeneous sample of over 700 informants, with recordings made via telephone (although telephone speech may itself be problematic – see section 5.6).

The effects of geographical space on linguistic variation are deconstructed by Britain (2002). Britain argues that sociolinguists have overemphasised the effects of Euclidean (physical) space, while neglecting social and perceived space. Maintenance and change in linguistic forms may be constrained not only by physical distance but by the social distance between speakers, viewed in socio-economic or political terms. The political division between England and Scotland, for example, explains why the Scottish-English border remains an abrupt division between dialects (Watt and Ingham 2000). Variation may also be linked to speakers' attitudes, and their perceptions of geographical or social distances (e.g. Britain 2002, Dyer 2002). Britain (2002) shows, for example, that the English city of Peterborough is much more influenced by London speech patterns than the adjacent rural areas of the Fens. The geographical distance from London is similar, but the social link is much closer with Peterborough than the Fens thanks to good road and rail links. Attitudinal factors further enhance the distance between Peterborough and the Fens, with urban dwellers often holding negative perceptions of their rural neighbours, and vice versa. This in turn means there is relatively little interaction between the urban and rural communities, thus further distancing the Fenlanders from London influences.

A number of perceptual studies have tested listeners' abilities to recognise and categorise regional dialects, including Wolfram, Hazen and Schilling-Estes (1999) (see further Thomas 2002a: 117-120). Clopper and Pisoni (2004) investigate which acoustic cues were utilised by listeners in detecting American regional dialects.

## 5.2 social class and social network

Socio-economic status, often abbreviated as 'class', is usually found to have a very strong influence on linguistic behaviour. Typically the class continuum correlates with a linguistic continuum from standard to vernacular, with vernacular forms most prevalent for members of lower social classes. Although many sociolinguistic studies investigate class differences, class itself is a difficult concept to quantify and interpret, particularly where female and child subjects are concerned (Rickford 1986, Ash 2002, Milroy and Gordon 2003). Recent studies tend to avoid the complex measuring systems for class that were used in early work such as Trudgill (1974). Instead, 'class' is often no more than a general label for the type of neighbourhood being investigated.

Our understanding of within-community differences has been enhanced by sociometrics and social network analysis (e.g. Eckert 2000, Milroy 2002). This is especially true where social class is relatively homogeneous, as in Belfast, for example (Milroy 1987b). Networks describe the type of regular contact a person has with other individuals. A dense network is a tight-knit one in which individuals all know each other. The ties between network members are strong if the individuals have regular contact with each other. The polar opposite is a loose network with weak ties between members. Network studies show that dense networks are often characteristic of broadly working class communities, and that these networks exert strong influences on group members to adhere to the norms of group behaviour. One result of this influence is the maintenance of local linguistic patterns. By contrast, looser networks are found in situations where group members are more physically and socially mobile, as is typical of communities higher up the social hierarchy. Such networks exert less influence on group members to conform to in-group norms, in turn rendering group members more susceptible to influence from outside the group. Britain (1997) elaborates on the role of network types and their effect on language use with reference to the effect of routines. Routine activities (e.g. regular patterns of work and leisure) promote the maintenance of patterns of behaviour. Typical 'middle class' communities are characterised by weaker cycles of routine, since they tend to enjoy greater mobility, which in turn disrupts routine activities.

Milroy and Milroy (1985) argue that loose networks and weak ties act as a conduit for linguistic change, since they increase the chances of exposure to external linguistic patterns (see also Watt and Milroy 1999, and, for critique of the network model, Marshall 2004). The degree to which an individual is central to a group is also influential on the individual's linguistic choices, as Labov, Cohen, Robins and Lewis (1968) showed in their analysis of AAVE speakers belonging to New York gangs. Gang members who were peripheral to the group produced fewer non-standard forms than those who were central.

## 5.3 sex and gender

Sex-based phonetic differences between adult speakers are very striking, and result to an extent from marked differences in vocal tract anatomy and physiology (section 2). The larger size of the average male vocal folds explains why male voices typically have lower

F0 than women, for example. However, biology is not the only source of variation between males and females. Children are not differentiated by the obvious variation in anatomy and physiology that adults are, and yet it seems that gender-correlated patterns of phonological variation are learned relatively early in childhood. Perceptual studies show that listeners can distinguish boys and girls in speech samples taken from children as young as three years old (Lee, Hewlett and Nairn 1995). Production studies confirm that children start to manifest the same gender-differentiated phonological patterns as the adults of their community at around three years (Roberts and Labov 1995, Roberts 1997a,b, Docherty, Foulkes, Tillotson and Watt in press).

Although speaker sex is relatively rarely attended to in laboratory phonetics or phonology (Byrd 1994), sex-correlated differences emerge in almost all sociolinguistic studies. Generally, women are found to adhere more closely than men to norms associated with standard language varieties (see the review by Cheshire 2002). There are, however, exceptions (e.g. Milroy 1987b), and the general correlation between sex and standardness has been shown to be an oversimplification. Milroy and Milroy (1985) redefine the effect of sex in terms of orientation to non-local versus local forms rather than a standard/non-standard continuum. Their conclusion is based on observations that women and men typically operate in different social network structures: men's networks are usually denser than women's, which explains why men orient more to vernacular norms (see 5.2 above). The local/non-local dimension is better able to capture observed patterns where standard forms appear to play little role. One such finding is described by Watt and Milroy (1999), in their study of vowels in Tyneside English. Their results show that women prefer variants which have a relatively wide currency over northern England, while men show a much higher use of more localised pronunciations.

The distinction between speakers' socially-defined gender and the binary distinction of biological sex is often merely an issue of terminology (Cheshire 2002: 423): results tend to be presented and interpreted in binary terms in any case. Eckert (1989, 2000), however, shows that analysis of informants' gender identity offers a much more refined understanding of their linguistic differences (see also Cameron this volume). Eckert's study of vowel variables used by Detroit teenagers revealed that many of the largest differences emerged not between male and female groups but between different groups of girls. She explains this finding in the following terms:

> 'the primary importance of gender lies not in differences between male and female across the board, but in differences within gender groups… a general constraint against competition across gender lines leads people to compete, hence evaluate themselves, within their gender group' (Eckert 2000: 122-123).

In the perceptual domain rather little attention has been paid to gender-based differences, although a series of experiments have shown that perceptual boundaries between sounds may be adjusted in line with the assumed gender of the talker. Strand (1999) presented listeners with a continuum of synthetic stimuli ranging from a clear [s] at one pole to a clear [ʃ] at the other, with intermediate stimuli gradually decreasing in the low frequency boundary of fricative energy. The listeners' task was to label the stimuli as either /s/ or

/ʃ/. While hearing the stimuli, some listeners were presented with a female face but others saw a male face. The category boundary differed for the two listener groups, in line with typical differences in speech production. Those who saw a female face placed the boundary at a higher frequency, since female voices produce fricatives with higher frequencies than male voices. A similar pattern was found in vowel categorisation by Johnson, Strand and D'Imperio (1999). These experiments demonstrate that sociolinguistic knowledge may influence basic speech perception tasks (cf. also Niedzielski 1999 on regional dialect differences; section 4.2).

5.4 race and ethnicity

The relationship between linguistic variation and ethnicity has been a prominent focus for North American sociolinguistics since the 1960s. Labov's early works included investigations of the phonological patterns of the Portuguese and Wampanoag Native American minorities in Martha's Vineyard (Labov 1963), and Puerto Ricans and African Americans in New York City (Labov, Cohen, Robins and Lewis 1968). Since then a wealth of work has been produced on African American Vernacular English (AAVE) in particular, both describing features of contemporary AAVE and also tracing its development from the early settlement of Africans in North America (see e.g. Wolfram 1969, Mufwene, Rickford, Bailey and Baugh 1998, Thomas and Bailey 1998, Wolfram, Thomas and Green 2000, Green 2002, Wolfram and Thomas 2002). Phonological features, however, have been less studied than other aspects of the grammar, and suprasegmentals fare worse still (but see Tarone 1973, Hudson and Holbrook 1982, and brief reviews of work by Green 2002, Wolfram and Thomas 2002). Furthermore, most work has concentrated on differences between AAVE and other varieties, with relatively little attention being paid to variation within AAVE itself (Wolfram and Schilling-Estes 1998: 174). Overall, however, it appears that AAVE varies relatively little geographically, and AAVE speakers collectively resist participation in major sound changes such as the Northern Cities shift (e.g. Wolfram and Schilling-Estes 1998, Milroy and Gordon 2003).

Other ethnic communities to have been studied in North America include Franco-Americans in New Hampshire (Ryback-Soucy and Nagy 2000), Lumbee Native Americans (Schilling-Estes 2000), Cherokees (Anderson 1999), Irish, Italian and Jewish groups in Boston (Lafarriere 1979), Pennsylvania Germans (Huffines 1984), Orthodox Jews (Benor 2001), and several rural enclaves in Canada (see Chambers 1991). Chicano speakers are perhaps the most extensively studied (Peñalosa 1980, Penfield and Ornstein-Galicia 1985, Fought 1999, 2003, Thomas 2000).

Ethnic differences in phonology have not been so extensively studied elsewhere in the English-speaking world, although there is a growing body of work on differences between Maori and Pakeha (European) English in New Zealand (e.g. Britain 1992, Holmes 1997). In Australia there has been little work on the phonological properties of Aboriginal English, although other ethnic groups have been studied (see Clyne, Eisikovits and Tollfree 2001 for a review). These include Torres Strait English (Shnukal

2001 and several communities of German and Greek origin (Clyne, Eisikovits and Tollfree 2001).

In the UK there have been few systematic phonological studies of ethnic varieties. Work in Northern Ireland has investigated differences drawn along religious divisions (Milroy 1987b, McCafferty 1999, 2001). The dearth of work, however, is regrettable in view of the rapidly changing ethnic composition of the UK. There has been a huge rise in immigration since the mid twentieth century, resulting in very large ethnic minority populations in cities such as Bradford and Leicester. Notable exceptions are Wells (1973), who presents a detailed study of London Jamaican English, and Khan (in progress), who compares phonological patterns across three ethnic groups in Birmingham. Brief information on aspects of Caribbean English in the UK is provided by Sutcliffe (1982), Local, Wells and Sebba (1985) and Hewitt (1986). Hewitt suggests that features of Caribbean Englishes are filtering into the speech of white adolescents in the south of England, a claim supported in recent work by Hirson, Holmes and Coulthrust (2003).

Heselwood and McChrystal (2000) present a preliminary study of the accent features of Panjabi-English bilinguals in Bradford. Intriguingly, their results suggest that differentiation from local Yorkshire patterns is much more marked in the speech of young males than females. For example, the males used more noticeable retroflexion in /t/ and /d/ articulations, a feature characteristic of Panjabi itself. It seems that the males may be adapting phonological features of one language for use as markers of ethnicity in the other. This 'recycling' of sociolinguistic features is also reported by Dyer (2002) in her study of the English steel town, Corby. The town saw a large influx of Scottish steel workers in the 1960s. Subsequent generations have abandoned many of the Scottish phonological features which characterised the immigrant community. However, certain features are being maintained with redefined social-indexical values. The use of monophthongs in words such as *boat, know*, for example, is emblematic of Scottish ethnicity for older speakers, but is now being used by younger speakers as a marker of local Corby identity. In this way young Corby speakers differentiate themselves from inhabitants of neighbouring areas.

Perceptual studies relating to ethnicity are almost all concerned with whether listeners can identify the ethnic origins of a speaker. Several studies (reviewed by Thomas 2002a, Thomas and Reaser 2004) show that listeners can indeed distinguish African Americans from Anglo Americans, although few of these studies identify which particular phonological features enable listeners to perform the task. An exception is Walton and Orlikoff (1994) who describe ethnic differences in voice quality, albeit from analysis of very short samples. Plichta (forthcoming) uses a matched guise experimental procedure similar to that of Strand (1999) and Niedzielski (1999), and shows that perceived ethnicity affects judgements of speakers' standardness.

5.5 age

The effect of age on phonological differences is very obvious when comparing the speech of adults with that of children. Of course, differences in anatomy and physiology are largely responsible, as we saw in section 2. However, socially-oriented variation also occurs across the course of life. In discussing such variation, Eckert (1997) shows that culturally-determined life stages are of greater relevance than biological age. She identifies three key life stages – childhood, adolescence and adulthood. Each of these stages exert quite different influences on linguistic patterns.

Childhood is obviously characterised by relatively immature speech patterns due to incomplete language learning and the ongoing development of the child's anatomy and motor control. Relatively little work has been carried out on the acquisition of socially-structured variation by children, despite the obvious variation which is a hallmark of child speech. This lack of study results in large measure from the dominance in child language work of structuralist and generative frameworks, and the emphasis on searching for the acquisition of language-specific contrasts (Ferguson 1986: 44). It is clear, though, that local forms of pronunciation, including quite complex patterns of allophonic distribution, emerge from the very start of the acquisition process (Roberts and Labov 1995, Roberts 1997a,b, 2002, Foulkes, Docherty and Watt 2001, Docherty, Foulkes, Tillotson and Watt in press). Typically, patterns characteristic of adult women's speech have the greatest chance of being acquired by children, as in most societies children will gain the majority of their linguistic input from female caregivers (Labov 1990).

In adolescence, the role of the peer group becomes very important, and may overtake the influence of the home. Conformity to peer group norms becomes increasingly important, and one reflex of this may be the rapid increase in usage of vernacular features in speech. Individuals may therefore undergo marked changes in phonological patterns as the influence of the home model wanes. A very clear example is provided in the context of the English new town, Milton Keynes (Kerswill 1996, Williams and Kerswill 1999, Kerswill and Williams 2000). Being a new town, Milton Keynes is characterised by a large number of in-migrants from various quarters of the British Isles and beyond. Children growing up in Milton Keynes are therefore exposed to an unusually wide array of dialects as their initial linguistic input. The variety of input dialects is clearly apparent in the speech of four year olds, who constitute as heterogeneous a linguistic group as their parents. However, by age 12 the pressure to conform to peer norms is such that most of the initial differences have been eradicated, and a strikingly homogeneous local accent has emerged. Eckert (2000) also reveals the important linguistic influence of the peer group on adolescents.

Adulthood, by contrast, is often assumed to be a stable period, with the phonological structure of the language having become fixed. Some studies reveal evidence for ongoing change in adulthood, however, depending on the personal circumstances of the speaker. Obvious situations which induce ongoing change include the learning of a new dialect or language after geographical relocation (e.g. Chambers 1992). Coupland (1980) and Mees and Collins (1999) also show that individual deployment of sociolinguistic variants may change markedly during adulthood, depending on factors such as the social ambition of the speaker. Mees and Collins, for instance, analyse the use of glottal variants of /t/ in a

real-time study of four Cardiff women. Glottal variants are not characteristic of Cardiff English, and are thus indexical of supra-local rather than local varieties. Individuals who are content to stay in Cardiff show relatively low use of glottal variants, whereas those speakers who signal an intent to leave the area show an increase in their use of glottals over the period studied. An even more striking example illustrating ongoing change is reported by Harrington, Palethorpe and Watson (2000), who identify various changes in Queen Elizabeth II's vowel production over several decades. Her pronunciation has gradually shifted from a stereotyped upper class RP towards a more mainstream RP variety.

5.6 communicative context

Variation in speech may result from many different types of influence emanating from the specific context in which communication takes place. Phonetic forms may be controlled in line with the style or register of speech; they may be tailored according to the relationship between the speaker and listener; they may be designed to provide coherence to a discourse; they may be linked to changes in the ambient physical conditions of the context; and they may be affected by temporary external influences such as alcohol or consciously adopted disguise.

Speaking style has been a long-standing focus in sociolinguistics (see Schilling-Estes 2002 for a review). Many studies have shown that speakers (particularly women) move closer to the standard in more formal styles of speech. Examples include the increased production in formal styles of post-vocalic [ɹ] in New York (Labov 1966), and [h] in British English (Trudgill 1974). Phonological variation may even be linked to quite particular registers, such as pop songs (where features of American accents are often adopted, Trudgill 1983) and horse racing commentary, which is notable for its particular rhythm, rate and intonational features (Horvath 1997).

In early sociolinguistic work speaking style was conceived as a linear continuum from vernacular to standard, with speakers shifting towards the standard pole of the continuum as a reflex of increasing self-consciousness (e.g. Labov 1972: 208). Subsequent work has refined this view somewhat, with researchers recognising that phonological choices are also affected by the interlocutor, communicative task, and discourse function.

Bell (1984) notes that interlocutors often accommodate to each others' linguistic patterns as a means of establishing solidarity. Trudgill (1986: 8), for instance, found that in the sociolinguistic interviews he carried out in Norwich his own use of glottal forms of (t) correlated with that of the interviewees. Alternatively, linguistic differences may be enhanced to create distance between speakers. In both cases phonological variation results not simply from the speaker's self-consciousness but from the relationship between the interlocutors in the communicative context. As such, speech is therefore subject to what Bell terms audience design. A similar conclusion is reached in phonetic work by Lindblom (1990), who claims that the structure of spoken discourse varies along a continuum from hyper-speech to hypo-speech. The former is characterised by relatively canonical pronunciation, and is generated when the listener's needs in the communicative

setting demand clear speech from the speaker (for example when conditions are noisy, or detailed new information is being given). Hypo-speech is characterised by increased rapidity and greater degrees of underarticulation. It is produced when the communicative context permits the speaker to be more egocentric, such as in narratives. Variation according to addressee was demonstrated very clearly in a study of the speech of one individual, Carol Meyers, in a range of situations (Labov 2001: 438ff.). Meyers' vowels differed quite radically depending on whether she was in a work or social context. Differences in phonological variant patterns have also been found in studies comparing speech between adults to that between adults and children (see Foulkes, Docherty and Watt 2005). Degrees of hyper- and hypo-articulation have furthermore been shown to depend on a word's relative frequency, and on the number of close phonological neighbours it has (Luce and Pisoni 1998, Wright 2003).

Research with bilinguals supports the view that situational context is an important influence on phonological choice, in that patterns of interference between languages depend upon the type of language mode being used (Grosjean 1998). In some circumstances a bilingual is likely to use just one language, such as speaking to a monolingual. In a monolingual mode, any interference between the speaker's two languages is minimal. However, in interaction with other bilinguals code-switching often emerges. That is, speakers engage in a bilingual mode where both languages are used and structures from one language may well be transposed onto the other. Khattab (2002a,b) provides evidence for mode-related phonological differences in Arabic-English bilingual children.

In addition to variation according to addressee, speakers exploit phonological choices for pragmatic and conversational purposes. For example, in Tyneside English fully-released non-glottalised voiceless stops seem to play a role in signalling transitions in speaking turns (Local, Kelly and Wells 1986, Docherty, Foulkes, Milroy, Milroy and Walshaw 1997). Turn transitions may also be controlled by intonational patterns that vary markedly across dialects. Local, Wells and Sebba (1985) describe patterns of pitch movement as a cue to turn-endings in London Jamaican English, while the use of high rising tone has been identified as a turn-holding mechanism in Australia (Guy, Horvath, Vonwiller, Disley and Rogers 1986) and New Zealand (Britain 1992, Warren and Britain 2000). Other studies reveal very fine control of phonetic parameters to give coherence to discourse, including timing, overlap between interlocutors, speech rate and F0 level (e.g. Couper-Kuhlen and Selting 1996, Curl 2003, Local 2003, Walker 2003).

Given communicative contexts may generate short-term effects on phonological patterns. Some of these result from the speaker's attitude to the addressee, topic of discourse or situation. Speakers usually indicate paralinguistic intent via suprasegmental features such as voice quality or intonation (reviewed by Ní Chasaide and Gobl 1997). Boredom, for instance, is typically conveyed by a narrow intonational range and low overall F0. Some such features are clearly voluntary, although the phonetic effect of others such as anger and fear appear to be largely beyond the speaker's control. Individuals nevertheless vary in the effects they manifest. Perceptual experiments show that listeners can detect attitudinal factors, and also that variation in paralinguistic voice qualities may affect

speech perception and voice recognition (Mullennix, Bihon, Bricklemyer, Gaston and Keener 2002).

Other short-term effects may result from temporary changes in ambient conditions, or through the presence of external influences such as intoxicating substances. Chin and Pisoni (1997) review work on the variable phonetic consequences of alcohol intake. Speech in noisy conditions, meanwhile, is often modified to counteract the effects of background noise. The Lombard reflex typically leads to louder speech, which results in various side-effects including higher F0 and complex modifications to vowel formants (Lane and Tranel 1971, French 1998). A similar response also typifies speech via telephones where the limitations of the transmission medium lead speakers to increase loudness (as anyone who has witnessed people using mobile phones will recognise) (Künzel 2001).

Variation resulting from factors such as telephone speech, alcohol and emotional states is a particular problem in forensic phonetics (Nolan 1997, Rose 2002). A frequent task in the application of forensic phonetics is to compare a speech sample with criminal content (e.g. a threatening message) with a sample from a known suspect, to assess the likelihood that the two samples were produced by the same person. However, the majority of criminal samples in real cases involve telephone calls, often made in emotional circumstances, and not infrequently by people who have had a few drinks. The phonological effects of these factors must all be catered for in the comparison with the suspect's sample, which is likely to have been recorded in quite different conditions (usually an interview in police custody). Active attempts to disguise a voice may further exacerbate analytic problems (Hollien, Majewski and Doherty 1982).

Perceptual effects of situational influences on speech have also been found, and again have particular relevance for the practices of forensic phonetics. It has been shown, for example, that identifying a known individual's voice is more difficult when the speech is heard through a telephone (Rathborn, Bull and Clifford 1981). Foulkes and Barron (2000) found in an experiment with phone samples that individuals who know each other well may fail to recognise each others' voices, and even their own voices.

What is perhaps most striking about the effect of communicative context is the sheer range of different influences on speech that can be found. In view of that, our understanding of how such factors are handled in phonological knowledge remains relatively poor. Work in experimental phonetics and theoretical phonology has largely ignored the sorts of factors outlined in this section, focussing instead on canonical materials collected in laboratory settings or 'neutral' interactional styles.

## 6. Individual constraints on phonological variation

Phonological differences between individuals have been alluded to throughout the previous sections. We have seen, for example, that differences may result from idiosyncracies in vocal tract anatomy, or, in the case of Carol Meyers and others, the effects of personal interactions.

It is probably true, in fact, that individual differences are demonstrated in every empirical study of speech production or perception, even if these differences are rarely the subject of much discussion. An obvious counter-example is the field of forensic phonetics, where there is a prime concern in identifying features particular to an individual (Nolan 1997). By contrast, the number of laboratory phonetic or phonological studies which draw attention to inter-speaker differences is very small (but see e.g. Abbs 1986, Vaissière 1988, Johnson, Ladefoged and Lindau 1993, and Allen, Miller and DeSteno 2003). Sociolinguistic studies likewise tend to focus on group patterns in favour of descriptions of general or average patterns within the group under investigation (but see e.g. Mees and Collins 1999, Llamas 2000).

While the lack of explicit interest in individual patterns is understandable, it does mean that we have only limited understanding of the parameters of variation across individuals. Johnstone and Bean (1997: 236) acknowledge that factors such as region, class and gender all have an important influence on speech, but point out that such factors 'do not *determine* how people sound'. Instead, the array of structured variation available to an individual, coupled with other factors such as ideology, can be seen as a rich resource from which the individual can choose elements in order to project their own identity. Johnstone and Bean's study of two Texan women discusses their self-expression with reference to lexical, syntactic and discourse structures. Studies of the role of phonological variables in the contruction of identity include Bucholtz (1998, focusing on [t] production by female nerds), Benor (2001, [t] production by Orthodox Jews) and Podesva, Roberts and Campbell-Kibler (2002, phonetic patterns in camp gay male speech).

Llamas (2000) takes a similar approach with reference to phonological variation in the speech of 32 inhabitants of Middlesbrough, England. Changes in English local government divisions have seen the official political identity of Middlesbrough change four times since 1968. At one time it was part of Yorkshire, but after two other reorganisations it is now an independent city borough. Llamas's analysis shows that speakers' use of phonological variants is intertwined with their differing perceptions of the regional identity of the city. These largely correlate in a predictable way with age, for instance with older speakers showing greater use of variants characteristic of Yorkshire. However, there are also individual differences in variant use, which Llamas argues are linked to the speakers' own degree of affiliation to the city, and their experience of other dialects. The work of Llamas takes a significant step towards explaining how phonological variability is exploited by people in the construction of their identity, and is singular in its attempt to do so with a relatively large sample of speakers. It is to be hoped that further work in this direction is undertaken, not only for sociolinguistic purposes but because understanding the scope and nature of individual variability may have wide-ranging implications for issues at the core of phonology and phonetics such as phonological representation and speech perception. Support seems very likely to come for the position adopted by Mufwene (1994: 208), who argues that there is 'no compelling justification for assuming that [individuals] develop identical speech strategies or that their competences do not vary from one speaker to another' (see also Hawkins 2003).

## 7. Theoretical implications of phonological variation

As we have seen in the preceding sections, different traditions in linguistic research have focussed on different aspects of variability, while in some traditions variability has generally been factored out of research designs or marginalised in interpreting results.

This section aims to summarise the contribution of phonological variation to aspects of linguistic theory. It also highlights areas in which an understanding of variation may prove more profitable than it has hitherto been.

The role of variation in shaping theory is most evident in sociolinguistics. The recognition that much variability is structured rather than random has enabled great strides to be made in understanding how linguistic change originates, and how it spreads through communities and grammars (e.g. Milroy 1992, Trudgill, Gordon, Lewis and Maclagan 2000, Kerswill and Williams 2000, Chambers 2003). Labov's work has been particularly influential in this sphere (see e.g. Labov 1994, 2001, and for critiques Gordon 2001, Thomas 2002b). Experimental phonetic work has further contributed to explaining the origins of regular sound changes (Ohala 1983). Dialect geography, too, although sometimes uncharitably depicted as a theory-free zone, has often had an eye on understanding change. The Survey of English Dialects, for instance, was largely geared to tracing the development of the Middle English vowel system (Orton, Sanderson and Widdowson 1978).

Sociolinguistic studies have, however, made only limited impact on grammatical theory. This is unsurprising in view of the general aims of twentieth century linguistic theory to describe synchronic grammars of particular languages, and the universal parameters of possible grammars. Few phonologists have therefore accorded a central place to issues of variation in the development of theory, although Lexical Phonology (e.g. Carr 1991, McMahon 1991) and Government Phonology (Harris 1994) are exceptions, and Articulatory Phonology is well equipped to deal with many of the types of variability discussed in section 3 (Browman and Goldstein 1989, 1990). Various phonological models have been applied to variationist data at some time or other, though, including the currently dominant model of Optimality Theory (OT) (e.g. Anttila 1997, Nagy and Reynolds 1997). Such applications, however, serve just as often to reveal the deficiencies of the models. OT analyses of variable data, for example, seem to be characterised by the discovery of a wide range of new constraints needed to account for the data, which sits rather uncomfortably with the tenet that all OT constraints are universal and innate (see McMahon 2000 for a thorough critique of OT and its devices for dealing with variation). That said, it is equally true that sociolinguistics has been slow to profit from advances within theoretical phonology (cf. Honeybone 2002: 414). Much sociolinguistic work refers to organisation at the level of the phoneme, an approach which has been superseded by many alternatives in phonological theory, some of which have radically different conceptions of what the basic phonological units are and how they are organised into lexical representations.

Like phonology, phonetic theory has also advanced with relatively little interest in variation beyond the contextual types discussed in section 3. Exceptions are the contribution of cross-dialect research to intonational phonology (Grabe 2002), and Shockey's (2002) detailed analysis of English in casual speech. Generally phonetic research is dominated by analysis of carefully controlled materials, usually canonical forms in standard dialects of American or British English, and gathered from few speakers under laboratory conditions. There are some departures from this norm, as exemplified by Byrd (1994), who analyses the effects of dialect and sex on reduction processes using the 630-speaker TIMIT database. The general concentration on small speaker samples is largely due to practical constraints: commonly used methodological techniques are often expensive and/or invasive (such as electropalatography, fibroscopy, or electromyography), and results may be difficult to quantify in such a way as to permit cross-speaker comparisons. Researchers are therefore often forced to investigate their own speech, or that of a small number of subjects. Obvious disadvantages, however, are that findings may potentially be unrepresentative of the speech community at large, and the methods do not permit investigation of how phonological variation is handled by the cognitive system.

Recent trends, though, have started to show that speech production, and particularly speech perception, are affected by detailed knowledge of structured variability. New theories are therefore coming to light, along with new methods designed to test those theories. Exemplar, episodic or multiple trace models of lexical representation have been proposed as a radical alternative to traditional models (Pisoni 1997, Goldinger 1997, Lachs, McMichael and Pisoni 2002). The perceptual work of Strand (1999) and Niedzielski (1999) and others, referred to earlier, have contributed to the development of these models. So too have psycholinguistic experiments which show that detailed features of speakers' voices are stored in long-term memory. For example, Nygaard, Sommers and Pisoni (1994) tested word recognition using stimuli drawn from a set of talkers. Listeners who had been trained to recognise the individual voices performed better than a control group who were encountering the voices for the first time in the test. Previous exposure to the voices thus aided subsequent perceptual processing of new words from those talkers, which suggests that highly specific information about the voices must be accessed in the process of speech perception. Lexical representations are therefore argued to contain speaker-specific details, rather than being stored solely in abstract, invariant, symbolic forms. More specifically, exemplar models propose that the cognitive representation of a word is richly detailed, and in fact consists of a potentially vast store of detailed individual traces. These traces reflect the detailed acoustic properties of tokens that a speaker has heard, and by extension articulatory properties of tokens the speaker has uttered. Exemplar models thus echo the view of sound structure espoused by the neogrammarians in the nineteenth century (e.g. Paul 1880/1978). Here the cognitive representation of a sound is seen as a set of 'memory pictures', based on articulatory and acoustic sensations and clustered around an average or prototype value.

Support for exemplar models comes from several quite disparate sources. Studies of second language learners support the view that experience of multiple talkers improves lexical recognition (Lively, Logan and Pisoni 1993). Studies of child language have also

stated support for exemplar models, both via perception experiments (Nathan, Wells and Donlan 1998) and production analyses (Docherty, Foulkes, Tillotson and Watt in press). In speech production studies with adults, Pierrehumbert (2002) finds effects on phonetic form linked to the frequency of occurrence of words. Common words are typically produced faster and less clearly than rare ones. The implication of this finding is that the on-line planning of speech is tailored differently according to the specific word involved, implying in turn that speakers have knowledge of frequency distributions for words and their phonological elements. Such a conclusion is compatible with the view that speakers have access to a store of individual exemplars of words – large sets for common words and smaller sets for rare ones (see further Coleman 2002 and Bod, Hay and Jannedy 2003). Further evidence is supplied by studies which show that phonetic realisation of words varies according to grammatical category (e.g. Ogden 1999; see section 4.1). While not explicitly supportive of exemplar models, Ogden adopts Firthian prosodic analysis, one tenet of which is that grammars are polysystemic. That is, rather than being seen as a single monolithic system, a language is held to be the product of numerous interwoven systems in which contrasts and the phonetic instantiations of those contrasts may vary from system to system. The perceptual model proposed by Hawkins and Smith (2001) and Hawkins (2003) combines exemplar representations with the polysystemic approach.

Exemplar models entail several important implications, many of which are themselves compatible with the various strands of work dealing with phonological variation that have been outlined throughout this chapter. Exemplar models may therefore potentially be the best candidates for a unitary account of the disparate sources of variation we have discussed. If so, one implication is that individuals possess their own unique lexical store (cf. Mufwene 1994, Hawkins 2003). Another is that lexical representations need not be stored in canonical form, as is usually assumed in phonological models. Furthermore, lexical and indexical information may not be stored as two separate knowledge bases, but as a single composite store of knowledge about sound in general (Pisoni 1997, see also Docherty, Foulkes, Tillotson and Watt in press). Thus phonological knowledge is not only a source of information about lexical contrast, it also contains information about specific voices, encompassing details of age, gender, dialect, contextual allophony and so on. Note that the 'lack of invariance problem' (section 2) is largely solved, since there is no cognitive stage at which invariant and abstract symbolic representations need to be mapped onto variable and continuous speech signals (Docherty and Foulkes 2000).

Modern exemplar models are, however, still in relative infancy, and while they appear advantageous in some respects they are problematic in others. The bulk of evidence in support of the models comes from speech perception: it is less clear how a vast store of exemplars is manipulated in the course of speech production. Pierrehumbert (2002) suggests that production goals are driven by exemplars that are most heavily weighted in perception, although no formal model of how weighting takes place has yet been proposed beyond simple statistical observations. Presumably there must also be weighting in respect of factors such as sociolinguistic preferences, stylistic choices, attitude and attention (Pierrehumbert 2002: 135). It is not clear either to what extent the store of traces is subject to abstraction, what form that abstraction takes, or what role (if

any) the abstract representation plays in speech production or perception. What is clear, though, is that exemplar models reignite the cognitive storage/computation debate of the 1970s (see e.g. Ladefoged 1972, Linell 1979). In generative models and their derivatives one aspect of the evaluation metric for grammars is that simpler and better grammars minimise storage at the expense of complex processes of derivation or manipulation. OT provides a clear illustration of this assumption, with invariant input forms (cf. generative underlying forms) filtered through a dense network of constraints en route to physical output. Exemplar models are diametrically opposed, with major demands on cognitive storage but little on-line computation. Much work therefore remains to be done to test and refine exemplar models, but they are at least to be welcomed for their fresh perspective on established issues.

## 8. Wider significance of phonological variation

Understanding phonological variation is not only important for linguistic theory but for a range of interests beyond mainstream linguistic theory. Speech technology, for example, must cater for social, regional and contextual variability to generate natural-sounding synthesised speech and to ensure speech recognition systems can tolerate natural variability (Hoequist and Nolan 1991, Laver 1995). Speech therapists benefit from informed views of language variation, enabling them to distinguish genuine pathology from natural non-standard variability (Milroy 1987a: 208ff., Ball 2004).

Information on variability is critical for practical casework in forensic phonetics. Comparison of criminal recordings with a suspect's speech involves making allowances for the effects of factors such as accent, style shifts, disguise, stress, emotion, and telephone speech. In other cases, for example the receipt of a call or tape from a kidnapper, there may only be a criminal recording. The analyst's task is therefore to create a speaker profile to help narrow the field of suspects (see e.g. Ellis 1994). The strength of conclusions that can be reached is largely dependent on the state of descriptive reference material, including the likely geographical origins of particular features and the frequency of speech disorders and other idiosyncracies throughout the population. A similar technique is currently being applied to assess the claims of asylum seekers, by analysing their speech to verify their country or region of origin (Simo Bobda, Wolf and Peter 1999). Worryingly, this is often done by government agencies or private companies rather than professional linguists.

Pedagogical issues are clearly informed by debate on phonological variation, most (in)famously perhaps in the case of the Ebonics debate in the USA (see Wolfram and Schilling-Estes 1998: 169ff., and volume 26(2) of the *Journal of English Linguistics*, 1998). On a wider platform, models of English for teaching as a foreign language are constantly being revised in line with changes in British and American standard varieties, as well as in respect of the development of influential new standards such as Australian in east Asia (Melchers and Shaw 2003: 101).

More widely still, it has been shown that people often develop strong attitudes, negative and positive, to features of linguistic variation (see Honey 1989 and Milroy and Milroy

1998 for a stimulating debate). These attitudes may affect communication between groups of people (Lambert, Hodgson, Gardner and Fillenbaum 1960, Gumperz 1982), job prospects (Lippi-Green 1997), and may be consciously tapped into for purposes of advertising and marketing (Bell 1991: 135ff.). Lippi-Green (1997) also highlights the subliminal effects of linguistic stereotyping with reference to the use of accents for characterisation in films. She shows, for example, that in Disney films 'good' characters usually have standard accents, with AAVE and foreign accents largely reserved for negatively-portrayed characters. Similar examples of language stereotyping abound in film and television, as witnessed, for instance, by the Cockney-sounding Orcs in the film versions of *The Lord of the Rings*.

## 9. Conclusion and outlook

We have seen that phonological variation results from many sources. The physical form of any utterance is governed simultaneously by the speaker's anatomy and physiology, the nature of airflow through the vocal tract, linguistic context, the social and regional background of the speaker, communicative context, and a range of psychological factors. We have seen also that the full range of effects are rarely countenanced together within academic pursuits. Phonetics, phonology and sociolinguistics have tended to focus on particular aspects of variability to the exclusion of others, or in some cases to peripheralise the study of variability.

Developments in recent years have started to recognise the importance of variability for our understanding of the structure and functioning of linguistic systems as well as for issues outside linguistic theory. There is a growing awareness that systematically controlled variation is something that must be learned in the course of language acquisition, and thus that it represents an aspect of knowledge about sounds and sound structure. Phonological models of varied hues are making progress in addressing issues in social and geographical variability, while new models are emerging which place some types of variability in centre stage. Sociolinguistic data are being more widely exploited as a testing ground for theoretical claims. The expanding field of 'sociophonetics', while somewhat ill-defined and encompassing an eclectic range of approaches, nevertheless testifies to the growing interest in the interrelationship between linguistic theory and variable data. This field is likely to continue to grow, thanks to a large extent to rapid changes in technology. Acoustic analysis of large data samples is now cheap and speedy, while newer articulatory techniques such as ultrasound (Gick 2002) and will provide new perspectives on variability in speech.

The most intriguing challenge remains how to weave together the various strands of knowledge about lexical forms and variability of all kinds into a unified theoretical framework. But the best chance of achieving this is by viewing variability not as a nuisance but as a universal and functional design feature of language.

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