21 Phonological Variation: A Global Perspective

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21.1 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 Pāṇini (ca. 600 BC) (Chambers 2002, p. 6). One of the earliest pronouncements on phonological variation in English comes from John of Trevisa (ca. 1385), who describes an antipathy to northern British accents which is preserved in some quarters even today:

> *Al the longage of the Norþumbres, and specialych at York, ys so scharp, slyttyng and frotyng, and unschape, þat we Souþeron men may þat longage unneþe undurstonde.*
>
> [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 et al. 1993, p. 23)]

My aim in this chapter is to outline the various causes and effects of phonological variability. I draw on the methods and findings of several academic traditions, especially phonetics, phonology, dialectology, sociolinguistics, psycholinguistics, pragmatics, language acquisition, and a range of applied disciplines. The integration of different strands of work serves to highlight areas of overlap and tension between disciplines, and to identify areas in which our understanding of variation remains 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. Since the turn of the millennium, there has been a pleasing increase in attention paid to varieties of English across the world, and to variation in other languages (e.g., Stanford and Preston 2009; Stanford 2016, and work in journals such as *World Englishes*). Yet our understanding of variation has traditionally been dominated by work on North American and British English varieties. It is thus vital to ensure our ideas and theories are put to the test by diverse data sets. Second, my focus is mainly on speech production, as we know rather more about how variation is manifested in production than about its effects on speech perception. However, research is now beginning to shed light on the latter, and theoretical accounts of variation are coming to integrate findings from production and perception. Third, I have interpreted *phonological* in the broad sense of "pertaining to speech sounds," in order to include work that deals both with the physical medium of speech and also the cognitive representation of speech "sounds." The

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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. Fourth, I only discuss language using the vocal medium, although systematic variation is also found in the phonological elements of sign languages (Sutton-Spence et al. 1990; Bayley et al. 2002, Schembri et al. 2009). 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, structural–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 variation must be understood with reference to them all simultaneously.

The sources of variation are discussed in Sections 21.2 to 21.6. Section 21.7 outlines the general contributions made by work on phonological variation to current theoretical debate in linguistics, while Section 21.8 similarly summarizes the relevance of phonological variation for applied fields. The final section offers concluding comments and a speculative outlook for future work.

21.2 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), which represents 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 channeling airflow through the vocal tract. The acoustic signal thereby creates 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. Note that the chain need not be considered fully linear, however: speakers also attune their speech in line with constantly updated observations about interactants in conversation, such that phonetic forms of words may be mutually negotiated (e.g., Couper-Kuhlen and Selting 1996).

The speech chain 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. Thorough reviews of particular links are provided by Hardcastle et al. (2010), Goldrick et al. (2014, production), Stevens (2000, acoustics), and Pisoni and Remez (2008, perception).

As far as speech production is concerned, there has been abundant work on the effects of structural context (Section 21.3). Until recently, however, the study of most types of variation has played a relatively peripheral role in phonetic theory. In fact, variation has traditionally 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—at some level at least—even when it is represented in varying acoustic forms. Theoretical models have therefore sought to explain the mapping between highly variable production strategies and acoustic forms on the one hand, and, on the other, 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 critical discussion, 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 21.7).

The speech chain model predicts certain types of 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 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 Ball et al. (2008). 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 (f_0, 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, p. 258ff.), including whispery phonation and further changes in average f_0. Smoking may also affect parameters such as f_0, and in turn may affect listeners' ability to estimate a speaker's age (Braun 1996).

Everyone is affected by short-term physical changes, occurring, for example, as a result of the common cold 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, p. 278) points out that this is in part because of methodological difficulties: it is often hard to distinguish the effects of physical change from those which stem from social and cultural influences such as regional accent (see further, Section 21.5). It is also often impractical to track individuals longitudinally. Phonetic changes reflecting elective physical change, for example, for transgender individuals, are addressed by Gorham-Rowan and Morris (2006) and Papp (2011), among others.

Although the study of variation has traditionally 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 f_0, with close vowels having higher f_0 than open vowels (Whalen and Levitt 1995). Similarly, voice onset time (VOT) in stop consonants varies in relation to several factors including place of articulation. This has been explained with reference to the variable aerodynamic demands of different vocal tract configurations (Westbury 1983).

21.3 Structural–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, the effect of position within words or syllables, and larger-scale effects reflecting predictability of sounds.

21.3.1 Coarticulation

The direct phonetic effect of one sound on another is termed *coarticulation* or *assimilation* (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 *seesaw* is likely to be rounded, whereas the first /s/ is more likely to have spread lips due to coarticulation with [i]), 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, p. 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 toward 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, p. 180). These formant *transitions* are an important cue to the identity of the consonant (Harris 1958; Mann and Repp 1980), and may also help listeners to identify the vowel (Verbrugge and Rakerd 1986). 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; West 1999).

Assimilatory effects have often been described as resulting from economy of articulatory effort (e.g., Abercrombie 1967, p. 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 of speaking rate on articulation (e.g., Gay 1968; Crystal and House 1988a, b; Perkell et al. 2002; but see Harris 1978, for contrary evidence). In general, faster speaking rate is characterized 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, p. 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 initially 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, p. 204).

Moreover, it is clear that coarticulatory effects are not universal. They differ across languages, dialects, individuals, and situations (Lindblom 1963; Byrd 1994; Laver 1994). For example, 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, p. 384). Similarly, vowels before voiceless consonants are generally shorter than before voiced consonants (Peterson and Lehiste 1960). Thus, *brute* has a shorter vowel than *brood* and *bruise*. However, the effect of the following consonant varies across dialects. In Scottish English and some north-eastern accents in England, vowels display a pattern known as the Scottish vowel length rule (SVLR; see, e.g., Scobbie et al. 1999; 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 socioeconomic groups. The overall degree of articulatory precision (i.e., citation-like production, as opposed to reduction) is also shaped in part by the demands of situational context related to interaction, and to sociolinguistic factors such as attitude, stance, and identity. Hawkins (2003) provides a neat anecdote to illustrate both, reporting a production of the phrase *I don't know* as [ə̰ə̰ə̰]. The heavily reduced form signals the informality of the situation and the speaker's attitude to the question she was answering. Local and Walker (2012) document a wider range of interactional functions, for example, noting that that reduction is used to signal talk projection (holding the floor).

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

21.3.2 Prosody

The examples discussed in Section 21.3.1 concern the 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 organization such as sentences and intonational phrases. 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, and it is also common to find increased duration of segments before major prosodic boundaries (for a review, see, e.g., Shattuck-Hufnagel and Turk 1996; Turk and Shattuck-Hufnagel 2007). Lavoie (2001), for instance, analyzed 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. 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.

21.3.3 Syllable and Word Position

With respect to syllable context, Byrd (1996) 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 glottalization of /t/. She hypothesizes that glottalization 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 glottalization are in conflict with the aerodynamic needs of fricatives. Glottalization 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 21.1 lend support to Pierrehumbert's hypothesis. This figure displays glottalization patterns produced by 32 speakers from Newcastle upon Tyne. The *y*-axis shows the proportion of glottalized tokens produced for word-final /t/ in pre-consonantal contexts. The data combine glottal stop realizations with those displaying laryngealization (see Docherty and Foulkes 1999, 2004). Data from older (45–67) and younger (15–27) speakers are shown separately. We can see that glottalization is lowest in the voiceless fricative contexts, particularly /f, s, ʃ, h/. Stops trigger higher rates of glottalization, 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 21.1 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 glottalization rates than the older generation, suggesting change in apparent time. Indeed, that is precisely what was found with glottalization in other contexts (Docherty et al. 1997).

As with coarticulation, there is some debate on the extent to which contextual effects are universal. While many effects seem to be found to similar degrees across languages, there are also clear differences between dialects in contextual realization 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 realized 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, p. 105).

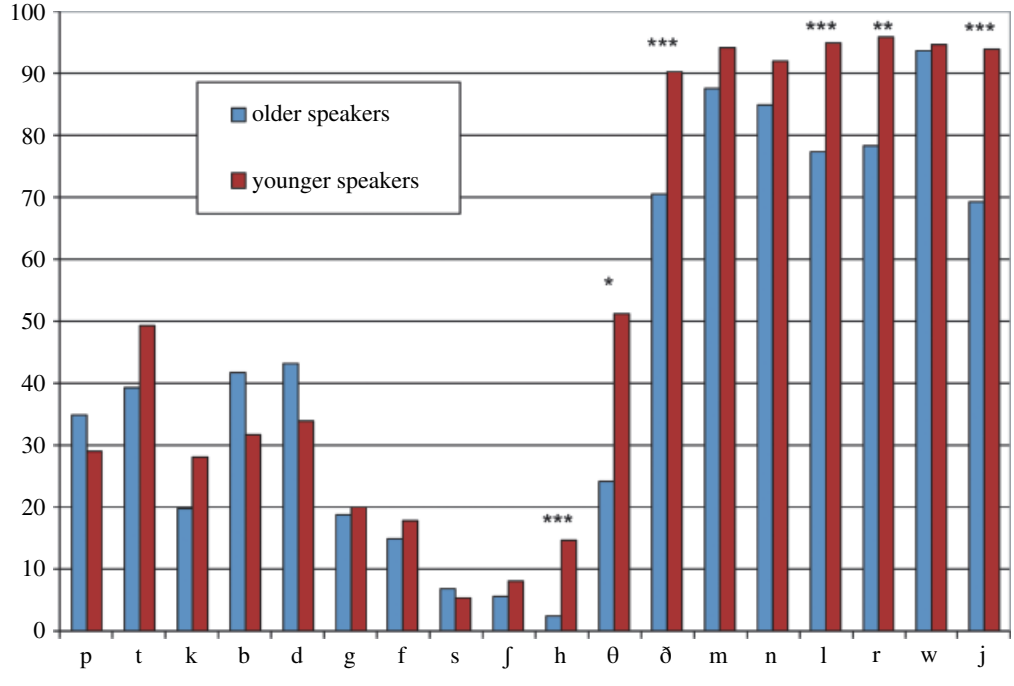

Figure 21.1 Glottalization rates for pre-consonantal /t/ in Newcastle English. (* indicates $p < .05$, ** $p < .01$, *** $p < .001$; N tokens = 4883; data for /v, tʃ, dʒ/ are not shown due to small number of tokens.)

The significant age effects in glottalization shown in Figure 21.1 also testify that universal explanations for variable patterns (in this case based on aerodynamic principles) cannot be wholly satisfactory. Instead, aspects of contextually 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 realization of word-final pre-pausal /t/. In addition to the expected voiceless oral stop variants, variants were also found 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.

21.4 Grammatical Constraints on Phonological Variation

It was noted in Section 21.3 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 (Section 21.4.1), while others occur as a result of speakers having access to grammars of more than one language or dialect (Section 21.4.2).

21.4.1 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 a phrase such as *perfect memory*, it is common for the /t/ of *perfect* to be deleted, particularly in casual speech (e.g., Cruttenden 2001b, p. 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 and the morphological status of the target word. Deletion is more likely in monomorphemes (*mist*) than in irregular past-tense forms (*kept*), and least likely 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 2005). 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 whereas *mistake* does not. Similar differences are found in SVLR accents (see Section 21.3.1): 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 21.3.2).

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 et al. 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*.

21.4.2 Predictability

In addition to variation shaped by syntagmatic and prosodic factors, a number of recent studies report significant effects on phonetic form as a function of predictability (Shaw and Kawahara 2018). This term encompasses both phonological and lexical predictability (e.g., the relative frequency of sounds in phonotactic context or words in the lexicon) and also message predictability or *informativity* (information content). The latter term refers to the average predictability of segments in the language as a whole. For example, in English, /ŋ/ is rare across the entire lexicon, but highly predictable if the preceding context is /standɪ-/ (Cohen Priva 2015). Segmental properties including duration, VOT, formant frequencies, and deletion rates vary in line with both local and overall informativity. Segments that are less predictable tend to be realized in a more citation-like form, for example, with longer duration and with a lower tendency to delete. These effects interact with those influenced by sociolinguistic factors such as social class and age. Hay and Foulkes (2016), for example, document a complex set of effects that have shaped the development of intervocalic /t/ from [t] to [d/ɾ] in New Zealand English. These include effects of lexical frequency (more frequent words attract more [d/ɾ]), and predictability effects in discourse context, for example, through repetition (repeated words are more likely to attract [d/ɾ], whereas the same words have [t] on first mention). Overall predictability has also been argued to shape change in phonological systems over time (e.g., Sóskuthy and Hay 2017; Currie Hall et al. 2018). Discussion of predictability effects has often been couched within exemplar models (discussed further in Section 21.7 below).

Findings such as these are largely the product of research based on data drawn from large corpora of speech recordings, but there is also evidence that such effects are attuned to in speech perception and comprehension (see further the papers collected in Shaw and Kawahara 2018).

21.4.3 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 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 2007; Flege et al. 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 influence of Afrikaans phonology (Melchers and Shaw 2003, p. 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 characterized by influence from other languages, including Cajun (French, see, e.g., Dubois and Horvath 1998) and Chicano (Spanish, e.g., Fought 2003). Interaction between two languages has also been shown in perceptual experiments. Elman et al. (1977), for example, found that bilinguals categorized synthetic stimuli differently depending on which of their languages they believed they were listening to (see also, e.g., Pallier et al. 1998).

Phonological studies of bilingual children also show that interference may take place between phonological systems (e.g., Leopold 1947). However, Khattab (2002a, b, 2007, 2009, 2011) shows that such interference is not automatic but may in fact testify to very sophisticated sociolinguistic learning on the part of bilingual children. As the following example shows, when searching for an Arabic word, the children often code-switched to English, but used L2 features such as tapped /r/.

Mother:	[miːn ˈhaɪda]	(“*who’s that?*”)
Child:	[ˈweɪtə]	
Mother:	[laʔ bɪlˈʕaɾabe]	(“*no, in Arabic*”)
Child:	[ˈweɪt**aɾ**]	

Thus, the “interference” is situation-dependent and serves to achieve goals in communication, both in terms of constructing a suitable Arabic-like word form on the fly, and also attempting to be cooperative. In such cases, the phonetic influence of one language on the other is not due to lack of competence, but instead indicates that the child tailors speech to the needs of the interlocutor or exigencies of the communication (see further, Section 21.5.6).

21.5 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(s) 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 (Chambers 2003; Tagliamonte 2011).

The following sections (Sections 21.5.1 to 21.5.6) 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

provided 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 Schneider (2004), Kachru et al. (2006), and Trudgill and Hannah (2017). See also studies reported in the journals *American Speech*, *English World-Wide*, *Journal of English Linguistics*, *Language Variation and Change*, and *World Englishes*.

United Kingdom and Ireland

Surveys are provided by Hughes et al. (2012), Corbett et al. (2003, Scots), and Foulkes and Docherty (2007, England). Several other studies are collected in Trudgill (1978), Foulkes and Docherty (1999), and Hickey (2015). Studies of particular regional dialects include Trudgill (1974, 1988, Norwich), Macaulay (1977, Glasgow), Bauer (1985, RP), Petyt (1985, West Yorkshire), Milroy (1987b, Belfast), Ramisch (1988, Channel Islands), Deterding (1997, RP), Kerswill and Williams (2000, Milton Keynes), McClure (2002, Doric), Marshall (2004, Huntly), Beal et al. (2012, North East England), Clark and Asprey (2013, West Midlands), Kallen (2013, Ireland), Schützler (2015, standard Scottish), Braber and Robinson (2018, East Midlands), and Paulasto et al. (2018, Wales).

United States

Fischer (1958), Labov et al. (1972), Pederson (1977), Feagin (1979), di Paolo and Faber (1990), Schneider (1996), Fridland (1999), Thomas (2001), Clopper and Pisoni (2004), Newman (2014), and Johnstone et al. (2015). Surveys are provided by Wolfram and Ward (2005) and Wolfram and Schilling (2015).

Canada

Chambers (1991), Clarke (1991, 1993, 2010), Esling (1991), Woods (1991), Boberg (2008), and Walker (2015).

Australia

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

New Zealand

Bauer (1986), Holmes (1997), Burridge and Mulder (1998), Bell and Kuiper (2000), Trudgill et al. (2000), Watson et al. (2000), and Hay et al. (2008).

Asia

Bansal (1990), Khan (1991), Pingali (2009, India), Deterding (2007, Singapore), and Setter et al. (2010, Hong Kong).

Africa

Simo Bobda (2003, several varieties); Mesthrie (2002, 2006, 2017, South Africa).

The Americas

Holm (1983, Central American creoles), Patrick (1996, Jamaican Creole), and Aceto and Williams (2003, Caribbean).

Lesser Known Varieties

Sudbury (2001, Falkland Islands), Tent (2001, Fiji), Schreier (2003, Tristan da Cunha), Schreier (2008, St Helena), Schreier et al. (2010), Williams et al. (2015), and Britain et al. (2019, Micronesia).

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 include Bilton (1982), Guy et al. (1986), Britain (1992), Douglas-Cowie et al. (1995), Rahilly (1997), Warren and Britain (2000), Daly and Warren (2001), Cruttenden (2001a), Fletcher et al. (2002), Sutcliffe (1982), Walters (2003), and Nance et al. (2018). Grabe (2002, 2004) and Fletcher et al. (2004) compare patterns across dialects, while Cruttenden (1997, p. 128ff.) summarizes dialect-specific intonation work. Warren (2016) discusses uptalk in English across the world, as well as providing excellent methodological advice for intonation research.

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, p. 396) as the "tendency underlying the production of the chain of segments in speech toward maintaining a particular configuration or state of the vocal apparatus." Examples of vocal settings include the use of breathy or creaky phonation. Further comments on regional or social variation in vocal setting and voice quality can be found in Honikman (1964), Trudgill (1974), Catford (1977, p. 103), Knowles (1978), Laver (1980, p. 4), and Podesva and Callier (2015). Other suprasegmental aspects to have been analyzed across dialects include pitch accent realization (Grabe et al. 2000) and rhythm (Low et al. 2000; Deterding 2001; Thomas and Carter 2006; Nokes and Hay 2012; Torgersen and Szakay 2012).

21.5.1 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 formalized 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 et al. 1994), England (Orton et al. 1962), 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 et al. 1939–1943; Allen 1973–1976; Pederson et al. 1986–1992; for Scotland, Mather and Speitel 1975; Labov et al. 2005; for England, Orton et al. 1978; Upton and Widdowson 1996). Older surveys were criticized for the lack of representativeness in their fieldwork, with the focus usually on accessing the speech of *NORMs* (non-mobile older rural males) (see, e.g., Pickford 1956; Milroy and Gordon 2003, p. 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). Modern surveys are more inclusive in design, involving urban as well as rural speakers and in some cases offering insights into variation within communities or within the repertoire of individuals. Advances in technology further facilitate data collection and analysis. Labov et al. (2005), for instance, collected much of their data via

telephone (although telephone speech may itself be problematic—see Section 21.5.6). Leemann et al. (2018) have developed mobile phone apps to collect data via crowdsourcing, and which produce results rapidly in the form of maps. An ongoing project in the United Kingdom has already collected data form over 47 000 respondents in the form of quiz responses, with over 3500 providing audio recordings.

The effects of geographical space on linguistic variation are discussed by Britain (2002). Britain argues that sociolinguists have overemphasized 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 socioeconomic 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 et al. 2013). 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 recognize and categorize regional dialects, including Wolfram et al. (1999), Thomas (2002a), Clopper and Pisoni (2004), and Montgomery (2012). It has also been shown that a listener's regional background affects perceptual processes (reviewed by Drager 2010). For example, Niedzielski (1999) conducted 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 synthesized 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. Hay et al. (2018) found that New Zealand listeners displayed different degrees of sensitivity to /r/ in a phoneme-monitoring experiment, with greater sensitivity for those who had greater experience of hearing /r/ in the relevant contexts. These studies therefore suggest that knowledge of dialect-specific variation is drawn upon in a range of perceptual tasks, and speech perception is not accomplished purely through interpretation of the acoustic signal.

21.5.2 Social Class and Social Network

Socioeconomic status, often abbreviated as "class," is usually found to have a very strong influence on linguistic behavior. 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), and few current studies use complex metrics for class. Instead, "class" is often used as a general label for the type of neighbourhood being investigated. Current studies, however, are beginning to explore class through the lens of contemporary models of class structure (Kerswill 2018).

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 all individuals 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 behavior. 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 behavior. Typical "middle class" communities are characterized 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 (for a critique of the network model, see Marshall 2004).

21.5.3 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 21.2). The larger size of the average male vocal folds explains why male voices typically have lower f_0 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 3 years old (Lee et al. 1995). Production studies confirm that children start to manifest the same gender-differentiated phonological patterns as the adults of their community at around 3 years (Roberts and Labov 1995; Roberts 1997a, b; Docherty et al. 2006).

Sex- or gender-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 Section 21.5.2 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 localized pronunciations.

The distinction between speakers' socially defined gender and the binary distinction of biological sex is often merely an issue of terminology (Cheshire 2002, p. 423): results tend to be presented and interpreted in binary terms in any case. Eckert (1989, 2000) and Stuart-Smith (2007), however, show that analysis of informants' gender identity offers a much more refined

understanding of their linguistic differences. In both Eckert's study of vowel variables used by Detroit teenagers and Stuart-Smith's research in Glasgow, some of the largest differences emerged not between male and female groups but between different groups of girls. Eckert (2000, pp. 122–123) 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"

Recent years have seen a rapid rise in interest in gender and sexuality, and phonetic variation associated with a wide range of gender identities (for a review, see Podesva and Kajino 2017).

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 categorization by Johnson et al. (1999). These experiments demonstrate that sociolinguistic knowledge, and accrued experience of physical differences in speech, may influence basic speech perception tasks (cf. also Niedzielski 1999, on regional dialect differences; Section 21.4.2).

21.5.4 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 et al. 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 (for recent accounts, see, e.g., Mufwene et al. 1998; Wolfram et al. 2000; Green 2002; Wolfram and Thomas 2002; Thomas 2007; Wolfram and Schilling 2015). 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, Thomas and Carter 2006, and brief reviews 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. 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 (Wolfram and Schilling-Estes 2015, p. 236).

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 Māori and Pākehā (European) English in New Zealand (e.g., Britain 1992; Holmes 1997, 2005). In Australia, there has been little work on the phonological properties of ethnic minority groups, but see Butcher (2008) on Aboriginal English, Shnukal (2001) on Torres Strait English, and Clyne et al. (2001) on German and Greek communities.

Work in Northern Ireland has investigated ethnic differences drawn along religious divisions (Milroy 1987b; McCafferty 1999, 2001). Wells's (1973) study of London Jamaican English is an isolated early example of research on ethnic varieties in the rest of the United Kingdom, although systematic phonological studies of ethnic varieties have increased in recent years as researchers have come to recognize the importance of language in a rapidly changing ethnic context. 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. Kirkham (e.g., 2017) and Wormald (2016) present detailed work on the English of British Asian groups, including comparative work on Punjabi-speaking communities. The Polish community in Manchester has been studied extensively by Drummond (2011, 2012, 2013). In contexts of interaction between ethnic groups, there is evidence of major change in local varieties through admixture of features originally from different ethnic origins. A particularly clear case is provided by work on Multicultural London English (e.g., Cheshire et al. 2011).

Heselwood and McChrystal (2000) present a preliminary study of the accent features of Punjabi-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 Punjabi 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 characterized 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.

21.5.5 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 21.2. 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 exerts quite different influences on linguistic patterns.

Childhood is obviously characterized 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, p. 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; Docherty et al. 2006). 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 characterized 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 4-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. An even more striking example illustrating ongoing change is reported by Harrington et al. (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 toward a more mainstream RP variety. Rhodes (2012) provides a thorough review of both acoustic and sociophonetic research on the effects of ageing.

21.5.6 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 or to negotiate interaction; 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 toward the standard pole of the continuum as a reflex of increasing self-consciousness (e.g., Labov 1972, p. 208). Subsequent work has refined this view somewhat, with researchers recognizing that phonological choices are also affected by the interlocutor, communicative task, and discourse function.

Bell (1984) notes that interlocutors often accommodate to each other's linguistic patterns as a means of establishing solidarity. Trudgill (1986, p. 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 characterized 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 characterized 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, p. 438ff.). Meyers's 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, also showing that adults tailor their speech differently to boys and girls (Foulkes et al. 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 (e.g., Luce and Pisoni 1998; Wright 2003; Hay and Foulkes 2016, and see further Section 21.3.3).

Research with bilinguals supports the view that situational context has 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, 2007, 2009, 2011) provides evidence for mode-related phonological differences in Arabic-English bilingual children (Section 21.4.2).

In addition to variation according to addressee, speakers exploit phonological choices for pragmatic and conversational purposes. For example, in Tyneside English, fully released nonglottalized voiceless stops seem to play a role in signaling transitions in speaking turns (Local et al. 1986). Turn transitions may also be controlled by intonational patterns that vary markedly across dialects. Local et al. (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, among many other functions (Warren 2016). Other studies reveal very fine control of phonetic parameters to give coherence to discourse, including timing, overlap between interlocutors, speech rate, and f_0 level (e.g., Couper-Kuhlen and Selting 1996; Curl 2003; Local 2003; Walker 2003; Local and Walker 2013).

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 physical situation. Speakers usually indicate attitude or 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 f_0. 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 et al. 2002). Topic has been shown to exert subtle statistical effects on phonetic variant usage, for example, by Love and Walker (2013, pronunciation of /r/ in context of football) and Hay and Foulkes (2016, variants of /t/ related to time depth of narrative).

Other short-term effects may result from temporary changes in ambient conditions, or through the presence of external influences such as intoxicating substances (e.g., Chin and Pisoni 1997).

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 f_0 and complex modifications to vowel formants (Lane and Tranel 1971). A similar response also typifies speech via telephones where the limitations of the transmission medium lead speakers to increase loudness. This has consequences for vowel formant patterning as well as f_0, in particular leading to a major upshift in the first formant (F1) (Künzel 2001; Byrne and Foulkes 2004).

Variation resulting from factors such as telephone speech, alcohol, and emotional states is a particular problem in forensic phonetics (Jessen 2008). 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).

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, focusing instead on canonical materials collected in laboratory settings or "neutral" interactional styles.

21.6 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 idiosyncrasies 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 focus of discussion. An obvious counterexample is the field of forensic phonetics, where there is a prime concern in identifying features particular to an individual (Jessen 2008). By contrast, the number of laboratory phonetic or phonological studies which draw attention to inter-speaker differences is small but growing (e.g., Johnson et al. 1993; Allen et al. 2003;

Yu et al. 2013). 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., Forrest 2015).

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, p. 236) acknowledge that factors such as region, class, and gender all have an important influence on speech, but make the important point 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. Studies of the role of phonological variables in the construction of identity include Bucholtz (1998, focusing on [t] production by female nerds), Benor (2001, [t] production by Orthodox Jews), and Podesva et al. (2002, phonetic patterns in camp gay male speech).

21.7 Theoretical Implications of Phonological Variation

As we have seen, different traditions in linguistic research have focused on different aspects of variability, while in some traditions variability has generally been factored out of research designs or marginalized in interpreting results. This section aims to summarize the contribution of phonological variation to aspects of linguistic theory. It also highlights areas in which a better understanding of variation may prove both challenging and profitable.

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 et al. 2000; Kerswill and Williams 2000; Chambers 2003; Tagliamonte 2011). Labov's work has been particularly influential in this sphere (see, e.g., Labov 1994, 2001, 2010, 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 et al. 1978).

Sociolinguistic studies have, however, made only limited impact on mainstream linguistic 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. Various phonological models have been applied to variationist data at some time or other, though, including optimality theory (e.g., Nagy and Reynolds 1997). That said, it is equally true that sociolinguistics has been slow to profit from advances within theoretical phonology (cf. Honeybone 2002, p. 414). Much sociolinguistic work refers to organization 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 organized into lexical representations.

Like phonology, phonetic theory has also advanced with relatively little interest in variation beyond the contextual types discussed in Section 21.3. Furthermore, phonetic research has been 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. However, the somewhat eclectic field of sociophonetics has grown rapidly in recent years (Foulkes et al. 2010; Thomas 2011). Studies under this banner generally

involve the use of large and heterogeneous data sets, representing multiple speakers and/or styles of speech. Such work has been facilitated by collaborative work between researchers with complementary expertise, and also by technological advances such as the development of large corpora. Sociophonetic studies have generally employed auditory or acoustic methods, though newer techniques are now being applied to issues of variation. For example, Stuart-Smith et al. (2014) and Turton (2017) use ultrasound to analyze /r/ and /l/, respectively.

Recent trends, though, have started to show that speech production, and particularly speech perception, are intimately affected by detailed knowledge of structured variability (see, e.g., Drager 2010; Nygaard et al. 1994). New theoretical accounts of such observations are therefore being developed, along with new methods designed to test those theories further. Exemplar models of lexical representation have in particular gained ground in recent years as an alternative to traditional models (Lachs et al. 2002; Pierrehumbert 2002; Bod et al. 2003; Foulkes and Docherty 2006; Foulkes and Hay 2015; Hay and Foulkes 2016). In exemplar models, lexical representations are hypothesized to contain speaker-specific details, rather than being stored solely in abstract, invariant, symbolic forms. Instead, the cognitive representation of a word is a richly detailed store of exemplars, constantly updated through experience. Note that this hypothesis is commonly misrepresented or misunderstood to suggest that every instance of every encountered word is memorized in full detail, like a library of extracts from a high-definition movie of the speaker's life. Exemplars are *memorized* forms of encountered tokens, mediated by both the perceptual system and the speaker's prior expectations, and subject to the constraints of attention and memory. The store of exemplars is nevertheless based on experience, and thus the cognitive representation of words reflects the detailed acoustic and phonological properties of tokens that a speaker has heard, and the articulatory properties of tokens the speaker has uttered.

Support for exemplar models comes from disparate sources. Studies of second language learners support the view that experience of multiple talkers improves lexical recognition (Lively et al. 1993). Studies of child language have also stated support for exemplar models, both via perception experiments (Nathan et al. 1998) and production analyses (Docherty et al. 2006). In speech production, many of the studies discussed in Section 21.3.3 on predictability are also couched within exemplar models.

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. Hawkins 2003). Another is that lexical representations need not be stored (solely anyway) 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 (Docherty et al. 2006). 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 21.2) 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 (Foulkes and Docherty 2006).

Exemplar models remain, however, problematic in various respects (Foulkes and Docherty 2006; Docherty and Foulkes 2014; Hay and Foulkes 2016). 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, p. 135). It is not clear either to what extent the store of exemplars 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 minimize storage at the expense of complex processes of derivation or manipulation. Exemplar models appear diametrically opposed, with major demands on cognitive storage but little online 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.

21.8 Wider Significance of Phonological Variation

Understanding phonological variation is not only important for linguistic theory but for a range of interests beyond linguistics. Speech technology, for example, must cater for social, regional, and contextual variability to generate natural-sounding synthesized speech and to ensure speech recognition systems that 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, p. 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 (Jessen 2008). 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 (Foulkes et al. 2019). 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 idiosyncrasies throughout the population. A similar technique is applied to assess the claims of asylum seekers, by analyzing their speech to verify their region of origin (Wilson and Foulkes 2014).

Pedagogical issues are clearly informed by debate on phonological variation, most famously perhaps in the case of the Ebonics debate in the USA (see Wolfram and Schilling 2015, p. 217ff., 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 English in East Asia (Melchers and Shaw 2003, p. 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). Indeed, it has been claimed that language variation is "the last acceptable public prejudice" (Edwards 2015). Examples abound, such as the online abuse leveled at the Manchester-born MP Angela Rayner because of her accent (BBC 2017).

Attitudes to linguistic variation may affect communication between groups of people (Lambert et al. 1960; Gumperz 1982), job prospects (Lippi-Green 2012), and may be

consciously tapped into for purposes of advertising and marketing (Bell 1991, p. 135ff.). Lippi-Green (2012) also highlights the subliminal effects of linguistic stereotyping with reference to the use of accents for characterization 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*.

21.9 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 a 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 peripheralize the study of variability.

Developments in recent years have started to recognize 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 center stage. Sociolinguistic data are being more widely exploited as a testing ground for theoretical claims. The expanding field of sociophonetics 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 will provide new perspectives on variability in speech. Computational modeling (e.g., Fagyal et al. 2010; Stanford and Kenny 2013) and exploitation of ever larger corpora will further add to our understanding of variation and change.

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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