Variability and change in spoken language communication

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Abstract

Historical sound change is ubiquitous and is often fossilized in spellings that reflect how words used to be pronounced. The issues to be considered in this chapter are why the sounds of languages necessarily change in time and the mechanisms that bring about these changes. To do so requires considering the inherent variation in producing and perceiving speech in everyday conversation. Then some of the main forces are identified that might cause this variation to turn into sound change. These include the listener's occasional failure to adjust or normalise in perception for the numerous contexts in which speech can occur; and the idiosyncratic way in which linguistic knowledge is shaped through experience. Another factor that contributes to the spread of sound change is the natural tendency that speakers imitate each other that may be heightened during language acquisition. The propagation of sound change depends, however, not only on its transmission from one generation of children to the next but is also manifested through a continual updating to an adult's pronunciation over the lifespan. The question of whether sound change can take place irrespective of its consequences or whether it is guided or shaped by existing patterns of sound structure in the language is also considered. A tentative overall conclusion is that sound change is the natural consequence of a dichotomy between speech as continuous movement on the one hand and the discrete categorical properties of language on the other. Further empirical research into the nature of this inherently ambiguous relationship that draws upon increasingly available speech databases spanning several decades of speech will be essential to shed further light on how this dichotomy evolves into sound change.

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1. Introduction

The opening lines of the poem *Sir Gawain and the Green Knight* written around the time of Chaucer's *Canterbury Tales* towards the end of the 14th century show how much English pronunciation has changed in 700 years:

Siþen þe sege and þe assaut watz sesed at Troye,
Þe borȝ brittened and brent to brondeȝ and askez,

There is at least one word, *brittened* derived from Anglo-Saxon *brytnian* meaning "to cut into pieces" or "divide" (Stratmann, 1867) that is related to modern *brittle*. The relationship between old and modern is perhaps more easily seen in *sege*, *assaut*, *sesed* which are derived from Old French and Latin and are *siege*, *assault*, and *ceased* (Glaser, 2011). Sometimes the relationship between the old and the new is more opaque: *askez* demonstrates a sound change by which /sk/ has changed to /ʃ/ to derive present-day /aʃɪz/ (*ashes*). The modern equivalent of *brent* is *burnt* and illustrates another example of a common sound change known as metathesis (Blevins & Garrett, 1998) by which two sounds over a period of time change the order in which they occur (cf. present day German *brennen*, *to burn*). The first word *siþen* is derived from middle English *sithenes* and by way of the deletion of two vowels and a consonant is present-day *since*.

The analysis of older texts such as the above has formed a major part of evidence for sound change using the so-called comparative method by which the relationship between languages and their evolution over centuries has been so successfully established. It is, however, no longer necessary to experience sound change by looking so far into the past. Although not as dramatic, many recordings especially of older speakers from the 1950s sound quite old fashioned to modern ears. Consider as an example an interview recorded by the BBC in 1955 with the crime fiction writer Agatha Christie[1], then aged 60 years: the first vowel in ***o**ften* produced near the beginning of this interview by the interviewee rhymes with *l**aw*** rather than with *l**o**t*. And her vowel in *f**a**ct* rhymes more closely with a present-day pronunciation of *p**e**cked* rather than with *p**a**cked*.

So why do the sounds of languages change with time? And what does this tell us about the structure of language, about how language is related to society's social and cultural changes, and about the way that language is used for communication? These are some of the main issues to be discussed in this chapter. To do so, it will first be necessary to confront an issue that stands at the heart of research in present-day phonetics: understanding variation.

2. Variation

A rough distinction can be made between language-internal and language-external variation. The first is to do with how the same utterance varies depending on the context in which it was

produced by any given speaker; the second derives from differences between speakers. There are many more types of variation than could be summarized here; the ones to be considered are those that are especially important for understanding sound change.

2.1 Internal variation

It seems on the one hand axiomatic that the utterances and words of languages are not stored in memory as entire gestalts but that they are instead built out of a finite set of abstract units that can be permuted and grouped in various ways. Applied to the sounds of speech communication, this *phonological principle* states that a word like *acts* is put together from smaller units (often known as phonemes) such as /a/, /k/, /t/, /s/ and that different permutations of these units give rise to other meanings including for this example /taks/ (*tax*), /akst/ (*axed*), /kats/ (*cats*), /skat/ (*scat*), /stak/ (*stack*), and /sakt/ (*sacked*). The idea that words are decomposable into separate sound units would seem to most people who grow up in a language with an alphabet writing system quite self-evident. So it comes as something of a shock to students who embark upon phonetics for the first time to find when they examine spectrograms (acoustic records in which speech signals are analysed into time, frequency, and amplitude components) that speech is instead a *continuous movement* which shows no respect for the clearly demarcated boundaries that are suggested by such units either within or between words. The latter is perhaps more readily apparent than the former. In the time before I went to school, I remember how my mother used to take her *ham-bag* to go shopping. In fact, this is a close approximation of how this word is typically pronounced: a pronunciation corresponding more closely to the way in which *hand-bag* is spelt never really occurs in everyday conversation. The more typical pronunciation with *ham* comes about because the /b/ of *bag* which is produced with closed lips extends forward in time into the last two consonants of *hand*: and a production of *hand* with closed lips over its last two consonants is very hard to tell apart from *ham*. Thus this simple example shows that the units out of which words are built overlap with each other in time i.e. they are co-produced or *coarticulated*.

Fig. 1 about here

Now consider as another example of coarticulation the data in Fig. 1 which shows the jaw's vertical up and down movement as a function of time recorded with a device known as an articulograph (Hoole & Zierdt, 2010). In order to interpret Fig. 1 more easily, put your finger on your chin and say *pass* and then *piece*: you will notice, consistently with the trajectory in Fig. 1, that the jaw moves down much more in the vowel of *pass*. The same figure also shows that the jaw height differences in these vowels are anticipated right at the beginning of the phrase /əp/ corresponding to ***a piece*** and ***a pass***: that is, because of coarticulation the sounds in bold are not produced in the same way and they also create quite different acoustic signals. This example of coarticulation, that occurs in

everyday spoken language communication, can be related to a well-known sound change by which the Old High German plural for *guests*, /g**a**sti/ (whose singular was /gast/), has become /g**ɛ**ste/ (*Gäste*) in modern times. What has happened here is that the high jaw and tongue positions of the final /i/ in /g**a**sti/ have influenced the vowel of the stem causing the /a/ to be produced with a higher tongue position than in the singular /gast/; and an /a/ produced with a higher tongue position is phonetically quite close to /ɛ/. This coarticulatory influence that almost certainly took place in the conversations of old High German speakers is obviously connected to the present-day *Gäste* produced with an /ɛ/. So this example shows that there can be a very close relationship between coarticulation and sound change.

Another type of variation that is ubiquitous in speech is due to speaking style. Research in the last fifty years has shown that speaking style often varies in relation to how predictable speech is in relation to the context in which it occurs. In general, when speech is unpredictable - such as when saying a name in introducing a person for the first time - then the speaking style is precise, clear, or *hyperarticulated*. But if the listener can guess much of what is being said from the broader context, then speech is often less precise, less clear and *hypoarticulated* or *reduced* (Lindblom, 1990). An extreme form of hypoarticulation/reduction would be to answer a question with an indifferent shrug of the shoulders and quite possibly no speech at all as opposed to replying in a maximally hyperarticulated speaking style with the words *I do not know*. Between these two extremes, there exist a whole range of possibilities (Hawkins, 2003) including *I don't know*, *I dunno*, *dunno*, *dno*, /ə̃ə̃ə̃/ the latter corresponding to not much more than three nasalised vowels similar to that found at the beginning of ***a**nother*, but said with pitch changes. It is astonishing that the meaning of these highly reduced forms is usually completely intelligible to the listener, but *only in the context in which they are situated*. So if /ə̃ə̃ə̃/ were artificially spliced out of context and presented on its own with no context at all to listeners who were then asked -'What words do you think are being said here?' - then the response might well be that this is not even English. There is moreover quite a close relationship between hypoarticulation and sound change. In everyday speech, unstressed syllables tend to be reduced because these are generally less important for identifying the word's meaning (Cutler & Carter, 1987). Sound change over several centuries can, in turn, obliterate unstressed material, as is apparent in considering place-names such as *Cholmondsten*, a small village in Cheshire in the north-west of England whose modern day pronunciation /tʃʌmstn̩/ ('Chumsten') preserves little of its middle unstressed syllable.

2.2 External variation

The very differently shaped vocal tracts and vocal organs of speakers have quite dramatic effects on the speech signal. Women tend to have shorter and thinner vocal folds which is why the pitch of female speech is usually much higher than it is in male speech. Women also have smaller mouth cavities and a different length ratio between the mouth and the throat cavity (pharynx): these

physiological differences cause marked acoustic differences between men and women to the resonances or formants of vowels which are the primary means by which listeners distinguish one vowel from another. Many of these effects are even more marked in the speech of children who have dramatically smaller and differently shaped vocal tracts compared with those of adults.

Speakers also differ along many other social dimensions such as social class (working/middle/upper class) but also more subtly in terms of group and gang membership (Jannedy & Weirich, 2012; Mendoza-Denton, 2008). Moreover, as research by Foulkes et al (2005) has shown, these social differences, that reflect class and group affiliation, are already learned from a very early age in children. Finally, another important factor in variation is the speaker's dialect which for many languages of Europe can vary markedly – even over small geographic distances.

All of these external differences due to the vocal tract size and shape, gender, social and regional affiliation create variation between speakers. However, the variation between speakers is likely to be far more acute than any of these broad categorizations suggest. Over the last 15-20 years, quite compelling evidence has been accumulated that speech is also shaped by experience. According to these theories (see e.g. Goldinger, 1996; Johnson, 1997; Pierrehumbert, 2002), the knowledge that a speaker has of the language is updated every time that a speaker takes part in a conversation. Earlier, it was reasoned that there are two different layers to the sounds of speech communication: the phonological level at which words are built out of permutations of a finite set of abstract units; and continuous speech movement. The implication of these recent findings is that this relationship, being shaped by experience, is idiosyncratic i.e. slightly different from one speaker to the next. As Laver (1994) commented: 'It will be apparent on reflection that the phonetic realizations of every phoneme of every speaker have the potential of being slightly different from those of many other speakers even of the same general accent.'

3. From variation to sound change

3.1 Internal variation and sound change

Theories that seek to establish a relationship between how internal variation can sometimes end up as sound change are generally concerned with the conditions that give rise to change, rather than with how change spreads through the community. One of the most influential of these has been developed by John Ohala (1981, 1993) who suggests that sound change comes about because of ambiguities in the transmission of speech between a speaker and a listener. Central to his model are several experimental findings that listeners typically normalise the speech signals according to the coarticulatory context in which they occur (Beddor & Krakow, 1999; Mann & Repp, 1980). Consider as an example of this the words *bad* and *man* which are formed from two consonants and - importantly for this example - the same vowel /a/. Now because of coarticulation, /a/ is produced differently in these words: in *man* but not in *bad*, /a/ is nasalized, i.e. produced with air flowing out of the mouth and the nose. The reason why this is so is clear enough: the vowel in *man* is surrounded by

nasal consonants /m, n/ that cause the vowel to become nasalized. Interestingly, however, listeners tend not to hear the vowel in *man* as nasalized. This is because they normalise for the effects of context: that is, they attribute the nasalisation in the vowel not to the vowel itself but to the context (the nasal consonants) that are the source of the nasalisation in the vowel. From another point of view, normalisation means in this case that listeners *subtract out* the nasalisation from the vowel (which then causes /a/ in *bad* and *man* to sound the same. This normalisation obviously only happens in context: so if the vowels were spliced out from these words and presented to listeners, then they would indeed judge the isolated vowel from *man* to be more nasalised than the isolated vowel from *bad* (see.e.g. Beddor, 2009; Beddor & Krakow, 1999).

According to Ohala (1981, 1993), sound change can be brought about if listeners occasionally make a mistake and fail to normalise or adjust the signal for coarticulation. Applied to the present example, listeners would not attribute the nasalisation in the vowel of *man* to the context in which it occurs and, as a result, the vowels in *bad* and *man* would no longer sound the same: the vowel in *man* would sound more nasalised. Just this type of listeners reinterpretation of coarticulation is suggested as a possible source of the sound change by which a sequence of an oral vowel and a nasal consonant as in Latin *manus* (*hand*) evolved into a nasal vowel in the present-day French for *hand*, /mɛ̃/ ('main', consisting of a single consonant following by a nasalised vowel). Notice that in this model, nothing has changed in how the speaker produces speech: what has changed is the *listener's interpretation of nasalisation*. So according to Ohala's model, the origins of sound change are as much in the ear of the listener as they are in the mouth of the speaker.

This example of nasalisation is an instance in which sound change is brought about because the listener does not normalise enough for coarticulation. But occasionally, listeners might normalise *too much*. An analogy in vision can help to explain this. In a picture of railway track, railway lines disappearing towards the horizon are drawn closer together.

Fig. 2 about here

Of course, as viewers of the image, we know that the railway lines are not *actually* closer together because we normalise for the context (in this case the perspective) in which the railway lines are drawn. Very occasionally, viewers of a picture or a photograph might normalise too much, as in the image in Fig. 2 in which the monozygotic twins appear to be of different sizes when they are identical. In this case, the skewed arrangement of the room and furniture causes the viewer to normalise the image to too great an extent for perspective giving the illusion that the twins differ in size (see also Ohala, 1981, p. 197 for another example of the relevance of visual illusions for sound change). An analogous kind of over-normalisation is presumed to have occurred in a sound change by which Latin /kwɪnkwe/ has evolved into Italian /tʃɪnkwe/ ('cinque', *five*). Notice that, apart from the change of /k/

to /tʃ/, the first /w/ has been lost. This has come about according to Ohala because /w/ is produced with rounded lips so that for reasons to do with coarticulation, *all* of the sounds of /kwɪnkwe/ are likely to have been produced with rounded lips. Now suppose that listeners were to normalise for this type of coarticulation, i.e. factor out lip-rounding from all of the sounds that preceded the *second* /w/: then, they would *correctly* subtract lip-rounding from the preceding /kɪn/ but *incorrectly* from the first /w/. If lip-rounding is subtracted by the listener from the first /w/, then the resulting sound is not really very different from the typical transition that is produced in /kɪ/: so once again, it is not the speaker that has changed anything but the listener who through over-normalisation hears /kwɪ/ as /kɪ/ (which then evolved into /tʃɪ/ by a separate sound change).

Whereas in Ohala's model, the level of variation that gives rise to sound change is coarticulation, in the model of Lindblom et al (1995) it is more closely related to speaking style. Recall from 2.1 that speakers tend to vary the clarity of their speech in relation to its predictability from meaning: when the listener can make a good guess of the meaning from context, then speakers tend to hypoarticulate and produce speech with a low degree of clarity. As discussed earlier, if hypoarticulated speech is artificially spliced out of context and presented for word identification, then listeners can have difficulty doing so, because the speech signal is unclear or unusual. In context however, listeners tend not to notice these hypoarticulated and/or anomalous signal properties precisely because their attention is focused not on *how* speech is being produced but instead on *what* is being said (necessarily so, because listeners need to predict the meaning from context in hypoarticulated speech). But if exceptionally, they should focus their attention in semantically redundant contexts on how speech was produced, then a new pronunciation could be suggested to listeners which could form the basis of sound change. One of the anecdotal examples given by Lindblom et al (1995) is that of a mother reproaching her daughter. The younger son says 'you sound funny when you yell at SA-mAn-thA', imitating his mother's loud, emotionally charged, drawn out vowels. So here the name *Samantha* was semantically redundant (the name is known/it was obvious who the mother was speaking to) and a new way of saying the word has been suggested. It is this type of addition of new pronunciations that is one of the ways that sound change can be brought about according to Lindblom et al (1995).

The model developed by Joan Bybee (2002, 2006) shares with that of Lindblom et al (1995) the idea that sound change is brought about as a result of the change to pronunciations of words (rather than directly to sounds). Her focus is in particular on words that are statistically frequent in the language that may be especially prone to sound change. As evidence for this, consider that the relatively frequently occurring words *memory* and *nursery* are often produced without the second vowel as *memry* and *nursry* - that is, they are often hypoarticulated. This type of hypoarticulation can end up as sound change as in *chocolate* and *vegetable* which are both words of high frequency with pronunciations that tend to be close to /tʃɒklət/ and /vɛdʒtəbəl/ i.e. with the second syllable all but deleted. However, words that are used less frequently are perhaps not so prone to these kinds of

hypoarticulation changes: for example, it is much less likely that the vowel of the second syllable of the infrequently occurring words *mammary* and *cursory* can be deleted in the same way that it can in *memory* and *nursery*.

There are two main mechanisms in Bybee's model for explaining the greater tendency for sound change to occur in high frequency words. The first is entrenchment: essentially, speakers will have much more practice in producing *chocolate* and *vegetable* as hypoarticulated forms and this practice causes a permanent change to speech production. Thus, there is no sense in Bybee's model in which sound change is brought about by an error, nor – in contrast to Ohala's model – that the listener has a major involvement in sound change. The second draws upon the ideas discussed earlier that linguistic knowledge is updated by experience. That is, a given speaker's production of *memory* is more likely to shift towards *memry* than *mammery* is to *mammry*, because *memry* is much more likely to be encountered/experienced in conversation. Thus entrenchment reinforces experience and *vice-versa* thereby leading ultimately to a permanent change.

Bybee's model is also important because it stands opposed to the well-known neogrammarian theory of sound change (Osthoff & Brugmann, 1878; Paul, 1880) according to which so-called regular sound change sweeps through all the words of the vocabulary at the same rate regardless of word frequency. Bybee's model is based instead more closely on the idea developed by Schuchardt (1885) and later by Wang (1977) that sound change affects words at different rates. The question of whether sound change is word-specific is much debated. In particular, as discussed in Garrett & Johnson (2013) it may be the case that sound change is entirely regular, affecting all words at the same time in the initial stages of sound change; and that the different influence of word-frequency on the progression of sound change only comes into effect later on as listeners become aware of the sound change and attach social meaning to it, in the manner outlined below (see also Bloomfield, 1933:352-362 and Labov, 1994:542-543 for similar views).

3.2 External variation and sound change

The concern in this section is more with how speaker differences and the interaction between speakers can influence sound change. Two themes are considered: firstly, that differences between speakers exacerbate the inherent ambiguity in speech signals; secondly, that speakers have a natural tendency to imitate each other. This combination of ambiguity on the one hand coupled with imitation suggests that *imperfect imitation* may be another important factor in explaining how variation can result in sound change.

Speaker differences and listener ambiguity

In 2.2, it was suggested that linguistic knowledge is updated depending on a speaker's experience, i.e. depending on the conversations that are held over a lifetime. If this is so, then the relationship between continuous speech movement on the one hand and the abstract units that function

to distinguish word meanings is itself idiosyncratic. The further implication of this idea is that, if linguistic knowledge is updated by experience, then listeners even of the same community may normalise the same speech signal slightly differently. There is indeed evidence that this is so: in perception experiments, listeners have been shown to differ in the extent to which they normalise for the effects of coarticulation (Beddor, 2009; Fowler & Brown, 2000; Harrington et al, 2008; Kleber et al, 2012a). Thus, earlier it was argued that the reason why the /a/ in *bad* and *man* tend to sound the same even though they are produced differently (one with, one without nasalisation) is because the listener factors out nasalisation from the vowel and attributes it to the context from which it originates, the nasal consonants. As long as there is normalisation, listeners perceive coarticulation in a way that is analogous to its production and there will be no sound change. But if the experience-based model is correct, then no two listeners will ever exactly normalise the same signal in an identical way: therefore, ambiguity in processing coarticulation that could form the basis of sound change is interwoven into every single conversation, simply because listeners normalise speech idiosyncratically.

Now consider that coarticulation - or more generally the way that speech sounds overlap with each other in time in producing continuous speech movement - is not just an automatic consequence of the sluggishness of the vocal organs but varies across different dialects and languages (Manuel, 1999). So although both English and German build words out of the differences between /l/ and /r/ (e.g. *lief*/*rief* in German; *leaf*/*reef* in English), the precise way in which these consonants are timed with respect to the vowel in the two languages is not the same: this is one of the reasons why English *leaf* and German *lief*, while phonetically similar, are certainly not identical. Coarticulatory differences are found not just between languages but also between dialects of the same language (e.g. Scobbie & Pouplier, 2011). This means that listeners from different dialects are likely to agree even less than those of the same dialect on how much of the speech signal to normalise for context. It has of course been well-documented in the sociolinguistics literature that sound change is often the outcome of dialect contact (Kerswill, 2003). One of the factors that may precipitate sound change when dialects come into contact with each other is that listeners of different dialects disagree on how to normalise speech signals for the contexts in which they occur.

Imitation

Speakers have a natural propensity to imitate each other. Bloomfield (1933) suggested that there is mutual imitation leading to convergence in speech patterns of speakers of a community. Research has shown that speakers imitate or, accommodate to, each other in face-to-face conversations (Giles, Coupland & Coupland, 1991; Garrod & Pickering, 2009) and there is now experimental evidence to show that speakers sound slightly more like each other after they have participated in a conversation than before (Pardo, 2006). Speech imitation is subtle and speakers are generally not aware that it takes place (Garrod & Pickering, 2009; Pardo, 2006). Although social

factors may place limits on imitation - for example, speakers are more inclined to imitate someone that they identify with (Babel, 2012) - speech imitation also takes place in the absence of any social motivation to do so (Nielsen, 2011). Imitation may be especially important when children acquire language: children have been shown to copy the detailed characteristics of the speech of their caregivers including those attributes that identify social class membership (Foulkes et al, 2005). Imitation has been argued to play a central role in the formation of colonial dialects such as Australian and New Zealand English (Trudgill, 2004, 2008): if speakers are generally predisposed to imitate each other, then when speakers are isolated together in a community, the differences between their accents should be levelled out, as they begin to sound more like each through imitation: that is, imitation is probably one of the forces that contributed to the development of these colonial varieties as a result of dialect mixture. This idea that speakers imitate each other when they are in close contact for a prolonged period of time has been demonstrated in a recent longitudinal study by Pardo et al (2012), who showed that students sounded more like each other after being room-mates for an academic year.

Earlier it was reasoned that there are inherent ambiguities in how coarticulation is transmitted because of the different ways that speakers update their knowledge depending on the range of conversations that they are exposed to. These ambiguities may be especially marked when children perceive adult speech, not only because children and adults have very different accumulated experiences of speech, but also for the reason discussed in 2.1 that the acoustic signals of child and adult speech are so very different due to the marked physiological differences of their vocal organs. A reasonable - but not yet properly tested hypothesis - is that young children may normalise speech for the effects of context in a way that is different from adults: that is, they may be especially likely to make the kinds of errors in interpreting coarticulation that in Ohala's model form the basis of sound change. But in addition, it was noted that children in the early stages of language acquisition are predisposed to imitation. These two ideas together suggest that one of the major sources of sound change is likely to lie in children's imperfect imitation of speech. The idea that language acquisition and language change are connected has a long history (Jacobson, 1941; Paul, 1880, Stampe, 1979) and there has also been much speculation about whether there are parallels between the errors that children typically make in acquiring speech and the types of sound changes that tend to occur in many languages. However, this is not the relationship that is being suggested here and there is in any case quite substantial evidence to show that there is no direct correspondence between the two (Diessel, 2012; Foulkes & Vihman, in press). What is being proposed here instead is that the coarticulatory relationships between speech sounds are copied from adults by children but sometimes slightly distorted: if, in comparison with adults, children attribute slightly more nasalisation to the vowel than to the consonants in words like *man*, then they may also nasalise fractionally more /a/ in such words. This distortion might then be further copied by the next generation leading to a progressive accumulation of distortions across several generations that could form the basis of incremental sound change that has been so well documented in the sociolinguistics literature (Labov, 2007).

However, as Yu (2007) correctly notes, the assumption that children or more generally those acquiring a language (such as second language learners) are the only agents of sound change is far too restrictive. It is also not the case that sound change takes hold simply as distortions are passed on incrementally from one generation to the next, because, as various studies have shown (Harrington et al 2000; Sankoff & Blondeau, 2007), adults participate in ongoing sound changes that take place in the community. The study in Harrington et al (2000) was concerned with acoustic analyses of the broadcasts that have been delivered by Queen Elizabeth II almost annually since 1952. The reason why these are so useful for exploring sound change in the individual is that, since the communicative intent of the broadcasts is more or less the same each time (originally a message to Britain and its Empire, subsequently to the Commonwealth), then the stylistic variation from one broadcast to the next is minimised and so unlikely to swamp the small effects of sound change from year to year. The acoustic analysis in Harrington et al (2000) showed that the Queen's accent which is an aristocratic form of the standard accent of England, Received Pronunciation, had shifted over 30-40 years in the direction of a more mainstream version of the standard (mainstream RP) that is more typical of the middle classes (see also Harrington, 2006). One of the reasons why this happened is that the 1960s saw a substantial rise of the middle and lower-middle classes to positions of power in England. Thus, the Queen is likely to have come into progressively greater contact across the decades with persons who speak a more mainstream RP - this also includes many of her prime ministers such as Tony Blair, Margaret Thatcher and John Major. The model by which linguistic knowledge is updated by experience would predict exactly the kinds of longitudinal shifts that were observed by Harrington et al (2000) in the Christmas broadcasts: the more the Queen converses with mainstream RP speakers, the more her accent should shift in that direction, assuming that her linguistic knowledge is updated by the increasing contact over the years with conversations with mainstream RP speakers. Moreover, since linguistic knowledge is shaped by an accumulation of the past and the present, then an experience-based model of speech predicts the finding in Harrington et al (2000) that the Queen's evolving accent should be a mixture of an aristocratic and a mainstream form of RP: that is, the Queen's accent shifted towards mainstream RP without actually attaining the mainstream RP characteristics entirely. Notice that there is nothing to suggest in this model that the Queen has shifted her accent with the *intention* of sounding more middle class: the annual shift in the Queen's vowel positions are in any case far too small for this type of introspection to be possible (Harrington, 2012). Instead, the shift follows directly and perhaps inevitably as a consequence of imitating the increasing number of mainstream RP speakers with which the Queen has interacted. Thus in summary, experience (through face-to-face conversations), imitation, and the rise to power of speakers of a particular kind of accent (in this particular case the lower-middle and middle classes in England) are likely to be additional forces that determine and shape the direction of sound change.

4. Sound change and the maintenance of structure

Another fascinating and largely unresolved issue in sound change is whether it somehow has knowledge of its consequences. According to the neogrammarian hypothesis referred to earlier, there is a class of so-called regular sound changes that does not. That is, the sound change sweeps through the entire vocabulary incrementally without any regard to how the system of contrasts that differentiates words might be changed after the sound change has applied. But there is a fundamental paradox here and it is this: If regular sound change is blind to its consequences, then why is there so much regularity in the sound systems across languages? For example, almost all languages have some form of /i, u, a/ vowels; there are no languages that have nasal vowels without also having oral vowels; there are no languages that have syllables built from a sequence of two consonants and a following vowel (such as /sta/) without also having the corresponding CV syllable (/ta/). But if sound change applies irrespective of its consequences, then this should not be so. There should also be more than a few examples of languages with quite anarchic sound systems. It should also not be the case that the same type of sound change applies even in quite unrelated languages. We should also not expect to see so many sound changes that are dependent on each other (see Jakobson, 1931 for many examples of this) such as vowel chain shifts (Labov, 1994) in which the historical change in one vowel can often influence another in quite a systematic way. For example, the vowels of present day New Zealand English differ from those of the standard accent of English as a result of the rotation *of the entire front vowel space* (Bauer, 1979; Maclagan & Hay, 2007; Watson et al, 2000) as a result of which New Zealand *head* and *had* sound very much like *hid* and *head* respectively to listeners of mainstream RP.

As a possible solution to this complex issue, consider that coarticulation has been argued to be a major factor in giving rise to sound change. This is based on the argument presented at various stages in this chapter that there is a parallel between coarticulation in everyday conversation (e.g., speakers nasalize their vowels before a nasal consonant) and sound change itself (vowels are often permanently nasalized before nasal consonants). Now although it has been argued that the nature of coarticulation varies between varieties and languages (no two varieties are likely to nasalize vowels before a nasal consonant in precisely the same way), coarticulation is nevertheless subject to biological and physical principles that are derived from the sequencing of speech sounds and how these are perceived. That is, coarticulation also has a language-*independent* component: for example, /i, a/ are much more likely to influence each other in /ipa/ than in /ita/. This is because the tongue-tip constriction in /t/ interrupts the tongue movement from /i/ to /a/ whereas there is no such interruption in /ipa/ because /p/ is produced with the lips and not the tongue. Thus the general point here is that coarticulation is to a very large extent shaped by the physical principles of vocal tract dynamics. Now if coarticulation is controlled by such physiological and also auditory principles (given that listeners also normalise for coarticulation), and if sound change originates to a large extent because of how coarticulation is sometimes imperfectly transmitted between a speaker and hearer, then the resulting

sound change itself must to a large extent be constrained by these same physiological and auditory principles. This may then be one of the reasons why, although sound change can operate blindly and without any regard to its future consequences, the output of sound change is not random because it is constrained physiologically and auditorily by similar principles that determine the type and extent of coarticulation in everyday conversations.

But whether coarticulation alone is sufficient to constrain the possible resulting sound changes is far from clear. There is, for example, a well established functional theory of sound change (Martinet, 1952) according to which two sounds that are important for distinguishing between meaning are less likely to merge with each other than those which distinguish meaning in only a handful words in the vocabulary (see Wedel et al., 2012 for a recent computational model in support of this view). According to this functional theory, /a, ɛ/ are not very likely to fuse into the same sound in English because they are crucial for the distinction between so many words (*bat*/*bet*, *band*/*bend*, *had*/*head* etc.). But on the other hand, *sure*/*shore* are now pronounced in the same way for many speakers, possibly because there are so few pairs of words for which the original distinction between /ʊə , ɔ/ was critical. So it could be that sound change is directed or controlled by the need to maintain sufficient contrasts between words.

However, such a planned or teleological view of sound change runs counter to the neogrammarian idea that sound change applies blindly without regard to its consequences and also to the various theories discussed in connection with Ohala's model that sound change comes about because of an error (and an error cannot by definition be planned). Recent advances in computational modelling are beginning to show how these apparent opposites can be reconciled. In one such model developed by Blevins & Wedel (2009), sound change is shown to be inhibited if the resulting sound change destroys numerous contrasts in the vocabulary. But this inhibition is shown in their model to emerge as a natural consequence of some of the ideas reviewed in this paper that speakers update their linguistic knowledge through experience and interact with each other. Thus although there is no intention on the part of speakers to maintain contrasts, they are maintained anyway as a simple by-product of conversational interaction and remembering and updating linguistic categories. From a computational point of view, there are parallels between this type of model in which categories emerge as a consequence of speaker-interactions and other phenomena in nature such as the formation of ice-crystals and the cathedral-like formation of termite nests that emerge simply as an unintended by-product of the way that termites interact with each other (see Lindblom et al, 1984; Oudeyer, 2006; Shockley et al, 2009).

According to Kiparsky (1995; in press), sound changes are also constrained by the *existing* pattern of phonological contrasts in a language (see also Lindblom et al, 1995, for a similar view). More specifically, he reasons that a sound change is much more likely to take place in a language, if there is also a similar type of phonological contrast in that language. For example, there is a sound change known as tonogenesis by which the distinction /ba, pa/ (analogous to the first two sounds in

bat vs. *pat*) can collapse to evolve into a tonal contrast: instead of words being distinguished by the voicing differences in the initial /b, p/, they come to be distinguished instead by tone i.e. by /pà, pá/ in which the same consonant-vowel sequence is distinguished entirely by a rising vs. falling pitch (see Hombert et al, 1979 for the physiological and coarticulatory motivation for this sound change). However, Kiparsky (1995) suggests that tonogenesis is only likely to occur in tone languages, i.e. languages that *already* distinguish word meanings based on pitch. Similarly, Kiparsky suggests that a sound change involving the total assimilation of consonant clusters resulting in geminates (e.g. where /kt/ turns into /tt/ as in Latin *octo* > Italian *otto*) happens primarily in languages such as Finnish, Ancient Greek, Latin, and Italian that already have geminates.

According to this phonological principle, a sound change could never take place such that English begins to contrast word meanings as do many African languages using so-called ejective stops (these are produced when the air in the mouth is compressed by raising the larynx rather than, as in English and in other European languages, through exhalation from the lungs). It could not do so according to Kiparsky (1995) because ejective stops are not currently used to differentiate word meanings in English. And yet, Simpson (2010) has recently reported that there are some varieties of English in which speakers are beginning to produce ejective stops. Presumably (and quite plausibly) following Kiparsky (in press), this astonishing innovation must be short-lived and cannot develop into a permanent sound change because English does not build meaning distinctions using this type of ejective consonant. But only time will tell.

5. Concluding remarks

Sound change is a fascinating area of study partly because it forces us to take a highly inter-disciplinary approach to the field: we need to keep an eye simultaneously on the dynamics of variation in speech which requires an understanding of acoustics, physiology, and perception; on the mechanisms by which speech is transmitted from a speaker to a hearer which draws upon cognition and psycholinguistics; on how sociolinguistic principles shape speech and language; on the comparative method in linguistics allowing family trees of languages and their ancestors to be derived; on linguistic principles governing the pattern of the distribution of sounds systems in the languages of the world (i.e. so-called linguistic universals); on how children acquire language; on how different dialects emerge; and on issues to do with parallels between language evolution and biological evolution (and modelling these computationally), which is yet another topic that has not been aired in this paper.

Another reason for studying sound change is that it takes us to the very heart of one of the toughest problems in the speech sciences that is to a certain extent concerned with how the body and mind are connected and one that is also central to progress in speech technology and understanding speech disorders: that is, how continuous movements in speech are related to the categorical aspects of language. It has been emphasised throughout this chapter that, contrary to the intuitions that are

artificially imposed on those of us who grow up learning to read and write in an alphabet-based writing system, these are not the same. Speech as produced and perceived is continuous movement in which speech sounds overlap with each other and influence each other in time. Studdert-Kennedy (1998) appropriately refers to this as a shingled pattern of movement. But the phonological principle is fundamental to language: this is the principle by which a potentially infinite vocabulary can be built from a finite number of building blocks that can be thought of as abstractions or generalisations across the different kinds of continuous speech movements. There is evidence that children acquire this phonological principle by 12-15 months (Kuhl et al, 1992) and then progressively refine it and develop further levels of abstraction (Munson et al, 2012): it is this abstraction that allows children and adults to process speech far more rapidly than if they were only able to process continuous speech movements. It is this principle that also makes human and so-called animal languages fundamentally different: whereas human languages can build different meanings through permuting these units (thus establishing at this more abstract level of representation a relationship between *cat* and its reversed sequence *tack*), there is no animal language that has this capability of deriving different meanings through permuting meaningless units of sound.

Throughout this chapter, I have been arguing that sound change is an inevitable consequence of this fundamental dichotomy between discrete units that function to distinguish meaning on the one hand and continuous speech movement on the other: if there were not these two different levels of representation, then there would be no sound change. Sound change comes about because their relationship is inherently ambiguous. It is an ambiguous relationship for reasons to do with internal variation (different ways of saying the same utterance) and also external variation (variation across different speakers and speaker groups). One of the forces that was identified as being particularly important to the conditions that give rise to sound change is the error that can sometimes occur in normalising the variation in the speech signal depending on the context in which it occurs. Another is that linguistic knowledge is updated by experience which adds to the variation between speakers. Yet another is the natural tendency to imitate or rather to imitate imperfectly in face-to-face conversations. Finally, the existing patterns of phonological structure of a language - whether a language is tonal, has ejective stops and so on - may be another force that contributes to the likelihood of sound change taking place.

In concluding, I would like to suggest three areas that are going to becoming increasingly important in understanding sound change. One of these lies in developing a better understanding of the dynamics of speech production and perception and how these can result in the kinds of ambiguities across contexts and speakers that can turn into sound change. This includes further studies of the extent to which coarticulation and the normalisation for context is idiosyncratic (Kataoka, 2011) or variable across speaker groups (Yu, 2010) or different prosodic contexts (Kleber et al, 2012b). The second lies in making use of recordings from the past to predict sound change in the future. It is now possible to measure sound change from recordings over at least a 60 year period so that the

reconstruction method that is necessarily based on written transcripts can be increasingly supplemented with real data: the speech scientist in two hundred years from now will be in an enviable position of having vast amounts of digitised data over a long time-span on which to model language evolution. These areas of research - carrying out detailed experiments to measure coarticulation and speech timing on the one hand and analyses of speech from archived recordings on the other- will provide some of the primary data for the third area in which progress has already been made (e.g. Kirby & Sonderegger (2013): using computer models to simulate and predict the types of sound change that can occur in the world's languages.

Notes

1. Available on-line at http://www.bbc.co.uk/archive/agatha_christie/12503.shtml

Figure legends

Fig. 1 The vertical height of the jaw measured with an articulograph in /əpa/ (left) and /əpi/ (right).

Fig. 2. Monozygotic twins photographed in a skewed room. From: http://www.welt.de/wissenschaft/article11443233/Darum-fallen-Sie-auf-optische-Taeuschungen-rein.html

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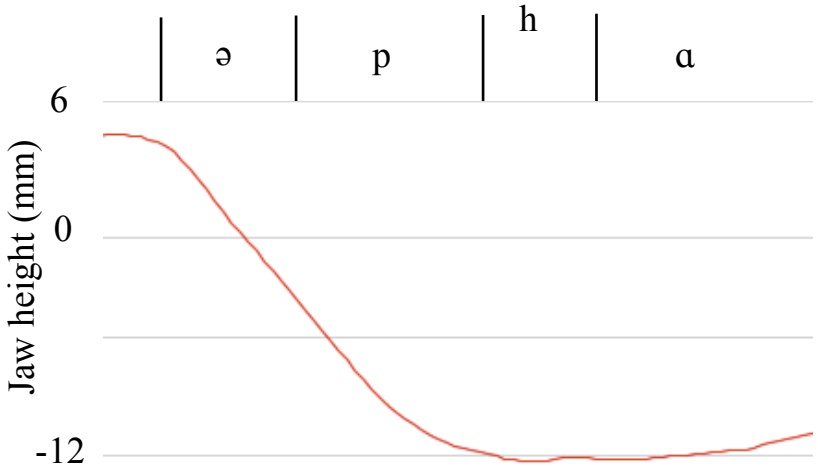
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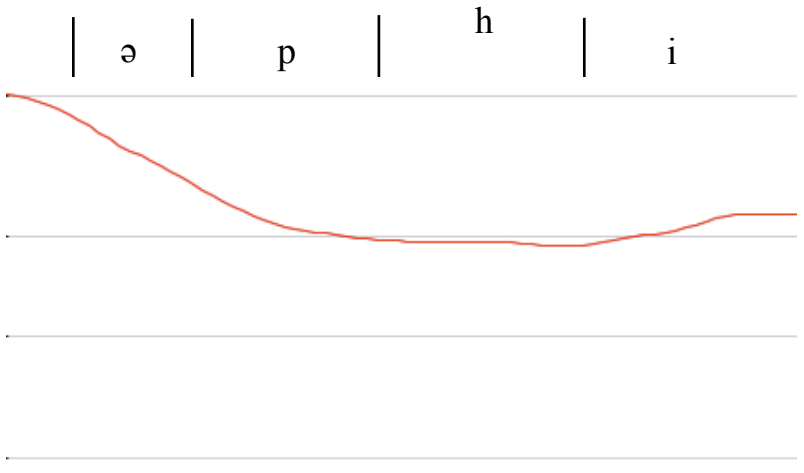
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